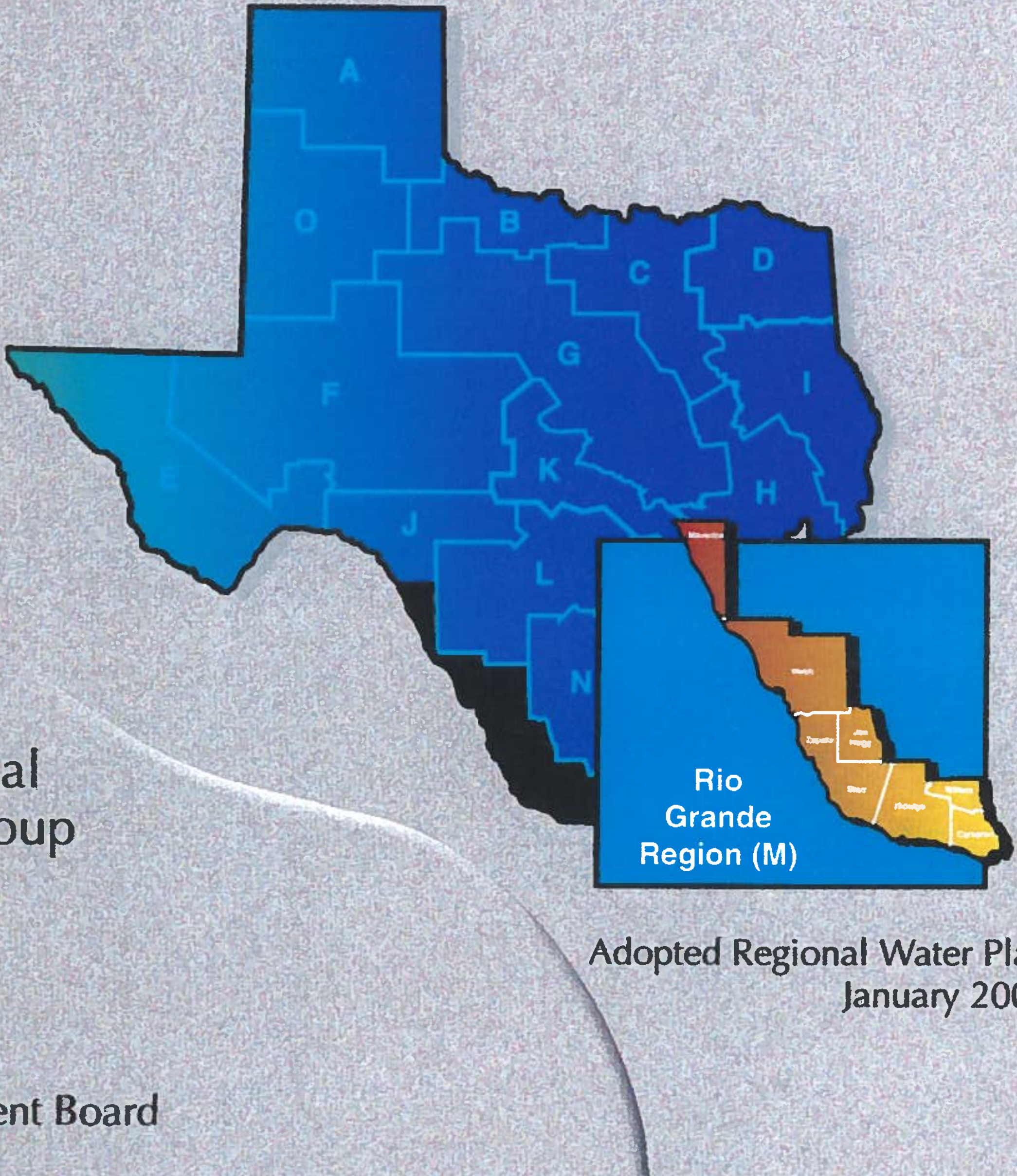
REGIONAL WATER SUPPLY PLAN FOR THE RIO GRANDE REGIONAL WATER PLANNING AREA (REGION M)

Volume I



prepared by
Rio Grande Regional
Water Planning Group
(Region M)

Adopted Regional Water Plan
January 2001

with funding assistance from
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ES.1 INTRODUCTION

The Rio Grande Region faces serious challenges in managing its limited water resources. Both municipal and agricultural uses show significant shortages throughout the planning horizon 2000-2050. In reality, shortages in irrigation water needs are already experienced in year 2000 despite the fact that "drought of record" conditions have not yet been experienced. And over the next 50 years, the amount of water available from surface and groundwater sources is projected to decline.

How can the region meet these challenges? Since 1998, the Rio Grande Regional Water Planning Group, (RGRWPG), representing water users and other stakeholders in eight counties adjacent to or in proximity to the middle and lower Rio Grande, has been wrestling with that question. The planning region encompasses Cameron, Hidalgo, Jim Hogg Maverick, Starr, Webb, Willacy, and Zapata Counties (Figure 1).

The RGRWPG, has developed and analyzed data on water supplies and projected needs and evaluated options for meeting those needs. The result, laid out in this document, is a plan with specific strategies for meeting water needs in the Rio Grande Region through the middle of the 21st century.

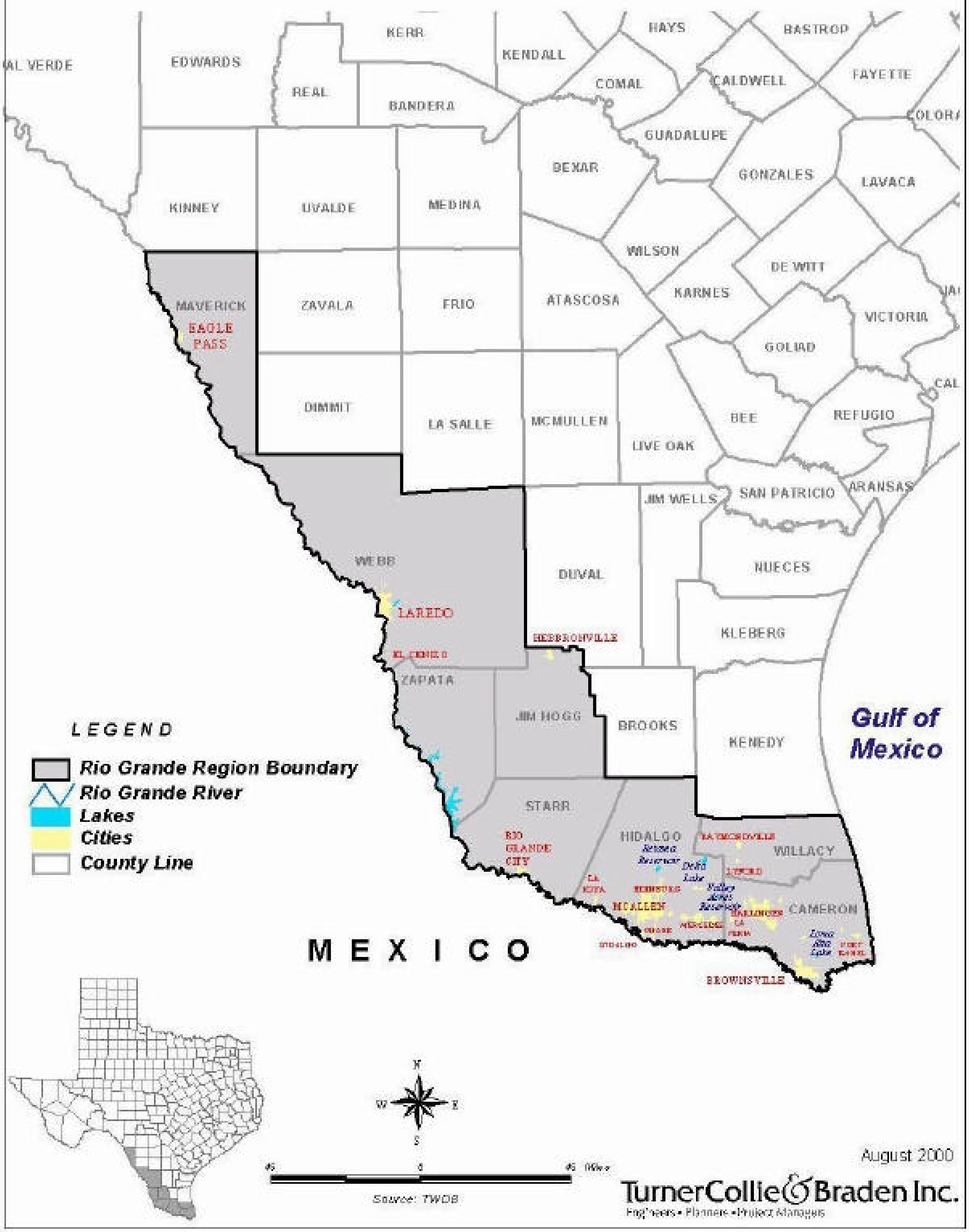
WATER MANAGEMENT GOALS FOR THE RIO GRANDE REGION

The Rio Grande RWPG has adopted five basic goals to underlie specific strategies presented in this regional water plan. They are:

- Optimize the supply of water available from the Rio Grande;
- Reduce projected municipal water supply needs through expanded water conservation programs;
- Diversify water supply sources for domestic, municipal, and industrial (DMI) uses through the appropriate development of alternative water sources (e.g., reuse of reclaimed water, groundwater, and desalinization);
- Minimize irrigation shortages through the implementation of agricultural water conservation measures and other measures; and,
- Recognize that the acquisition of additional Rio Grande water supplies will be the preferred strategy of many DMI users for meeting future water supply needs.

The rationale for these goals and recommendations for implementing strategies to achieve them are presented in this document.

Figure 1 : Rio Grande Regional Water Planning Area (Region M)



ES.2 REGIONAL WATER PLANNING PROCESS

During 1997, the 75th Texas Legislature enacted Senate Bill 1 (SB 1), often referred to as the Brown-Lewis Water Plan, after its Senate and House sponsors. With SB 1, the Legislature established a "grass roots" approach whereby future state water plans are to be based on a compilation of regional water plans prepared and adopted by appointed regional water planning groups (RWPGs).

The Rio Grande Regional Water Planning Group, one of 16 local bodies established by the Texas Water Development Board (TWDB) in accordance with SB 1, consists of 17 voting members representing 10 of the 11 interest group categories specified in SB 1 (See Table 1). One category, river authorities, is not represented on the Rio Grande RWPG since there are no river authorities in existence within the boundaries of the Rio Grande Region. The Rio Grande RWPG also includes non-voting members representing federal and state agencies and the Mexican federal government.

The regional water plans must assess future water demands and currently available water supply and include specific recommendations for meeting identified water needs through 2030. The plans should also include recommendations for meeting long-term needs (through 2050) and recommendations regarding legislative designation of ecologically unique rivers and streams, reservoir sites, and policy issues. The regional water plans must be completed, and submitted to the TWDB by 5 January 2001.

Table 1: Rio Grande Regional Water Planning Area Interest Groups and Voting Members

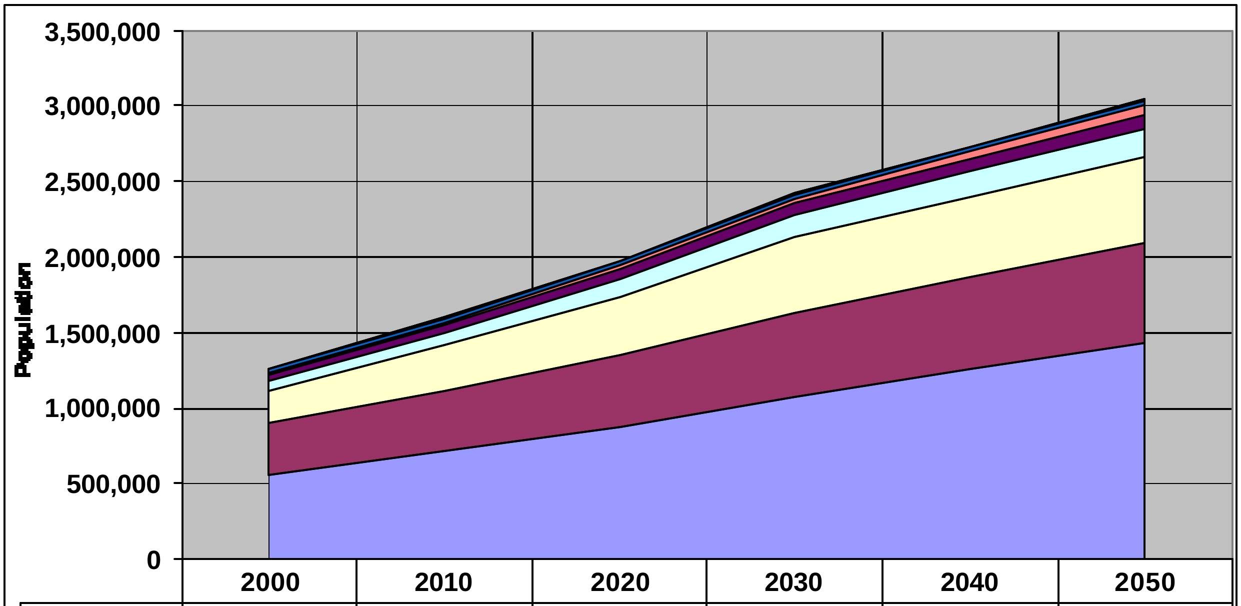
Interest Group	Member	Affiliation	City
Agriculture	Robert Fulbright* Ray Prewett	Rancher Texas Citrus Mutual	Hebbronville Mission
Counties	James R. Matz Mecurio Martinez, Jr.	Cameron County Commissioner Webb County Judge	Harlingen Laredo
Electric Generating Utilities	Jaime Gomez	Central Power & Light	Laredo
Small Business	Maria Eugenia Guerra	LareDOS Newspaper	Laredo
Industry	Jack Nelson	Rio Grand Valley Sugar Growers, Inc.	Santa Rosa
Public	Mario Gracia-Rois	Texas A&M International	Laredo
Other	Glenn Jarvis*, Chairman Lee Kirkpatrick*, Secretary	Attorney Texas State Bank	McAllen Brownsville
Municipalities	Roberto Gonzalez William "Bart" Hines Fernando Roman*, Vice-Chairman	Water Works Public Utility Council Water Utilities	Eagle Pass McAllen Laredo
Environmental	Mary Lou Campbell*	Sierra Club	Mercedes
Water Districts	Gordon R. Hill Sonny Hinojosa	Bayview Irrigation Dist. #11 Hidalgo Co. Irrigation Dist. #2	Los Fresnos San Juan
Water Utilities	Charles "Chuck" Browning	North Alamo WSC	Edinburg

**Executive Committee Member*

ES.3 OVERVIEW OF THE RIO GRANDE REGION

The Rio Grande Region is one of the fastest growing areas of Texas. In Texas, its population increased from approximately 398,700 in 1950 to over 1.17 million in 1998. Nearly 89 percent of the region's total population is concentrated in Cameron, Hidalgo, and Webb Counties. Population in the region is projected to more than double over the next 50 years, from approximately 1.26 million people at present to 3.05 million in 2050 (see Figure 2). Additionally, population within Mexico's portion of the Rio Grande Basin is projected to increase from approximately 1.8 million at present to 3.7 million in 2020.

Figure 2: Population Projections for the Rio Grande Region (U.S. only)



	2000	2010	2020	2030	2040	2050
■						
■ Jim Hogg	6,176	7,401	8,717	9,791	10,499	11,238
■ Willacy	21,165	23,722	25,857	27,284	28,280	29,077
■ Zapata	13,567	19,218	26,827	35,955	49,008	67,272
■ Maverick	48,180	57,618	65,517	71,699	80,082	90,351
■ Starr	58,158	80,333	109,240	146,407	169,917	188576
■ Webb	219,725	293,939	384,260	501,318	527,244	571,916
■ Cameron	337,689	405,463	476,992	554,513	614,396	652,931
■ Hidalgo	559,922	712,383	879,381	1,078,637	1,256,080	1,435,319

The vast majority of the Rio Grande basin is comprised of rural, undeveloped land used principally for farming and ranching operations. Historically, agriculture has been the predominant component of the economy in the region. While the region is becoming more urbanized and its economy more diversified, agriculture still plays a major role. More than 75 percent of the region's total land area is used for agriculture and livestock.

The Rio Grande has been nationally designated as one of the fourteen American Heritage Rivers, pursuant to Executive Order 1306. This special designation recognizes this river's significance in history and establishes a framework whereby communities will receive federal assistance to address locally defined priorities related to the river's environmental, economic, and cultural values.

Due in part to its proximity to Mexico, the trade, services, and manufacturing sectors are becoming increasingly important to the Rio Grande Region's economy. The trade and service sectors of the economy have been responsible for much of the economic growth in the Rio Grande Region over the past decade in terms of both revenue and employment. Manufacturing is also an important sector of the economy, primarily in the fast-growing areas of Brownsville-Harlingen-San Benito, McAllen-Edinburg-Mission, and Laredo. The most important factor in the expansion of the region's manufacturing sector has been the growth of the maquiladora industry in Mexico.

In Jim Hogg, Webb, Starr, and Zapata Counties, oil and gas production and trade are also important sources of income.

ES.3.1 Water Sources

While the Rio Grande Region in Texas encompasses portions of three river basins (the Rio Grande, the Nueces and the Nueces-Rio Grande Coastal), practically all of the surface water available to and used within the region is from the Rio Grande. Nearly all of the dependable surface water supply available to the Rio Grande Region is from the combined yield of the Amistad and Falcon International Reservoirs, the two major reservoirs on the Rio Grande. The Rio Conchos in the State of Chihuahua, Mexico and the Pecos River in Texas contribute most of the inflow to the Amistad-Falcon Reservoir System. The estimated firm yield of the reservoir system for the U.S in 2000 is 1.17 million acre-feet per year. (Firm yield is the amount of water available in the drought of record.) The dependence upon surface water from the Rio Grande as the predominant source of supply for the Rio Grande Regional Water Planning Area (RGRWPA) is not expected to change over the next 50 years.

Throughout the Rio Grande Region groundwater provides water supply for municipal, irrigation, livestock, and industrial uses.

ES.3.2 Water Users

Municipal water users and irrigation together account for more than 98 percent of the total water demand in the Rio Grande Region. The majority of the water used in the region is in the Lower Rio Grande Valley, where approximately three quarters of a million people live and where irrigated farming is practiced extensively. At present, approximately 85 percent of total water use within the region is used for irrigation; and 15 percent for municipal manufacturing, steam electric, mining and livestock.

The 29 irrigation districts within the Rio Grande Region represent the major irrigation demand centers. These districts supply irrigation water users primarily in Cameron, Willacy, Hidalgo, and Maverick Counties. They hold the majority of irrigation water rights and account for nearly all of the irrigation demand in the region.

Under the water rights system for the middle and lower Rio Grande, domestic-municipal-industrial (DMI) water rights have a very high degree of reliability. By comparison, irrigation and mining water rights are residual users of stored water from the reservoirs, and therefore, bear the brunt of water supply shortages. In essence, irrigation and mining water demand must adjust to the available water supply. An additional threat to the availability of water from the Rio Grande for irrigation use is the development and operation of reservoirs on Mexican tributaries that contribute flow to the Rio Grande.

ES.4 PROJECTED WATER DEMANDS

Along with dramatic growth in population, the water demands of municipal, manufacturing, and steam electric users in the Rio Grande Region are projected to increase. However, total annual water demand for the Rio Grande Regional Water Planning Area is projected to decrease by approximately 65,000 acre-feet or 3.6 percent over the 50-year planning period. The decrease in total regional water demand is due to a projected decline in irrigated acreage, particularly in the Lower Rio Grande Valley, as land use changes from agriculture to urban uses. The current and projected regional water demands for the six major water use categories are described below and depicted graphically in Figure 3.

ES.4.1 Projected Water Demand by Use Category

Irrigation water demand is projected to decrease from approximately 1.53 million acre-feet per year at present to 1.19 million acre-feet per year in 2030 and thereafter. This 22 percent decrease in projected irrigation demand is due to anticipated decreases in irrigated acreage in Cameron and Hidalgo Counties due to urbanization.

Municipal water demand within the region is projected to almost double from 2000 to 2050. While this represents a significant increase in municipal water use over the planning period, this rate of increase is significantly slower than the rate of increase in the region's population. This is due to anticipated improvements in municipal water use efficiency through water savings associated with the adoption of various water conservation measures. Municipal water demand is concentrated in Cameron, Hidalgo, and Webb Counties, which together account for nearly 72 percent of municipal water demand in the region.

Manufacturing water demand is projected to increase from approximately 5,000 acre-feet per year at present to approximately 7,500 acre-feet per year in 2050 (a 50% increase), predominately due to projected growth in Cameron and Hidalgo Counties.

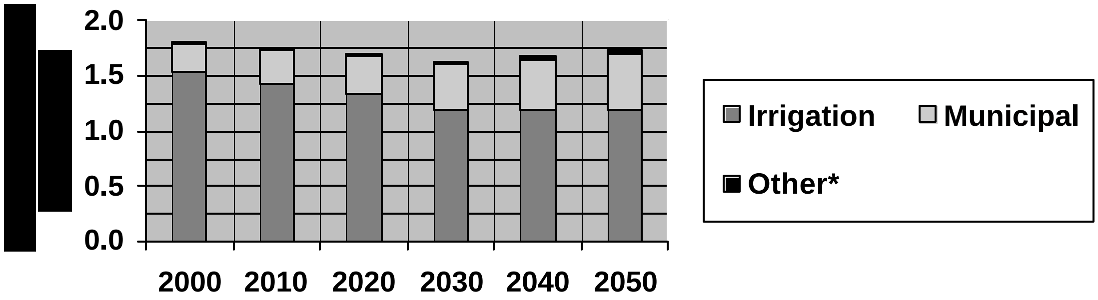
Steam electric water demand is projected to increase from 9,100 acre-feet per year in 2000 to 24,400 acre-feet per year in 2050 (a 268% increase). The majority of this increase is expected to occur between the years 2000 and 2030 as a result of the addition of new steam electric power generating capacity.

Mining water demand, which represents less than one percent of total regional water demand, is expected to remain relatively constant over the 50-year planning period.

Livestock water demand, representing only about one-half of one percent of total water demand in the Rio Grande Region, is projected to remain constant over the 50-year planning period.

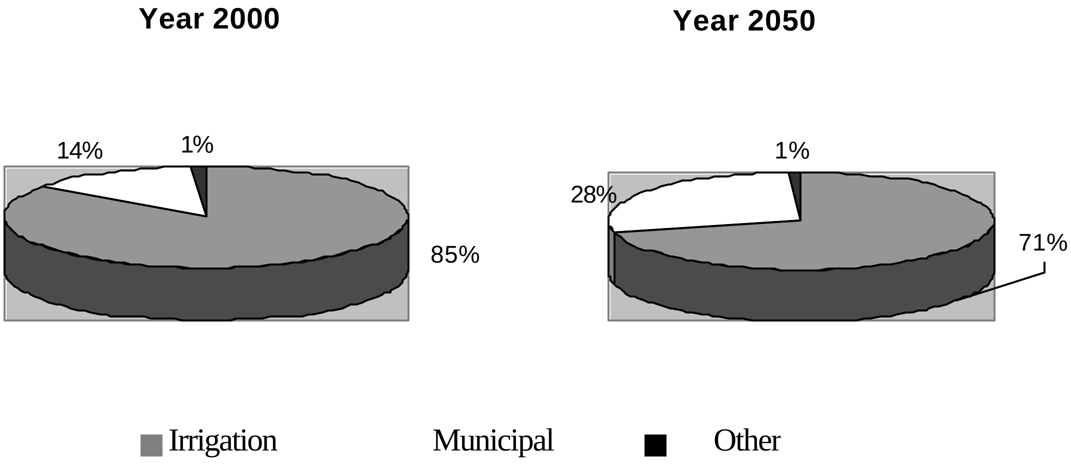
Figure 4 illustrates the Rio Grande Regional water demand distribution, by use category, between 2000 and 2050.

Figure 3: Water Demand Projections for the Rio Grande Region



** Other includes steam electric, livestock, manufacturing, and mining*

Figure 4: Water Demand Distribution for the Rio Grande Region by Use Category



ES.4.2 Projected Water Demand by County

The following is an overview of projected water demands in the Rio Grande Region, by county, for the 50-year planning period, as listed in Table 2.

Cameron County: With a current (year 2000) population of 337,689 expected to increase to 652,931 by year 2050: Water is used almost exclusively to meet municipal and irrigation water demands. Over the planning

Table 2: Projected Rio Grande Regional Water Demands, by County and Use Sector (ac-ft/yr)

County	Sector	2000	2010	2020	2030	2040	2050
Cameron	Irrigation	438,485	418,931	395,950	369,464	369,464	369,464
	Municipal	68,097	76,892	85,636	97,885	105,618	111,651
	Steam Electric	2,400	2,000	2,000	11,600	11,600	11,600
	Livestock	1,456	1,456	1,456	1,456	1,456	1,456
	Manufacturing	1,257	1,391	1,504	1,628	1,804	1,985
	Mining	12	8	4	1	0	0
	County Total	**511,707**	**500,678**	**486,550**	**482,034**	**489,942**	**496,156**
Hidalgo	Irrigation	849,696	782,044	702,124	601,000	601,000	601,000
	Municipal	109,821	127,648	147,045	174,412	198,953	226,715
	Steam Electric	4,700	5,500	6,000	6,000	7,000	7,000
	Livestock	763	763	763	763	763	763
	Manufacturing	3,718	4,115	4,374	4,541	4,927	5,307
	Mining	689	670	708	751	796	849
	County Total	**969,387**	**920,740**	**861,014**	**787,467**	**813,439**	**841,634**
Jim Hogg	Irrigation	145	141	136	132	132	132
	Municipal	801	891	988	1,076	1,127	1,189
	Steam Electric	0	0	0	0	0	0
	Livestock	878	878	878	878	878	878
	Manufacturing	0	0	0	0	0	0
	Mining	19	9	5	3	1	0
	County Total	**1,843**	**1,919**	**2,007**	**2,089**	**2,138**	**2,199**
Maverick	Irrigation	123,421	121,664	117,099	111,873	111,873	111,873
	Municipal	7,611	8,517	9,125	9,743	10,665	11,924
	Steam Electric	0	0	0	0	0	0
	Livestock	1,288	1,288	1,288	1,288	1,288	1,288
	Manufacturing	76	91	108	127	148	171
	Mining	116	59	29	15	6	4
	County Total	**132,512**	**131,619**	**127,649**	**123,046**	**123,980**	**125,260**
Starr	Irrigation	45,376	42,046	40,193	38,419	38,419	38,419
	Municipal	9,264	11,687	15,042	19,907	22,840	25,390
	Steam Electric	0	0	0	0	0	0
	Livestock	1,220	1,220	1,220	1,220	1,220	1,220
	Manufacturing	0	0	0	0	0	0
	Mining	1,284	1,085	1,406	1,009	999	1,027
	County Total	**57,144**	**56,038**	**57,501**	**60,555**	**63,478**	**66,056**
Webb	Irrigation	5,569	5,318	5,014	4,729	4,729	4,729
	Municipal	47,979	60,338	75,125	96,328	100,641	108,195
	Steam Electric	2,000	3,900	3,900	5,800	5,800	5,800
	Livestock	1,079	1,079	1,079	1,079	1,079	1,079
	Manufacturing	33	38	43	49	57	65
	Mining	489	390	312	268	248	255
	County Total	**57,149**	**71,063**	**85,473**	**108,253**	**112,554**	**120,123**
Willacy	Irrigation	61,203	61,878	62,951	63,396	63,396	63,396
	Municipal	6,395	6,786	7,017	7,251	7,366	7,553
	Steam Electric	0	0	0	0	0	0
	Livestock	144	144	144	144	144	144
	Manufacturing	0	0	0	0	0	0
	Mining	12	8	5	2	0	0
	County Total	**67,754**	**68,816**	**70,117**	**70,793**	**70,906**	**71,093**
Zapata	Irrigation	2,238	2,123	2,012	1,906	1,906	1,906
	Municipal	3,021	4,000	5,305	7,027	9,487	13,050
	Steam Electric	0	0	0	0	0	0
	Livestock	446	446	446	446	446	446
	Manufacturing	0	0	0	0	0	0
	Mining	20	6	3	1	0	0
	County Total	**5,725**	**6,575**	**7,766**	**9,380**	**11,839**	**15,402**
Region M	**Region Total**	**1,803,221**	**1,757,448**	**1,698,077**	**1,643,617**	**1,688,276**	**1,737,923**

period, irrigation demand is projected to decrease due to urbanization, while municipal water demands are projected to increase substantially, fueled by a projected doubling in the county population between 2000 and 2050.

***Hidalgo County*:** With a current population of 559,922 expected to increase to 1,435,319 by year 2050: Population is projected to increase by more than 150 percent from 2000 to 2050, and municipal water demand is projected to double. Nevertheless, annual water demand is projected to decrease by more than 127,000 acre-feet, due to decreases in irrigation water demand as a result of urbanization.

Jim Hogg County: With a current population of 6,176 expected to increase to 11,238 by year 2050: With both the smallest population and total water demand of the eight counties in the region, Jim Hogg County uses water primarily for municipal, livestock, and irrigation purposes. Municipal water demand is projected to increase nearly 50 percent from 2000 to 2050. Livestock water demand is projected to remain constant while irrigation and mining water demands are projected to decrease.

Maverick County: With a current population of 48,180 expected to increase to 90,351 by year 2050: Population is projected to almost double over the planning period and municipal water demand to increase 56 percent. However, irrigation needs account for approximately 90 percent of water used in Maverick County.

Starr County: With a current population of 58,158 expected to increase to 188,576 by year 2050: Population is projected to increase dramatically, more than tripling from about 58,200 persons in 2000 to 188,600 in 2050. Annual municipal water demand is projected to increase from approximately 9,300 acre-feet to 25,400 acre-feet in 2050. However, irrigation water demands still represent the greatest portion of total water demand for the County.

Webb County: With a current population of 219,725 expected to increase to 571,916 by year 2050: Fueled by a projected increase of more than 350,000 in the County's population, municipal water demand is projected to more than double over the planning period. By 2050, irrigation water demand is projected to compose less than 5 percent of the total water demand in the County.

Willacy County: With a current population of 21,165 expected to increase to 29,077 by year 2050: With population projected to increase from approximately 21,200 in 2000 to approximately 29,100 in 2050, the County's municipal water demand is projected to increase by 18 percent over this period. Even with this increase, irrigation water demand is projected to account for nearly 90 percent of the County's total water demand in 2050.

Zapata County: With a current population of 13,567 expected to increase to 67,272 by year 2050: Population is projected to increase by nearly 500 percent over the 50-year planning period, the highest growth rate in the Rio Grande Region. As a result, municipal water demand is projected to increase from approximately 53 percent of the County's total water demand to 85 percent by 2050. Irrigation and livestock water demands are relatively constant over the 50-year planning period.

ES.5 CURRENT AND PROJECTED RIO GRANDE REGION WATER SUPPLIES

An understanding of the current availability of water supplies is critical to effective planning to meet projected water demands in the Rio Grande Region. Surface water from the Rio Grande provides most of the supply for municipal, industrial and irrigation purposes. Some very limited use is made of surface water from tributaries of the Rio Grande in Maverick, Webb, Zapata, and Starr Counties; from the Arroyo

Colorado which flows through southern Hidalgo County and northern Cameron County to the Laguna Madre; from the pilot channels within the floodways that convey local runoff and floodwaters from the Rio Grande through the Lower Rio Grande Valley to the Laguna Madre; and from isolated lakes and resacas in Hidalgo and Cameron Counties.

ES.5.1 Surface Water Sources

ES 5.1.1 Rio Grande Basin:

The Rio Grande is the primary water source for the Rio Grande Region and is anticipated to remain so for the foreseeable future. The 1944 Treaty between the United States and Mexico[1], which is administered by the International Boundary and Water Commission (IBWC), contains provisions relating to the portion of the Rio Grande from Fort Quitman, Texas to the Gulf of Mexico. Amistad and Falcon Reservoirs are the two international reservoirs that are located on the Rio Grande. These impoundments provide controlled storage for over eight million acre-feet of water owned by the United States and Mexico, of which 2.25 million acre-feet are allocated for flood control purposes and 6.05 million acre-feet are reserved for silt and conservation storage (water supply). The United States owns 58.6 percent, or 1.56 million acre-feet, of the sedimentation and conservation storage in Falcon Reservoir; and, in Amistad Reservoir, which was completed in 1968 just upstream of the city of Del Rio, the United States owns 56.2 percent of the total conservation storage capacity (or approximately 1.77 million acre-feet). The remainder of the conservation storage, in both reservoirs, is owned and used by Mexico.

At present, the dependable firm water supply available from the Amistad/Falcon Reservoir System during drought-of-record conditions is approximately 1.17 million acre-feet per year. This represents more than 91 percent of the total amount of water presently available to the region from all sources (e.g., groundwater, reuse, Rio Grande tributaries, and other local sources). Over time, however, the total dependable water supply from the Rio Grande is projected to decrease significantly, largely as a consequence of reduced conservation storage capacity due to sedimentation of the Amistad/Falcon Reservoir System. By 2050, the firm yield of the reservoir system is projected to decrease by nearly 115,000 acre-feet or by nearly 10 percent.

Because of the manner in which available Rio Grande water supplies from the Amistad/Falcon Reservoir System are managed and allocated, the impact of declining supply availability will be borne directly by irrigation and mining water users. Under the water rights system for the middle and lower Rio Grande, domestic-municipal-industrial (DMI) water rights have a very high degree of reliability. A DMI reserve of 225,000 acre-feet that is continually maintained in the reservoir system provides the assurance. By comparison, irrigation and mining water rights are residual users of stored water from the reservoirs, thus bearing the brunt of water supply shortages. In essence, irrigation and mining water demand must adjust to the available water supply.

An additional concern involves the operation of reservoirs in Mexico's portion of the watershed that contributes flows to the Amistad/Falcon Reservoir System. Mexico has constructed an extensive system of reservoirs on the tributaries, especially in the Conchos River Basin. Reservoir simulations indicate that the U.S. portion of the firm yield of the Amistad/Falcon Reservoir System could be reduced by an additional 280,000 to 316,000 acre-feet per year if the minimum flows specified by the 1944 treaty are not provided. Based on records published annually by the IBWC regarding historical flows in the Rio Grande and its major

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[1] "Treaty Between the United States and Mexico, Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande"; February 3, 1944; Washington, D. C.

tributaries, the deficit in the quantities of inflows allotted to the United States from the Mexican tributaries during the five-year accounting cycle ending October 2, 1997, was 1,024,000 acre-feet. From October 1997 through September 2000, the cumulative deficit in the current accounting cycle was 384,100 acre-feet, or since October 1992, the total amount of the inflow deficit that has been incurred by Mexico on the six tributaries identified in the 1944 Treaty was 1,408,100 acre-feet as of October 2000. Because of the substantial amount of the current Mexican water deficits and because agricultural interests in the Lower Rio Grande Valley have been severely impacted during the current drought as available water supplies from Amistad and Falcon Reservoirs have diminished, there has been increased concern by all Rio Grande water users regarding the reasons for the deficits and Mexico's ability to repay the deficits in accordance with the terms of the 1944 Treaty. The uncertainty related to the availability, or unavailability, of this water from Mexico obviously has a direct bearing on water supply planning for the RGRWPA. The State Department and Mexico are working together to resolve this issue. However, no resolution has yet been reached. Again, because irrigation and mining are the "residual" users of water from the reservoir system, the impact of any reduction in inflows due to upstream reservoir development in Mexico would be borne entirely by those users.

ES 5.1.2 Nueces-Rio Grande Coastal Basin:

The Arroyo Colorado traverses both Hidalgo and Willacy Counties, represents a second potential water supply. Its daily flows are comprised primarily of return flows from agriculture and municipalities and locally generated runoff. Use of the water in the Arroyo Colorado for municipal, industrial or irrigation purposes is severely limited because of poor quality conditions. Nonetheless, the Arroyo Colorado is an important source of freshwater inflows to the lower Laguna Madre. This portion of the Laguna Madre is both economically and ecologically important to the region, and the availability of freshwater inflows from the Arroyo Colorado is critical to maintaining its biological resources.

ES.5.2 Groundwater Sources in the Rio Grande Region

The major aquifers that exist within the Rio Grande Region include the Gulf Coast aquifer, which underlies the entire coastal region of Texas, and the Carrizo aquifer, a broad band that sweeps across the State from the Rio Grande north of Laredo, then continuing northeasterly in an arc south and then east of San Antonio before continuing on to the northeastern corner of the state near Tyler. Less significant aquifers within the region may produce significant quantities of water for relatively small areas. Within the Rio Grande Region, minor aquifers include the Rio Grande Alluvium, also called the Rio Grande Aquifer, and the Laredo Formation. While groundwater is available from these and other formations, it is generally of such poor quality that it cannot be used for agriculture or municipal use without treatment. Due to the poor quality, groundwater is usually considered as a secondary source, and as such, higher demand for groundwater usually results when sufficient surface water is not available.

Gulf Coast Aquifer: Total groundwater withdrawals were approximately 22,770 acre-feet in 1997, about half for municipal uses. The greatest total use from this aquifer in recent years was 37,990 acre-feet, which was driven primarily by irrigation demands of 26,540 acre-feet. The largest volume of groundwater used to meet municipal demands was 11,685 acre-feet in 1996.

Carrizo-Wilcox Aquifer: The reported total groundwater withdrawals from this aquifer were only 806 acre-feet in 1997, with about 53 percent for municipal use. The greatest total use in recent years was estimated at 6,561 acre-feet in 1991, primarily driven by irrigation demands of 5,960 acre-feet, with 3,867 acre-feet applied for irrigation in Maverick County and 2,093 acre-feet applied for irrigation in Webb County. The largest volume used from this aquifer to meet municipal demands was 512 acre-feet in 1995.

ES.5.3 Reuse and Other Supply Sources

Approximately 13,000 acre-feet per year (one percent) of supply is available from use of reclaimed water for irrigation, manufacturing, and steam electric uses. Another 24,000 acre-feet per year of supply is estimated to be available from Rio Grande tributaries and other local surface water sources.

ES.5.4 Water Supply for the Region

Table 3 provides a summary of the total amounts of available current water supplies for the Rio Grande Region by water use category and by source of supply for each decade through 2050. This table is a regional summary by water use category that are presented in Table 3.12 in Chapter 3.

Table 3: Current and projected water supplies for the Rio Grande Region (af/yr)

Water Use Category	2000	2010	2020	2030	2040	2050
Irrigation	963,692	904,390	842,599	750,444	684,956	603,599
Municipal	302,938	298,242	298,373	298,315	298,041	297,812
Steam Electric	21,884	21,884	21,884	21,884	21,884	21,884
Livestock	24,588	24,588	24,588	17,284	17,284	17,284
Manufacturing	7,517	7,929	8,205	8,391	8,798	9,201
Mining	18,725	18,481	18,414	14,363	14,211	14,082
Region Total	**1,339,344**	**1,275,514**	**1,214,063**	**1,110,681**	**1,045,174**	**963,862**

ES.6 PROJECTED WATER SUPPLY SHORTAGES

Even though overall demand for water in the Rio Grande Region will decline over the next 50 years, the region faces significant water supply needs, primarily because of decreasing supplies from both reduced reservoir yield due to sedimentation and conversion of irrigation rights to DMI rights (See Figure 5). A user-by-user comparison of supply and demand reveals that 48 of the 92 designated "water user groups" within the Rio Grande Region are projected to experience shortages during the 50-year planning period. Figure 6 illustrates the regional shortages for sectors in the Rio Grande Region with significant water supply deficits during the 50-year planning period. No shortages are projected for the mining or livestock category of water use for any of the counties in the region.

Sections 4.1 - 4.6 of this report identifies individual water user groups that show an unmet need during drought-of-record supply conditions for each decade from 2000 to 2050. The water shortages of the Rio Grande Region amount to about 34 percent of the forecasted demand by 2020, rising to 42 percent of demand in 2040, and to 48 percent of demand in 2050. This means that by 2050 the region would be able to supply only 52 percent of the projected needs unless supply development or other water management strategies are implemented. Section 4.7 of this report presents the TWDB's evaluation of the economic and social impacts of not meeting water needs for each water user group with a need.

Figure 5: Water Supply and Demand in the Rio Grande Region, 2000-2050

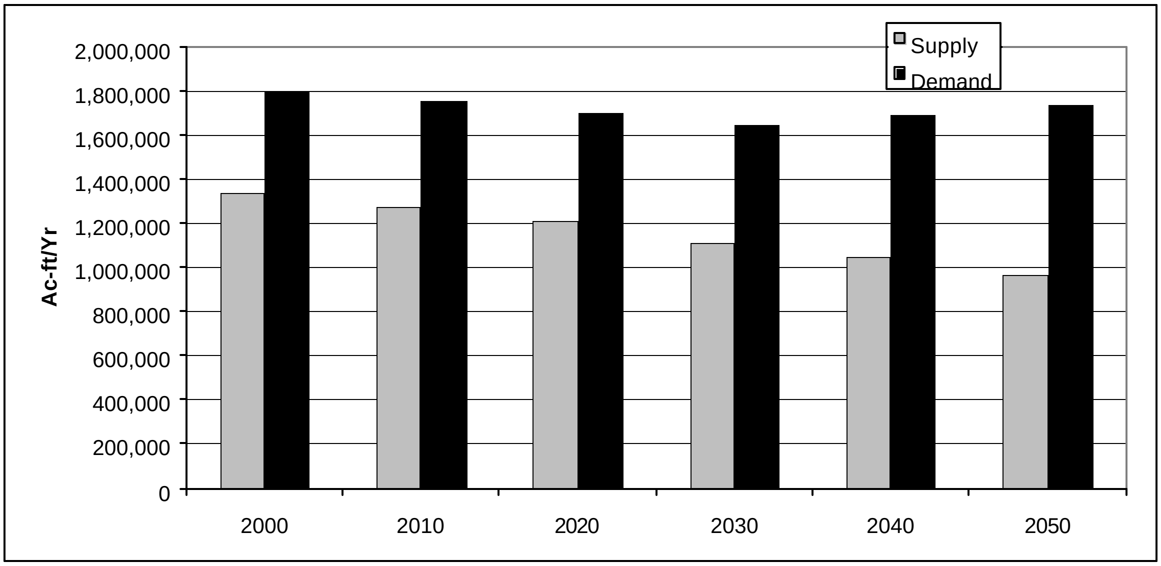
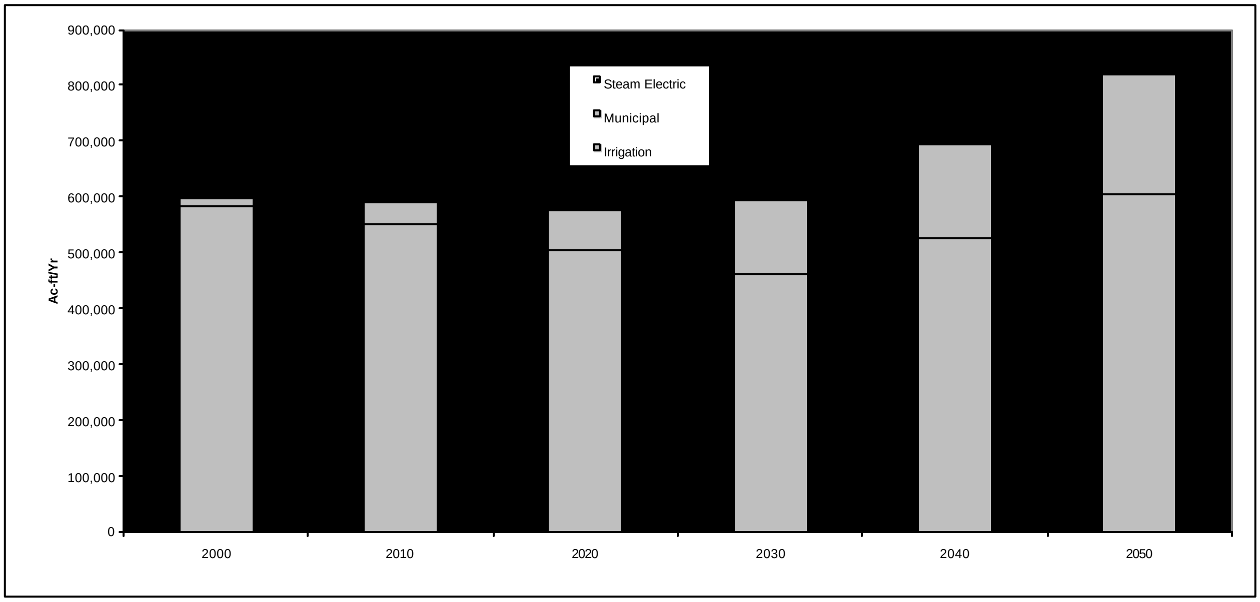


Figure 6: Regional Shortages for Sectors with Significant Water Supply Deficits, 2000-2050g



Note: Manufacturing, mining, and livestock not shown. There are only minor shortages in manufacturing and no shortages in both mining and livestock.

ES. 6.1 Projected Shortages by Use Categories

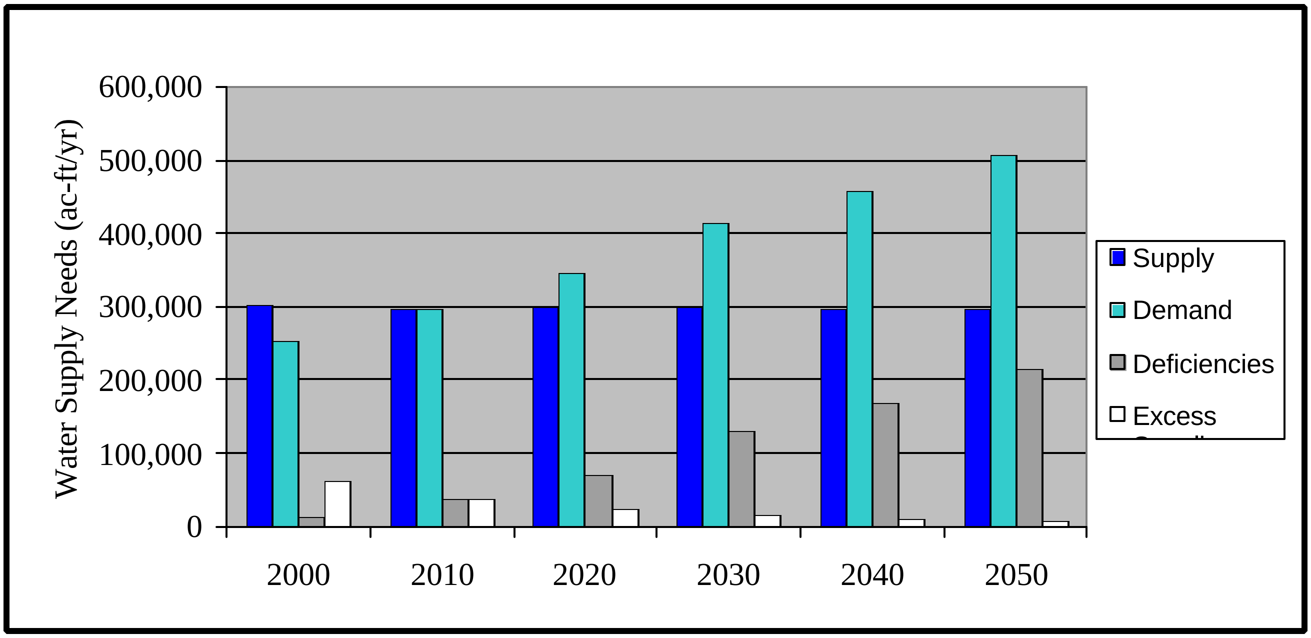
Projected shortages in the Rio Grande Region are grouped into two major categories: shortages for domestic-municipal-industrial (DMI) users, which include the municipal, manufacturing and steam electric use categories, and shortages for irrigation. No shortages are projected for the mining or livestock category of water use for any of the counties in the region.

ES.6.1.1 Shortages for DMI Users

Shortages for (DMI) users are projected to increase from 13,000 acre-feet per year at present to more than 214,000 acre-feet per year by 2050. Projected shortages within the municipal sector are widespread, with 39 of the 52 municipal water user groups in the region showing shortages at some point during the 50-year planning period (See Figure 7). Jim Hogg County is the only county without projected municipal water shortages during the entire planning period. A county-by-county review of municipal water needs is found in Chapter 4.

Steam electric water user groups in Cameron and Webb Counties are projected to develop shortages during the planning period. Only minor water shortages are projected for the manufacturing sector.

Figure 7: Rio Grande Regional Municipal Water Needs Summary

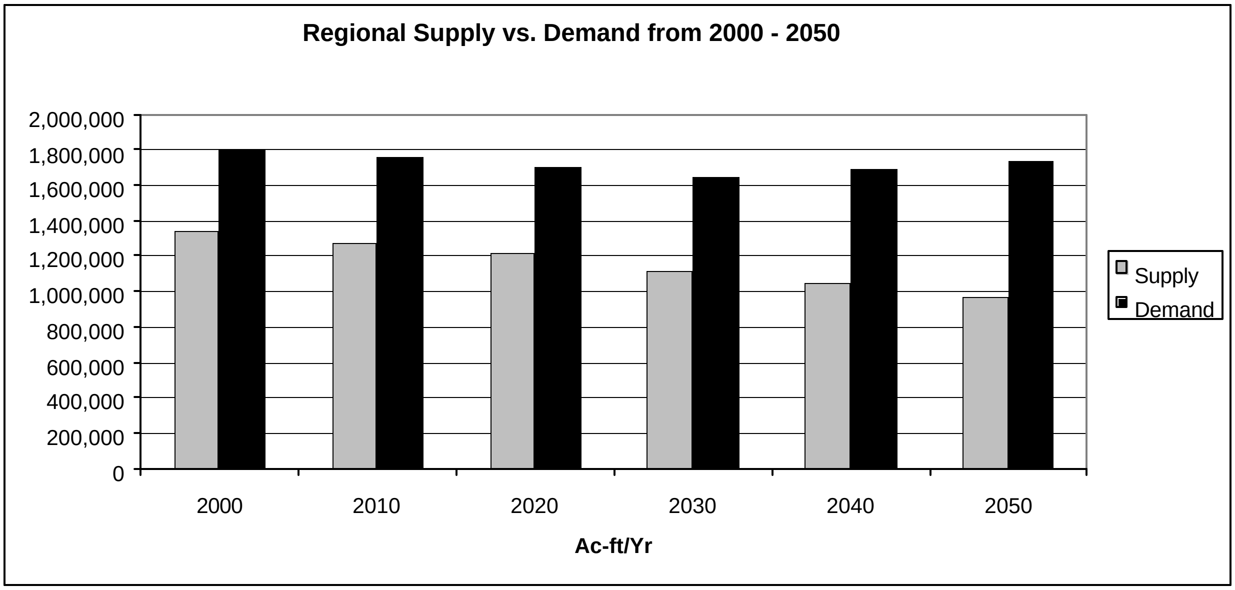


ES.6.1.2 Shortages for Irrigation

Supply shortages in the irrigation sector are particularly acute and are projected to decrease from approximately 580,000 acre-feet per year at present to 460,000 acre-feet per year by 2030, and then increase to more than 605,000 acre-feet per year by 2050. Decreases in irrigation supply availability are nearly offset by projected decreases in irrigation demand. Six of the eight irrigation water user groups in the Rio Grande

Region show shortages during the 50-year planning period (i.e., Cameron, Hidalgo, Maverick, Starr, Willacy, and Zapata Counties) (See Figure 8).

Figure 8: Rio Grande Region Irrigation Water Needs Summary



ES.7 RIO GRANDE REGION WATER MANAGEMENT PLAN STRATEGIES

The Rio Grande RWPG has recommended water management strategies for each water user group (WUG) with identified water needs during the 50-year planning period that are consistent with the goals described earlier. It should be noted that the water management strategies recommended and adopted by the Rio Grande RWPG and presented herein are for the entire 50-year planning period, applicable towards both near-term needs (2000-2030) and long-term needs (2030-2050).

In January 2000, the Rio Grande RWPG adopted a two-tiered approach to the evaluation of water management strategies. The first tier of criteria focused on the estimated water supply yield, cost, and environmental impact of each water management strategy. The second tier of evaluation included consideration, as appropriate, of other factors outlined in TWDB rules, for example, impacts on recreation, third-party impacts, impacts on agricultural and natural resources. Each strategy was evaluated against criteria of yield developed, cost, environmental significance and socio-economic impacts. Recommended strategies are viewed as those that, by consensus, are compatible with these criteria.

ES.7.1 Evaluated Strategies

The strategies evaluated by the Rio Grande RWPG are grouped according to the two major categories of shortages, as described below.

ES.7.1.1 DMI Strategies Evaluated

The basic principle of the planning process is to identify strategies to balance future water supply with projected demands. Under the SB 1 planning process, this includes identifying unique water supply strategies for each individual community with a population of 500 or more. The unique solutions address costs associated with supply development as well as delivery of water to the major point of use and treatment to the level required for the intended use. For DMI users, the strategies evaluated for this plan are:

- Municipal water conservation;
- Reuse of reclaimed water;
- Acquisition of additional Rio Grande water;
- Desalinization of brackish groundwater and sea water;
- Aquifer storage and recovery;
- Development of a third reservoir on the Rio Grande;
- Construction of a gravity canal to deliver water to users in the Lower Rio Grande Valley (LRGV);
- Construction of a pipeline to deliver water from Falcon Reservoir to municipal users in the LRGV;
- Off-channel storage of excess Rio Grande flows;
- Construction of the proposed Brownsville Weir and Reservoir;
- Collection and use of local runoff in the LRGV;
- Interbasin transfer of surface water from Lavaca and Nueces river basins; and,
- Groundwater development.

In addition, reallocation of storage in the Amistad-Falcon Reservoir System, and voluntary redistribution of existing water resources were also evaluated as potentially feasible strategies for meeting DMI needs.

ES.7.1.2 Irrigation Strategies Evaluated

The economics of the agriculture industry are such that water management strategies considered feasible for the Rio Grande Region are not sufficient to satisfy the projected deficits in their entirety. Consequently, development of new water supply sources for irrigated agriculture – whether surface or groundwater – is not seen as a viable strategy. There nevertheless are strategies that could significantly reduce irrigation demand or increase the available supply of water for irrigation.

For irrigation users, the water management strategies considered for this plan are:

- Agricultural water conservation;
- On-farm water use efficiency;
- Modification of current TNRCC rules for the operation of the Amistad-Falcon Reservoir System;
- Reuse of water;
- Brush control;
- Weather modification; and.
- Retaining water rights associated with “excluded” properties.

In addition, because of assumptions made in estimated irrigation water availability during drought-of-record hydrologic conditions (see Chapter 3), additional irrigation supplies are projected to be available as a consequence of recommended strategies for DMI users that will lessen the need for DMI users to acquire additional Rio Grande supplies than would otherwise be the case. In essence, strategies such as municipal water conservation and use of reclaimed water for DMI purposes are also strategies for reducing the magnitude of projected irrigation shortages.

ES.7.2 Recommended Strategies

ES.7.2.1 Recommended Strategies for DMI Shortages

The recommended strategies for meeting current and projected municipal water demands in the Rio Grande Region are presented in Tables 4 and 5 and depicted graphically in Figure 9 (See Chapter 5 for details). As indicated, the key strategies are:

- Additional or "advanced" water conservation measures for all municipalities, with a target goal of achieving one to two percent reduction in water demand per decade beginning in 2010 above and beyond the conservation already built in to the demand projections. This would reduce municipal demands 15,100 acre-feet per year in 2030 and 30,200 acre-feet per year in 2050.
- Reuse of water. Non-potable water reuse is recommended for those cities with a potential to have a total of at least 5.0 million gallons per day (mgd) wastewater treatment plant capacity. This criteria was applied to cities with projected population exceeding 50,000 by year 2030, assuming 100 gallons per day (gpd) of wastewater generated per person. For the cities that met the above criteria, the following reduction in water demand per decade was assumed: 5 percent in 2010, 15 percent in 2020, 25 percent in 2030, 2040 and 2050. This strategy will contribute 32,800 acre-feet per year of additional supply 2030 and 43,300 acre-feet by 2050.
- Acquisition, by purchase or contract, of an additional 81,400 acre-feet per year of Rio Grande supplies by 2030 and 134,100 acre-feet per year by 2050.
- Local groundwater development, which is recommended to provide an additional 11,000 acre -feet per year of supply through the planning period.
- Construction of the proposed Brownsville Weir and Reservoir, which will provide an additional 20,640 acre-feet of dependable surface water supply for the City of Brownsville by the Year 2010 and thereafter.
- Renewal of existing water supply contracts.

It should also be noted that a given WUG may implement any combination and/or order of the above mentioned recommended strategies for DMI shortages to meet its specific needs.

Because a portion of future DMI needs will be met through the acquisition of additional supply from the Rio Grande, conversion of water from agricultural to DMI uses will be required, which will have the effect of reducing the availability of water for agricultural use. However, the strategies designed for meeting the irrigation shortages complement the strategies proposed for DMI use and offer significant opportunities for constructive partnerships between DMI users and agricultural water users that will further the interests of both groups, and the region as a whole.

The recommended strategies for meeting projected municipal water needs in 2030 and 2050, by county, are graphically depicted in Figures 10 and 11.

Small manufacturing water shortages are projected for Webb County. It is recommended that these demands be supplied by the City of Laredo or by Webb County.

Table 4: Recommended Water Management Strategies to Meet 2030 Regional Municipal Water Needs

			Water Conservation	Non-Potable Reuse	Conversion from Ag. to Mun. Water	Purchase of RG supply	Brownsville Weir	Groundwater development	Final (Deficit)/ Surplus
	2030	COST	$232	$360	$325	$430	$438	$580	
	Demand	Water Deficit							
Cameron Co.									
Brownsville	43,555	-15,127	0	6,000	131	131	20,643		11,777
Combes	234	-4	7		4	4			10
County Other (R.G)	251	-151	8		136	8			0
County Other (RG-N)	17,070	6,145	512						6,657
Harlingen	17,971	414	539	4,493	270	270			5,985
La Feria	1,100	700	33						733
Los Fresnos	1,003	-153	30		93	30			0
Palm Valley	476	-70	14		41	14			0
Port Isabel	3,613	248	108		54	54			465
Primera	672	145	20		10	10			185
Rio Hondo	635	255	19						274
San Benito	7,289	-1,789	219		1,352	219			0
So. Padre Island	2,988	11	90		45	45			190
County Total	***96,857***	***-17,294***	***1,599***	***10,493***	***2,135***	***783***	***20,643***		18,359
Hidalgo Co.									
Alamo	2,790	-1,137	84		970	84			0
Alton	1,505	0	45						45
County Other	50,893	-11,976	1,527		8,922	1,527			0
Donna	7,222	-3,032	217		2,599	217			0
Edcouch	970	370	29						399
Edinburg	14,480	-6,499	434	3,620	2,010	434			0
Elsa	2,315	-475	69		336	69			0
Hidalgo	1,709	-3	51		26	26			100
La Joya	1,213	-544	36		471	36			0
La Villa	741	-241	22		197	22			0
McAllen	35,514	-1,965	1,380	8,879	1,395	690			10,379
Mercedes	4,446	-619	133		352	133			0
Mission	20,197	-9,908	606		8,696	606			0
Palmview	863	-550	26		498	26			0
Pharr	11,439	-2,908	343	2,860	172	172			638
Progreso	403	-136	12		112	12			0
San Juan	6,021	-3,675	181		3,314	181			0
Sullivan City	701	-688	21		646	21			0
Weslaco	10,990	-3,014	330	2,748	165	165			393
County Total	***174,412***	***-47,370***	***5,547***	***18,106***	***30,880***	***4,421***			11,583
Maverick Co.									
County Other (R.G)	3,552	-1,073	213			860			0
County Other (N)	77	319	2						321
Eagle Pass	6,114	1,415	183			183			1,782
County Total	***9,743***	***-1,073***	***399***	***0***	***0***	***1,043***			369
Starr Co.									
La Grulla	1,844	-1,377	111			1,266			0
Rio Grande City	6,330	-3,862	380			3,482			0
Roma	4,109	-1,267	247			1,020			0
Starr Co Other (R.G.)	6,920	-4,871	415			4,456			0
Starr Co Other (N)	704	1,370	21						1,391
County Total	***19,907***	***-11,377***	***1,173***	***0***	***0***	***10,225***			21
Webb Co.									
Laredo	84,571	-40,998	5,074	4,229		20,745		10,950	0
Webb Co Other	11,347	-7,767	681			7,145			59
County Total	***95,918***	***-48,765***	***5,755***	***4,229***	***0***	***27,890***		***10,950***	59
Willacy Co.									
Lyford	841	217	25						242
Raymondville	4,890	780	147						927
San Perlita	187	-48	6		37	6			0
Willacy Co Other	1,146	-70	34		17	17			-1
County Total	***7,064***	***-118***	***212***	***0***	***54***	***23***			171
Zapata Co.									
Zapata	5,437	-3,653	326			3,327			0
Zapata Co Other	1,590	-680	95			585			0
County Total	***7,027***	***-4,333***	***422***	***0***	***0***	***3,911***			0

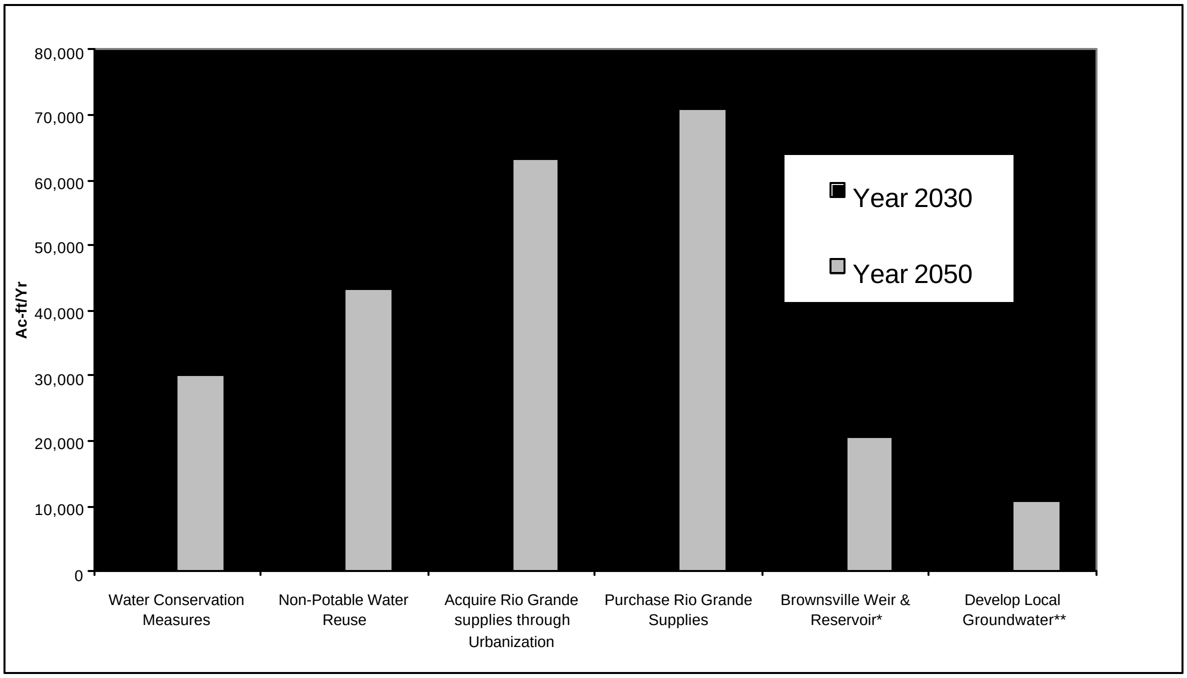
Note: Implementation issues associated with the recommended strategies for DMI use may encourage an individual community to place deferring priorities to its specific solution. However, any combination of the recommended strategies is viewed as a possible solution.

Table 5: Recommended Water Management Strategies to Meet 2050 Regional Municipal Water Needs

			Water Conservation	Non-Potable Reuse	Conversion from Ag. to Mun. Water	Purchase of RG supply	Brownsville Weir	Groundwater development	Final (Deficit)/ Surplus
	2050	COST	232	$360	$325	$430	$438	$580	
	Demand	Water Deficit							
Cameron Co.									
Brownsville**	48,069	-19,641	0	10,000	240	240	20,643		11,483
Combes	247	-17	12		6	6			8
County Other (R.G)	322	-222	16		190	16			0
County Other (RG-N)	21,703	1,512	1,085						2,597
Harlingen	19,608	-1,223	980	4,902	490	490			5,640
La Feria	1,517	283	76						359
Los Fresnos	1,378	-528	69		390	69			0
Palm Valley	550	-144	28		89	28			0
Port Isabel	3,990	-129	200		100	100			270
Primera	844	-27	42		21	21			57
Rio Hondo	727	163	36						199
San Benito	7,936	-2,436	397		1,642	397			0
So. Padre Island	3,652	-653	183		288	183			0
County Total	***110,543***	***-25,020***	***3,124***	***14,902***	***3,457***	***1,549***	***20,643***		18,655
Hidalgo Co.									
Alamo	3,177	-1,525	159		1,207	159			0
Alton	1,760	0	88						88
County Other	66,849	-28,696	3,342		22,011	3,342			0
Donna	9,543	-5,353	477		4,399	477			0
Edcouch	1,204	136	60						196
Edinburg	18,968	-10,987	948	4,742	4,348	948			0
Elsa	2,872	-1,032	144		745	144			0
Hidalgo	2,321	-615	116		383	116			0
La Joya	1,486	-817	74		668	74			0
La Villa	962	-462	48		366	48			0
McAllen	46,250	-12,701	2,300	11,563	2,325	1,150			4,637
Mercedes	5,644	-1,817	282		1,253	282			0
Mission	26,620	-16,331	1,331		13,669	1,331			0
Palmview	1,157	-844	58		728	58			0
Pharr	15,456	-6,925	773	3,864	1,515	773			0
Progreso	461	-194	23		148	23			0
San Juan	6,786	-4,440	339		3,761	339			0
Sullivan City	817	-804	41		722	41			0
Weslaco	14,382	-6,406	719	3,596	1,372	719			0
County Total	***226,715***	***-99,949***	***11,323***	***23,764***	***59,621***	***10,025***		***0***	4,785
Maverick Co.									
County Other (R.G)	4,261	-1,782	426			1,356			0
County Other (N)	94	302	5						307
Eagle Pass	7,569	-40	378			378			717
County Total	***11,924***	***-1,822***	***809***	***0***	***0***	***1,734***		***0***	722
Starr Co.									
La Grulla	2,453	-1,986	245			1,741			0
Rio Grande City	8,359	-5,891	836			5,055			0
Roma	5,408	-2,566	541	0		2,025			0
Starr Co Other (R.G.)	8,322	-6,273	832			5,441			0
Starr Co Other (N)	848	1,226	42						1,268
County Total	***25,390***	***-16,716***	***2,497***	***0***	***0***	***14,262***		***0***	42
Webb Co.									
Laredo	92,483	-48,910	9,248	4,624		24,088		10,950	0
Webb Co Other	15,324	-11,744	1,533			10,212			1
County Total	***107,807***	***-60,654***	***10,781***	***4,624***	***0***	***34,300***		***10,950***	1
Willacy Co.									
Lyford	907	151	45						196
Raymondville	5,131	539	257						796
San Perlita	219	-80	11		58	11			0
Willacy Co Other	1,101	-25	55		28	28			85
County Total	***7,358***	***-105***	***368***	***0***	***86***	***38***		***0***	387
Zapata Co.									
Zapata	9,820	-8,036	982			7,054			0
Zapata Co Other	3,230	-2,320	323			1,997			0
County Total	***13,050***	***-10,356***	***1,305***	***0***	***0***	***9,051***		***0***	0

Note: Implementation issues associated with the recommended strategies for DMI use may encourage an individual community to place deferring priorities to its specific solution. However, any combination of the recommended strategies is viewed as a possible solution.

Figure 9: Recommended Strategies for Meeting Projected Municipal Needs in the RGRWPA



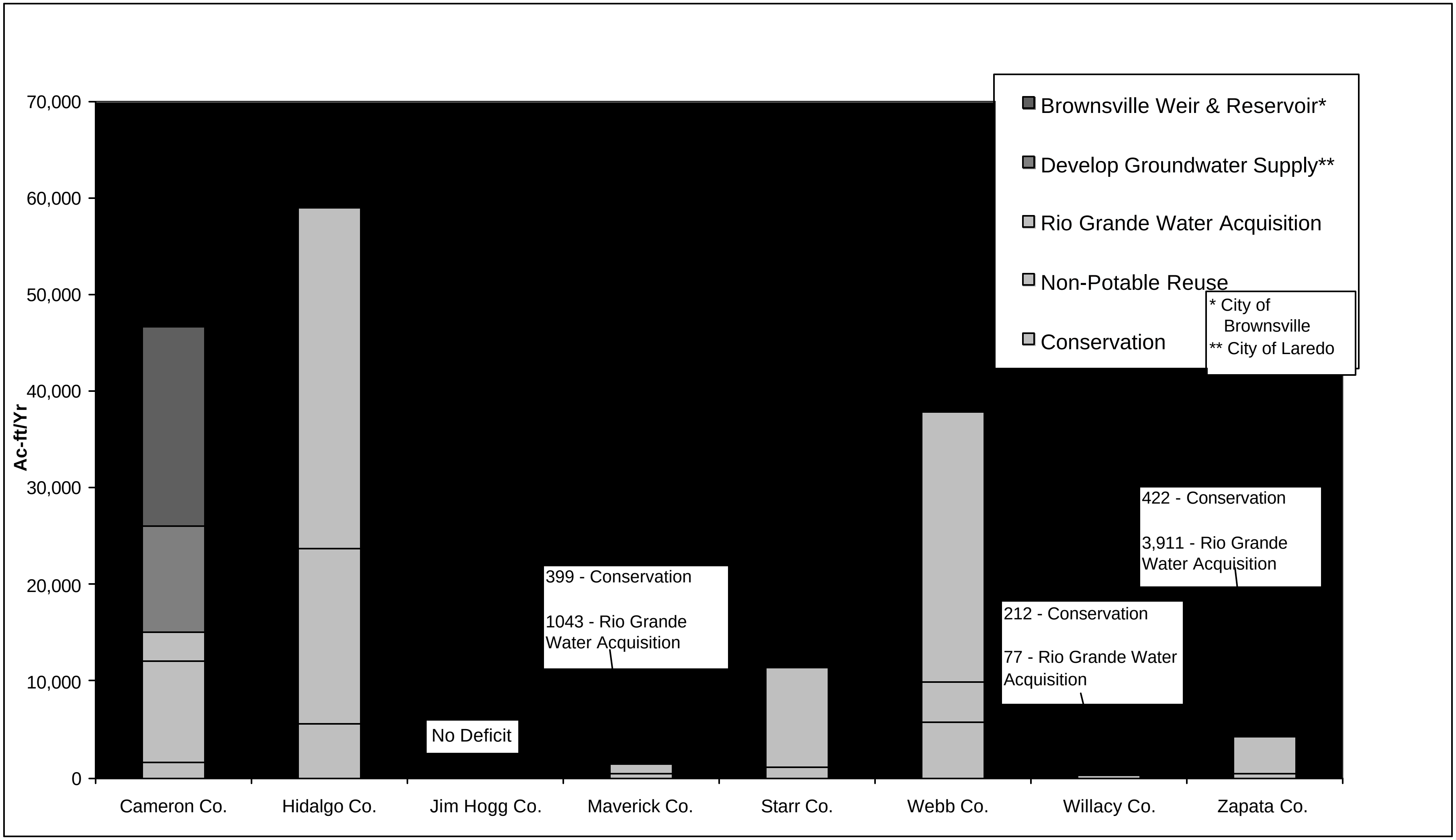
Together, the county-level steam electric power generation WUGs in Cameron and Webb Counties are projected to have shortages of 12,800 acre-feet per year by 2030 and thereafter through 2050. Water management strategies considered potentially applicable to this need include acquisition of additional Rio Grande supplies, use of reclaimed water, and groundwater. It is recommended that the projected steam electric demands be met through a combination of the three listed strategies.

Desalination of brackish groundwater as a technology should continue to be evaluated as potential strategy for DMI use as cost efficiencies continue to improve and environmental issues can be economically addressed. However, desalination of brackish groundwater could be considered a recommended strategy in a few specific local areas where it already is cost-effective (see Section 5.5.1)

It should be noted that although groundwater development is selected as a recommended water management strategy only for the City of Laredo, the Rio Grande RWPG considers groundwater as a viable alternative to augment supplies in some areas. This is a current practice that is likely to continue.

In addition, the Rio Grande RWPG recognizes that surface water uses that will not have significant impact on the region's water supply may be required above and beyond the recommended strategies even though they are not specifically recommended in the plan. The region may also face the need to develop water supply projects in the future that do not involve the development of or connection to a new water source even though such projects are not specifically recommended in the plan.

Figure 10: Summary of Recommended Strategies for Meeting Municipal Needs in 2030



* City of Brownsville
** City of Laredo

399 - Conservation

1043 - Rio Grande Water Acquisition

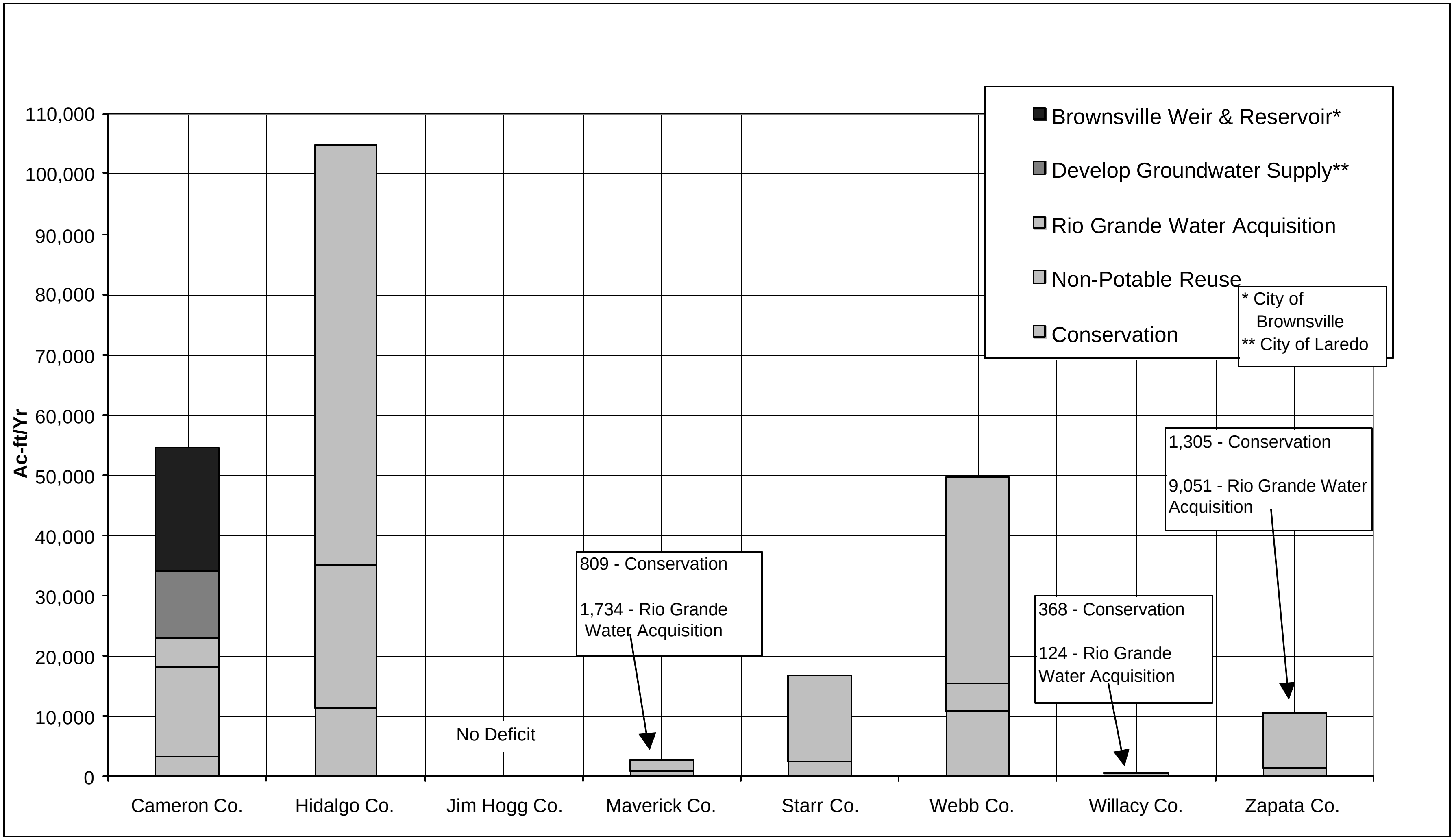
212 - Conservation

77 - Rio Grande Water Acquisition

422 - Conservation

3,911 - Rio Grande Water Acquisition

Figure 11: Summary of Recommended Strategies for Meeting Municipal Needs in 2050



ES.7.2.2 Recommended Strategies for Reducing Projected Irrigation Shortages

Agriculture is an important industry to the Rio Grande region and is anticipated to remain as a key aspect of the overall economic well being of the area. Meeting irrigation water needs is considered vital to the success of the agriculture industry. It is reported that in 1999, a 20% shortage in water for irrigation resulted in the loss of $400 million to the State's economy and the loss of 8,000 jobs locally.

Because of the economics of farming, the amount that irrigators can afford to pay for water is limited. Consequently, development of new water supply sources for irrigated agriculture – whether surface or groundwater – is not seen as a viable strategy. There nevertheless are strategies that could significantly reduce irrigation demand or increase the available supply of water for irrigation. Any strategy that requires significant financial resources to implement will require a form of subsidy to agricultural users in order to make water affordable to the farmer. These subsidies could be either grants or loans, or cooperative participation by the DMI users to develop water resources for joint use.

Water conservation in the agricultural sector will not only reduce projected irrigation shortages, it will also "free up" additional Rio Grande water supplies for future domestic-municipal-industrial (DMI) needs. For this planning effort, water savings estimates were developed for the five counties within the region with significant irrigation demands: Cameron, Hidalgo, Maverick, Starr, and Willacy. The current studies have confirmed the findings of previous investigations - there are significant opportunities to reduce irrigation water demands through the implementation of measures to reduce water losses in irrigation district conveyance and distribution facilities, and through the implementation of measures to improve on-farm water use efficiency.

The Rio Grande RWPG recommended the following water management strategies for reducing irrigation shortages:

- Agricultural water conservation;
- On-farm water use efficiency; and,
- Modification of current TNRCC rules for the operation of the Amistad-Falcon Reservoir System.

Agricultural Water Conservation and On-Farm Water Use Efficiency: Specifically, it is recommended that investments be made such that 75 percent of the achievable water savings from efficiency improvements in irrigation water conveyance and distribution are "captured" by 2020. It is further recommended that on-farm water conservation measures be implemented at a rate such that 80 percent of achievable savings are realized by 2050. The implementation scenario for on-farm water conservation measures are based on the implementation of the conveyance and distribution improvements. The resultant water savings to be obtained from these strategies is shown below in Table 6.

Table 6: Water Supply Yield from Implementation of Recommended Agricultural Water Conservation Strategies Under Drought Conditions (ac-ft/yr)

Strategy	2000	2010	2020	2030	2040	2050
Conveyance Improvements	0	59,862	119,724	119,724	119,724	119,724
On-Farm Measures	0	43,635	87,270	104,722	122,176	139,630
Total	**0**	**103,497**	**206,994**	**224,446**	**241,900**	**259,354**

Note: Estimated water savings are based on reduced irrigation demand during drought conditions.

A summary of recommended strategies for reducing irrigation shortages is depicted in Figure 12. Additionally, the re-evaluation of irrigation supply availability, in light of reduced DMI needs for additional Rio Grande supplies resulting from advanced water conservation and reuse, will reduce the projected irrigation deficit by 21,700 acre-feet per year (4.7 percent) in 2030 and by 35,300 acre-feet per year (5.8 percent) in 2050.

At a regional level, implementation of the recommended agricultural water conservation strategies will require a total capital investment of approximately $204 million at a total annualized cost of $17.9 million for conveyance improvements and $31.5 million for on-farm conservation measures. At the regional level, the resultant annualized unit costs of water provided by these strategies would be $150 per acre-foot per year for conveyance improvements and $225 per acre-foot per year for on-farm measures.

Modification of current TNRCC rules for the operation of the Amistad-Falcon Reservoir System: The remaining unmet irrigation need would be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that are maintained in the Amistad-Falcon Reservoir system. The Rio Grande RWPG has adopted a recommendation with the following elements: establish maximum Operating Reserve as a fixed amount at 75,000 acre-feet; allow Operating Reserve to be reduced down to zero as necessary when reservoir inflows are not sufficient to offset system losses and municipal diversions in a given month; make Negative Allocations from Irrigation and Mining accounts when the remaining Operating reserve is less than zero, with the amount of the total Negative Allocation sufficient to restore the Operating reserve to 48,000 acre-feet; after a Negative Allocation has been made in one month, continue normal reservoir storage accounting in subsequent months until the Operating Reserve is fully restored to 75,000 acre-feet; make Positive Allocations to Irrigation and Mining accounts each month when sufficient excess inflows to the reservoirs are available as determined by the Watermaster; and continue to maintain the DMI reserve at 225,000 acre-feet.

It should be noted that retaining irrigation water rights associated with "excluded" properties, if implemented, may help further reduce the irrigation shortages. The Rio Grande RWPG also recommends that weather modification programs be continued in the future in this region for augmenting water supplies.

Additionally, in support for the implementation of the recommended agricultural water conservation strategies, the Rio Grande RWPG recommended various actions, including assistance from the state and the federal government for financing irrigation water efficiency improvements through the provision of low interest loans and/or grants. A more detailed discussion is presented in section 5.7.8.

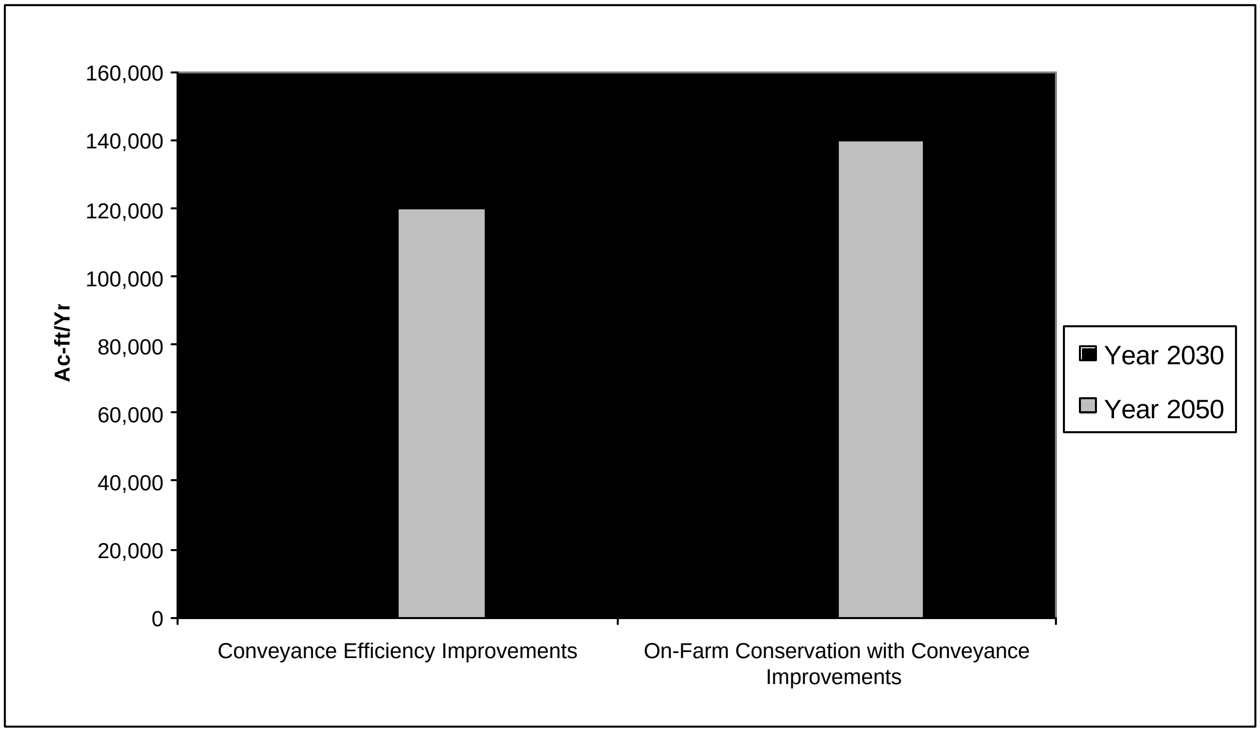
Although the recommended strategies will reduce irrigation deficits, there still remain some needs for which no feasible water management strategies have been identified. A summary of recommended strategies for reducing irrigation shortages is depicted in Figure 12. Figures 13 and 14 present the reduction in irrigation shortages for each county in the Region for Year 2030 and 2050.

ES.7.3 Other Recommended Strategies

Opportunities to increase the available water supply from the Rio Grande are limited. Nonetheless, three management strategies are recommended for implementation or further study that could optimize and increase the dependable water supply from the Rio Grande. These are:

- Improved real-time monitoring of the Rio Grande and major tributaries to minimize river conveyance losses and to maximize utilization of unregulated "excess" river flows (i.e., no-charge pumping). This effort should be closely coordinated with Mexico to ensure that there is a comprehensive monitoring program for the entire portion of the Rio Grande Basin that contributes flows to the middle and lower Rio Grande; and

Figure 12: Recommended Strategies for Meeting Projected Irrigation Water Needs, 2030 and 2050



- On-going control of hydrilla, water hyacinth, and other noxious vegetation in the lower portions of the Rio Grande, using environmentally compatible procedures to minimize water losses associated with increased evapo-transpiration, river channel bank losses, and increased releases from reservoir storage that are required to "push" flows through infested areas.

The water supply benefits associated with improved real-time monitoring of the Rio Grande and control of exotic plant species cannot be quantified. It is nonetheless believed that these strategies will be of general benefit to water users throughout the region and should be implemented by appropriate state, federal, or regional agencies.

ES.8 POLICY RECOMMENDATIONS

Texas Water Development Board rules for SB 1 regional planning also allow regional water planning groups to include additional recommendations relating to designation of ecologically unique streams and reservoir sites and policy issues.

Ecologically unique streams– The SB 1 process allows RWPGs to submit recommendations for designation of a river or stream segments as ecologically unique. If the Legislature opted to make such designation, no state agency or local government could develop a water supply project on that segment that would destroy its

Figure 13: Rio Grande Regional Summary of Recommended Irrigation Strategies for 2030, by County

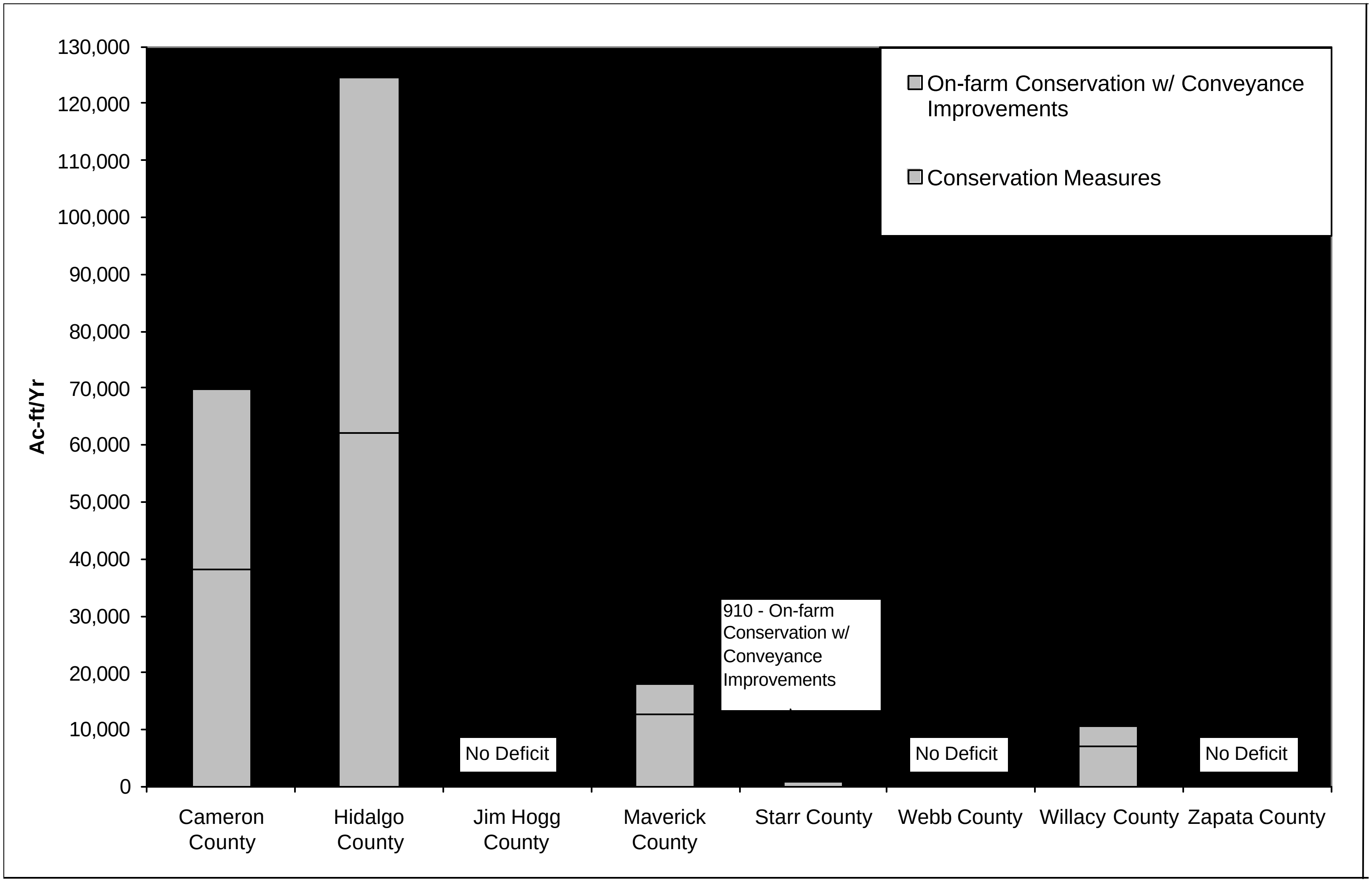
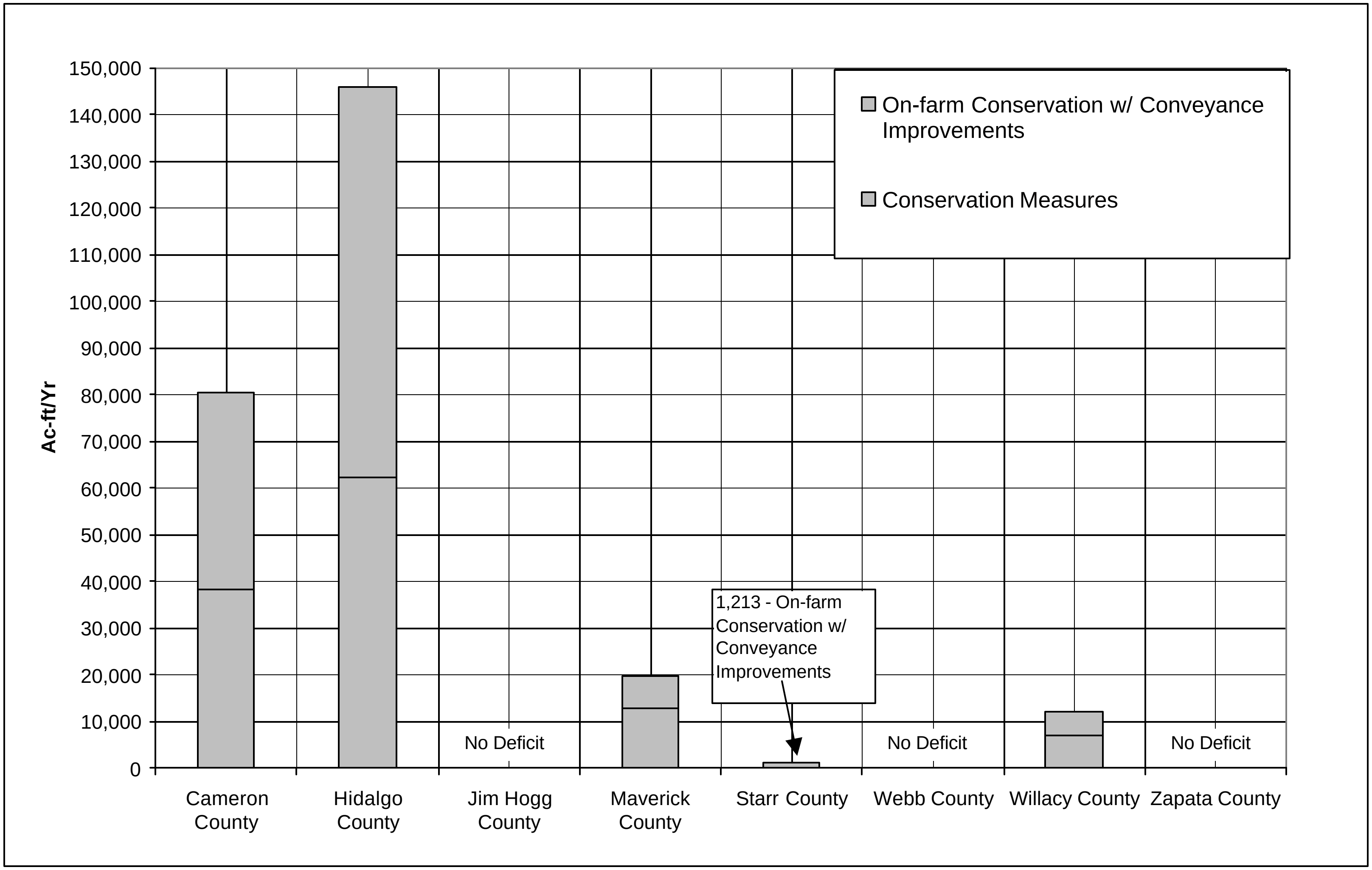


Figure 14: Rio Grande Regional Summary of Recommended Irrigation Strategies for 2050, by County



ecological value. Furthermore, TWDB is prohibited from financing water supply projects located on designated stream segments.

Because of concerns regarding the potential impacts of stream designation on private property owners and on governmental activities other than water development, the Rio Grande RWPG offers no recommendations at this time. Instead, the group requests that the Texas Legislature reconsider and amend current state law to clarify the implications of stream segment designation. With legislative clarification, the Rio Grande RWPG intends to reconsider the issue in the first update of the regional water plan.

Ecologically Unique Reservoir sites – Two potential reservoir projects on the Rio Grande were considered during the planning process: the Brownsville Weir and Reservoir and a low-water dam in Webb County near Laredo. The Rio Grande RWPG evaluated the Brownsville Public Utilities Board's intended Brownsville Weir and Reservoir project, and the Webb County low-water dam. However, neither site is recommended for designation as a unique reservoir site at this time. The group endorsed further investigation of the feasibility of the low water dam in Webb County to improve water quality, provide a diversion location for a new regional water treatment plant, and furnish hydroelectric power.

Creation of a regional water management entity – The Rio Grande RWPG recommends that the Texas Legislature create a regional water entity for the purposes of management of the waters of the Rio Grande, development of water conservation and water supply projects, water quality monitoring and planning, and other purposes and functions typically performed by agencies created under Article 16, Chapter 59 of the *Texas Constitution*. In developing legislation to implement this recommendation, the Rio Grande RWPG further recommends that:

- The geographic jurisdiction of the regional authority may correspond to the jurisdiction of the Rio Grande Watermaster Program (i.e., Ft. Quitman to the Gulf of Mexico);

- The Legislature provide an initial appropriation of state general revenue to be used by the regional entity to establish its corporate functions; and,

- That the governance of the regional entity be provided as consistent with Article 16, Chapter 59 with appropriate representation based on such considerations as geography, population, and water rights.

Mexico's compliance with the 1944 Treaty – Recognizing that Mexico's full compliance with the 1944 Treaty provisions and Minute No. 234 is essential to providing the water supply needs of the Region, the Rio Grande Regional Water Planning Group hereby strongly recommends that the government of the United States take all necessary and appropriate actions to ensure full compliance by Mexico with the terms of the 1944 Treaty and Minute No. 234 governing the development and use of the waters of the Rio Grande. This includes full and expeditious repayment of current water deficits in accordance with Minute No. 234, since Mexico has failed to come up with an acceptable repayment plan to date. It is also recommended that the dialog continue between the United States and Mexico with regard to the development of an operating plan for Mexican tributary reservoirs that will ensure full compliance with the treaty while also optimizing the amount of water supply available to Mexico for beneficial use. It is further recommended that the United States Section of the International Boundary and Water Commission continue to seek and provide opportunities for direct stakeholder participation in bi-national discussions regarding the management of the waters of the Rio Grande. In particular, the State of Texas may be represented directly by the Secretary of State's Office, the Texas Natural Resource Conservation Commission, and the Texas Water Development Board. Further, the Governor should designate one of these agencies to have the lead role in representing the State on this issue.

Agricultural lands preservation – Reduction of irrigated acreage as a result of urbanization has important implications for the operations of irrigation districts. In Cameron and Hidalgo Counties, rapid urbanization along the U.S. Highway 83 corridor is bisecting many irrigation districts into southern and northern areas divided by growing swathes of land in urban use. This may make it increasingly difficult to operate and properly maintain irrigation distribution facilities. Also, urbanization is an important factor to consider in developing plans for rehabilitation or replacement of irrigation district conveyance and distribution facilities. Finally, the degree and extent of future urbanization in some areas is such that the financial viability and political stability of some irrigation districts may be threatened. Therefore, Rio Grande RWPG recommends that municipalities and irrigation districts in the Lower Rio Grande Valley coordinate closely on matters of urbanization and its implications for both urban and agricultural water supply infrastructure planning and development.

Regionalization of water and wastewater utility services – Regionalization of urban water supply and/or wastewater systems offers the potential for significant cost savings in acquiring water supplies for urban use, as well as the potential for reduced costs and improved reliability of water and wastewater utility services. Regionalization can take several forms. It can include development of regional water supply facilities, the physical interconnection or consolidation of two or more independent utility systems or the consolidated management of two or more physically separate utility systems by a single entity. The Rio Grande RWPG recommends that further regionalization of water and wastewater utility services be investigated and implemented where appropriate.

Irrigation district water allocation policies – Most irrigation districts in the Rio Grande Region provide water on a first-come, first-served basis without limitations on the quantity of water available to individual irrigators. During periods of water supply shortage, many districts suspend the first-come, first-served approach and "go on allocation". While allocation (a.k.a. rationing) policies vary among districts, most involve the pro rata apportionment of the available supply, or a portion of the available supply, to each active irrigation account. Because most districts lack farm-level water measurement capabilities, allocations are typically expressed in terms of the number of "irrigations" each irrigator will be allowed during a water year or season.

Going "on allocation" is considered a beneficial drought response measure in that it ensures an equitable apportionment of limited water supplies. In addition, knowing how much water is available enables irrigators to make informed decisions about the types and amounts of crops to plant and provides an incentive for conservation.

In addition to providing a method for equitable water distribution during periods of shortage, water allocation by irrigation districts has also enabled an active water market within the agricultural sector. Most districts allow individual irrigators to sell all or a portion of their water allocations to other irrigators. Thus, higher value water-intensive crops, such as citrus and sugar cane, can gain access to additional water over and above the allocations from an irrigation district. Arguably, allowing a limited water supply to move from lower to higher value uses provides economic benefit to the entire region.

The Rio Grande RWPG encourages irrigation districts to review their water allocation policies, procedures, and practices to facilitate water transfers among agricultural users.

Consolidation of irrigation district operations – Currently, 28 irrigation districts operate within Cameron, Hidalgo, and Willacy Counties serving as few as 1,200 irrigable acres to as many as 75,000 irrigable acres. The eight largest irrigation districts combined account for over 70 percent of total irrigable acreage and 69 percent of the irrigation water rights held by districts. Over the years, the number of irrigation districts has decreased through mergers and consolidations. In addition, some of the larger districts have assumed the day-to-day management and operations of smaller adjacent districts. Further mergers and/or consolidated management of irrigation districts may provide benefits, both in terms of water savings and reduced operating costs. However, the Rio Grande RWPG has adopted no recommendation regarding the consolidation of irrigation districts.

Boundaries of the Rio Grande Region – The Rio Grande Region, as defined by the TWDB, consists of eight counties – Cameron, Hidalgo, Jim Hogg, Maverick, Starr, Webb, Willacy, and Zapata. With the exception of Jim Hogg County, the current boundaries of the Rio Grande Region correspond to the area supplied by the Amistad/Falcon Reservoir System. However, under the current regional water planning area boundaries, Amistad Reservoir is located in the Plateau Region (J) and is therefore designated as a "special water resource" in that it lies outside of the boundaries of the region, which relies upon the water supplies it provides. Amistad Reservoir does not represent a major source of supply to the Plateau Region. The Rio Grande RWPG considered, but decided not to recommend to the TWDB to extend the boundaries of the Rio Grande Region (M) to include Val Verde County for the purposes of future updates of the regional water plan.

Water availability models – During 1999, the 76th Texas Legislature amended SB 1 by including the following section in the Texas Water Code (Section § 16.012(h)):

> *Not later than 31 December 2003, the commission shall obtain or develop an updated water supply model for the Rio Grande. Recognizing that the Rio Grande is an international river touching on three states of the United States and five states of the United Mexican States, and draining an area larger than the State of Texas, the model shall encompass to the extent practicable the significant water demands within the watershed of the river as well as the unique geology and hydrology of the region. The commission may collect data from all jurisdictions that allocate the waters of the river, including jurisdictions outside this state.*

However, no funding was appropriated during the 76th Legislative Session for the TNRCC to develop the Rio Grande Water Availability Model (WAM). The Rio Grande River Basin has water rights based on both the prior appropriation doctrine and the storage-based allocation system established by the Rio Grande Valley Water Case. The Rio Grande RWPG, therefore, recommends that state funding be provided for the development of a state water availability model for the Rio Grande River Basin.

Re-channelization/Restoration of the Rio Grande – The International Boundary and Water Commission (IBWC) has requested appropriations for a study to determine whether re-channelization of the Rio Grande below Fort Quitman is technically, environmentally, and financially feasible. The proposed study would include investigation of potential water supply benefits. Questions include whether periodic removal of salt cedar and other vegetation, along with channel improvements, would increase water flows in this stretch of the Rio Grande and allow passage of more flows from upstream reaches of the river. The Rio Grande RWPG joins with the Far West Texas RWPG (Region E) in recommending and requesting that federal funding be provided to the IBWC for an in-depth investigation of the costs, benefits, and impacts of re-channelizing a portion of the Rio Grande upstream of the Amistad Reservoir.

***Desalination* -** Use of brackish groundwater as a viable supply alternative is discussed as a potential strategy for use in the Rio Grande region under Section 5.6.6. Many areas in the region consider the use of groundwater as a potential solution on a localized basis. However, sufficient historical information is not yet available to allow the local community to determine the practicality of desalination as an economic alternative. The Rio Grande RWPG recommends that State funding for additional research/development of desalination and offering financial assistance and incentives for implementation be considered.

***Funding for data collection, review, reporting activities and for preparation of feasibility level studies* -** The fundamental component of water supply planning is the availability of adequate data from which to assess the probability of costs, impacts and overall strategy success. In some areas of supply planning, notably groundwater conditions in rural areas, only minimal or no data exists. The US Geological Survey, the primary agency for water data collection activities, has been forced through budget reductions to reduce its data collection efforts in both stream quantity and quality measurements.

The Rio Grande RWPG makes the following recommendations: (i) The TWDB should provide funding for data collection activities in rural areas, including establishing and adequately funding the collection and distribution of groundwater availability data; (ii) the Legislature should provide funding for the cooperative, federal-state-local program of basic water data collection. The Legislature should fund the collection, assimilation and analysis of basic data needed to assess the ground and surface water resources of each region to a 90 percent accuracy level; (iii) the TWDB and TNRCC should facilitate access to water data essential for local and regional planning and plan implementation purposes; (iv) the TWDB and TNRCC should expand activities in collecting, managing, and disseminating information on groundwater conditions and aquifer characteristics; (v) SB1 should be amended to allow state funding of ongoing regional data collection activities that are sponsored by RWPGs; and (vi) the TWDB should study the effects of groundwater consumption on springflow.

***Modifications to Planning Process* -** The Rio Grande RWPG makes the following recommendations: (i) The Rio Grande RWPG supports the grass roots regional water planning process enacted by SB1 and strongly encouraging the process be continued with appropriate funding; (ii) the TWDB and TNRCC should evaluate the effect of groundwater withdrawal on surface water availability and streamflows; (iii) there needs to be a consistency in whether normal water conservation assumptions should be included in the supply and demand projections, or as water management strategies for conserving/developing water supplies; (iv) the next phase of planning should include the review of population estimates immediately after 2000 census results are available and making revisions as necessary; (v) TWDB needs to revise its rules for regional water planning to allow multiple options to be put forth as recommended strategies for meeting the needs of individual water user groups current planning rules require a single scenario to be developed for meeting near-term needs. Since future permits must be consistent with the regional plan, a single state-approved scenario may hamper the ability of a water provider to make choices among viable sources of additional water supply; instead, allowing development of alternative near-term scenarios would provide more flexibility; (vi) water quality should play a more important role in future planning efforts; (vii) wildlife and environmental water needs should be established as a category of water use and should be quantified by the TPWD, at their expense, for input into the next planning phase. The Rio Grande RWPG recommends that the definition of beneficial use regarding water rights permit be expanded to include usage by natural resources, wildlife, and wildlife habitat; and, (viii) as the planning process move to implementation, the TWDB should work to expedite the funding for implementing strategies on a localized level.

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CHAPTER 1.0: INTRODUCTION - OVERVIEW OF THE SENATE BILL 1 PLANNING PROCESS

During 1997 the 75th Texas Legislature enacted Senate Bill 1 (SB 1), often referred to as the Brown-Lewis Water Plan after its Senate and House sponsors. This legislation provided a major overhaul of many longstanding state water laws and policies and was in part a response to the statewide drought of 1996 and increasing public awareness of the state's rapidly increasing water demands. SB 1 addressed a wide range of issues and concerns including state, regional, and local planning for water conservation, water supply and drought management; administration of state water rights programs; interbasin transfer policy; groundwater management; water marketing; state financial assistance for water-related projects; and state programs for water data collection and dissemination.

SB 1 radically altered the manner in which future state water plans are to be prepared. Historically, the state water plan has been prepared by the Texas Water Development Board (TWDB), with input from other state and local agencies and the public. With SB 1, the Legislature established a "bottom up" approach whereby future state water plans are to be based on regional water plans prepared and adopted by appointed regional water planning groups (RWPGs). The RWPGs serve without compensation and are responsible for overseeing the preparation of the regional water plans.

The regional water plans are to be based on an assessment of future water demands and currently available water supply and are to include specific recommendations for meeting identified water needs through 2030. The plans may also include recommendations regarding strategies for meeting long-term (2030-2050) needs, as well as recommendations regarding legislative designation of ecologically unique rivers and streams, reservoir sites, and policy issues. By law, the regional water plans are to be completed by January 5, 2001, at which time the TWDB will have one year to compile a new state water plan. The regional water plans and the state water plan are to be updated every five years.

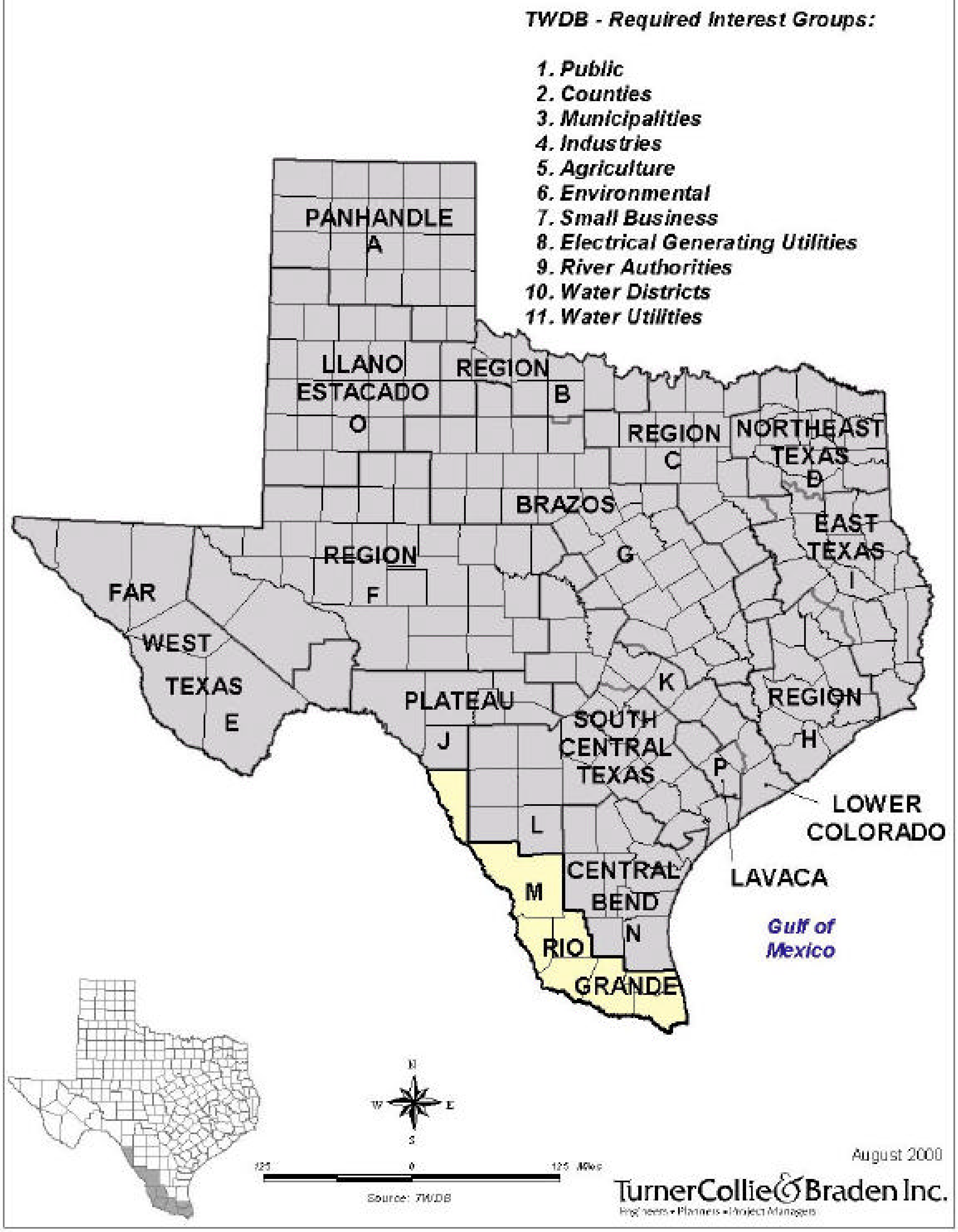
In February 1998 the TWDB adopted administrative rules, which included the delineation of 16 regional water planning areas (see Figure 1.1) and the definition of the procedures and requirements for the development of the regional water plans. The TWDB also appointed the initial members of 16 RWPGs. Subsequently, the RWPGs adopted by-laws, selected a political subdivision to act as its administrative agent, and developed a scope of work and budget for preparation of the regional water plans. Funding for the preparation of the regional water plans was provided in the form of grants from the TWDB.

Initially designated by TWDB as "Region M", the Rio Grande Regional Water Planning Area (herein referred to as the Rio Grande Region) consists of the eight counties adjacent to or in proximity to the middle and lower Rio Grande (see Figure 1.2). These are:

Cameron	Starr	Maverick	Zapata
Hidalgo	Webb	Jim Hogg	Willacy

The Rio Grande Regional Water Planning Group, at the time of the adoption of this plan, consists of 17 voting members representing 10 of the 11 interest group categories specified in SB 1. One category, river authorities, is not represented on the Rio Grande RWPG, as there are no river authorities in existence within the boundaries of the Rio Grande Region. In addition to its voting membership, the Rio Grande RWPG includes non-voting members representing state agencies and the Mexican federal government.

Figure 1.1 : TWDB Designated Regional Water Planning Areas



TWDB - Required Interest Groups:

1. *Public*
2. *Counties*
3. *Municipalities*
4. *Industries*
5. *Agriculture*
6. *Environmental*
7. *Small Business*
8. *Electrical Generating Utilities*
9. *River Authorities*
10. *Water Districts*
11. *Water Utilities*

Source: TWDB

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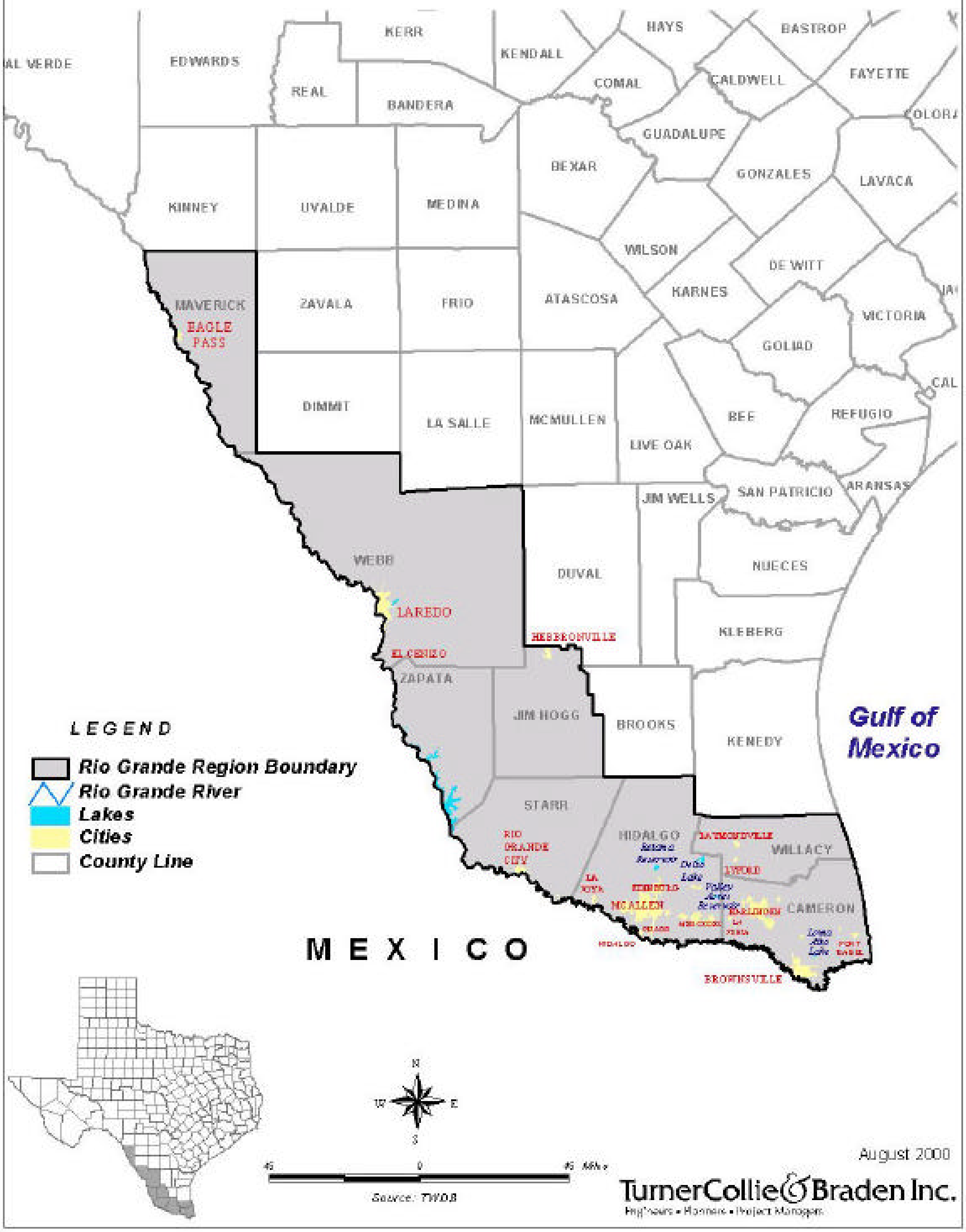
Figure 1.2 : Rio Grande Regional Water Planning Area (Region M)



Voting members of the Rio Grande RWPG are shown in Table 1.1 and non-voting members are shown in Table 1.2. The Lower Rio Grande Development Council (LRGVDC) serves as the administrative agency on behalf of the Rio Grande RWPG.

Table 1.1: Voting Members of the Rio Grande Regional Water Planning Group

Name	Interest Category	Entity	County
Glenn Jarvis	Other	Private Attorney	Hidalgo
Fernando Roman	Municipalities	City of Laredo	Webb
Lee Kirkpatrick	Other	Texas State Bank	Cameron
Charles W.Browning	Water Utilities	North Alamo WSC	Hidalgo
Mary Lou Campbell	Environmental	Sierra Club	Hidalgo
Robert E. Fulbright	Agriculture	Rancher	Jim Hogg
Jaime Gomez	Electric Power Generation	Central Power and Light	Webb
Roberto Gonzales	Municipalities	City of Eagle Pass	Maverick
Maria Eugenia Guerra	Small Businesses	*Laredos*, Newspaper	Webb
Gordon Hill	Water Districts	Bay View Irrigation District	Cameron
William"Bart" Hines	Municipalities	City of McAllen	Hidalgo
Sonny Hinojosa	Water Districts	Hidalgo Co.Irrigation Dist.# 2	Hidalgo
Mercurio Martinez	Counties	Webb County Judge	Webb
James R. Matz	Counties	Cameron Co. Commissioner	Cameron
Jack Nelson	Industry	Rio Grande Valley Sugar Growers Inc.	Cameron
Ray Prewett	Agriculture	Texas Citrus Mutual	Hidalgo
Mario Garcia Rios	Public	Texas A&M Laredo	Webb

Table 1.2: Non-Voting Members of the Rio Grande Regional Water Planning Group

Name	Representing
Randy Blankenship	Texas Parks and Wildlife Department
Zach Davis	Plateau RWPG (Region J)
Jimmy Day	Texas Department of Agriculture
Robert Flores	Texas Water Development Board
Amando Garza	South Texas Development Council
Pedro Garza	Economic Development Administration, US Department of Commerce
Robert Hannesschlager	U.S. Environmental Protection Agency
Gordon Hill	Representative for extra-regional holder of 1,000+ ac-ft of water rights
Charles Johnson	South Central Texas RWPG (Region L)
John Keiser	South Texas Development Council
Debra Little	International Boundary Water Commission
Carlos Lopez	Bureau of Reclamation, U.S. Department of the Interior
David Negrete Arroyos	Commission Internacional De Limited y Aqua (CILA), Mexico
Ernesto Reyes	U.S. Fish & Wildlife Service
Dexter J. Svetlik	Natural Resource Conservation Service, USDA
Jaime Tinoco Rubi	Commission Nacional Del Agua (CNA), Mexico
Richard Tomlinson	U.S. Army Corps of Engineers
Fausto Yturria	Coastal Bend RWPG (Region N)

By rule, the TWDB has set forth specific requirements and guidelines for the preparation of the regional water plans (31 Texas Administrative Code, Chapter 357, Regional Water Planning Guidelines Rules). Accordingly, there are several key tasks that are common to the development of the water plans in all regions:

- Development of population and water demand projections by decade for the period 2000-2050;
- Evaluation of the adequacy of currently available water supplies under drought of record hydrologic conditions;
- Comparison of currently available water supplies with projected demands to identify where and when there is a surplus of supply or a need for additional supplies;
- Evaluation of the social and economic impacts of not meeting the identified water needs; and,
- Development of recommendations regarding strategies for meeting near-term water needs (2000 to 2030) and strategies or scenarios to meet long-term future needs (2030 to 2050).

In addition, each RWPG may, at their discretion, include recommendations in their regional water plans with regard to:

- Legislative designation of ecologically unique river and stream segments;
- Identification of sites uniquely suited for reservoir construction;
- Regulatory, administrative, or legislative actions to improve water resource management in the region or in the state; and,
- Coordinated planning with neighboring regions concerning mutual interests and shared resources.

This document presents the approved water supply plan for the Rio Grande Region. Pursuant to TWDB requirements, the plan is organized into seven chapters.

Chapter 1 presents a description of the regional water planning area. This includes information regarding current water uses and major water demand centers, sources of surface and groundwater supply, agricultural and natural resources, and the demographic and socioeconomic characteristics of the region. Also included is a summary of existing regional water plans, a summary of recommendations in the current state water plan, a summary of local water plans, and an assessment of threats to agricultural and natural resources.

Chapter 2 of this plan presents current and projected population and water demands. This information is reported by city and county and for the portion of each river basin within the Rio Grande Region. Water demand projections are presented for six water use categories: municipal, manufacturing, irrigation, steam electric power generation, mining, and livestock.

Chapter 3 presents the results of an assessment of the quantity of water currently available to water users in the region under drought-of-record hydrologic conditions. This includes information on both surface and groundwater availability by source and information regarding the amount of water currently available to each water user group in the region.

Chapter 4 illustrates a comparison of currently available water supply with projected water demands. The purpose is to identify water user groups within the Rio Grande Region which are projected to experience surpluses or shortages of water during the planning period. In addition, information concerning the social and economic impacts of not meeting projected water needs is included.

Chapter 5 of the regional water plan represents the results of evaluations of various strategies for meeting identified water needs. This includes specific recommendations for meeting near-term needs (2000-2030) and recommended strategies and scenarios for meeting long-term needs (2030-2050). Water needs for which there are no feasible strategies are also identified.

Chapter 6 presents policy recommendations adopted by the Rio Grande RWPG are presented in Chapter 6. In addition, information is provided concerning river and stream segments within the Rio Grande Region that may meet one or more criterion for legislative designation as ecologically unique.

Chapter 7 describes the efforts undertaken by the Rio Grande RWPG to inform and obtain input from the public and key stakeholders in the development of the regional water plan.

1.1 PHYSICAL DESCRIPTION OF THE RIO GRANDE REGION

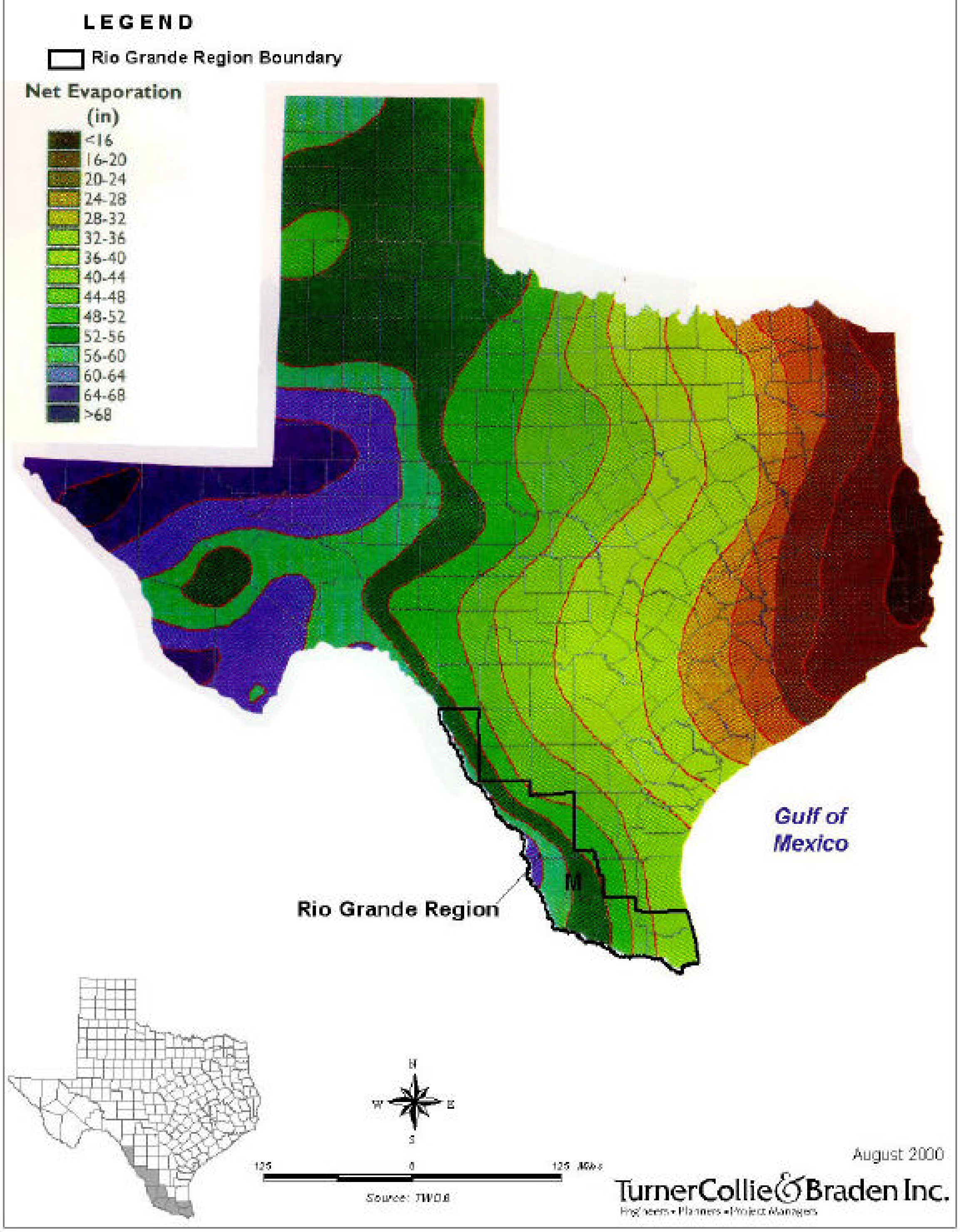
The following sub-sections provide a general description of the region's physical characteristics including climate, topography, geology, soils, and natural resources.

1.1.1 Climate

The climate of the Rio Grande Region ranges from a humid subtropical regime in the eastern portion of the region to a tropical and subtropical regime in the remaining portion of the region. Prevailing winds are southeasterly throughout the year and the warm tropical air from the Gulf of Mexico produces hot and humid summers and relatively mild and dry winters. The July maximum temperature in the region ranges from about 96°F to 98°F. The January minimum temperature in the region ranges from about 40°F to 49°F (TWDB, 1977). The number of frost-free days (growing season) varies from 320 days at the coast to 230 days in the northwestern portion of the region near Maverick County. Average annual net lake evaporation in the Rio Grande Region varies from 40 to 44 inches at the coast to approximately 60 to 64 inches at the central portion of the region near southern Webb County (Figure 1.3). Lake-surface evaporation rates are highest in the summer months.

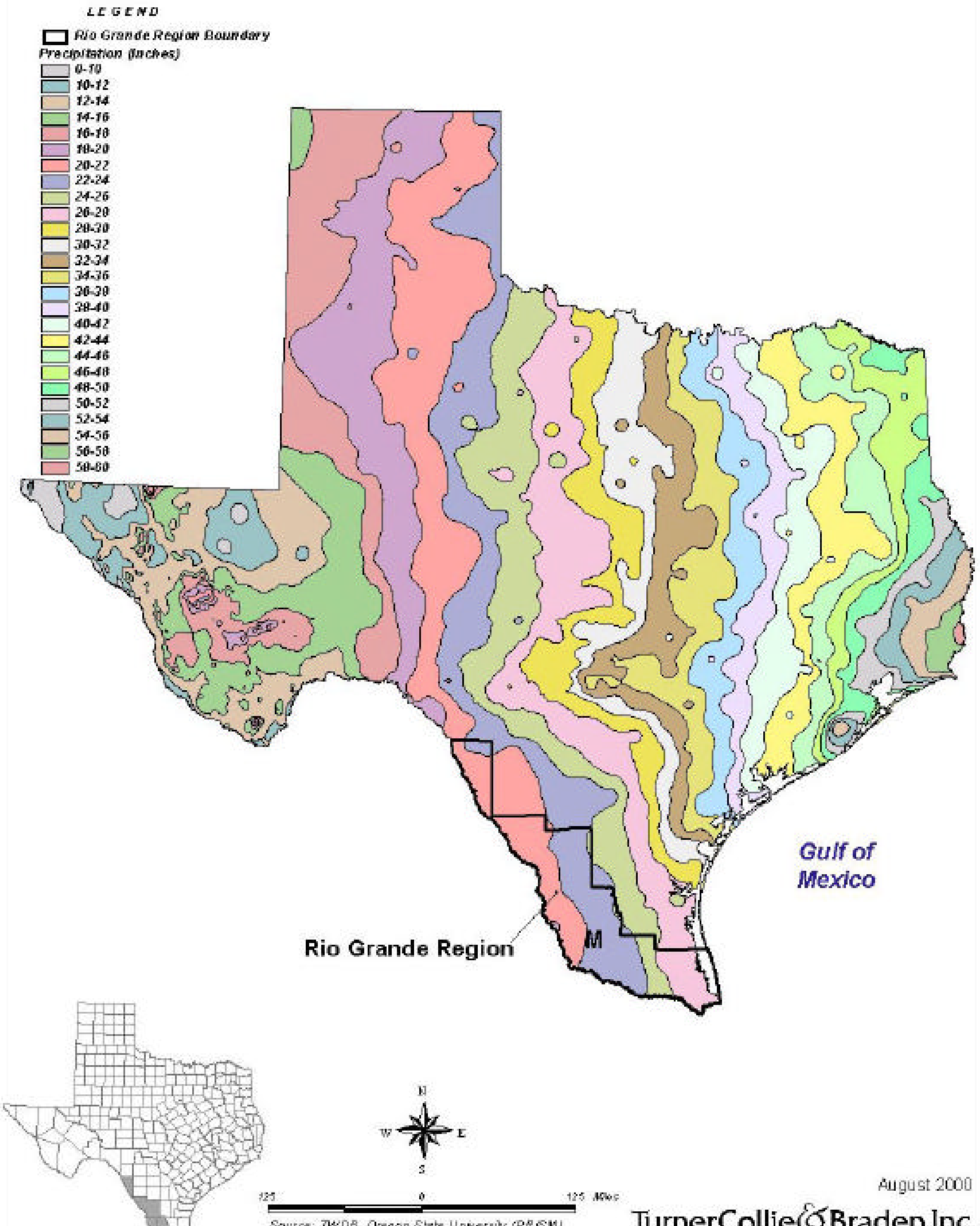
The amount of rainfall varies across the Lower Rio Grande Region from an average of 28 inches at the coast to 18 inches in the northwestern portion of the region (Figure 1.4). Most precipitation occurs during the spring from April through June, and during the late summer and early fall, from August through October. Spring precipitation is the result of seasonal transition as inflowing warm, moist air from the Gulf of Mexico and the Pacific Ocean generates thunderstorms. The period from late summer to early fall is the hurricane season, during which Atlantic and Gulf storms may move ashore along the Texas or Upper Mexican Gulf Coast. These storms can generate tremendous amounts of rainfall over a short period of time causing extensive flooding due to the relatively flat nature of the region's terrain. It is these fall storms, which provide a large portion of the surface water runoff captured in water supply reservoirs within the Rio Grande Basin.

Figure 1.3 : Rio Grande Regional Water Planning Area (Region M)
Average Annual Net Evaporation



Source: TWDB

Figure 1.4 : Rio Grande Regional Water Planning Area (Region M) Average Annual Precipitation



Source: TWDB, Oregon State University (PRISM)

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1.1.2 Topography, Geology, and Soils

The Rio Grande Region is located entirely within the Western Gulf Coastal Plains of the United States, an elevated sea bottom with low topographic relief. Topography in the region ranges from a rolling, undulating relief in the northwestern portion becoming progressively flatter near the Gulf Coast. The lower portion of the region consists of a broad, flat plain which rises gently from sea level at the Gulf of Mexico in the east to an elevation of approximately 960 feet in the northern part of Maverick County at the upper end of the region. The western edge of this plain culminates in a westward-facing escarpment known as the Bordas Escarpment. Drainage in the region is by the aforementioned river basins and their tributaries. The Rio Grande River flows southeasterly through the region before turning east to its confluence with the Gulf of Mexico.

Geologic formations exposed in the region include Cretaceous, Tertiary, and Quaternary-aged deposits. In general, the geologic strata of the Rio Grande Region decreases in age from west to east across the area. The oldest strata, which are of Cretaceous age, outcrop in northwestern Maverick County and consist of chalky limestone and marl. The youngest or most recent sediments are located in Cameron County.

In general, soils in the Rio Grande Region generally consist of calcareous to neutral clays, clay loams and sandy loams. A general soils map is presented in Figure 1.5.

A general description of the topography, geology, and soils for each county in the region is presented in the following sections.

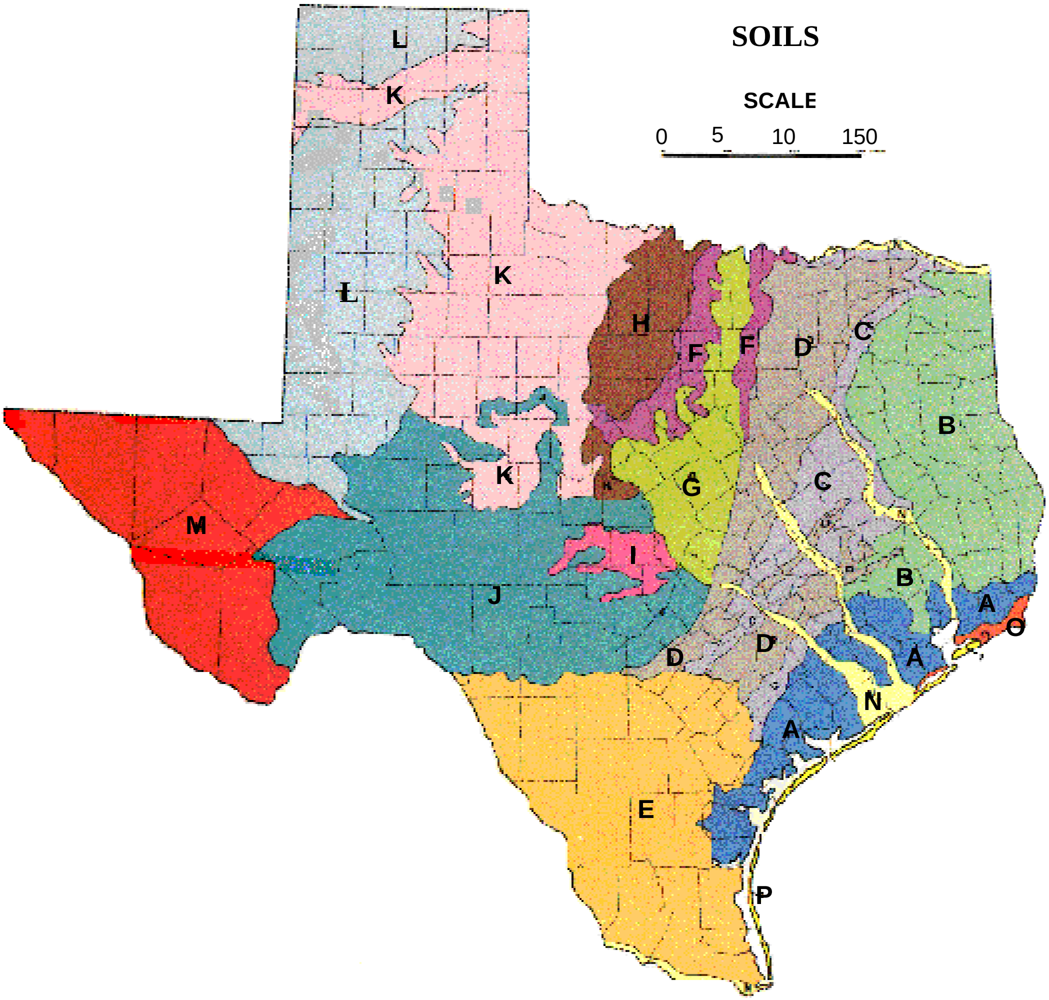
1.1.2.1 Cameron County

Cameron County is located at the extreme southern tip of Texas. The geologic formations in the county are unlithified (not cemented or crystallized) and dip gently toward the Gulf of Mexico. They are of Pleistocene age or younger, and only two geologic formations are exposed in the county; the Beaumont Formation and the overlying sediments of recent age (Holocene).

Cameron County consists of a flat plain that slopes gently to the northeast with an elevation that varies from sea level to 70 feet. The greater part of the area is an alluvial plain or delta of the Rio Grande River.

The county is located in an area of highly intensified and specialized farming. A narrow band of saline coastal soils parallels the Gulf of Mexico and is used as range. Portions of the northern and eastern parts of the county are used for dryland farming. Soil associations mapped in Cameron County include: Sejita-Lomalta - Barrada, Laredo - Lomalta, Willamar, Laredo - Olmito, Rio Grande - Matamoras, Willacy - Racombes, Lyford - Raymondville - Lozano, Hidalgo - Raymondville, Willacy - Raymondville, Raymondville, Harlingen-Benito, Harlingen, Mercedes, and Mustang-Coastal dunes associations (Soil Survey of Cameron County, 1977).

Figure 1.5: Soils of Texas
(Source: University of Texas Bureau of Economic Geology, 1977)



lighter colored sandy loams; acid soils mostly east of Trinity River.

B Light-colored, acid sandy loams, clay loams, & sands; some red soils & clays.

C Light-brown to dark-gray, acid sandy loams, clay loams, & clays.

D Dark-colored calcareous clays; some grayish-brown, acid sandy loams & clay loams along eastern edge of the major prairie & interspersed in minor prairies.

E Dark calcareous to neutral clays & clay loams; reddish-brown, neutral to slightly acid sandy loams; grayish-brown, neutral sandy loams & clay loams; some saline soils near coast.

F Light-colored, acid loamy sands & sandy loams.

G Dark-colored, deep to shallow clay loams, clays, & stony calcareous clays over limestone.

H Reddish-brown to grayish-brown, neutral to slightly acid sandy loams & clay loams; some stony soils.

to slightly acid, gravelly & stony sandy loams.

J Dark, calcareous stony clays & clay loams.

K Dark-brown to reddish-brown, neutral to slightly calcareous sandy loams, clay loams, & clays.

L Dark-brown to reddish-brown neutral sands, sandy loams, & clay loams; some very shallow calcareous clay loams.

M Light reddish-brown to brown sands; clay loams & clays (mostly calcareous, some saline) & rough stony lands.

N Light-brown to reddish-brown, acid sandy loams; acid & calcareous clay loams & clays.

O Light- & dark-colored, acid sands, sandy loams, & clays.

P Tan, loose sand & shell material.

1.1.2.2 Hidalgo County

The land surface in Hildalgo County is nearly level to gently sloping. The elevation ranges from about 40 feet above mean seal level on the eastern side of the county to 375 feet above msl on the western side. The surface sedimentary rocks, mostly unlithified, dip gently toward the gulf.

The major soils in Hidalgo County, used primarily for non-irrigated and irrigated crops, are generally deep, well drained, moderately permeable, and loamy throughout. They are on a nearly level to gently sloping upland plain. Soil associations in Hidalgo County include: Hidalgo, McAllen-Brennan, Brennan-Hidalgo, Willacy-Delfina-Hargill, Delmita-Randado, Willacy-Racombes, Nueces-Sarita, Delfina-Hebbronville-Comitas, Harlingen, Runn-Reynosa, Raymondville-Mercedes, Raymondville-Hidalgo, Rio Grande-Matamoras, and Pits-Jimenez-Quemado associations (Soil Survey for Hidalgo County, 1981).

1.1.2.3 Jim Hogg County

The topography in Jim Hogg County is mostly level to gently sloping and gently undulating. Wind-blown sand deposits are located across much of the south-central portion of the county. About 98 percent of the county is used for range. Raising cattle is the main agricultural enterprise, but some cultivated crops are also produced. Seven soil associations are mapped for the county and consist of mostly sandy loams and fine sands. The soil associations in the county include: Delmita, Nueces-Sarita, Falfurrias-Sarita, Brennan-Hebbronville, Copita-Brennan, Cuevitas-Randado-Zapata, and Comitas associations (Soil Survey of Jim Hogg County, 1974).

1.1.2.4 Maverick County

The topography of Maverick County ranges from nearly level to rolling. Elevation in the county ranges from about 540 above msl in the southern part to 960 feet in the northern part. The drainage pattern is distinctly expressed in most of the county, except in the north-central part, which is a nearly level and featureless plain. On the rolling hills, geological erosion occurs almost as fast as the soils form due to these soils being underlain at a shallow depth by strongly cemented caliche. Soil associations in Maverick County include: Copita-Pryor-Dant, Elindio-Montell, Jimenez-Olmos-Zapata, Catarina-Maverick, Brundage-Dant, Lagloria-Laredo, and Brustal associations (Soil Survey of Maverick County, 1977).

Approximately 92 percent of Maverick County is native rangeland used primarily for raising cattle. Significant irrigated cropland occurs in the county in an area generally paralleling the Rio Grande. The soils in the northern portion of the county consist of clays that produce mainly short grasses. Mesquite has invaded areas of these soils. Ridges and drainage-ways in these areas characterize the central and southern parts of the county. These soils are sandy loams and clay loams that produce a number of grasses and many shrubs. Shallow and gravelly soils on ridges, and hills along the Rio Grande produce good browse such as that provided by cuajillo, grasses, and forbs (Soil Survey of Maverick County, 1977).

1.1.2.5 Starr County

Starr County has a nearly level to undulating topography in most areas, but is rolling or hilly in a few locations. The most prominent landscape feature is the line of low hills that forms the boundary between the flood plain of the Rio Grande and the plain to the north. These gravelly, highly dissected ridges form an escarpment 50 to 100 feet above the flood plain. At the southern extension of the west-facing Bordas Escarpment is a gently rolling plain with rounded hills and broad valleys. The hills are drained by a number of arroyos that flow into the Rio Grande. A minor but prominent landscape feature of Starr County is the sand sheet that covers the extreme northeastern part of the county. This area is the southwestern extension of an area of windblown sand that covers about 2,800 square miles of area in South Texas.

A majority of the county consists of deep, clayey and loamy soils on uplands. The parent material of most soils in the county consists of alkaline and calcareous, unconsolidated material deposited mainly in a fluvial (river) environment, as well as the windblown sand deposits discussed above. Eight different soil associations are mapped in Starr County and include the McAllen-Brennan, Catarina-Copita, McAllen-Zapata, Copita, Delmita, Rio Grande-Reynosa, Sarita, and Jimenez-Quemado associations (Soil Survey of Starr County, 1972).

1.1.2.6 Webb County

The land surface of Webb County is nearly level to rolling, with elevations ranging from 400 feet to about 900 feet above sea level. The surface geology consists of consolidated and unconsolidated sedimentary and eolian (wind-blown) deposits that dip gently toward the Gulf of Mexico. Soils in Webb County consist of mostly deep, nearly level to gently sloping, clayey and loamy soils that vary widely in their potential for major land uses. Soil associations in Webb County include: Montell-Moglia-Viboras, Catarina-Maverick-Palafox, Catarina-Maverick-Moglia, Duval-Brystal, Aguilares-Montell, Hebbronville-Brundage-Copita, Copita-Verick, Delmita-Randado-Cuevitas, Maverick-Jimenez-Quemado, Laglori-rio Grande, and Nueces-Delfina (Soil Survey of Webb County, 1985).

1.1.2.7 Willacy County

Geologic formations in Willacy County crop out in bands that parallel the Gulf and dip gently gulfward. The oldest surface geologic unit in the county is the Pleistocene-age Lissie Formation. Willacy County is on nearly level stream and coastal terraces where slopes are generally less than one percent; however, there is enough relief in the higher areas that well drained soils with well developed profiles have formed. Most of the soils in the county consist of loamy and clayey soils on nearly level flats and gently sloping ridges on stream and coastal terraces. Soil associations in Willacy County include: Raymondville-Mercedes, Lyford-Lozano, Hidalgo Racombes, Willacy-Racombes, Delfina-Hargill-Willacy, Willacy-Raymondville, Nueces-Sarita, Galveston-Mustang-Dune land, Sauz, Falfurrias, Satatton-Tatton, Willamar-Porfirio, Barrada-Lalinda-Arrada, and Saucel-Latina associations (Soil Survey of Willacy County, 1982).

1.1.2.8 Zapata County

Geologic units mapped in the county consist of mostly Eocene-aged deposits. The relief of the county is nearly level. Along the present stream channel of the Rio Grande, there are recent sediments derived from the wide variety of parent rocks within the vast watershed of the river. These sediments are mainly silty and alkaline or calcareous and they contain a high proportion of weatherable minerals.

A soil survey publication and map has not been prepared by the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service) for Zapata County. Review of general soil map prepared by the Bureau of Economic Geology (Figure 1.5, above) indicates that the soils in the county consist of dark calcareous to neutral clays and clay loams and reddish-brown, neutral to slightly acid sandy loams.

1.1.3 Vegetation Areas (Biotic Communities)

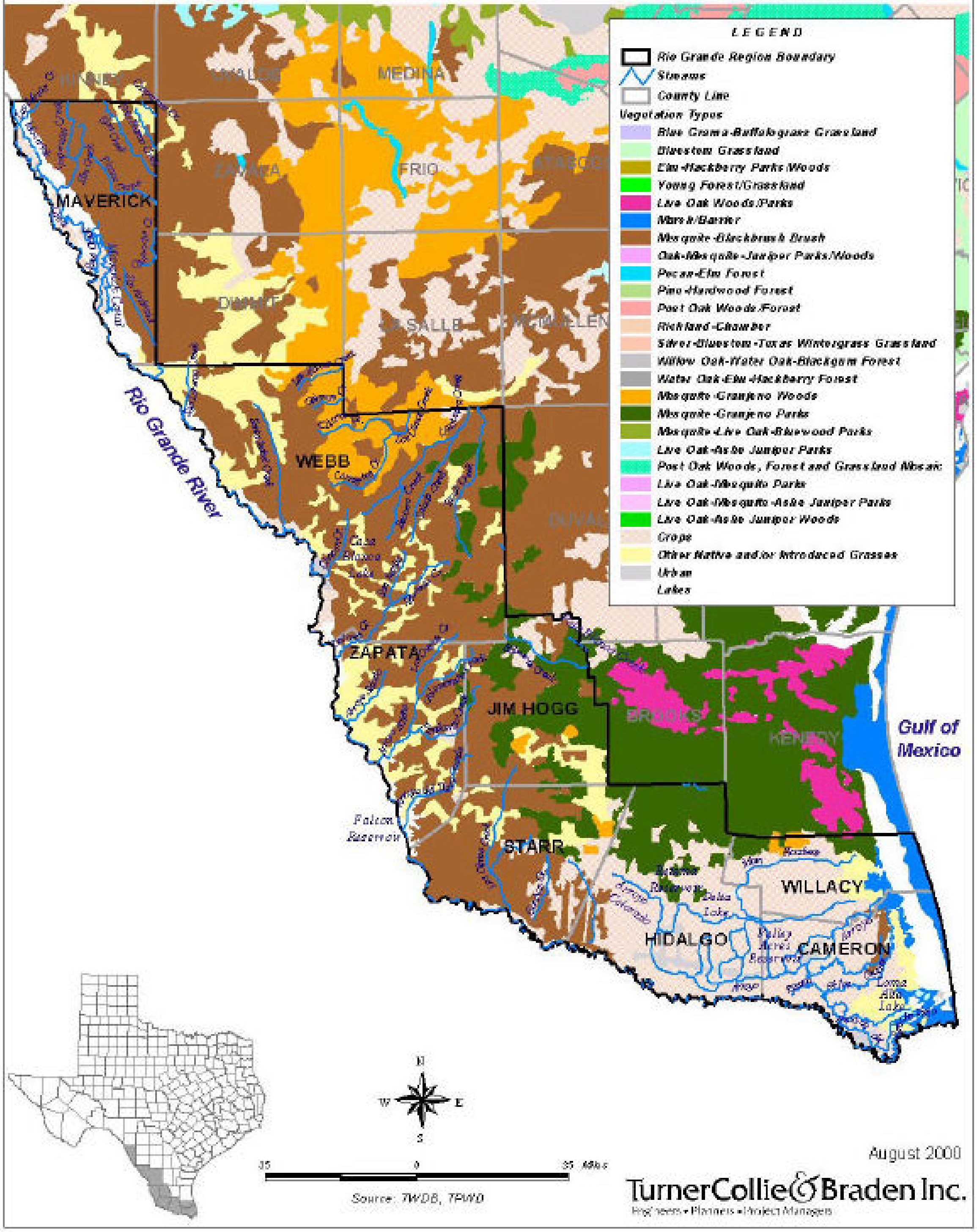
Located within the Matamoran district of the Tamaulipan Biotic Province (Blair, 1950), the Lower Rio Grande Valley is the northern boundary of much of the semitropical biota of Mexico. A number of plant and animal species from the more xeric and mesic areas to the west and northeast respectively, converge in the Lower Rio Grande area.

1.1.3.1 Terrestrial Vegetative Types

The predominant vegetation type in this area is thorny brush, but there is overlap with the vegetative communities of the Chihuahuan desert to the west, the Balconian province to the north (Texas Hill Country), and the tropical plant communities of Mexico to the south. The result is unique and varied flora and fauna. Xeric plants such as mesquite (*Prosopis glandulosa*), leatherstem (*Jatropha dioica*), lotebrush (*Ziziphus obtusifolia*), and brasil (*Condalia hookeri*) are found in this area. Sugar hackberry (*Celtis laevigata*) and Texas persimmon (*Diospyra texana*), more prevalent to the north, are also located in the Lower Rio Grande Valley. Other common species such as lantana (*Lantana horrida*), Mexican olive (*Cordia boisierri*), and Texas ebony (*Pithecellobium ebano*) are typically more tropical in location. Montezuma bald cypress (*Taxodium mucronatum*), Gregg wild buckwheat (*Eriogonum greggi*), Texas ebony and anacahuita (Mexican olive) have their northernmost extension in the Lower Rio Grande Valley. More than 90 percent of total riparian vegetation has been cleared since 1900. Surface water remains only briefly in arroyos following substantial rainfall. Because of this scarcity of water the resulting vegetation types are closely correlated to topographic characteristics (LBJSPA, 1976).

Eleven distinct biotic communities compose the Lower Rio Grande Valley, stretching from Falcon Reservoir to the Gulf of Mexico (USFWS, 1997). The communities to the northwest are arid, semi-desert, thorny brush. Vegetation communities toward the coast are comprised of more wetlands, marshes and saline environments. (see Figure 1.6)

Figure 1.6 : Rio Grande Regional Water Planning Area (Region M) Vegetation Distribution



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Source: TWDB, TPWD

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1.1.3.1.1 Ramaderos

This region, which occupies west-central Starr County, consists of arroyos that provide wildlife habitat.

1.1.3.1.2 Chihuahuan Thorn Forest

Located below Falcon Dam along the Rio Grande, the Chihuahuan Thorn Forest includes a narrow riparian zone and an upland desert shrub community. Rare plants such as the Montezuma bald cypress and the federally endangered Johnston's frankenia (Frankenia johnstonii) are found here, as well as such uncommon birds as the brown jay (Cyanocorax morio), ringed kingfisher (Ceryle torquata) and red-billed pigeon (Columba flavirostris).

1.1.3.1.3 Upper Valley Flood Forest

This community is located along the Rio Grande from south-central Starr County to the western border of Hidalgo County. The floodplain narrows in this region, with typical riverbank trees including Rio Grande ash (Fraxinus berlandieriana), sugar hackberry, black willow (Salix nigra), cedar elm (Ulmus crassifolia). Only a short distance from the river the dominant species shift to honey mesquite, granjeno (Celtis pallida), and prickly pear (Opuntia lindheimeri).

1.1.3.1.4 Barretal

The Barretal community occurs in southeastern Starr County, just north of the Upper Valley Flood Forest. Barreta (Helietta parvifolia), a small tree located on gravelly caliche hilltops, and paloverde (Parkinsonia texana), guajillo (Acacia berlandieri), blackbrush (Acacia rigidula), anacahuita, yucca (Yucca treculeana) and many species of cacti are typical of this community.

1.1.3.1.5 Upland Thorn Scrub

Upland Thorn Scrub, the most common community in the Tamaulipan Biotic Province, occurs in southwestern Hidalgo County. Typical woody plants include anacahuita, cenizo (Leucophyllum frutescens), and paloverde.

1.1.3.1.6 Mid-Valley Riparian Woodland

This community is located along the Rio Grande from western Hidalgo County eastward to the Sabal Palm Forest. This tall, dense, closed-canopy bottomland hardwood forest is favored by chachalacas (Ortalis vetula) and green jays (Cyanocorax yncas), birds more typical of Mexico. Trees of this community include Rio Grande ash, sugar hackberry, black willow, cedar elm, Texas ebony, and anaqua (Ehretia anacua).

1.1.3.1.7 Woodland Potholes and Basins

Central Hidalgo County and western Willacy County contain this community of seasonal wetlands and playa lakes. Additionally, three hypersaline lakes are present, attracting migrating shorebirds. The federally endangered ocelot (Leopardus pardalis) occupies dense thickets in this area. Wetlands are located in low woodlands of honey mesquite, granjeno, prickly pear, lotebush, elbow bush (Forestiera angustifolia) and brasil.

1.1.3.1.8 Mid-Delta Thorn Forest

The Mid-Delta Thorn Forest originally covered eastern Hidalgo County, the western two-thirds of Cameron County, and southwest Willacy County. Conversion of land for agricultural and urban uses has left only isolated pockets of native vegetation remaining. Typical plants include honey mesquite, Texas ebony, coma (Bumelia lanuginosa), anacua, granjeno, colima (Zanthoxylum fagara), and other thicket-forming species. This region provides excellent wildlife habitat and is a preferred area for white-winged dove (Zenaida asiatica).

1.1.3.1.9 Sabal Palms Forest

This area of riparian forest contains the last remaining acreage of original Sabal Palm Forest in south Texas. It is located on the Rio Grande at the southernmost tip of Texas. Vegetation in this region includes Texas sabal palm (*Sabal texana*), Texas ebony, tepeguaje (*Leucaena pulverulenta*), anacua, brasil, and granjeno. The National Audubon Society's Sabal Palm Grove Sanctuary is located in this area.

1.1.3.1.10 Loma Tidal Flats

Located at the mouth of the Rio Grande, this community consists of clay dunes, saline flats, marshes, and shallow bays along the Gulf of Mexico. Sea ox-eye (Borrichia frutescens), saltwort (Batis maritima), glasswort (Salicornia sp.), gulf cordgrass (Spartina spartinae), Berlandier’s fiddlewood (Citharexylum berlandieri), Texas ebony and yucca are typical plants of this region.

1.1.3.1.11 Coastal Brushland Potholes

This community is comprised of dense brushy woodland around freshwater ponds, changing to low brush and grasslands around brackish ponds, and saline estuaries nearer the Gulf of Mexico. Typical plants include honey mesquite, granjeno, barbed-wire cactus (*Acanthocereus pentagonus*), and gulf cordgrass. Area wetlands provide important habitat for migratory wildlife.

1.1.3.2 Lower Laguna Madre

The lower Laguna Madre is a hypersaline bay most of which lies in the eastern portions of Cameron and Willacy counties. Shallow depth, extensive seagrass meadows, and tidal flats characterize it. Small portions of the lower Laguna Madre are estuarine in nature with more moderate to brackish salinities. The Arroyo Colorado provides most of the freshwater inflow to the bay with other drainage canals and floodways having smaller contributions. Freshwater from these sources aid in moderating salinities in the bay and are vital to the success of estuarine dependant aquatic species. The lower Laguna Madre supports a wide variety of marine aquatic organisms and wildlife. It also supports considerable water-related recreational activities (i.e. boating, sportfishing, bird watching, etc.) and commercial fisheries.

1.1.4 Protected Areas

Public and private interests have created several refuges and preserves in the Lower Rio Grande Valley to protect remaining vegetation and the habitats of endangered and threatened species. These include the Lower Rio Grande Valley National Wildlife Corridor/Refuge, Laguna Atascosa National Wildlife Refuge (NWR), Santa Ana NWR, Anzalduas County Park, Falcon State Park (SP), Bentsen-Rio Grande Valley SP, Boca Chica SP, Las Palomas Wildlife Management Area (WMA), Arroyo Colorado WMA, Sabal Palm Audubon Center and Sanctuary, the Nature Conservancy's Chihuahua Woods Preserve, and the SouthBay Coastal Preserve. Ten local communities and Texas Parks and Wildlife Department (TPWD) are currently in the final states of planning for the World Birding Center committing $20-25 million to the project. These ten sites will be “world class” birding destinations attracting thousands of visitors to “bird” and learn about conservation of natural resources.

1.1.4.1 Lower Rio Grande Valley National Wildlife Refuge and Wildlife Corridor

The U.S. Fish and Wildlife Service (USFWS), with the support and assistance of the TPWD and several private organizations and individuals, is creating a wildlife corridor along the Rio Grande from Falcon Dam to the Gulf of Mexico. The wildlife refuge serves as the largest component of the Lower Rio Grande Wildlife Corridor. It currently includes 270 individual tracts totaling 86,246 acres. The completed refuge is projected to total 132,000 acres in fee and conservation easements. The wildlife refuges described below are part of this system. Additional acreage is purchased from willing sellers at fair market value or obtained through conservation easements.

1.1.4.2 Laguna Atascosa National Wildlife Refuge

Laguna Atascosa NWR contains more than 45,000 acres of land, providing essential habitat for a variety of south Texas wildlife. It is located north of the Rio Grande and south of the Arroyo Colorado along the Laguna Madre.

1.1.4.3 Santa Ana National Wildlife Refuge

This 2,000-acre refuge receives extensive bird watching attention because it is located at the convergence of two major migratory waterfowl flyways, the Central and the Mississippi. More than half of all butterfly species in the U.S. are found in this refuge.

1.1.4.4 Falcon State Park

This park, managed by the TPWD, contains over 500 acres above Falcon Dam. It is popular with bird watchers because of its diversity of bird species.

1.1.4.5 Sabal Palm Audubon Center and Sanctuary

This sanctuary, owned by the National Audubon Society, is located in the southernmost point of Texas on the Rio Grande. It is a 527-acre forested area that includes a substantial portion of the remaining sabal palm forest. The sanctuary is popular with bird watchers and other nature enthusiasts for its wildlife. The state threatened southern yellow bat (*Lasiurus ega*) is a year-round resident. The ocelot and jaguarundi (*Herpailurus yagouaroundi*) are believed to inhabit parts of the sanctuary.

1.1.4.6 Bentsen-Rio Grande Valley State Park

This park, managed by the TPWD, is located west of Mission in Hidalgo County. It consists of almost 600 acres of subtropical resaca woodlands and brushland, and is a popular bird-watching area. Boca Chica State Park, administered by Bentsen-Rio Grande Valley SP, is located in Southeastern Cameron County. Endangered and rare birds, such as Brown Pelicans, Reddish Egrets, Osprey, Peregrine Falcons, and several others, are commonly found in the park area.

1.1.5 Rare, Threatened, or Endangered Plant Species

The federal Endangered Species Act (ESA) of 1973, with amendments, provides a means to conserve endangered and threatened species and the ecosystems on which these species depend. The ESA provides for conservation programs for endangered and threatened species, and to take steps as may be appropriate for achieving the purposes of conserving species of fish and wildlife protected by international treaty. Federal agencies are required to ensure that no actions that an agency would undertake will jeopardize the continued existence of any endangered or threatened species, except as provided by the ESA. Any federal permits required to implement components of this water plan would be subject to the terms of the ESA. Specifically, Section 7 of the ESA requires that: "Each Federal agency shall, in consultation with and with the assistance of the Secretary (of the Interior), insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined…to be critical…. In fulfilling the requirements of this paragraph each agency shall use the best scientific and commercial data available."

Within the Rio Grande Region, twenty-six (26) plant species occur which have been designated by the USFWS and/or the TPWD as rare, threatened, or endangered (Appendix 1A). Seven out of the twenty-six species are federally listed species. Species designated as threatened or endangered receive full protection under the ESA. Species of Concern (SOC) are those species for which there is some information showing evidence of vulnerability, but lacking sufficient data to support listing at the present time.

1.1.6 Rare, Threatened, or Endangered Animal Species

There are sixty-nine rare, threatened, or endangered animal species with habitat found within the Rio Grande Region that are listed by the USFWS and/or the TPWD (Appendix 1A). These include seven species of amphibians, 29 birds, nine fishes, eight mammals, 14 reptiles, and two insects. Thirteen out of the sixty-nine species are federally listed species.

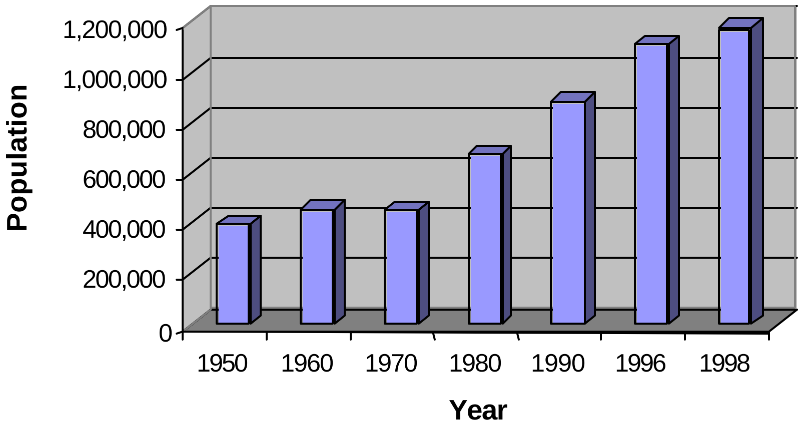
1.2 DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS OF THE RIO GRANDE REGION

The following sub-sections provide an overview of the demographic and economic characteristics of the Rio Grande Region.

Population in the Rio Grande Region increased from approximately 398,700 in 1950 to over 1.17 million in 1998. As shown in Figure 1.7, most of this increase has occurred since 1970. During the period from 1970 to 1990, six of the 31 fastest growing counties in Texas were within the Rio Grande Region. Hidalgo, Maverick, Starr, and Zapata counties more than doubled their populations during this 20-year period.

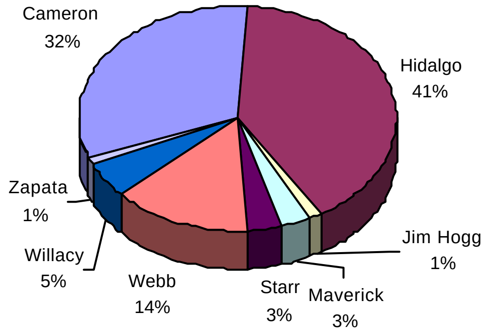
Population distribution in the Rio Grande Region is concentrated in Cameron, Hidalgo, and Webb counties. In 1998 the combined population of these three counties accounted for nearly 89 percent of the region's total population. Figures 1.8 and 1.9 show the population distribution for the region in 1950 and in 1998.

Figure 1.7 - Historical Population for the Rio Grande Region



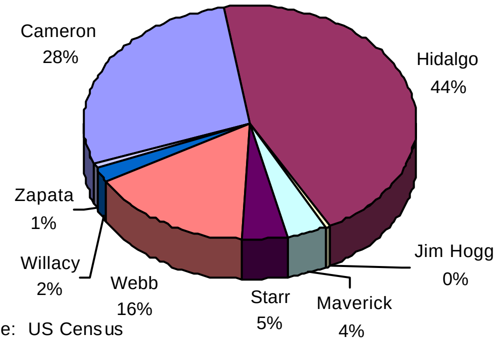
Source: US Census Bureau

Figure 1.8 - 1950 Region Population - 398,711



Source: US Census

Figure 1.9 - 1998 Region Population - 1,176,976



Source: US Census

1.2.1 Historical and Current Population

As indicated, the percentage of the region's population living in Cameron, Willacy and Jim Hogg counties has decreased slightly since 1950, while the portion of the population in the other five counties has either remained the same or increased. Chapter 2 of this report presents population growth projections for the Rio Grande Region for the 50-year planning period (2000 - 2050).

An important factor driving rapid population growth in the Rio Grande Region is its proximity to and its cultural, social, economic relationship with Mexico. Over the past 50 years, Mexico's population growth rate has been approximately three times greater than that of the United States. Much of that growth has occurred in the northern border states of Mexico. It is estimated that nearly seven million people currently live in the portion of the Rio Grande Basin that lies within Mexico. These population growth trends along both sides of the border are expected to continue for the foreseeable future.

1.2.2 Economic Activities

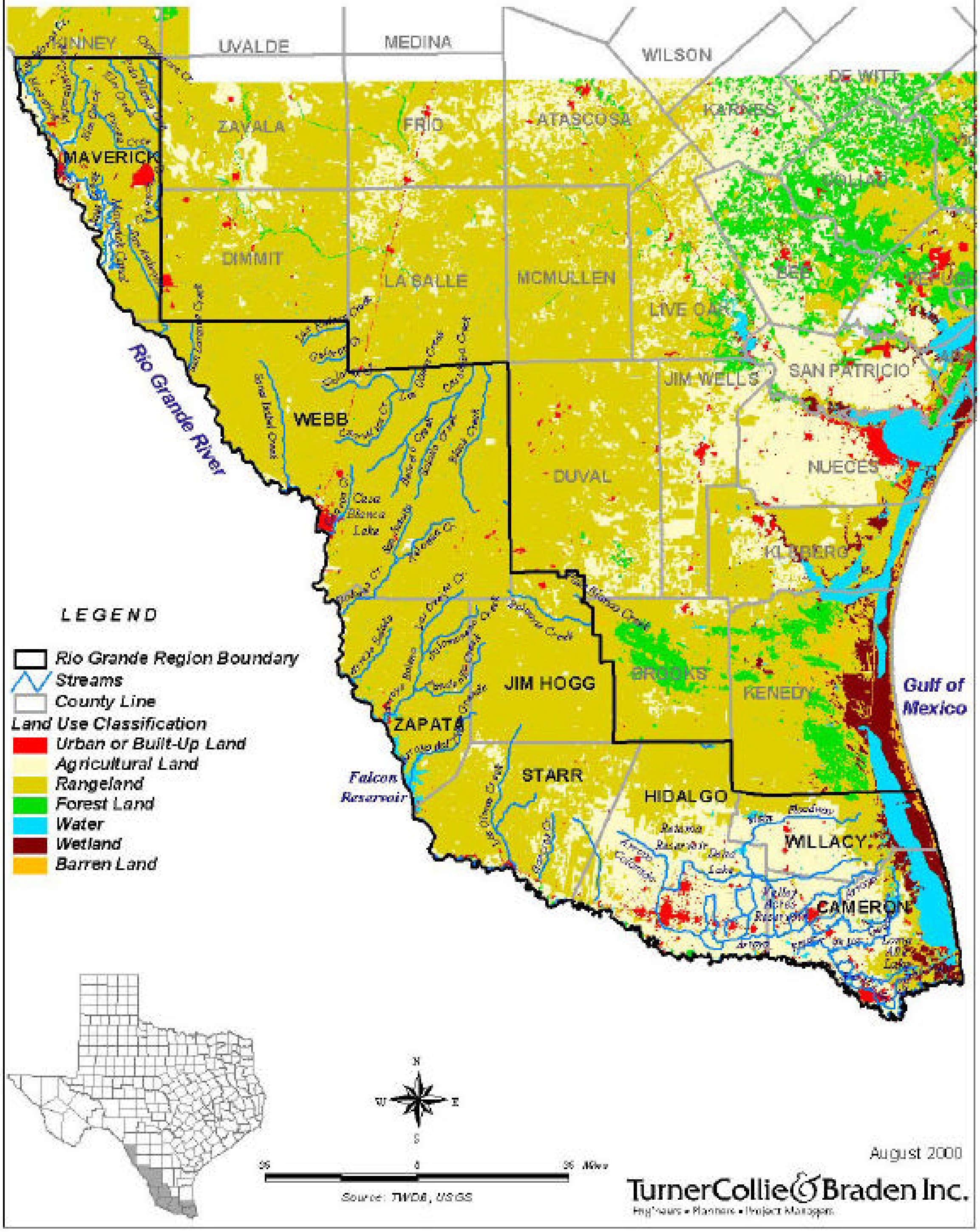
Historically, agriculture has been the predominant component of the economy of the Rio Grande Region. While the region is becoming more urbanized and its economy is becoming more diversified, agriculture still plays a major role in the regional economy. More than 75 percent of the region's total land area is used for agriculture and livestock (Figure 1.10). The Texas Comptroller of Public Accounts (CPA) website shows that agricultural income during the last five years have averaged more than $500 million per year for Cameron, Hidalgo, Willacy, and Starr counties, of which, more than 80 percent was from crop production. The primary crops produced in the region are fruits, vegetables, cotton, and sorghum. Agriculture receipts in the other counties within the region come primarily from livestock, with some vegetable crop production.

Over the last five years, beef cattle have made up an average of 99 percent of total livestock cash receipts in the valley. That is an average value of more than $77 million a year. The majority of the receipts for beef cattle have come from Starr County, averaging about $57 million a year since 1993 (CPA website).

Due in part to its proximity to Mexico, the trade, services, and manufacturing sectors are becoming increasingly important to the region's economy. The trade and service sectors of the economy have been responsible for much of the economic growth in the Rio Grande Region over the past decade in terms of both revenue and employment. Growth in these sectors of the economy is largely attributable to the significant expansion of trade between the U.S. and Mexico under the North American Free Trade Agreement (NAFTA). Under NAFTA, the region is becoming increasingly important as a transportation hub for trade with Mexico.

Manufacturing is an important sector of the economy, primarily in the region's three U.S. Census Bureau designated Metropolitan Statistical Areas of Brownsville-Harlingen-San Benito, McAllen-Edinburg-Mission, and Laredo. The most important factor in the expansion of the region's manufacturing sector has been the growth of the maquiladora industry in Mexico. In 1998, approximately 81 percent of the more than 2,000 maquila plants in Mexico were located in the six northern border states. The maquila industry was originally designed to take advantage of certain U.S. tariff code provisions that allowed U.S. firms to export unassembled products to Mexico for assembly. The assembled products are then imported

Figure 1.10 : Rio Grande Regional Water Planning Area (Region M) Land Use Distribution



Source: TWDB, USGS

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in the U.S. Duties were only paid on the value added during the assembly process rather than on the full value of the product. Even more favorable tariff conditions are now in place under NAFTA and the maquiladora industry has been shifting toward full transformation of raw materials for finished products.

In Jim Hogg, Webb, Starr, and Zapata counties, oil and gas production and trade are also important sources of income, averaging over $1 billion per year in taxable value from 1983 to 1993.

The Texas Department of Economic Development (TDED) website illustrates that in 1997 the total destination spending for tourism for Cameron, Hidalgo, Willacy, and Starr counties was over $1,000 million. Tourism in Falcon State Park has significant economic impact in Zapata and Starr Counties. In addition, water-related recreational activities (boating, sportfishing, bird watching, etc…) and commercial fishing in the lower Laguna Madre and adjacent waters also influence the regional economy. In 1995, the direct impact of water-related recreational activities in the Laguna Madre to South Texas and the state was $221 million. The direct impact of commercial fishing in South Texas was $63.1 million.

Wildlife viewing in and around areas with aquatic habitats contributes considerably to the Rio Grande Valley Economy. The economic impact of bird watchers at surveyed refuges in the Rio Grande Valley is estimated to be approximately $90 million dollars per year (Source: TPWD, USFWS, and World Birding Center Community Council comments, 2000). Santa Ana NWR attracts an estimated 99,000 bird watchers per year, most of whom have traveled from outside of the four county area, and most from other states. These visitors inject $36 million dollars into the local economy, with a total gross input of almost $89 million dollars. Also, within the last two years, two new businesses have been added, which have begun taking tourists on canoeing and river exploration trips on the Rio Grande new birding lodging facilities. Additionally, existing outfitters on the Arroyo Colorado continue to do business. The four Valley nature festivals generate significant income to the local economics. The quality of the river and its adjacent wildlife habitat will affect the number of ecotourists visiting the Valley in the future.

Although the Rio Grande Region has seen a large increase in the number of jobs during the decade of the 1990s, unemployment remains significantly above the state and national averages, and median household income are significantly lower. High unemployment is attributed largely to the constant influx of immigrants from Mexico and the area's abundance of migrant workers. Table 1.3 presents median household income and unemployment rate by county.

Table 1.3: Median Household Income and Unemployment Rate, by County

County	Median Household Income* ($)	Percent of Labor Force that is Unemployed** (%)
Cameron	21,928	12.1
Hidalgo	19,957	18.2
Jim Hogg	20,130	9.1
Maverick	17,150	27.0
Starr	16,727	26.5
Webb	24,288	9.3
Willacy	19,063	20.7
Zapata	20,696	14.0

* Source: Bureau of the Census, Small Area Income and Poverty Estimates Program (1995)
** Source: Bureau of the Census, USA Counties 1996 CD-ROM

1.3 SURFACE WATER RESOURCES

The Rio Grande Region encompasses portions of three river basins: the Rio Grande, the Nueces and the Nueces-Rio Grande (see Figure 1.11). An overview of the characteristics and surface water resources of each of basin is provided in the sections that follow and more detailed descriptions are provided in Chapter 3.

1.3.1 Rio Grande Basin

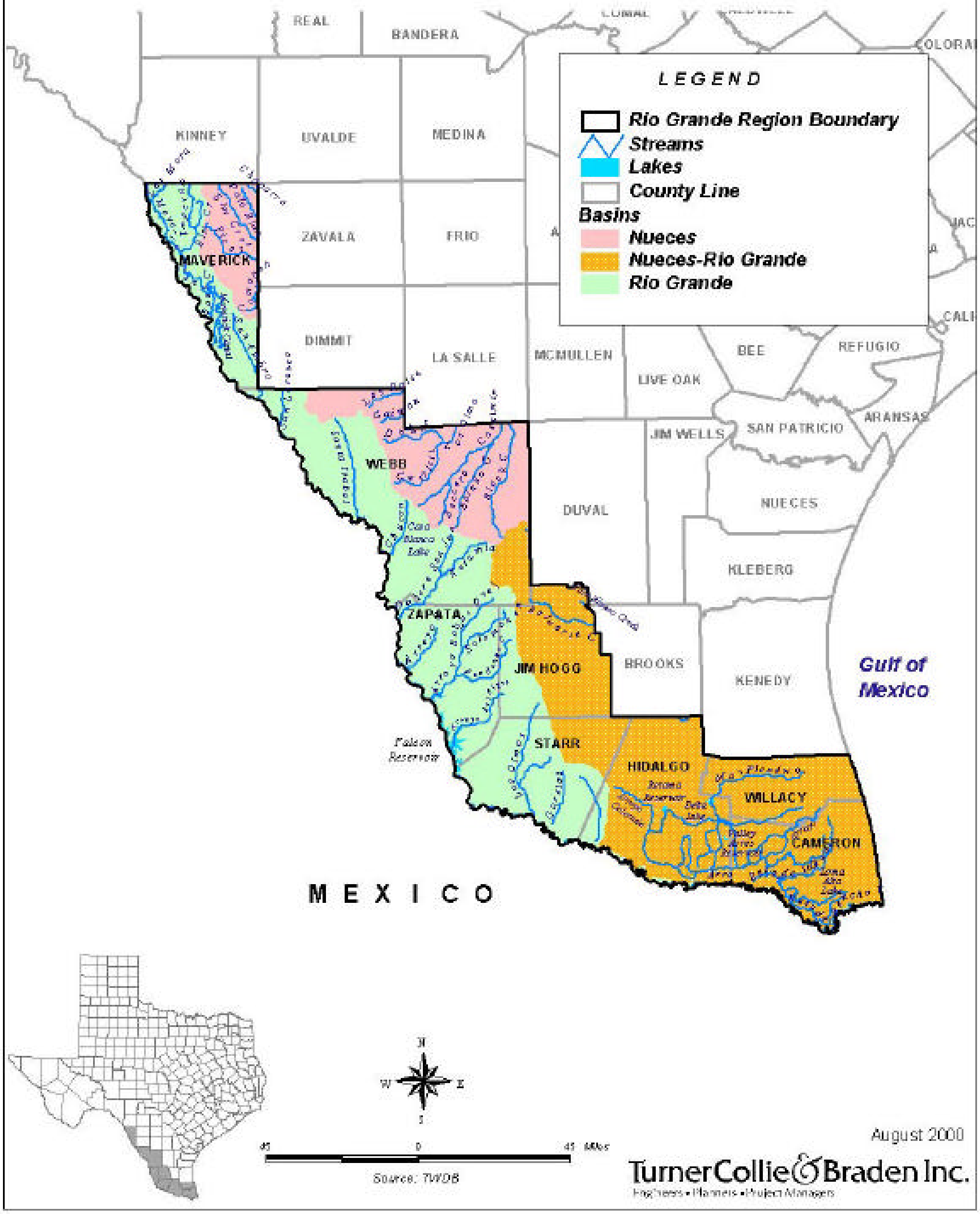
As depicted in Figure 1.12, the Rio Grande Basin extends southward from the Continental Divide in southern Colorado through New Mexico, and Texas to the Gulf of Mexico. From El Paso, Texas to the Gulf, the Rio Grande forms the international boundary between the United States and Mexico, a straight-line distance of 700 miles and a river mile distance of nearly 1,250 miles. Approximately 176,000 square miles of the 355,500 square miles in the entire Rio Grande Basin contributes to the Rio Grande. The remainder of the Basin consists of internal closed sub-basins. The Texas portion of the contributing watershed encompasses approximately 54,000 square miles. Approximately 8,100 square miles within the Texas portion of the basin are in closed sub-basins that do not contribute flows to the Rio Grande. The Pecos and Devils Rivers are the principal tributaries of the Rio Grande in Texas. Both of these rivers flow into Amistad Reservoir on the Rio Grande, which is located upstream of the City of Del Rio, Texas, about 600 river miles from the mouth of the Rio Grande. There are no major springs in this region which could be used as source of water supply.

In Mexico, the Rio Conchos, Rio Salado, and the Rio San Juan are the largest tributaries of the Rio Grande. The Rio Conchos drains over 26,000 square miles and flows into the Rio Grande near the town of Presidio, Texas, about 350 river miles upstream of Amistad Reservoir. The Rio Salado has a drainage area of about 23,000 square miles and discharges directly into Falcon Reservoir on the Rio Grande. Falcon Reservoir is located between the cities of Laredo, Texas and Rio Grande City, Texas, about 275 river miles upstream from the Gulf of Mexico. The Rio San Juan has a drainage area of approximately 13,000 square miles and enters the Rio Grande about 36 river miles below Falcon Dam near Rio Grande City, Texas. Amistad-Falcon Reservoir system is designated as a special water resource by the TWDB (31 TAC 357.5(g)).

In addition to the two international reservoirs on the Rio Grande (i.e., Amistad and Falcon), Mexico has constructed an extensive system of reservoirs on tributaries of the Rio Grande. Figure 1.13 shows the location of these reservoirs. The impacts of the development of the tributary reservoirs in Mexico on the supply of water available to the Rio Grande Region has been evaluated as part of the regional planning effort and is discussed in Chapter 3.

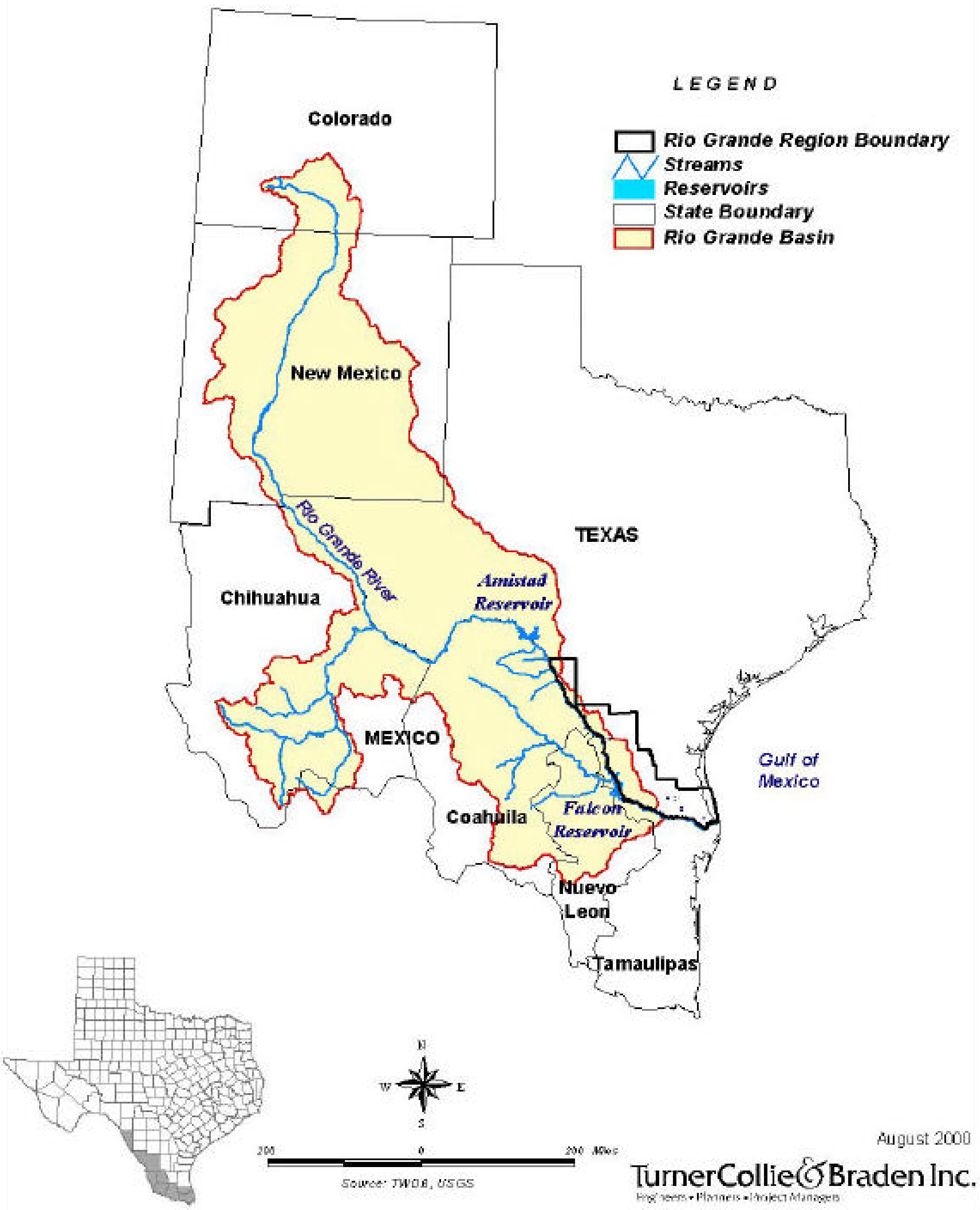
The vast majority of the Rio Grande Basin is comprised of rural, undeveloped land that is used principally for farming and ranching operations. In Texas, the major urban centers include El Paso in the far western portion of the state; the cities of Del Rio, Eagle Pass, and Laredo on the river in the central portion of the basin; and Mission, McAllen, Harlingen, and Brownsville in the Lower Rio Grande Valley. In Mexico, there are several major urban areas along the Rio Grande including Juarez, Nuevo Laredo, Reynosa, Monterrey, and Matamoras.

Figure 1.11 : Rio Grande Regional Water Planning Area (Region M) Surface Water Hydrology



Source: TWDB

Figure 1.12 : Rio Grande Regional Water Planning Area (Region M)
Rio Grande Watershed



Source: TWDB, USGS

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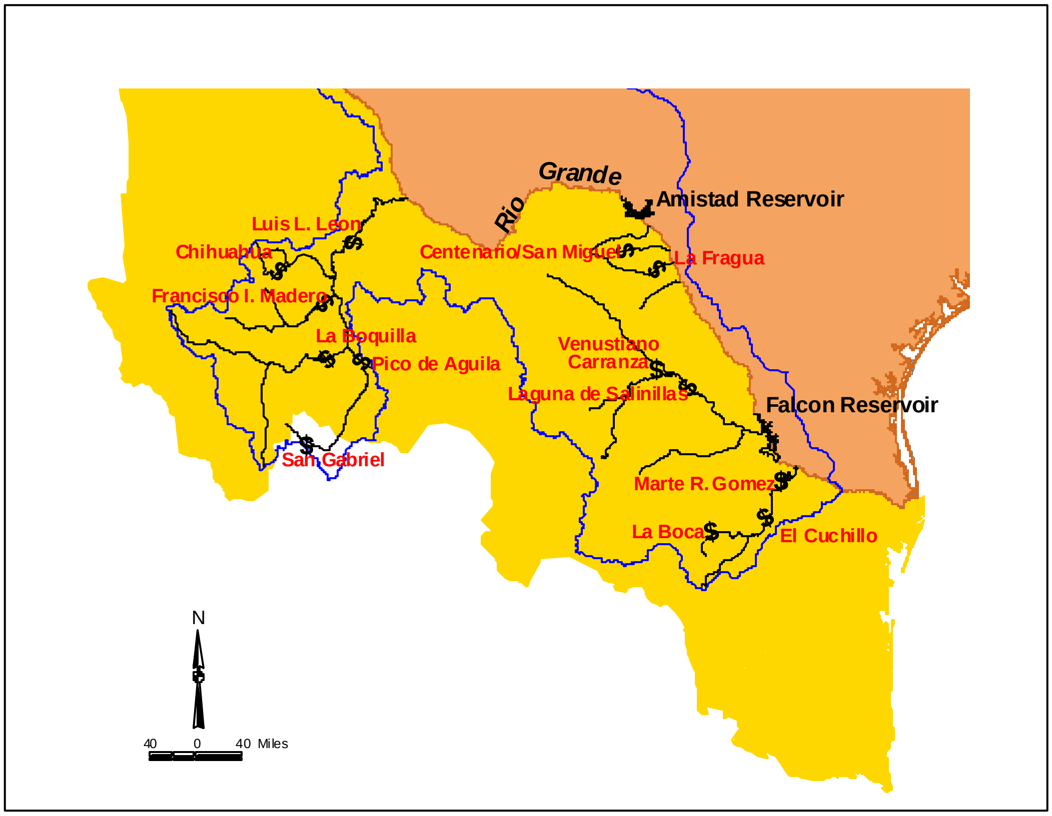
Figure 1.13: Major Reservoirs Located on Tributaries of the Rio Grande in Mexico



Practically all of the surface water available to and used in the Rio Grande Region is from the Rio Grande. Nearly all of the dependable surface water supply that is available to the Rio Grande Region is from the yield of the Amistad and Falcon International Reservoirs. These reservoirs are operated as a system by the International Boundary and Water Commission (IBWC) for flood control and water supply purposes. These impoundments provide controlled storage for over eight million acre-feet of water owned by the United States and Mexico, of which 2.25 million acre-feet are allocated for flood control purposes and 6.05 million acre-feet are reserved for sedimentation and conservation storage (water supply).

Some very limited supplies are available from tributaries of the Rio Grande in Maverick, Webb, Zapata, and Starr counties; from the Arroyo Colorado which flows through southern Hidalgo County and northern Cameron County to the Laguna Madre; from the pilot channels within the floodways that convey local runoff and floodwaters from the Rio Grande throughout the Lower Rio Grande Valley to the Laguna Madre; and from isolated lakes and resacas in Hidalgo and Cameron counties. Under drought of record conditions, surface water supplies from sources other than the Rio Grande are of little significance.

According to available publications and literature, existing springs within the Rio Grande Basin of the Region M planning area (primarily Maverick, Webb, Zapata, Jim Hogg, and Starr Counties) are not numerous and small in terms of their discharge quantities. There are no major springs that are extensively relied upon for water supply purposes. Many of the small springs do provide water for livestock and wildlife when they are flowing.

1.3.2 Nueces River Basin

The Nueces River Basin is bounded by the Rio Grande and Nueces-Rio Grande Basins on its southern boundary and by the Colorado, San Antonio, and San Antonio-Nueces Basins on its northern boundary. The basin extends from Edwards County in Texas to its discharge point in Nueces Bay, which flows into Corpus Christi Bay and ultimately to the Gulf of Mexico. As shown in Figure 1.11 (above), only a small portion of the Nueces Basin in Webb and Maverick counties is located within the Rio Grande Region. No part of the Nueces River passes through the Rio Grande Region and the Nueces Basin is of little consequence in terms of the surface water supply available to the region.

1.3.3 Nueces-Rio Grande Coastal Basin

The Nueces-Rio Grande Coastal Basin is bounded on the north by the Nueces River Basin, on the west and south by the Rio Grande Basin. The drainage area of the Nueces-Rio Grande Coastal Basin is 10,442 square miles. The area drains to the Laguna Madre Estuary. Within the Rio Grande Region the basin encompasses the southeastern portion of Webb County, nearly two-thirds of Jim Hogg County, the majority of Hidalgo and Cameron counties, and all of Willacy County (Figure 1.11, above). There are two major drainage courses in the basin: the main floodway and the Arroyo Colorado. The Arroyo Colorado is of special importance because it flows directly into the hyper-saline lower Laguna Madre. Freshwater inflows from the Arroyo Colorado are critical to the ecological health of the Laguna Madre estuary and the commercial and sport fishing industries that are dependent upon it. In addition to natural drainage, most of the surface water diverted from the lower Rio Grande, as well as water discharges and irrigation tailwater, flows to the Arroyo Colorado. However, there are no natural perennial streams within the drainage area and the basin is of little consequence in terms of water supply.

According to available publications and literature, existing springs within the Nueces-Rio Grande Coastal Basin of the Region M planning area (Cameron, Hidalgo and Willacy Counties) are not numerous and small in terms of their discharge quantities. There are no major springs that are extensively relied upon for water supply purposes. Many of the small springs do provide water for livestock and wildlife when they are flowing.

1.3.4 Surface Water Quality

Surface water quality is addressed in this section for portions of two basins - the Rio Grande, which flows directly into the Gulf of Mexico; and the Arroyo Colorado, which discharges into the Laguna Madre and then into the Gulf of Mexico. Surface and sub-surface discharges that arise from both natural processes and the activities of man affect the quality of these water resources. In general, the presence of minerals, which contribute to the total dissolved solids concentration in surface water, arise from natural sources, but can be concentrated as flows travel downstream. Return flows from both irrigation and municipal uses can concentrate dissolved solids, but can also add other elements such as nutrients, sediments, chemicals, and pathogenic organisms.

Water in the Rio Grande normally is of suitable quality for irrigation, treated municipal supplies, livestock, and industrial uses; however, salinity, nutrients, and fecal coliform bacteria are of concerns throughout the basin. Salinity concentrations in the Rio Grande are the result of both human activities and natural conditions: the naturally salty waters of the Pecos River are a major source of the salts that flow into Amistad Reservoir and continue downstream. Untreated or poorly treated discharges from inadequate wastewater treatment facilities primarily in Mexico, is the principal source for fecal coliform bacteria contamination. A secondary source is from nonpoint source pollution on both sides of the river, including poorly constructed or malfunctioning septic and sewage collection systems and improperly managed animal wastes. Although frequently identified as a concern, nutrient levels do not represent a threat to human health, nor have they supported excessive aquatic plant growth or caused widespread depressed dissolved oxygen levels. In the Rio Grande, below Amistad Reservoir, contact recreation use is not supported due to the elevated levels of fecal coliform bacteria that have been observed.

The Arroyo Colorado traverses Willacy, Cameron, and Hidalgo counties and is the major drainageway for approximately two dozen cities in this area, with the notable exception of Brownsville. Almost 500,000 acres in these three counties are irrigated for cotton, citrus, vegetables, grain sorghum, corn, and sugar cane production, and much of the runoff and return flows from these areas are discharged into the Arroyo Colorado. The Arroyo Colorado and the Brownsville Ship Channel both discharge into the Laguna Madre near the northern border of Willacy County. The Arroyo Colorado includes the TNRCC Classified Stream Segment 2201 and 2202. Use of the water in the Arroyo Colorado for municipal, industrial, and/or irrigation purposes is severely limited because of the poor water quality conditions that exist there. A more detailed discussion of surface water quality is presented in Section 3.9.

1.4 GROUNDWATER RESOURCES

Throughout the Rio Grande Region groundwater provides water supply that ranges from sustainable municipal supplies to quantities of water suited for irrigation, livestock, and industrial supply. The major aquifers within the region include the Gulf Coast aquifer, which underlies the entire coastal region of Texas and the Carrizo aquifer that exists in a broad band that sweeps across the state beginning at the Rio Grande north of Laredo and continuing northeast to Louisiana. Figure 1.14 illustrates the location of these aquifers. The minor aquifers that exist within the region have not been identified in prior water plans developed by the TWDB as "minor aquifers," but they may produce significant quantities of water that supply relatively small areas. These minor aquifers in the region include the Rio Grande Alluvium, which is also called the Rio Grande aquifer, and the Laredo Formation. A more detailed discussion of each of these groundwater sources is presented in Chapter 3.

1.4.1 Groundwater Quality

In general, groundwater from the various aquifers in the region has total dissolved solids concentrations exceeding 1,000 mg/L (slightly saline) and often exceeds 3,000 mg/L (moderately saline). The salinity hazard for groundwater ranges from high to very high[1]. Localized areas of high boron content occur

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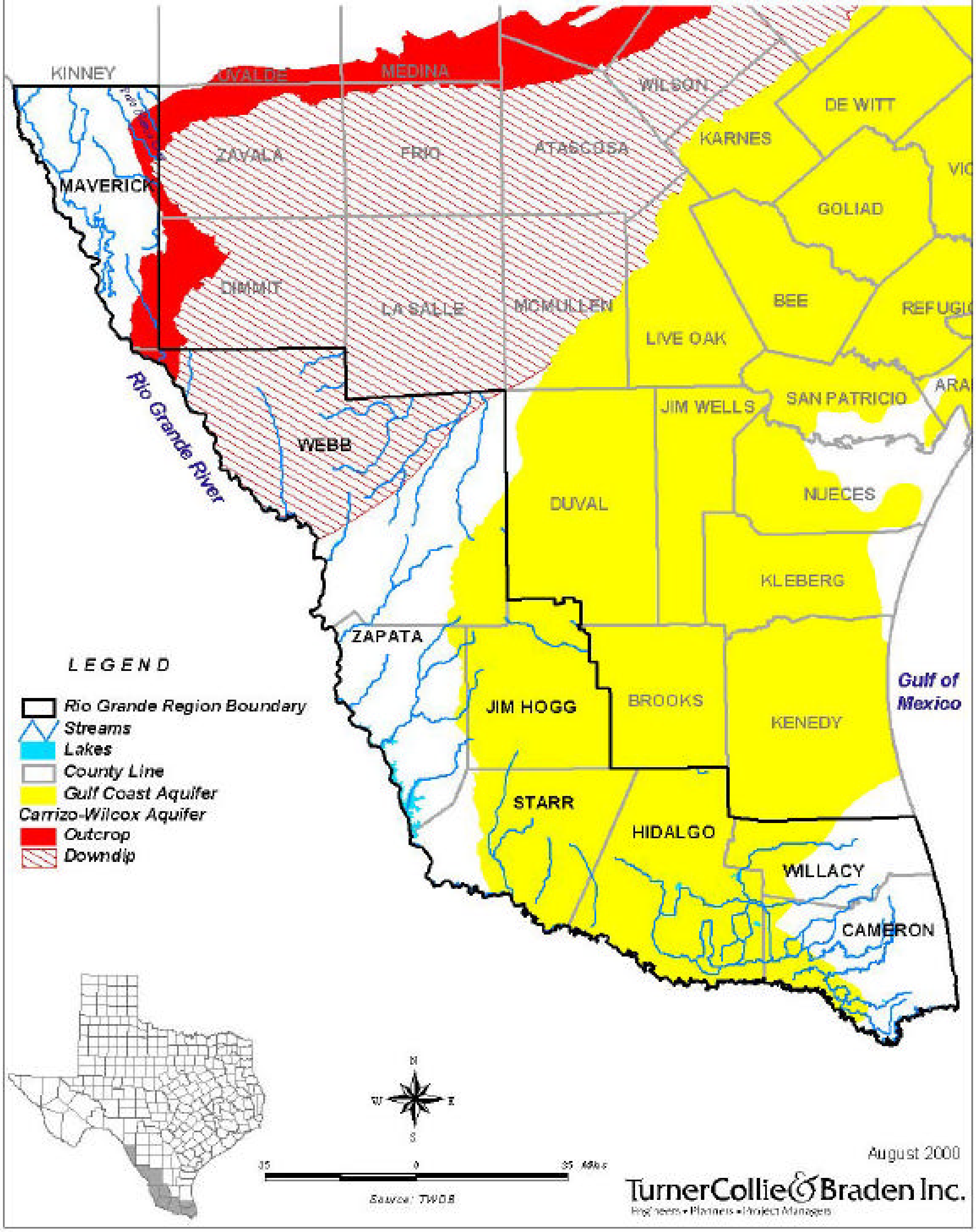
[1] Salinity hazard is a measure of the potential for salts to be concentrated in the soil from high salinity groundwater. Accumulation or buildup of salts in the soil can affect the ability of plants to take in water and nutrients from the soil. Salinity hazard is usually expressed in terms of specific conductance in micromhos per centimeter at 25° C.

Figure 1.14 : Rio Grande Regional Water Planning Area (Region M) Major Aquifers



Source: TWDB

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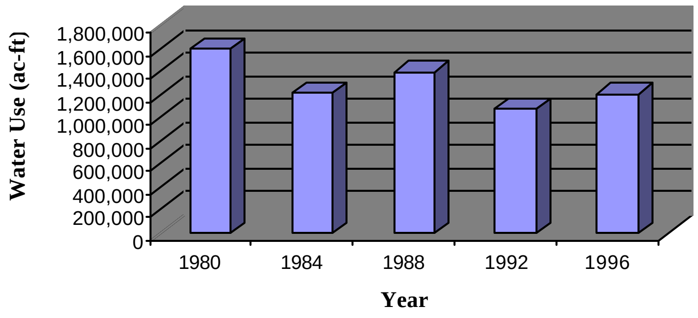
throughout the study area. Chapter 3 presents a detailed description of groundwater quality in the Gulf Coast aquifer, Carrizo Wilcox aquifer, Laredo Formation, Rio Grande Alluvium and in other aquifers in the Rio Grande Region.

1.5 WATER DEMAND IN THE RIO GRANDE REGION

While population in the Rio Grande Region has increased rapidly since 1980, total reported water use over this period has actually decreased. As shown in Figure 1.15, reported water use in 1996 is approximately 25 percent less than was reported in 1980.

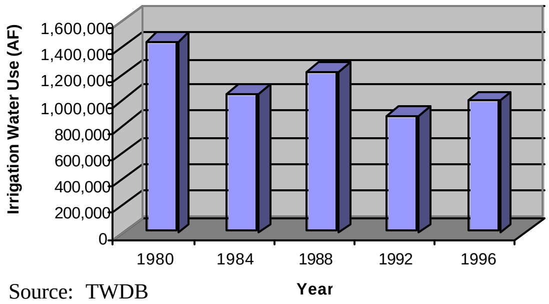
Although water use in any given year can be quite variable, there has been a steady trend towards decreasing irrigation water use since 1980 and a more pronounced increase in municipal water use over this same period (see Figures 1.16 and 1.17). The decrease in irrigation water use is at least partly attributable to improved irrigation efficiency and reductions in irrigated land as a result of urbanization. The pronounced increase in municipal water demand (up 45 percent since 1980) is directly related to the large population increases over this period.

Figure 1.15: Total Rio Grande Region Water Use - 1980 to 1996



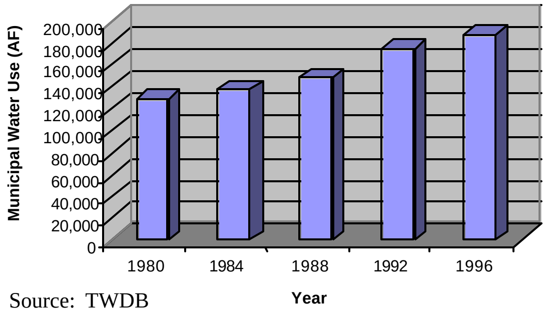
Source: Texas Water Development Board

Figure 1.16 - Irrigation Water Use for the Rio Grande Region - 1980 to 1996



Source: TWDB

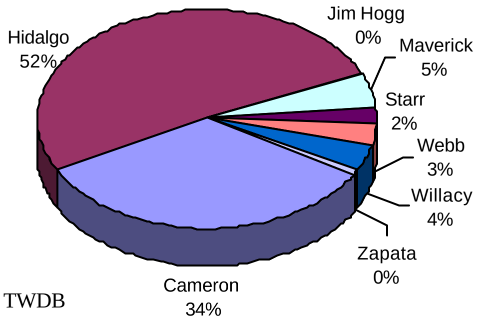
Figure 1.17 - Municipal Water Use for the Rio Grande Region 1980 to 1996



Source: TWDB

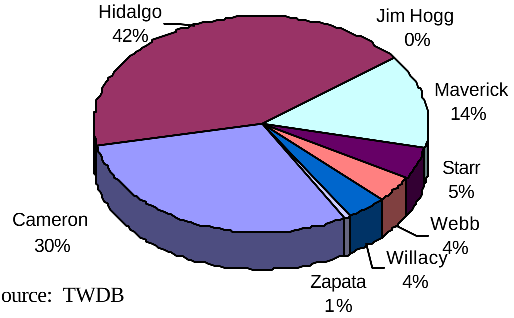
The majority of the water used in the region is in the Lower Rio Grande Valley, where approximately three quarters of a million people live and where irrigated farming is practiced extensively. In 1980, water use in Hidalgo and Cameron counties alone accounted for 86 percent of the total water use in the Rio Grande Region. However, by 1996 water use in Cameron and Hidalgo counties accounted for only 72 percent of the regional total. This shift in the relative share of total regional water demand is primarily the result of decreasing irrigation demand in Cameron and Hidalgo counties. This reduction was also influenced by the shortage of Rio Grande water supply that this region experienced in 1996. Figures 1.18 and 1.19 present total water use by county for the years 1980 and 1996.

Figure 1.18 - 1980 Region Water Use - 1,600,616



Source: TWDB

Figure 1.19 - 1996 Region Water Use - 1,205,708



Source: TWDB

Municipal water user and irrigation together account for more than 98 percent of the total water demand in the Rio Grande Region. The major municipal demand centers in the region correspond to the three Metropolitan Statistical Areas (MSA): Brownsville-Harlingen-San Benito in Cameron County, McAllen-Edinburg-Mission in Hidalgo County, and Laredo in Webb County. It is important to note that these municipal demand centers include both the cities listed and smaller adjacent communities. For example, the McAllen-Edinburg-Mission MSA includes the City of Pharr and other suburban and rural areas in proximity.

Most of the 29 irrigation districts operating within the Rio Grande Region represent the major irrigation demand centers. Some of the irrigation districts no longer supply water for irrigation, rather supply water only to municipalities. These irrigation districts hold the majority of irrigation water rights and account for nearly all of the irrigation demand in the region, with the remainder being demand by independent water rights holders diverting directly from the Rio Grande. These irrigation districts supply irrigation water users primarily in Cameron, Willacy, Hidalgo, Starr, and Maverick counties. The three municipal demand centers described above and the 29 irrigation districts operating in the Rio Grande Region are shown in Table 1.4 and 1.5 respectively.

Table 1.4: Major Water Demand Centers in the Rio Grande Region

Major Municipal Water Demand Centers	
County	***Demand Center***
Cameron	Brownsville-Harlingen-San Benito
Hidalgo	McAllen-Edinburg-Mission
Webb	Laredo

Table 1.5: Major Water Demand Centers in the Rio Grande Region

Irrigation Major Water Demand Centers						
Irrigation District	***Irrigable Acres***	***Authorized Water Right (ac-ft)***		***Irrigation District***	***Irrigable Acres***	***Authorized Water Right (ac-ft)***
Adams Gardens	7,400	18,737		HCWID#3 (McAllen)	3,200	9,752
Bayview	6,000	17,978		HCWID#5 (Progresso)	5,700	14,234
Brownsville	17,000	34,876		HCID#6 (Mission)	16,531	42,545
CCID#2 (San Benito)	75,000	151,941		HCCID#9 (Mercedes)	65,000	177,151
CCID#6(Los Fresnos)	15,000	52,142		HCID#13	1,200	4,856
CCWID#10	3,453	10,213		HCID#16 (Mission)	4,948	30,749
CCWID#16	1,753	3,913		HCWCID#18	2,100	5,505
CCWID#17	1,399	625		HCWCID#19	5,000	11,777
Delta Lake	70,000	174,776		La Feria ID CC#3	27,500	75,626
Donna	32,000	94,063		Santa Cruz ID #15	32,800	82,008
Engleman	7,761	20,031		Santa Maria ID CC#4	3,700	10,182
Harlingen	39,000	98,233		United ID	26,836	69,461
HCID#1 (Edinburg)	30,000	85,615		Valley Acres	7,948	22,500
HCID#2 (San Juan)	46,709	147,675		Maverick Co. ID	-	-
HCMUD	0	1,120				

1.5.1 Major Water Providers

Texas Water Development Board guidelines provide that that each regional water planning group may identify and designate "major water providers." These guidelines define major water provider as an entity *"…which delivers and sells a significant amount of raw or treated water for municipal and/or manufacturing use on a wholesale and/or retail basis."* The intent of TWDB requirements is to ensure that there is an adequate future supply of water for each entity that receives all or a significant portion of its current water supply from another entity.

For this initial regional water plan, the Rio Grande RWPG elected to not designate any water suppliers in the region as "major water providers." This decision was made primarily based on the unique nature of water rights and water marketing in the Rio Grande Region. Although there are numerous entities, including irrigation districts and municipalities, that currently supply or deliver water to other entities, these relationships are not fixed and can change with the changing water needs of a water user group. Designation of major water providers will be re-considered in future updates of the regional water plan.

1.6 EXISTING WATER PLANNING IN THE RIO GRANDE REGION

1.6.1 Local Water Planning

In addition to its impacts on state and regional water planning, Senate Bill 1 has also had a significant impact on local water planning in the Rio Grande Region and throughout the state. Under SB 1 and associated rules of the Texas Natural Resource Conservation Commission (TNRCC):

- Municipal, industrial and non-irrigation water right holders of 1,000 or more acre-feet and irrigation rights holders of 10,000 or more acre-feet are required to prepare and implement water conservation plans;
- All such water rights holders and all public water systems with more than 3,300 connections were required to prepare and submit a drought contingency plan by September 1, 1999; and,
- All public water systems with less than 3,300 connections were required to prepare a drought contingency plan by September 1, 2000.

Because of these requirements and recent drought conditions, many communities in the Rio Grande Region have addressed drought preparedness. A review of TNRCC records shows that many communities and irrigation districts in the region have water conservation and drought contingency plans. Specifically, as of February 2000:

- Twenty-nine of the 39 municipal, industrial and non-irrigation water right holders of 1,000 or more acre-feet and irrigation rights holders of 10,000 or more acre-feet have prepared and filed water conservation plans with the TNRCC; and,
- 24 of the 26 public water systems in the region with more than 3,300 connections have prepared and filed drought contingency plans with the TNRCC.

Table 1.6 lists the entities that have prepared and filed water conservation and drought contingency plans. It should be noted that smaller public water systems (i.e., those with fewer than 3,300 connections) are not required to prepare drought plans until September 2000. Furthermore, these small systems do not have to file their drought plans with the TNRCC.

In addition to drought preparedness at a local level, the on-going drought in the Rio Grande watershed has shown that the water rights system for the middle and lower Rio Grande functions effectively as a regional drought contingency plan. Under this system, domestic, municipal, and industrial (DMI) water rights have a very high degree of reliability and are provided with further assurance through a DMI reserve of 225,000 acre-feet that is maintained in the reservoir system. By comparison, irrigation and mining water rights are treated as residual users of stored water from the reservoirs and therefore bear the brunt of water supply shortages. In essence, irrigation and mining water demand must adjust to the available water supply. Furthermore, many irrigation districts allow transfers of water between individual irrigators. Such transfers have the effect of reallocating limited irrigation supplies from lower to higher value uses, thereby minimizing the economic impact of water shortages.

Table 1.6: Existing Local Water Plans filed with the TNRCC

Water Supplier		Water Conservation Plan	Drought Contingency Plan
1.	Brownsville PUB	X	X
2.	Laguna Madre Water District	X	X
3.	City of Edinburg	X	X
4.	City of Mercedes	X	X
5.	City of Mission	X	X
6.	City of Pharr	X	X
7.	Sharyland WSC	X	X
8.	City of Eagle Pass	X	X
9.	City of Laredo	X	X
10.	City of McAllen	X	X
11.	Los Fresnos	X	X
12.	La Joya WSC	X	
13.	Military Highway WSC	X	
14.	Olmito WSC	X	
15.	North Alamo WSC	X	X
16.	City of San Benito	X	
17.	City of San Juan	X	
18.	City of Alamo	X	X
19.	City of Weslaco	X	
20.	City of Donna	X	
21.	Maverick County WCID # 1	X	
22.	Rio Grande City	X	
23.	City of Roma	X	
24.	East Rio Hondo WSC	X	
25.	San Ygnacio MUD	X	
26.	Zapata County Waterworks	X	
27.	Adams Garden ID # 19		X
28.	Harlingen ID CC # 1		X
29.	Bayview ID # 11		X
30.	Delta Lake ID		X
31.	Donna ID	X	X
32.	Hidalgo/Cameron Co. WCID # 9	X	X
33.	HCID # 2	X	X
34.	HCID # 1	X	X
35.	HCID # 16	X	X
36.	HCID # 5	X	X
37.	HCID # 6	X	X
38.	HCWID # 3	X	X
39.	La Feria ID CC # 3	X	X
40.	Santa Cruz ID # 15	X	X
41.	Cameron County ID # 2	X	X
42.	TxDOT	X	X
43.	United ID	X	X
44.	Valley Acres ID	X	X
45.	CP&L	X (Laredo, JL Bates, La Palma)	(TNRCC submittal not required)
46.	Brownsville IDD	X	X

1.6.2 Existing Regional Water Plans

Immediately prior to the initiation of the SB 1 regional water planning program, two regional water supply planning projects were conducted within the Rio Grande Region. In February 1998, Phase I of the South Texas Regional Water Supply Plan (STRWSP) was completed under the sponsorship of the South Texas Development Council, with funding assistance from the TWDB. This plan addressed water supply needs in Jim Hogg, Starr, Webb, and Zapata counties. The report for this initial planning phase provided background data and identified key issues that need to be addressed in future water planning. Specific recommendations regarding water supply strategies were not developed.

In February 1999, the Integrated Water Resources Plan (IWRP) for the Lower Rio Grande Valley was completed. This planning effort was sponsored by the Lower Rio Grande Valley Development Council with funding from the TWDB, the U.S. Economic Development Administration, the U.S. Bureau of Reclamation, and local sources. This plan addressed water planning issues in Cameron, Hidalgo, and Willacy counties. In addition to comparing projected water supplies and demand, the IWRP makes specific recommendations regarding water supply for the three counties it addressed. One of the key conclusions of the plan is that:

> "The dramatic population growth will result in an increase in municipal water demands to supply domestic, manufacturing, and steam electric needs. However, these increasing municipal demands, and the remaining agricultural water requirements after the impacts of urbanization are considered, can be met through:
>
> - improvements to the irrigation canal delivery system;
> - aggressive water conservation efforts in all areas of consumption; and,
> - implementation of wastewater reuse, desalination of brackish groundwater and desalination of seawater where cost effective."

Both the IWRP and the STRWSP were carefully reviewed as a part of this water planning process and serve as valuable references for this regional water plan.

1.6.3 Summary of Recommendations from the Current State Water Plan

The 1997 State Water Plan, *Water for Texas*, provides an overview of water-related problems and supply needs within the Rio Grande Region. The primary recommendation in this report by the Rio Grande Regional Water Planning Group is that the transfer of irrigation water rights to municipal use will be necessary to satisfy growing municipal demands. This recommendation represents a continuation of a trend that began when water rights for the Lower Rio Grande Valley were adjudicated in 1971. To illustrate, in 1971 there were approximately 155,000 acre-feet of Rio Grande water rights held for domestic-municipal-industrial (DMI) use. At present, there are approximately 240,000 acre-feet of water rights for DMI use in the area below Falcon Reservoir and approximately 58,000 acre-feet of water rights for DMI use in the middle Rio Grande. This increase in the amount of DMI water rights is a result of the gradual conversion of irrigation rights through voluntary, market-based transfers between willing buyers and willing sellers.

The current State Water Plan also recommends that the City of Brownsville, acting through the Brownsville Public Utilities Board (PUB), meet its long-term projected water supply needs with the development of the Brownsville weir and reservoir. The project would consist of a weir in the Rio Grande that is located approximately eight miles downstream of the Gateway Bridge in Brownsville. This project would capture unregulated flows that normally discharge into the Gulf of Mexico and would provide an additional water supply for the City of Brownsville. Chapter 5 of this report presents a more detailed discussion of this project.

1.7 THREATS TO AGRICULTURAL AND NATURAL RESOURCES

1.7.1 Quantity

As described in section 1.3.3 and in detail in Chapter 3, under the existing water rights system irrigation water use is a "residual" claimant to available water supplies from the Rio Grande. During periods of low inflows to the reservoir system, when there are little or no allocations made to irrigation and mining storage accounts, these users deplete their storage accounts and may suffer shortages. Under "drought of record" conditions, hydrologic simulations of reservoir operations indicate that only 60-80 percent of the potential irrigation demand can be satisfied. In essence, the system for the administration of Rio Grande water rights functions as a regional drought management plan in that DMI uses are given a priority over irrigation and mining uses and, during drought conditions, irrigation and mining demands must be reduced to levels that match the available supply. Consequently, irrigated agriculture bears the brunt of drought in terms of supply shortages and the associated economic costs of such shortages.

An additional threat to the availability of water from the Rio Grande for irrigation use is the development and operation of reservoirs on Mexican tributaries. An evaluation of the operation of existing reservoirs during the current drought indicates that significant quantities of water are owed to the United States by Mexico under the terms of the 1944 treaty. Because of the manner in which available supplies are managed by the State of Texas, any decrease in water availability due to the operation of reservoirs in Mexico will result in further decreases in the available water supply for irrigation and mining use.

Another threat to the agricultural and natural resources of the region is the impact of ongoing and projected urbanization on currently undeveloped areas. Particularly in Cameron and Hidalgo counties, projected urbanization is expected to significantly reduce the area of irrigable farmland. Within the Lower Rio Grande Valley, urbanization is expected to be concentrated in corridors along State Highways 77 and 83, which run through agricultural areas. In addition to the direct reduction of irrigable farmland acreage due to change in land use, urbanization also impacts adjacent farmland by increasing property values and restricting some types of agricultural activities (e.g. use of pesticides).

Increased pumping of groundwater from the Gulf Coast Aquifer and the Rio Grande Alluvium may threaten riparian habitats fringing resacas and potholes. This would have a negative impact on ecotourism. The lowering of Falcon Lake level due to reduced inflow could negatively impact the diversity of bird species that currently exists.

1.7.2 Water Quality

According to *The State of Texas Water Quality Inventory*, issued by the TNRCC in 1996, the size and wide range of geologic and climatic conditions in the Rio Grande Basin are responsible for a wide range of water quality in the river system. Most of the flow of the Rio Grande is diverted for irrigation and municipal uses at the American Canal in Texas and the Acequia-Madre Canal in Mexico before it reaches

El Paso. Downstream of El Paso, most of the flow consists of treated municipal wastewater from El Paso and irrigation return flow. The Rio Grande flow is intermittent to Presidio, where inflow from Mexico's Rio Conchos enters the river. The presence of metals and pesticides has been identified sporadically throughout the Rio Grande Basin. Elevated fecal coliform levels occur in the river downstream of mayor U.S./Mexico border cities due to municipal wastewater discharges in Texas and untreated wastewater discharges in Mexico. Levels of chloride and total dissolved solids are increasing in the Rio Grande downstream of Falcon Reservoir due to repeated use of water for irrigation. Elevated nutrient levels are also common in the Rio Grande.

Major tributaries to the Rio Grande are the Devils River and Pecos River in Texas, and the Rio Conchos, Rio Salado, Rio San Juan, Rio Alamo, and Rio San Rodrigo in Mexico. The Devils River has no known water quality problems. The Pecos River drains a substantial part of New Mexico and far West Texas. The saline waters of the Pecos River entering Texas are stored in Red Bluff Reservoir. Downstream of the reservoir, the salinity in the Pecos River continues to increase.

The TNRCC's 1996 Clean Rivers Program also has summarized water quality concerns and possible water quality concerns on a river basin basis (TWDB, 1997).

The water quality of the Rio Grande Basin has been studied extensively in recent years to assess concentrations of salts, conventional pollutants, and toxics. Data indicate increasing levels of fecal coliform as an indicator of declining water quality. However, through the construction of new wastewater treatment facilities in Nuevo Laredo, as well as active programs for wastewater treatment improvements administered by the Border Environmental Cooperation Commission, these influences are not considered to be of long-term significance (STDC, 1998). Wastewater treatment plant expansions should be encouraged in the colonias to improve the quality of water that is discharged into the river.

The Texas Water Commission (now the TNRCC) in cooperation with IBWC and CAN completed intensive salt balance studies in 1988 and in 1993. These studies were incorporated into analyses by Miramoto, Fenn, and Swietlik (*Flow, Salts, and Trace Elements in the Rio Grande*, TR-169, July 1995). This report found that the salt load to the Amistad Reservoir was approximately 1.84 million tons per year. The contributing flow from Fort Quitman and the Pecos River was found to contribute 48 percent of the salt load while delivering only 21 percent of the flow. Salinity levels were observed to be increasing due to the specific influences of the Pecos River, Rio Salado, and tailwater from Fort Quitman. These three water sources were found to contribute 50 percent of the salt load and only 26 percent of the Texas/Mexico flow in the Rio Grande River.

The report observed that due to these salinity loads, concentrating effects of evaporation, and low flow contributions from non-point sources, the salinity levels of the Rio Grande were increasing. Furthermore, the salinity levels in Amistad Reservoir are projected to double from their 1969 levels by the year 2004 (increasing at a rate of 15 mg/L per year). Meanwhile, salinity concentration in Falcon Reservoir is projected to reach levels as high as 885 mg/L by the year 2000.

This report relied on data observed after the drought of record in the 1950s and before the existing drought. Implicitly, it can be assumed that the salt load has only increased with continued low flows to this reservoir system. Also, evidence of a non-equilibrium state for salinity concentrations suggests increasing costs for water treatment and counterpart lowered yields for certain types of crops.

The TNRCC has participated in a Bi-national Toxic Substances Study of the Rio Grande River and is currently authoring a technical report addressing the study's results. This study, conducted with the IBWC and CAN, used regulatory screening levels for protection of aquatic life, human health, toxic concentrations considered for federal criteria and other criteria to screen water samples collected from the Rio Grande. Results suggest that the public water supply could be threatened if detected constituents were found in sufficiently high concentrations. The data may have more relevance to aquatic life than drinking water supply.

In *The State of Texas Water Quality Inventory*, the TNRCC noted that the Arroyo Colorado, the major drainage way in the Lower Rio Grande Valley, receives much of its flow from municipal, industrial, and agricultural wastewater generated in the area. In the above-tidal segment, which is wastewater effluent dominated, fecal coliform bacteria levels are elevated, preventing attainment of the standard for contact recreation use. In the tidal segment, the aquatic life use is not supported because of depressed dissolved oxygen concentrations. Nutrient and chlorophyll concentrations exceed screening levels in both segments (TWDB, 1997).

In the above-tidal portion of Petronila Creek, ortho-phosphorus concentrations are elevated. In addition, chloride, sulfate, and total dissolved solids concentrations exceed segment criteria, as a result of leaching from deposits left by past oil field activity (TWDB, 1997).

Elevated concentrations of various metals and/or pesticides occur in sediment in the Arroyo Colorado above tidal and Petronila Creek above Tidal. Pesticide residues derived from agricultural runoff have been a long-standing problem in the Arroyo Colorado (TWDB, 1997).

The Texas Department of Health has issued a restricted-consumption advisory for the Arroyo Colorado in the above-tidal portion. The advisory recommends that fish consumption be limited to one meal per month due to elevated levels of chlordane, toxaphene, and DDT in fish tissue. The advisory covers portions of Willacy, Cameron, and Hidalgo counties. An aquatic life closure has been issued for Donna Reservoir due to elevated levels of PCBs in fish tissue (TWDB, 1997).

Additionally, the TNRCC's 1996 Clean Rivers Program has summarized water quality concerns and possible water quality concerns for the coastal basin and some of the associated bays and estuaries (TWDB, 1997).

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APPENDIX 1A

RARE, THREATENED, AND ENDANGERED SPECIES TABLES

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CHAPTER 2.0: CURRENT AND PROJECTED POPULATION WATER DEMAND FOR THE RIO GRANDE REGION

Key task in the preparation of the water plan for this region is to estimate current and future water demands within the region. In subsequent chapters of this plan, water demand projections are compared with estimates of currently available water supply to identify the location, extent, and timing of any future water shortages or surpluses. Texas Water Development Board rules (357.7(a)(2)) require that the results of the analyses of current and projected population and water demands be reported by:

> *"…city, county and that portion of a river basin within the regional water planning area for major providers of water for municipal and manufacturing purposes, and for categories of water use including municipal, manufacturing, irrigation, steam electric power generation, mining and livestock watering."*

The following table provides a summary of population and water demand projections by category of use for the Rio Grande Region.

Table 2.1: Population and Water Demand Projections Summary for the Rio Grande Regional Water Planning Area

Regional Total Projection	2000	2010	2020	2030	2040	2050
Population	1,264,582	1,600,077	1,976,791	2,425,604	2,735,506	3,046,680
Municipal Water Demand (AF/YR)	252,989	296,759	345,283	413,629	456,697	505,667
Manufacturing Water Demand (AF/YR)	5,084	5,635	6,029	6,345	6,936	7,528
Irrigation Water Demand (AF/YR)	1,526,203	1,434,145	1,325,479	1,190,919	1,190,919	1,190,919
Steam Electric Water Demand (AF/YR)	9,100	11,400	11,900	23,400	24,400	24,400
Mining Water Demand (AF/YR)	2,641	2,235	2,112	2,050	2,050	2,136
Livestock Water Demand (AF/YR)	7,274	7,274	7,274	7,274	7,274	7,274
TOTAL WATER DEMAND (AF/YR)	**1,803,291**	**1,757,448**	**1,698,077**	**1,643,617**	**1,688,276**	**1,737,923**

As indicated, the population in the Rio Grande Region is projected to more than double over the next 50 years, growing from approximately 1.26 million people at present to 3.05 million in 2050. This dramatic growth is the principal factor underlying the projected increases in municipal, manufacturing, and steam electric water demands. However, in terms of total projected water demand within this region, projected increases in urban water demands are more than offset by projected decreases in irrigation water demand. The result is a projected decrease in total water demand of approximately 20 percent over the 50-year planning period.

The following sections of this chapter describe the methodology used to develop this region's population and water demand projections. This chapter also presents projections of population and water demand for cities, major providers of municipal and manufacturing water, and for categories of water use including municipal, manufacturing, irrigation, steam electric power generation, mining, and livestock watering. Projected demands are also provided for each of the two river basins and the one coastal basin partially located within this region.

2.1 TWDB GUIDELINES FOR REVISIONS TO POPULATION AND WATER DEMAND PROJECTIONS

SB 1 and associated rules of the Texas Water Development Board (TWDB) require the use of population and water demand projections from the 1997 State Water Plan. Specifically, Section 357.5 (2)(1) of TWDB rules for regional water planning state:

> *" In developing regional water plans, regional water planning groups shall use:*
>
> *(1) state population and water demand projections contained in the state water plan or adopted by the board after consultation with the Texas Water Natural Resource Conservation Commission and the Texas Parks and Wildlife Department, in preparation for revision of the state water plan; or*
>
> *(2) in lieu of paragraph (1) of this subsection, population and water demand projection revisions that have been adopted by the board, after coordination with the Texas Natural Resource Conservation Commission and the Texas Parks and Wildlife Department, based on changed conditions and availability of new information".*

In essence, TWDB rules require that the state's projections be used as the "default" for regional water planning unless there are substantiated reasons to revise those projections. The TWDB established guidelines to be used in developing proposed revisions. Based on these guidelines, a number of revisions to the state's "default" projections were proposed by the Rio Grande Regional Water Planning Group and adopted by the TWDB in September 1999.

2.2 POPULATION PROJECTIONS

The population and water demand projections presented in this chapter were developed by revising the state "default" projections to incorporate more current information, in accordance with TWDB guidelines. This section describes the methodology applied by the planning group to develop the approved population projections for the Rio Grande Region.

Municipal water demand projections are the product of three variables: current and projected population, per capita water use rates, and assumptions regarding the effects of certain water conservation measures.

The following describes the procedures followed in the development of revised population projections for the Rio Grande Region:

- ***Identify the initial baseline projection:*** The baseline population projection for S.B. 1 regional water planning is the state's "most likely" scenario for each county, each city of 500 population and greater, and for cities of less than 500 population and rural areas (designated by TWDB as "county-other"). These projections represent "default" values, which are used except where revisions were justified per TWDB guidelines.

- ***Evaluate recent population growth trends:*** As indicated above, TWDB guidelines allow for adjustments of population projections if new or better information warrants such a revision. Using the 1990 census and a January 1998 population estimate provided by the State Data Center (SDC), the growth rate for this period was calculated and the trend extrapolated to the year 2000. This adjusted year 2000 population estimate was then used as the starting point for a revised population projection through 2050. Growth rates for each decade from the default projections were then applied to derive an adjusted projection for the planning period.

- ***Select proposed population projection:*** Proposed population projections were determined after the TWDB, the revised, and other available projections were compared. The higher of either the TWDB or the SDC adjusted projection was selected as the proposed projection except in cases where better information was available. These population projections are summarized below.

The population of the eight counties that comprise the Rio Grande Regional Water Planning Area is projected to grow at an average annual growth rate of nearly 1.8 percent over the 50-year planning period. This results in an increase in population from approximately 1.26 million at present to over 3.04 million in 2050. Table 2.2 presents these projections by county for each decade of the 50-year planning period.

Figure 2.1: Rio Grande Regional Water Planning Area Population Projections

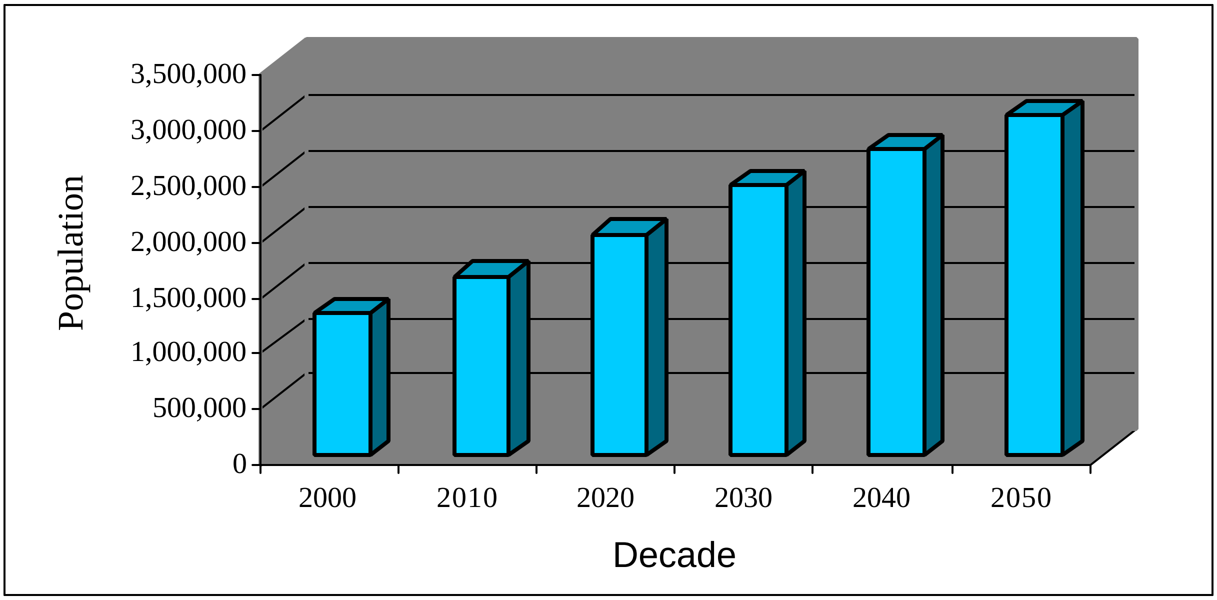


Table 2.2: RGRWPA Population Projections by County

County	1996	2000	2010	2020	2030	2040	2050
Cameron	312,064	337,689	405,463	476,992	554,513	614,396	652,931
Hidalgo	496,485	559,922	712,383	879,381	1,078,637	1,256,080	1,435,319
Jim Hogg	5,164	6,176	7,401	8,717	9,791	10,499	11,238
Maverick	44,107	48,180	57,618	65,517	71,699	80,082	90,351
Starr	49,206	58,158	80,333	109,240	146,407	169,917	188,576
Webb	177,147	219,725	293,939	384,260	501,318	527,244	571,916
Willacy	19,584	21,165	23,722	25,857	27,284	28,280	29,077
Zapata	10,662	13,567	19,218	26,827	35,955	49,008	67,272
TOTAL	**1,114,419**	**1,264,582**	**1,600,077**	**1,976,791**	**2,425,604**	**2,735,506**	**3,046,680**

* Population projections by city, county, and portion of a river basin within a county for each of the eight counties in the Rio Grande Region are provided in Appendix 2A.

As discussed in Chapter 1, the Rio Grande Regional Water Planning Area covers a portion of the Nueces and Rio Grande river basins as well as a portion of the Nueces-Rio Grande coastal basin. Figure 2.2 shows the approximate boundaries of these basins in relation to the region. Table 2.3 presents the population projections by basin for the region.

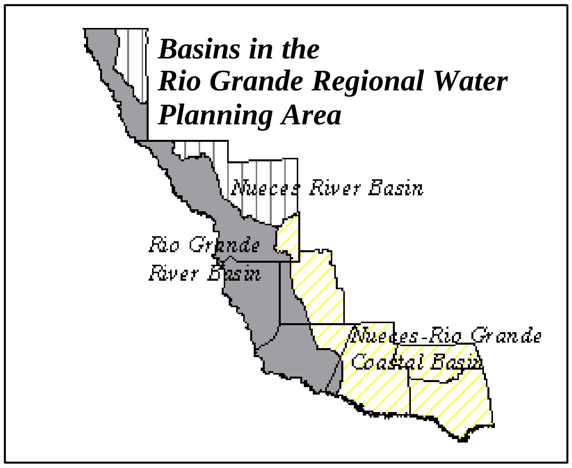


Figure 2.2: River Basins in the Rio Grande Regional Water Planning Area

Table 2.3: Population Projection by River Basin

River/Coastal Basin	1996	2000	2010	2020	2030	2040	2050
Nueces	916	1,766	2,330	2,951	3,728	3,957	5,034
Nueces-Rio Grande	826,480	918,892	1,140,907	1,381,074	1,658,535	1,894,891	2,113,549
Rio Grande	287,023	343,924	456,840	592,766	763,341	836,658	928,097
TOTAL	**1,114,419**	**1,264,582**	**1,600,077**	**1,976,791**	**2,425,604**	**2,735,506**	**3,046,680**

2.3 WATER DEMAND PROJECTIONS

Total annual water demand for the Rio Grande Regional Water Planning Area is projected to decrease by approximately 65,000 acre-feet or 3.6 percent over the 50-year planning period (see Figure 2.3). The projected decrease in total water demand is expected to occur even with a projected doubling of municipal water demand over the same period. The decrease in total regional water demand is due to a projected decline in irrigated acreage, particularly in the Lower Rio Grande Valley as land use changes from agriculture to urbanization. Consequently, over time, the proportion of total regional water demand for irrigation is projected to decrease from approximately 85 percent at present to 70 percent in year 2050. Figures 2.4 and 2.5 show the relative portion of projected water demand by type of use for the year 2000 and the year 2050.

Figure 2.3: Rio Grande Regional Water Planning Area Total Water Demand Projections

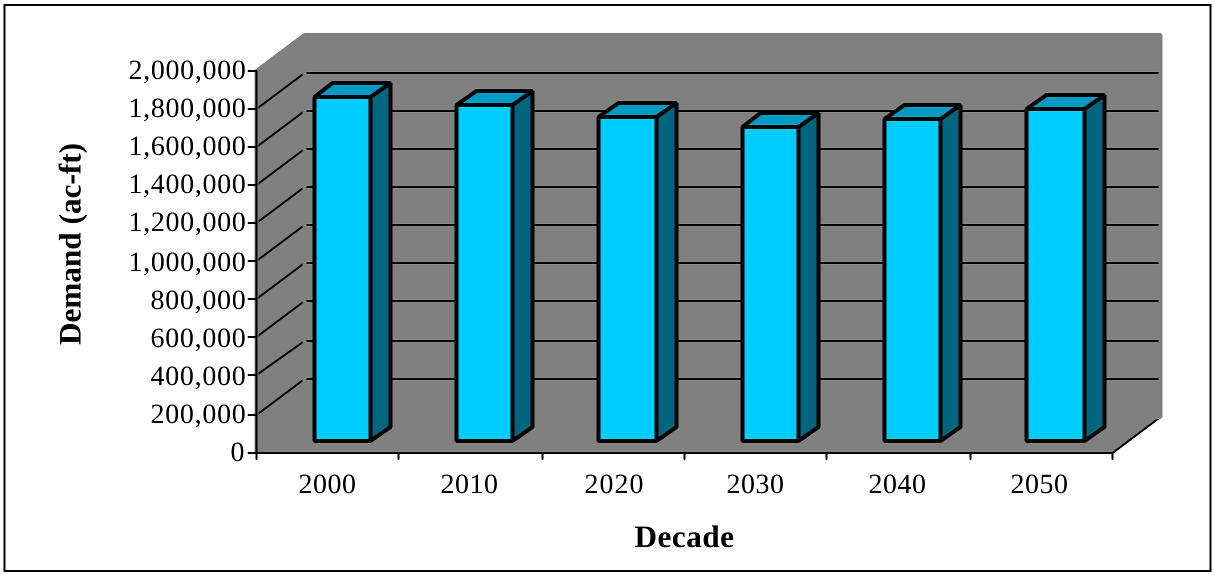


Figure 2.4: Year 2000 Total Water Demand by Type of Use

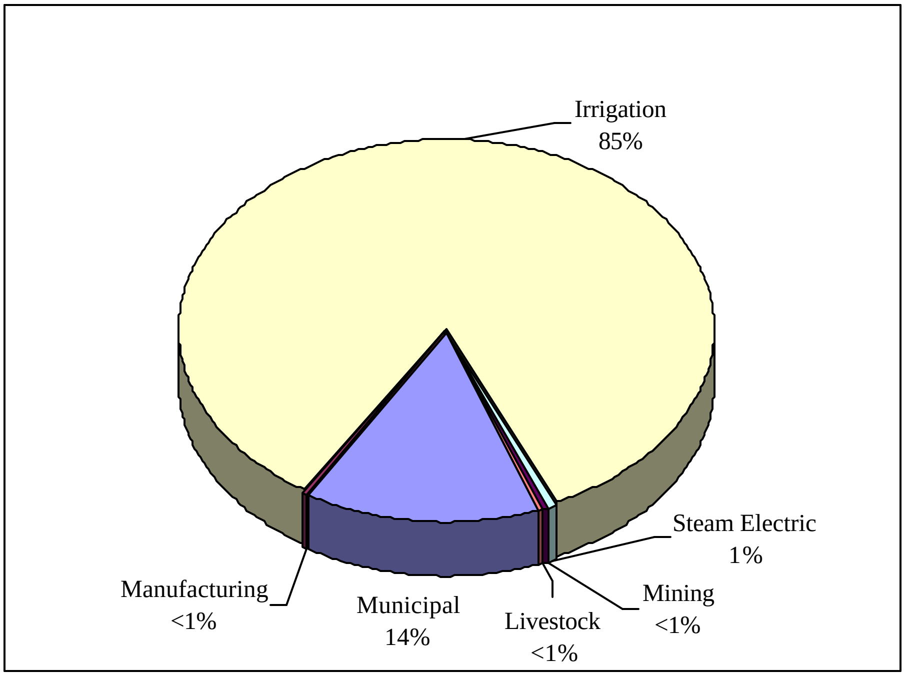
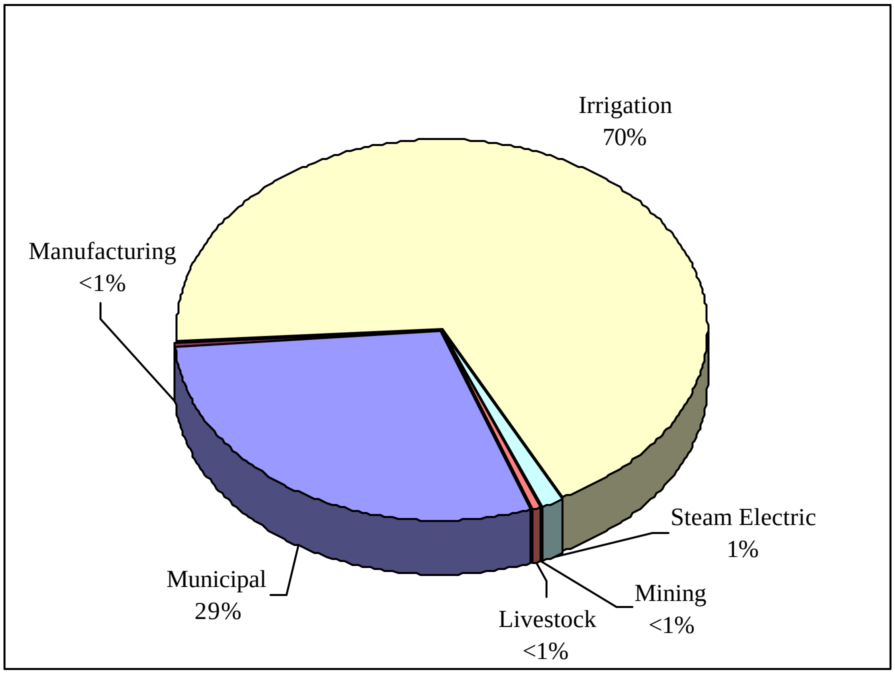


Figure 2.5: Year 2050 Total Water Demand by Type of Use



2.3.1 Municipal Water Demand Projections

As with the population projections, municipal water demand projections were developed by starting with the state default projections and making adjustments on the basis of better or more current information, as described below. The following procedure describes the methodology used for generating these projections:

- ***Identify TWDB projected per capita use rate:*** Estimated per capita water use for the year 2000 under a "below normal rainfall" and "no conservation" scenario was identified from state default projections. This value is typically the highest per capita use reported to the TWDB from the 1982-1991 period.
- ***Identify reported historical (1980 to1996) per capita water use rate:*** Using data provided by the TWDB, per capita water use from 1980 to 1996 was calculated. These values were determined to gather information about the trend of each city's per capita use and to identify a recent measure of per capita use under "below normal rainfall" conditions.
- ***Identify 1995 per capita use from Rio Grande Water master diversion data:*** In several cases, apparent errors in reporting and inconsistency in the type of information submitted by each city to the TWDB was found. In particular, in Cameron, Hidalgo, and Willacy counties much of the water diverted from the Rio Grande River for municipal purposes is transported by irrigation districts and is subject to a wide range of conveyance loss factors. For some municipal water users, annual water use data reported to TWDB did not include the amounts associated with conveyance losses that were charged against that entity's water rights or water rights held by another entity on behalf of the municipal water user. Although conveyance losses do not represent actual water use by or within a particular city, the total amount charged against each municipal water right is the most accurate measure of total water demand relative to currently available water supply. As a consequence of this error in reporting, the per capita use rates calculated by TWDB for these entities did not accurately reflect gross diversions from the Rio Grande. Through an analysis of the Rio Grande Water master records for 1995, total diversions for each municipal user were determined and, where applicable, per capita use rates were adjusted accordingly.
- ***Select per capita use rate*:** A conservative, yet realistic per capita water use rate was selected based on the information described above.
- ***Determine conveyance losses for municipal water deliveries:*** For Cameron, Hidalgo, and Willacy counties, an additional step was needed to determine the conveyance loss rates charged for the delivery of municipal water supplies from the Rio Grande. These values were determined by contacting each irrigation district that delivers water to individual municipal users in the region. An average conveyance loss rate of 25 percent was applied for the "county other" areas in each of these counties. The conveyance loss rates were then applied to the gross per capita use rates. For these counties, the result is an estimate of per capita municipal water use by each municipal user and an estimate of the per capita use associated with water delivery losses.
- ***Apply "expected case" conservation:*** Projected water savings due to "expected case" water conservation savings was applied to the per capita use values determined above to derive per capita use rates for each decade of the planning period. Expected case conservation includes
- ***Water savings from three components:*** increases in plumbing efficiency due to new plumbing code standards, seasonal conservation due to water conservation programs, and water savings due to other measures (e.g., leak detection and repair, water efficient appliances, and public education).

- ***Calculate municipal water demand projections:*** The proposed municipal water demand projections are calculated as the product of the approved population projections and the per capita use rates for each municipal water user group described above.

Annual municipal water demand within the region is projected to almost double from the year 2000 to the year 2050 (see Figure 2.6). While this represents a major increase in municipal water use over the planning period, this rate of increase is significantly slower than the rate of increase in region's population. This is due to anticipated improvements in municipal water use efficiency through water savings associated with the adoption of various water conservation measures. Table 2.4 presents projected municipal water demands by county for each of the eight counties in the region. As indicated, municipal water demand in the region is concentrated in Cameron, Hidalgo, and Webb counties, which together account for nearly 72 percent of municipal water demand in the region.

Figure 2.6: Rio Grande Regional Water Planning Area Municipal Water Demand Projections

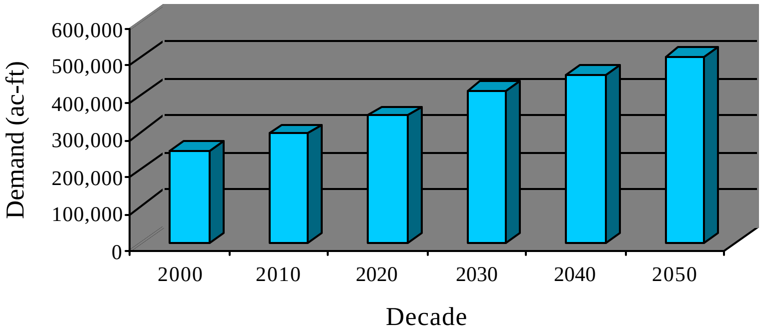


Table 2.4: Municipal Water Demand Projections by County (in acre-feet/year)

County	1996	2000	2010	2020	2030	2040	2050
Cameron	51,408	68,097	76,892	85,636	97,885	105,618	111,651
Hidalgo	77,371	109,821	127,648	147,045	174,412	198,953	226,715
Jim Hogg	896	801	891	988	1,076	1,127	1,189
Maverick	7,093	7,611	8,517	9,125	9,743	10,665	11,924
Starr	7,982	9,264	11,687	15,042	19,907	22,840	25,390
Webb	35,056	47,979	60,338	75,125	96,328	100,641	108,195
Willacy	5,245	6,395	6,786	7,017	7,251	7,366	7,553
Zapata	2,146	3,021	4,000	5,305	7,027	9,487	13,050
TOTAL	187,197	252,989	296,759	345,283	413,629	456,697	505,667

* Municipal water demand projections by city, county, and portion of a river basin within a county for each of the eight counties in the Rio Grande Region are provided in Appendix 2A.

It should be noted that the approved water demand projections for the City of Eagle Pass and for portions of the County-Other water user group located within the Rio Grande Basin do not accurately portray current or projected water demands. Specifically, based on current information provided by the City of Eagle Pass, total water demand in 1999 was 5,772 acre-feet, which is approximately 29 percent higher than the approved demand projection for the City in the year 2000. For planning purposes, it is recommended that the projections for the City of Eagle Pass be adjusted to reflect actual historical demand with the same rates of growth for each decade of the planning period as are used in the approved projections. This alternative projection is as follows:

2000	2010	2020	2030	2040	2050
5,772	6,615	7,190	7,765	8,604	9,611

In addition to adjustments to the City of Eagle Pass' municipal water demand projections for its current service area, the City has initiated planning to become a regional water and wastewater service provider. Specifically, Eagle Pass is expected to become the provider of water and wastewater utility services to a large area of rural Maverick County, which is currently served by the El Indio Water Supply Corporation (WSC) and is located within the Rio Grande Basin. Once adequate utility service becomes available, this area is expected to develop rapidly, resulting in significantly higher demand projections than are shown in the approved projections for the portion of the County-Other WUG in the Rio Grande Basin. Preliminary projections developed by the City of Eagle Pass for the El Indio WSC service area are:

2000	2010	2020	2030	2040	2050
1,645	2,416	3,154	3,859	4,531	5,171

Note: This projection includes a 2.0 percent per decade reduction in demand from water conservation measures.

The City of Eagle Pass has requested that these alternative demand scenarios be included in the approved water plan for the Rio Grande Region. Formal amendment of the regional water plan will be requested once the City has completed it regional water and wastewater facility plan. This approach was presented and approved by the Rio Grande RWPG on July 28, 2000.

Table 2.5 presents projected municipal water demand in the region by river basin. As with population, the largest portion of current and projected municipal water demand occurs in the Nueces-Rio Grande coastal basin (approximately two-thirds of the regional total in the year 2050).

Table 2.5: Municipal Water Demand Projections by River Basin (in acre-feet/year)

River Basin	1996	2000	2010	2020	2030	2040	2050
Nueces	132	317	395	480	597	628	796
Nueces-Rio Grande	133,920	184,207	211,118	239,435	279,202	311,351	345,373
Rio Grande	53,145	68,465	85,246	105,368	133,830	144,718	159,498
TOTAL	**187,197**	**252,989**	**296,759**	**345,283**	**413,629**	**456,697**	**505,667**

2.3.2 Manufacturing Water Demand Projections

For SB 1 regional water planning purposes, manufacturing water use is considered to be the cumulative water demand by county and river basin for all industries within specified industrial classifications (SIC) determined by the TWDB. Manufacturing water use projections that were developed by the TWDB and used in the 1997 State Water Plan are used as the default projections except where better information warranted a revision.

Manufacturing water demand for the region is projected to increase from approximately 5,000 acre-feet per year in the year 2000 to 7,500 acre-feet per year in the year 2050 (see Figure 2.7). This increase in manufacturing water demand is predominately due to projected growth in Cameron and Hidalgo counties. According to TWDB data, Jim Hogg, Starr, Willacy, and Zapata counties have no current or projected manufacturing water demand. Table 2.6 presents the projected manufacturing water demand for each county in the region.

Figure 2.7: Rio Grande Regional Water Planning Area Manufacturing Water Demand Projections

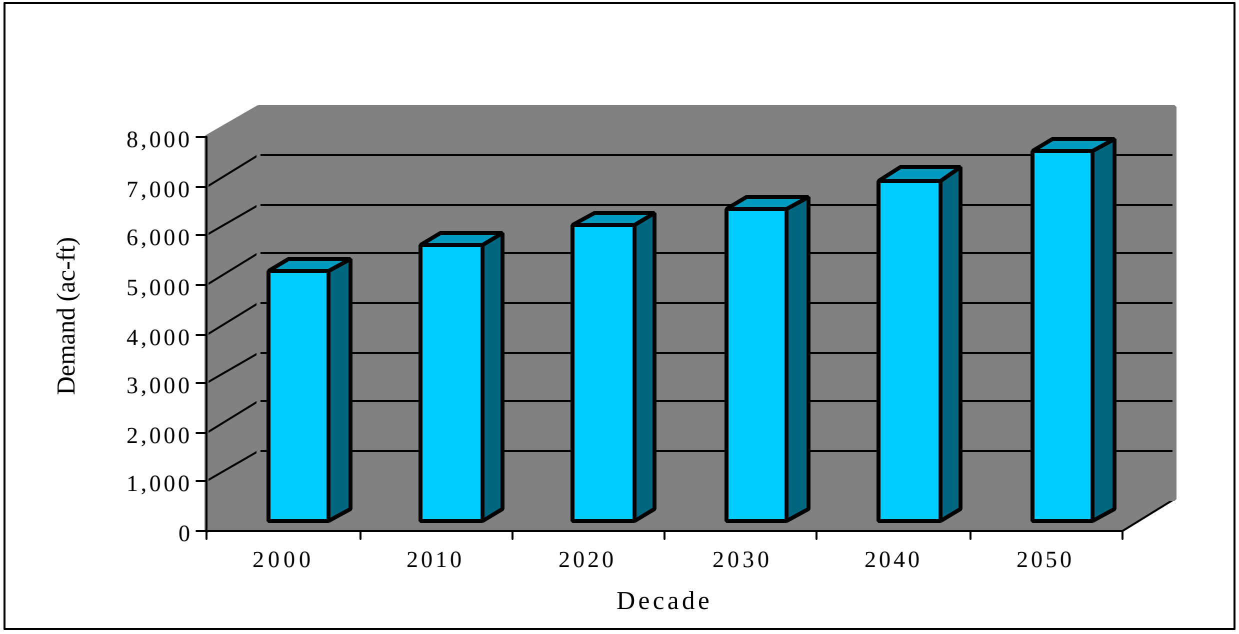


Table 2.6: Manufacturing Water Demand Projections by County (in acre-feet/year)

County	1996	2000	2010	2020	2030	2040	2050
Cameron	991	1,257	1,391	1,504	1,628	1,804	1,985
Hidalgo	2,981	3,718	4,115	4,374	4,541	4,927	5,307
Jim Hogg	0	0	0	0	0	0	0
Maverick	47	76	91	108	127	148	171
Starr	0	0	0	0	0	0	0
Webb	2	33	38	43	49	57	65
Willacy	0	0	0	0	0	0	0
Zapata	0	0	0	0	0	0	0
TOTAL	**4,021**	**5,084**	**5,635**	**6,029**	**6,345**	**6,936**	**7,528**

* Manufacturing water demand projections by county and portion of a river basin within a county are provided in Appendix 2A.

Manufacturing water demand in the region is located predominately in the Nueces-Rio Grande Coastal Basin. Table 2.7 presents projected manufacturing water demand by river basin for the region.

Table 2.7: Manufacturing Water Demand Projections by River Basin (in acre-feet/year)

River Basin	1996	2000	2010	2020	2030	2040	2050
Nueces	0	0	0	0	0	0	0
Nueces-Rio Grande	3,972	4,975	5,506	5,878	6,169	6,731	7,292
Rio Grande	49	109	129	151	176	205	236
TOTAL	**4,021**	**5,084**	**5,635**	**6,029**	**6,345**	**6,936**	**7,528**

2.3.3 Irrigation Water Demand Projections

The irrigation water use projections that were developed by the TWDB and used in the 1997 State Water Plan were used as the default projections except where better, more current information was submitted. The TWDB projections were determined with assistance from Texas Agricultural Extension Service and assumes expected case water conservation practices and no reduction in Federal farm program subsidies.

Annual irrigation water demand for the region is projected to decrease from approximately 1.53 million acre-feet per year in 2000 to 1.19 million acre-feet per year in the year 2030 and then remain constant for the last two decades of the planning period (see Figure 2.8). Irrigation water demand in the region is most heavily concentrated in Cameron and Hidalgo counties. The decrease in projected irrigation demand is largely due to anticipated decreases in irrigated acreage in Cameron and Hidalgo counties due to urbanization. An analysis and projection of urban growth patterns performed by the Texas Agricultural Experiment Station projects "effective" irrigated acreage in Cameron and Hidalgo counties to decrease by 23 percent and 41 percent, respectively, over the 50 year planning period.

Figure 2.8: Rio Grande Region Irrigation Water Demand Projections

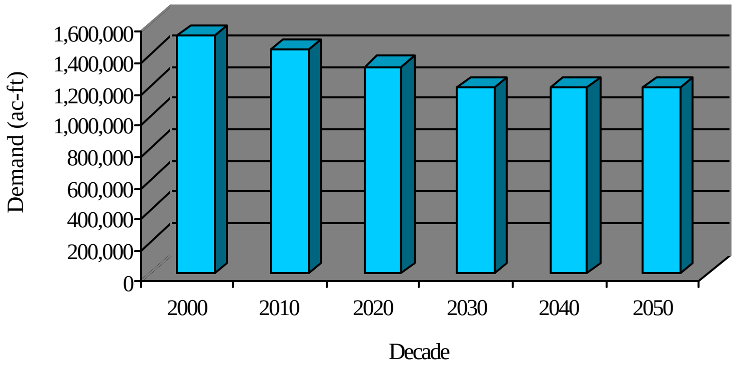


Table 2.8: Irrigation Water Demand Projections by County (in acre-feet/year)

County	1996	2000	2010	2020	2030	2040	2050
Cameron	311,381	438,485	418,931	395,950	369,464	369,464	369,464
Hidalgo	427,849	849,696	782,044	702,124	601,000	601,000	601,000
Jim Hogg	313	145	141	136	132	132	132
Maverick	159,156	123,421	121,664	117,099	111,873	111,873	111,873
Starr	45,674	45,376	42,046	40,193	38,419	38,419	38,419
Webb	9,717	5,639	5,318	5,014	4,729	4,729	4,729
Willacy	39,344	61,203	61,878	62,951	63,396	63,396	63,396
Zapata	4,545	2,238	2,123	2,012	1,906	1,906	1,906
TOTAL	**997,979**	**1,526,203**	**1,434,145**	**1,325,479**	**1,190,919**	**1,190,919**	**1,190,919**

* Irrigation water demand projections by county and portion of a river basin within a county are provided in Appendix 2A.

It is important to note that irrigation demands are highly variable from year to year. For example, over the period from 1994 to 1998, reported diversions from the Rio Grande for irrigation range from a low of 685,000 acre-feet (1996) to a high of 1.15 million acre-feet (1994). Overall economic conditions in the agricultural sector, weather conditions, and water availability are factors that directly influence irrigation demand. Economic conditions, such as market prices of agricultural commodities, influence the amount of irrigated acreage planted each year and the types of crops planted. Above or below normal precipitation in the irrigated areas of the region can either suppress or increase irrigation demand. Also, because Rio Grande irrigation rights are based on availability, irrigation shortages can have the effect of suppressing water demand. The projections adopted for this plan represent relatively high acreage levels, dry-year conditions and no shortages of irrigation supply.

By far, the largest share of total irrigation demand in the Rio Grande region is concentrated in the portions of the Nueces-Rio Grande Coastal Basin within Cameron and Hidalgo counties. Water diverted from the Rio Grande and delivered to these areas is therefore an interbasin transfer. The Rio Grande Basin also contains a significant portion of irrigation water demand. Table 2.9 presents these projected irrigation water demands for the region.

Table 2.9: Irrigation Water Demand Projections by River Basin (in acre-feet/year)

River Basin	1996	2000	2010	2020	2030	2040	2050
Nueces	1,279	5,064	4,868	4,679	4,498	4,498	4,498
Nueces-Rio Grande	749,644	1,299,140	1,215,922	1,118,110	995,919	995,919	995,919
Rio Grande	247,056	221,999	213,355	202,690	190,502	190,502	190,502
TOTAL	**997,979**	**1,526,203**	**1,434,145**	**1,325,479**	**1,190,919**	**1,190,919**	**1,190,919**

2.3.4 Steam Electric Water Demand Projections

Steam electric water use projections that were developed by the TWDB and used on the 1997 State Water Plan are used as the default projections except where better or more current information indicated the need for revision. Annual steam electric water demand is projected to increase from 9,100 acre-feet per year in the year 2000 to 24,400 acre-feet per year in the year 2050 (see Figure 2.9). The majority of this increase is expected to occur between the years 2020 and 2030 as a result of the addition of new steam electric power generating capacity in Cameron and Webb counties.

Figure 2.9: Rio Grande Regional Water Planning Area Steam Electric Water Demand Projections

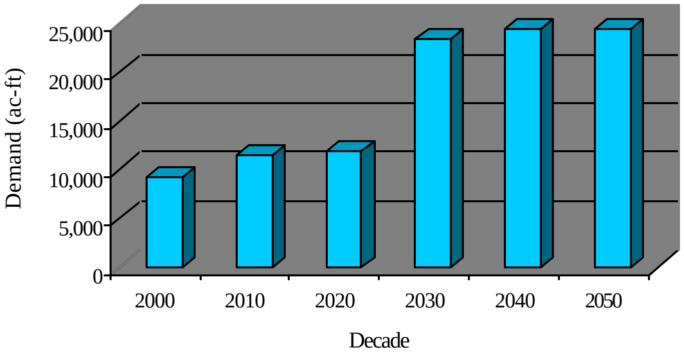


Table 2.10 presents the projected steam electric water demand by county for each of the eight counties in the region.

Table 2.10: Steam Electric Water Demand Projections by County (in acre-feet/year)

County	**1996**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	1,755	2,400	2,000	2,000	11,600	11,600	11,600
Hidalgo	2,786	4,700	5,500	6,000	6,000	7,000	7,000
Jim Hogg	0	0	0	0	0	0	0
Maverick	0	0	0	0	0	0	0
Starr	0	0	0	0	0	0	0
Webb	1,758	2,000	3,900	3,900	5,800	5,800	5,800
Willacy	0	0	0	0	0	0	0
Zapata	0	0	0	0	0	0	0
TOTAL	**6,299**	**9,100**	**11,400**	**11,900**	**23,400**	**24,400**	**24,400**

* Steam electric water demand projections by county and portion of a river basin within a county are provided in Appendix 2A.

All of the current and projected steam electric water demand for the region is located within the Nueces-Rio Grande Coastal Basin and the Rio Grande Basin. Table 2.11 shows the projected steam-electric water demand by basin.

Table 2.11: Steam Electric Water Demand Projections by River Basin (in acre-feet/year)

River Basin	**1996**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Nueces	0	0	0	0	0	0	0
Nueces-Rio Grande	4,541	7,100	7,500	8,000	17,600	18,600	18,600
Rio Grande	1,758	2,000	3,900	3,900	5,800	5,800	5,800
TOTAL	**6,299**	**9,100**	**11,400**	**11,900**	**23,400**	**24,400**	**24,400**

2.3.5 Mining Water Demand Projections

State default projections for mining water use were adopted for the region. These projections are based on forecasts of future production levels by mineral category and expected water use rates. These production projections are derived from state and national historic water use rates and are constrained by accessible mineral reserves in the region. Mining water demand represents less than one percent of total regional water demand and is expected is to remain relatively constant over the 50 year planning period (see Figure 2.10). Mining water demand is greatest in Hidalgo and Starr counties. Table 2.12 presents the projected mining water demand by county for each of the counties in the region.

Figure 2.10 - Rio Grande Regional Water Planning Area Mining Water Demand Projections

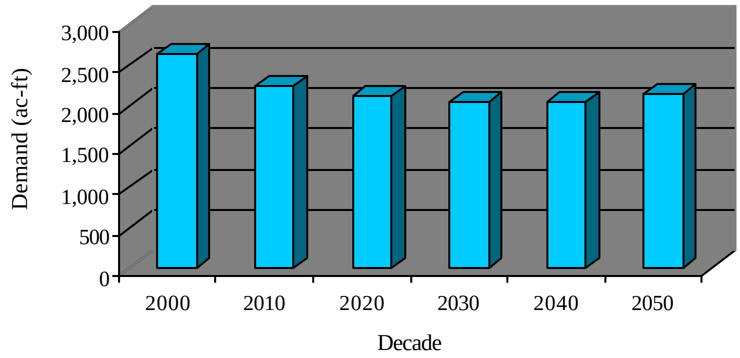


Table 2.12: Mining Water Demand Projections by County (in acre-feet/year)

County	1996	2000	2010	2020	2030	2040	2050
Cameron	8	12	8	4	1	0	0
Hidalgo	1,243	689	670	708	751	796	849
Jim Hogg	27	19	9	5	3	1	0
Maverick	140	116	59	29	15	6	4
Starr	983	1,284	1,085	1,046	1,009	999	1,027
Webb	452	489	390	312	268	248	255
Willacy	6	12	8	5	2	0	0
Zapata	27	20	6	3	1	0	0
TOTAL	**2,886**	**2,641**	**2,235**	**2,112**	**2,050**	**2,050**	**2,135**

* Mining water demand projections by county and portion of a river basin within a county are provided in Appendix 2A.

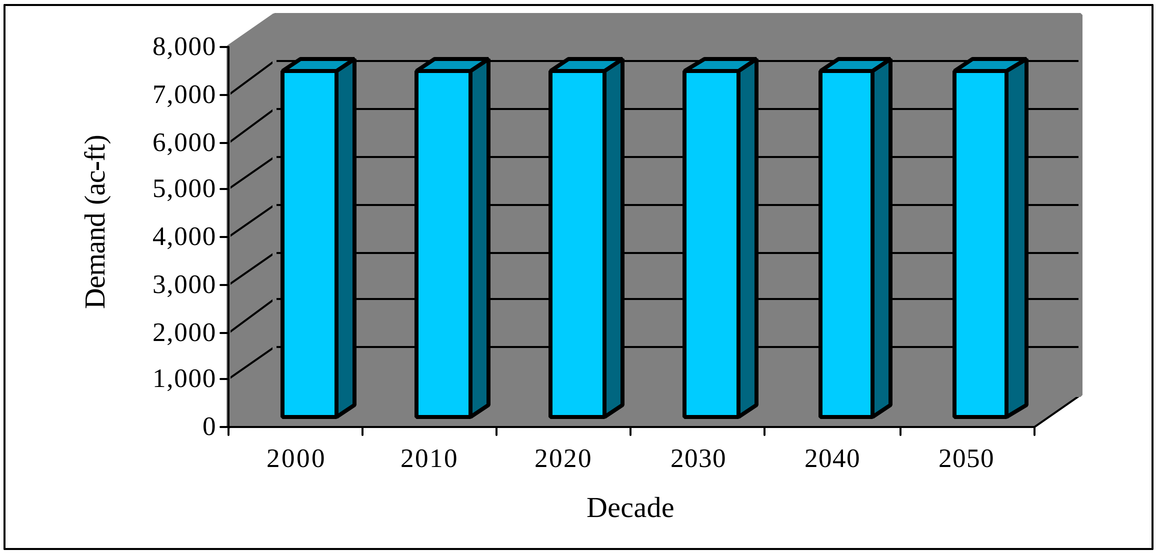
Table 2.13: Mining Water Demand Projections by River Basin (in acre-feet/year)

River Basin	**1996**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Nueces	239	302	208	126	83	60	59
Nueces-Rio Grande	2,104	1,581	1,390	1,377	1,395	1,439	1,511
Rio Grande	543	758	637	609	572	551	565
TOTAL	**2,886**	**2,641**	**2,235**	**2,112**	**2,050**	**2,050**	**2,135**

2.3.6 Livestock Water Demand Projections

The livestock water use projections developed by the TWDB and used in the 1997 State Water Plan are used for each of the eight counties in the region. These projections were developed using Texas Agricultural Statistics Service projections of the numbers and types of livestock and Texas Agricultural Extension Service estimates of water use rates for each type of livestock.

Figure 2.11: Rio Grande Regional Water Planning Area Livestock Water Demand Projections



Annual livestock water demand for the region represents only about one-half of one percent of total water demand in the Rio Grande Region. Livestock water demand is distributed relatively uniformly over the eight counties in the region and is projected to remain constant over the 50-year planning period (see Figure 2.11). Table 2.14 presents these projected demands by county for the region.

Table 2.14: Livestock Water Demand Projections by County (in acre-feet/year)

County	1996	2000	2010	2020	2030	2040	2050
Cameron	903	1,456	1,456	1,456	1,456	1,456	1,456
Hidalgo	792	763	763	763	763	763	763
Jim Hogg	761	878	878	878	878	878	878
Maverick	701	1,288	1,288	1,288	1,288	1,288	1,288
Starr	1,725	1,220	1,220	1,220	1,220	1,220	1,220
Webb	1,767	1,079	1,079	1,079	1,079	1,079	1,079
Willacy	124	144	144	144	144	144	144
Zapata	513	446	446	446	446	446	446
TOTAL	**7,286**	**7,274**	**7,274**	**7,274**	**7,274**	**7,274**	**7,274**

* Livestock water demand projections for each county and portion of a river basin within a county are provided in Appendix 2A.

Table 2.15: Livestock Water Demand Projections by River Basin (in acre-feet/year)

River Basin	1996	2000	2010	2020	2030	2040	2050
Nueces	1,068	1,004	1,004	1,004	1,004	1,004	1,004
Nueces-Rio Grande	2,788	3,239	3,239	3,239	3,239	3,239	3,239
Rio Grande	3,430	3,031	3,031	3,031	3,031	3,031	3,031
TOTAL	**7,286**	**7,274**	**7,274**	**7,274**	**7,274**	**7,274**	**7,274**

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CHAPTER 3.0: EVALUATION OF THE ADEQUACY OF CURRENT WATER SUPPLIES

3.1 INTRODUCTION

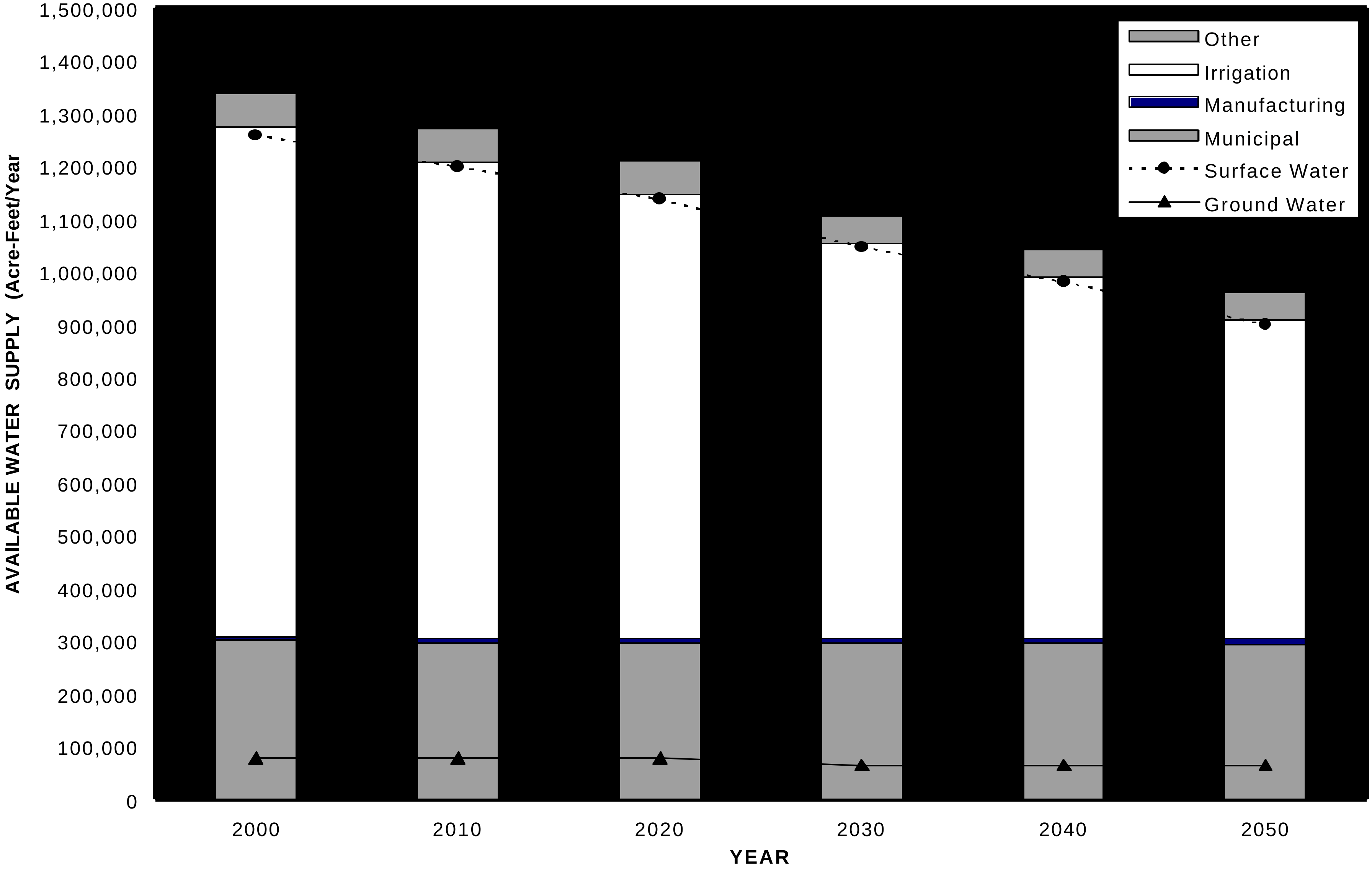
An understanding of the availability of current water supplies is critical to effectively planning for meeting the future water demands that are projected to occur in the Rio Grande Regional Water Planning Area (RGRWPA). Both surface water and groundwater are currently used within the region; however, surface water from the Rio Grande provides the vast majority of the supply for municipal, industrial, and irrigation purposes. The dependence upon surface water from the Rio Grande as the predominant source of supply for the RGRWPA is not expected to change over the next 50 years.

Guidelines from the Texas Water Development Board (TWDB) pursuant to the provisions of 31 TAC 357.7(a)(3) regarding regional water supply planning require that three data tables be developed to present and summarize the current water supplies available to the RGRWPA by each decade through the year 2050. The first, referred to in the TWDB guidelines as "Table 4", provides a summary of the total quantities of water available to the region from individual and unique sources, including amounts of water available by river basin, by river or stream course, by reservoir, and by aquifer. A completed Table 4 for the RGRWPA is contained in the TWDB Exhibit B tables section of Volume II, Technical Appendix, of this report. The second table, referred to by the TWDB as "Table 5", contains similar information as Table 4, but presents it for specific "water user groups" by county in the RGRWPA. Water user groups (WUGs) typically are cities or communities that provide water to their citizens and to other users in adjacent areas; however, they also can include rural areas served by a particular water supply authority, district or corporation. A completed Table 5 for each of the eight counties in the RGRWPA is contained in the TWDB Exhibit B tables section of Volume II, Technical Appendix, of this report. The last table defined by the TWDB, "Table 6", is intended to present a summary of the available current water supplies for entities designated as "major water providers" for municipal and manufacturing users. For the RGRWPA, no major water providers have been designated; therefore, Table 6 has not been prepared. The data and procedures used in developing the current water supply amounts presented in Tables 4 and 5 for the region and a discussion of these results are presented in subsequent sections of this chapter.

A general indication of the quantities of water that are projected to be available by decade in the RGRWPA over the next 50 years based on current supplies is provided by the bar chart in Figure 3.1. The distribution of these available supplies among various water use categories is indicated on each of the bars in the chart. As is the case today, most of the available water supply will be used for irrigation of crops over the next 50 years. The portions of the available supplies to be derived from surface water and from groundwater each decade also are plotted on the chart. As shown, surface water, almost entirely from the Rio Grande, will provide most of the available supply for the region.

It is important to recognize that the current water supply information for the RGRWPA as presented in Tables 4 and 5 and on the bar chart in Figure 3.1 reflects certain limiting criteria and assumptions set forth by the TWDB in its guidelines for conducting regional water supply planning studies. First of all, the available current water supply amounts reflect "drought of record" conditions. This means that they represent the annual amounts of water that would be available if the worst drought known to have previously occurred in the region as documented by existing hydrologic records should reoccur in the future. As will be discussed later, while much of the Rio Grande Basin in Texas and Mexico currently is

Figure 3.1 - Currently Available Water Supplies by Use Category and by Source for the Rio Grande Water Planning Region



experiencing an extended drought, the drought of record for the river with respect to United States water still is the drought of the 1950s. Hence, the firm annual yield[1] of the system of international reservoirs on the Rio Grande[2] with respect to United States water continues to be determined by the hydrologic conditions that occurred during the drought of record[3], and to a large extent, it is the firm annual yield of these reservoirs that limits the available supply of water in the RGRWPA. Other factors that have been considered in establishing the amounts of water available for the RGRWPA based on current supplies include the current capacity of existing groundwater well fields; the hydrogeologic properties of aquifers in the region; the quality of existing water supplies with regard to usability; current water rights, permits, and other regulatory restrictions; the hydraulic capacity of existing conveyance infrastructure; current contracts and/or option agreements; and, obligations that a WUG may have in terms of contracts or direct/indirect water sales to other WUGs. In some instances, one or more of these factors have determined the available water supply of individual water users.

This chapter presents information regarding the baseline data used to develop the future water supply estimates for the RGRWPA and describes the procedures and methodologies applied in analyzing current water supply sources for the region as a whole and for individual water users (WUGs). Also included are descriptions of and results from special studies that have been undertaken as part of the overall investigation of the available supplies of water for the RGRWPA, including an evaluation of the extent to which Rio Grande water could be delivered to municipalities in the Lower Rio Grande Valley during a severe drought without the benefit of irrigation carrying water in the river or in the irrigation district canal systems, an analysis of the potential impacts of Mexico's water use and tributary reservoir development on the yield of the international reservoirs on the Rio Grande and the supply of surface water available to the United States from the Rio Grande under the 1944 Treaty, and a review of the quality of the surface water and groundwater supplies that are projected to be available to the RGRWPA.

3.2 SURFACE WATER SOURCES

The RGRWPA includes eight counties that encompass portions of three river or coastal basins; the Rio Grande Basin, the Nueces River Basin, and the Nueces-Rio Grande Coastal Basin. The RGRWPA counties are identified on the map of the region in Figure 3.2 along with the boundaries of the three basins. Although water users are located in all three of these basins within the RGRWPA, practically all rely upon surface water from the Rio Grande or groundwater for their water supplies. Some very limited use is made of surface water supplies available from tributaries of the Rio Grande in Maverick, Webb, Zapata, and Starr counties; from the Arroyo Colorado which flows through southern Hidalgo County and northern Cameron County to the Laguna Madre; from the pilot channels within the floodways that convey local runoff and floodwaters from the Rio Grande through the Lower Rio Grande Valley to the Laguna Madre; and, from isolated lakes and resacas in Hidalgo and Cameron counties.

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[1] The firm annual yield of a reservoir or a system of reservoirs is defined as the maximum amount of water that can be withdrawn from the reservoir(s) each year during the occurrence of the drought of record without causing the reservoir(s) to go dry.

[2] Amistad Reservoir, located just upstream of Del Rio, Texas, and Falcon Reservoir, located between Laredo and Rio Grande City, Texas, are the two major international reservoirs presently in existence on the Rio Grande.

[3] As will be discussed later in this report, the drought of record with respect to Mexico's water in the lower and middle Rio Grande now appears to the current drought of the 1990's.

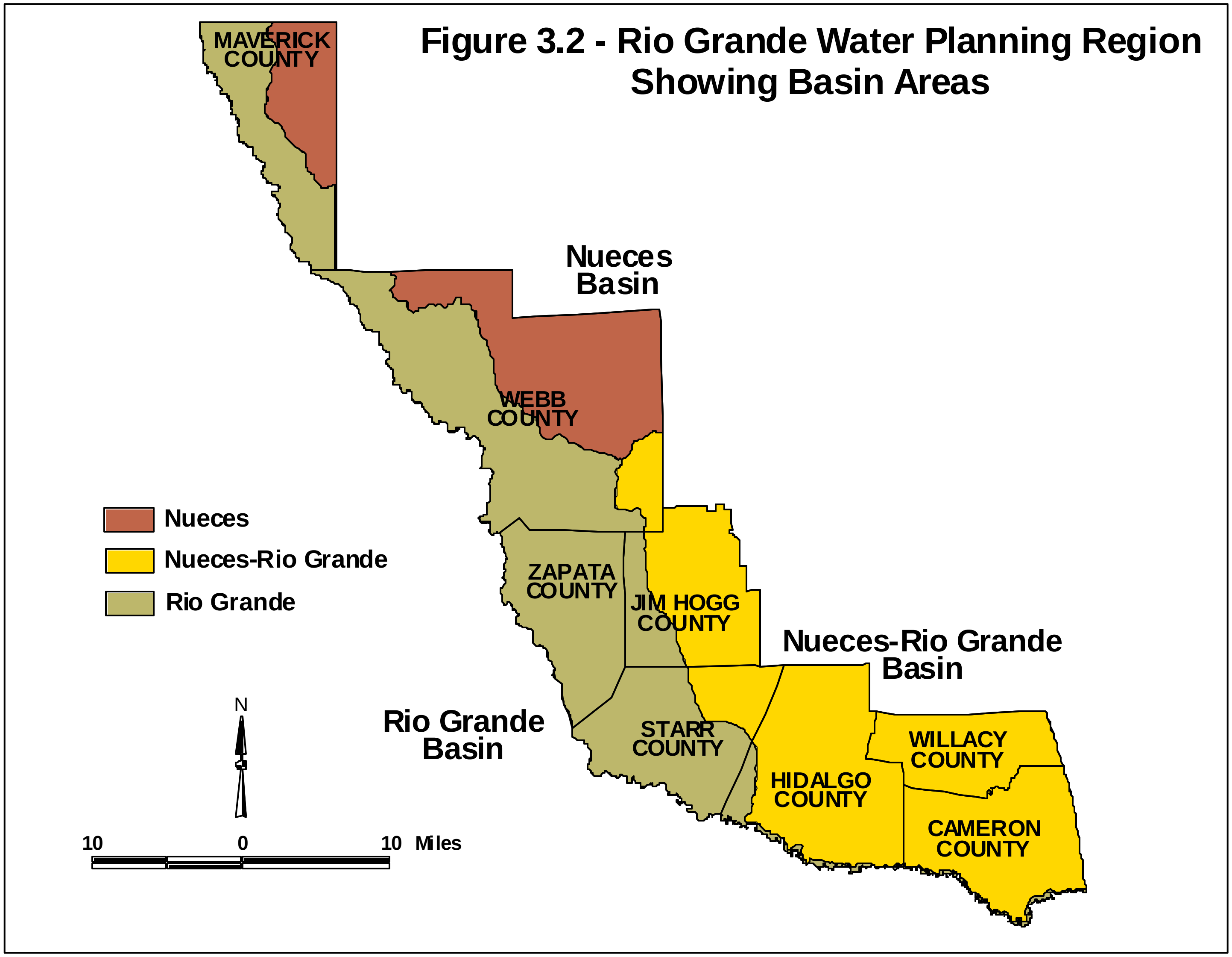

Figure 3.2 - Rio Grande Water Planning Region Showing Basin Areas

3.2.1 Rio Grande

The Rio Grande Basin extends southward from the Continental Divide in southern Colorado through New Mexico and Texas to the Gulf of Mexico. The Rio Grande forms the international boundary between the United States and Mexico from El Paso, Texas, to the Gulf, a straight-line distance of about 700 miles and a river-mile distance of almost 1,250 miles. The entire Basin (United States and Mexico) covers approximately 355,500 square miles; however, only about half of this area yields runoff to the Rio Grande. The non-contributing areas drain into internal closed sub-basins. The area of the contributing watershed is approximately 176,000 square miles, of which about 89,000 square miles, or 50.4 percent, are located within the United States. A map of the entire Rio Grande Basin is presented in Figure 3.3.

The Texas portion of the contributing watershed of the Rio Grande Basin encompasses about 54,000 square miles, or about one third of the total contributing watershed. In addition, there are about 8,100 square miles within the Texas portion of the basin that do not contribute runoff to the Rio Grande. These noncontributing areas extend generally southward from the New Mexico state line and include a large closed basin in portions of Hudspeth, Culberson, Jeff Davis, and Presidio counties in extreme western Texas.

The Pecos and Devils Rivers are the principal tributaries of the Rio Grande in Texas. Both of these rivers flow into Amistad Reservoir on the Rio Grande, which is located upstream of the City of Del Rio, Texas, about 600 river miles from the mouth of the Rio Grande. On the Mexican side, the Rio Conchos, Rio Salado, and Rio San Juan are the largest tributaries. The Rio Conchos drains over 26,000 square miles and flows into the Rio Grande near the town of Presidio, Texas, about 350 river miles upstream of Amistad Reservoir. The Rio Salado has a drainage area of about 23,000 square miles and discharges directly into Falcon Reservoir on the Rio Grande. Falcon Reservoir is located between the cities of Laredo, Texas and Rio Grande City, Texas, about 275 river miles upstream from the Gulf of Mexico. The Rio San Juan enters the Rio Grande about 36 river miles below Falcon Dam near Rio Grande City. The drainage area of the Rio San Juan covers about 13,000 square miles.

The Texas portion of the Rio Grande Basin is fairly broad upstream of the Devils River with a maximum width of about 200 miles. Downstream from the Devils River to below Falcon Dam, the Basin tapers down to a relatively narrow band bordering the Rio Grande and varying in width from 10 to 30 miles. In Hidalgo and Cameron counties, at the extreme lower end of the basin, the watershed is confined between levees and is generally less than a few miles in width. This system of levees and the associated drainage channels were constructed by the United States and Mexico to control flooding of the extensive agricultural and urbanized areas along the river in the Lower Rio Grande Valley.

The vast majority of the Rio Grande Basin is comprised of rural, undeveloped land that is used principally for farming and ranching operations. In Texas, the major urban centers include El Paso in the far western end of the state; the cities of Del Rio, Eagle Pass, and Laredo on the river in the central portion of the basin; and, Mission, McAllen, Harlingen, and Brownsville in the Lower Rio Grande Valley. Although these and most other cities in the Lower Valley actually are located outside of the contributing watershed of the Rio Grande, the river serves as the primary source for their water supplies. Substantial quantities of surface water are diverted from the Rio Grande in Texas to meet both municipal and agricultural demands. Much of this demand is in the Lower Rio Grande Valley where approximately three quarters of a million people reside and where irrigated farming is extensively practiced.

Figure 3.3 - Rio Grande Basin

For the most part, the water that is diverted from the Rio Grande in the Lower Valley is not returned to the river either as irrigation tailwater or treated wastewater effluent because of the natural slope of the land away form the river due to historical depositions of sediment along the floodplain of the river. Generally, these return flows are discharged into interior drainage channels and floodways that ultimately flow into the Laguna Madre and the Gulf of Mexico.

3.2.1.1 Rio Grande Reservoirs

Amistad and Falcon Reservoirs are the two major international reservoirs that are located on the Rio Grande. These impoundments provide controlled storage for over eight million acre-feet of water owned by the United States and Mexico, of which 2.25 million acre-feet are allocated for flood control purposes and 6.05 million acre-feet are reserved for silt and conservation storage (water supply). Falcon Reservoir, completed in 1953 and located on the river about midway between the cities of Laredo and McAllen, was the first major reservoir constructed on the Rio Grande under the 1944 Treaty between the United States and Mexico. Today, it is considered to be the "lowest major international dam or reservoir" on the river in accordance with the provisions of the 1944 Treaty. The United States has 58.6 percent (or 1.56 million acre-feet) of the silt and conservation storage in Falcon Reservoir; Mexico owns the balance, 1.10 million acre-feet. In Amistad Reservoir, which was completed in 1968 just upstream of the City of Del Rio, the United States utilizes and controls 56.2 percent of the total conservation storage capacity, or about 1.77 million acre-feet. The remainder of the conservation storage, 1.38 million acre-feet, is owned and used by Mexico. Together, Amistad and Falcon Reservoirs make available a substantial supply of water for the United States and Mexico, and they provide significant flood control benefits for properties along the middle and lower reaches of the river.

Anzalduas Dam, completed in 1960 just south of the City of Mission, provides for the diversion of the United States' share of the Rio Grande floodwaters into an interior floodway system, and it also enables the gravity diversion of water into Mexico's main water supply canal, referred to as the Anzalduas Canal. Anzalduas Reservoir has a total storage capacity of about 15,000 acre-feet at its normal maximum operating level of 104.5 feet above mean sea level. Of this amount, between 3,037 and 4,214 acre-feet are available as conservation storage for use by the United States. Anzalduas Reservoir serves as a storage and flow regulation facility for partially controlling and managing the United States' share of water in this reach of the lower Rio Grande.

3.2.1.2 Mexican Tributary Reservoirs

To develop its water resources, Mexico has constructed an extensive system of reservoirs on tributaries of the Rio Grande whose combined storage capacity substantially exceeds the total storage capacity available to Mexico in Amistad and Falcon Reservoirs on the mainstem of the Rio Grande. Water stored in these tributary reservoirs is used for municipal, industrial, and irrigation purposes in the vicinity of the reservoirs and downstream along the tributaries and the Rio Grande. Because the 1944 Treaty between the United States and Mexico stipulates that the United States is to receive certain minimum quantities of inflows to the Rio Grande from some of the Mexican tributaries on which reservoirs have been constructed (see Section 3.2.1.6.1 of this report), the potential impacts of these reservoirs on the delivery of the required minimum amounts of water to the United States are of particular concern with regard to water supply planning for the RGRWPA. This is especially critical since Mexico has stated that it does not operate its tributary reservoirs for the purpose of meeting its obligations under the 1944 Treaty, but rather, solely to capture water for meeting its own internal water demands. In light of the fact that Mexico currently has accrued deficits with respect to the minimum tributary inflows to the Rio Grande required by the 1944 Treaty (see Section 3.8.3 of this report), the supply of water that will be available in the future to the United States and to the RGRWPA from the Mexican tributaries is somewhat uncertain.

The major reservoirs located on Rio Grande tributaries within Mexico are identified on the map in Figure 3.4. Pertinent features of these reservoirs are summarized in Table 3.1. As illustrated on the map, much of the reservoir development within Mexico has occurred in the Rio Conchos Basin in the State of Chihuahua. As noted previously, the Rio Conchos flows into the Rio Grande upstream of Amistad Reservoir, and it is one of the six Mexican tributaries of the Rio Grande that are named in the 1944 Treaty from which the United States is allocated a portion of the inflows to the Rio Grande.

As shown in Table 3.1, the combined conservation storage capacity of all of Mexico's major reservoirs on Rio Grande tributaries is approximately 6,240,000 acre-feet, which is about 2.5 times the available conservation storage capacity that Mexico has in Amistad and Falcon Reservoirs on the Rio Grande. The seven major tributary reservoirs located in the Rio Conchos Basin have a combined storage capacity of about 3,212,000 acre-feet, which includes the largest of the tributary reservoirs, La Boquilla, with a storage capacity of 2,353,500 acre-feet. Above Falcon Dam, including the Rio Conchos Basin, the combined storage capacity of the Mexican tributary reservoirs is approximately 4,410,000 acre-feet. Below Falcon Dam on the Rio San Juan, the combined storage capacity of the Mexican tributary reservoirs is about 1,833,000 acre-feet.

The year in which construction of each of the tributary reservoirs was completed also is indicated in Table 3.1. As shown, the oldest tributary reservoir is La Boquilla on the Rio Conchos, which was completed in 1916. The most recent reservoirs were constructed in 1993: El Cuchillo on the Rio San Juan; and Pico de Aguila on the Rio Florido in the Rio Conchos Basin. It should also be noted that Mexico is in the process of constructing a new reservoir on the lower reach of the Rio San Alamo, one of the tributaries of the Rio Grande that flows into the river below Falcon Dam. This reservoir, called Las Blancas, apparently will be used to capture flood flows on the Rio Alamo, which then will be conveyed by canal to the existing Marte R. Gomez Reservoir on the Rio San Juan.

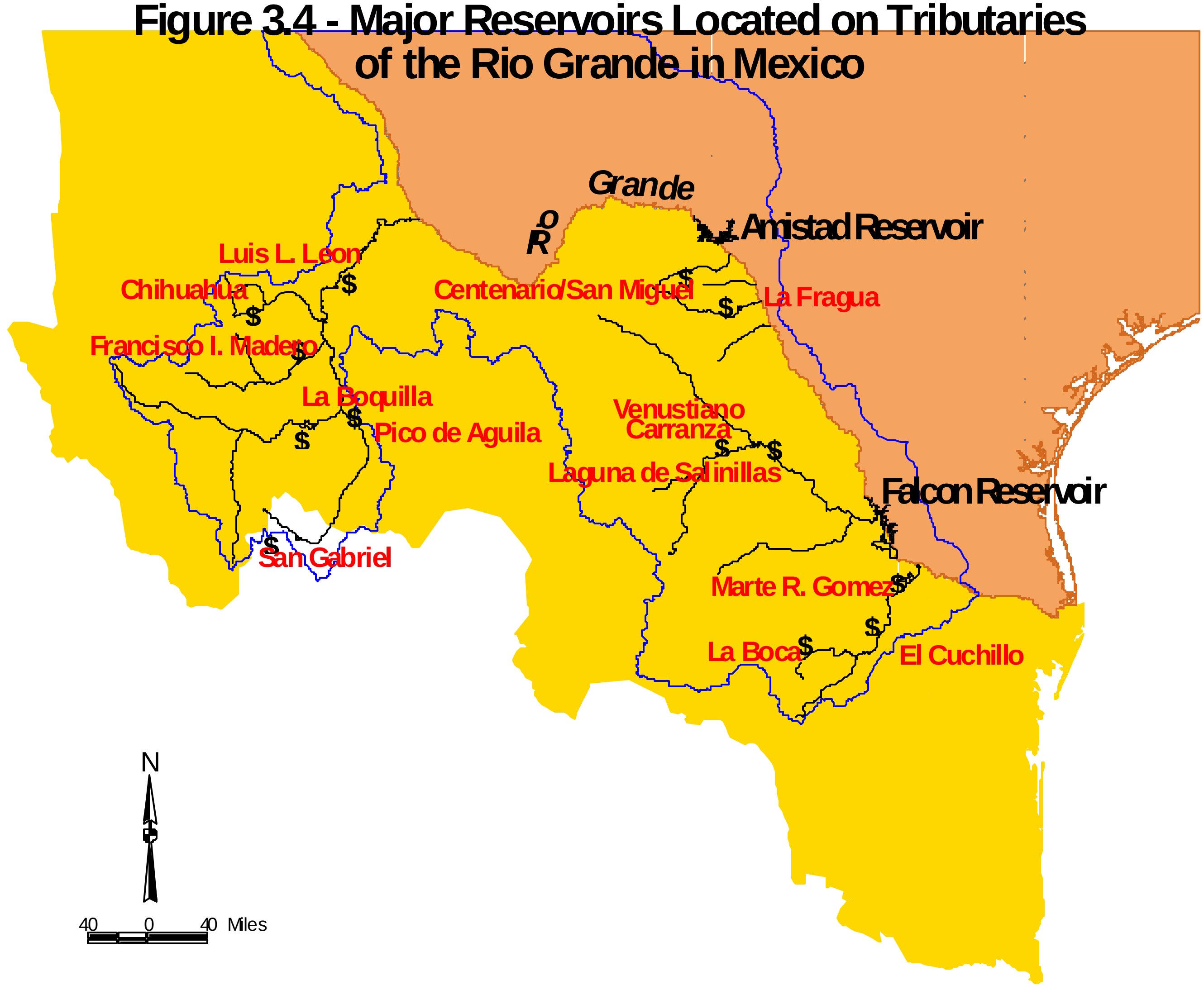

Figure 3.4 - Major Reservoirs Located on Tributaries of the Rio Grande in Mexico

Table 3.1 - Pertinent Features of Major Reservoirs Located on Rio Grande Tributaries in Mexico

River Basin / Name	River	State	Year Closed	Storage Capacity	
				Million Cubic Meters	Acre-Feet
Rio Conchos Basin					
La Boquilla	Rio Conchos	Chihuahua	1916	2,903	2,353,501
La Colina	Rio Conchos	Chihuahua	1927	24	19,538
Francisco I. Madero	Rio San Pedro	Chihuahua	1949	348	282,128
Chihuahua	Rio Chuviscar	Chihuahua	1960	26	21,079
Luis L. Leon	Rio Conchos	Chihuahua	1968	356	288,614
San Gabriel	Rio Florido	Durango	1981	255	206,732
Pico de Aguila	Rio Florido	Chihuahua	1993	50	40,536
Rio Conchos Basin Total Reservoir Storage Capacity:				3,962	3,212,127
Rio San Diego Basin					
San Miguel	Rio San Diego	Coahuila	1935	20	16,214
Centenario	Rio San Diego	Coahuila	1936	26	21,322
Rio San Diego Basin Total Reservoir Storage Capacity:				46	37,536
Rio San Rodrigo Basin					
La Fragua	Rio San Rodrigo	Coahuila	1990	45	36,482
Rio San Rodrigo Basin Total Reservoir Storage Capacity:				45	36,482
Rio Salado Basin					
Venustiano Carranza	Rio Salado	Coahuila	1930	1,385	1,122,838
Laguna de Salinillas	Rio Salado	Nuevo Leon	1931	- -	- -
Rio Salado Total Reservoir Storage Capacity:				1,385	1,122,838
Rio San Juan Basin (1)					
Rodrigo Gomez (La Boca)	Rio San Juan	Nuevo Leon	1963	41	33,239
El Cuchillo	Rio San Juan	Nuevo Leon	1993	1,123	910,512
Marte R. Gomez	Rio San Juan	Tamaulipas	1943	1,097	889,271
Rio San Juan Total Reservoir Storage Capacity:				2,261	1,833,023
Total Tributary Reservoir Storage Capacity:				7,699	6,242,006

1 Flow from these reservoirs is dedicated to Mexico by treaty.

Mexico's Share of Conservation Storage in Major International Reservoirs on the Rio Grande

River Basin / Name	River	State	Year Closed	Storage Capacity	
				Million Cubic Meters	Acre-Feet
Rio Grande Basin					
Falcon	Rio Grande	Tamaulipas	1953	1,355	1,098,674
Amistad	Rio Grande	Coahuila	1969	1,703	1,380,278
Total Rio Grande Reservoir Storage Capacity:				3,058	2,478,952

3.2.1.3 Rio Grande Flood Flow Operations

All of the mainstem dams and reservoirs located on the Rio Grande within Texas are under the sole supervision and control of the International Boundary and Water Commission (IBWC). The International Boundary Commission was originally created as a joint commission by the United States and Mexico at the Convention of March 1, 1889, for the purpose of establishing the exact boundary between the two countries. Now, following a change in its name by the 1944 Treaty, the United States Section of the IBWC functions as an arm of the U. S. Department of State and is responsible for addressing all boundary and water issues along the United States-Mexico border. When the potential for flooding occurs, the reservoirs are operated by IBWC to minimize flood flows and flood damages along the middle and lower Rio Grande within the RGRWPA.

Both the United States and Mexico maintain interior floodway systems in the Lower Rio Grande Valley that receive flood flows diverted from the Rio Grande during high runoff periods. Each of these floodways is designed to carry up to 105,000 cfs (cubic feet per second). With the floodway diversions, the design discharge for the river can be reduced from 250,000 cfs at Rio Grande City (River Mile 235[4]) to 20,000 cfs below Retamal Dam (i.e., the lowest point where flood waters are diverted into the Mexican floodway system). A discharge level of 20,000 cfs is considered to be the safe capacity of the leveed reach of the lower Rio Grande through the Brownsville-Matamoros urban area; however, to the extent possible, IBWC attempts to limit flows through this reach to no greater than 15,000 cfs.

3.2.1.4 Rio Grande Normal Flow Operations

During non-flood periods, when low to average flows occur in the Rio Grande, requests for releases of water from the conservation storage pools in Amistad and Falcon Reservoirs are made to the IBWC by water users in both the United States and Mexico. In Texas, these requests for releases are made through the Rio Grande Watermaster, an official employed by the Texas Natural Resource Conservation Commission (TNRCC).

Water users along the Rio Grande between Amistad and Falcon Reservoirs are delivered water released from Amistad Reservoir. Major municipal water users include the cities of Ciudad Acuna, Piedras Negras, and Nuevo Laredo in Mexico; and the cities of Eagle Pass and Laredo in Texas. Most of the water released from Amistad Reservoir is used for irrigation along the Rio Grande in both countries. The majority of the water diverted for irrigation along this reach in Texas is used in Maverick County.

Water released from Falcon Reservoir at the request of Mexico is diverted from the river primarily through the Anzalduas Canal, which has its headgates located in Anzalduas Reservoir. The City of Matamoros, located downstream near Brownsville, also diverts water directly from the river for municipal and industrial use. In addition, there are several other small Mexican diverters that are unauthorized, but are known to pump water from the river for domestic and agricultural purposes. In Texas, water is diverted from the river at hundreds of locations extending over the entire length of the Rio Grande below Falcon Dam. The vast majority of the diversions are made by irrigation districts that supply water to agricultural users, as well as to municipalities and industries in the Lower Rio Grande Valley. The principal municipal water users include the cities of Raymondville, Harlingen, Brownsville, McAllen, Mission, Edinburg, Pharr, Weslaco, and Rio Grande City.

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[4] The term "River Mile" refers to the distance in statute miles along the course of the Rio Grande upstream from its mouth at the Gulf of Mexico.

3.2.1.5 Rio Grande Watermaster

Requests for releases from the United States' conservation pools in Amistad and Falcon Reservoirs are administered and processed by the Rio Grande Watermaster under the purview of the Texas Natural Resource Conservation Commission (TNRCC). The Rio Grande Watermaster makes daily requests to the IBWC for releases from the reservoirs to meet municipal, industrial, and agricultural demands in the Lower Rio Grande Valley below Falcon Dam, as well as, along the mainstem of the Rio Grande in the Middle Rio Grande Valley between Falcon and Amistad Reservoirs. For some users at the extreme lower end of the river, the requests are made five to seven days in advance of need to allow for the travel time required for the released water from Falcon Reservoir to flow downstream along the more than 200 miles of river channel to the various points of diversion.

In determining the reservoir release amounts for downstream users, the Rio Grande Watermaster considers the quantity of water requested by all diverters and their respective locations along the river, potential channel losses and gains, watershed runoff and tributary inflows, channel and bank storage, waters impounded by instream weirs operated by individual diverters, and any available United States water that may be stored in Anzalduas Reservoir. To project the magnitude and timing of the releases needed to satisfy the requested individual diversions at their respective locations along the river, the Rio Grande Watermaster uses a series of seven river reaches below Falcon Dam and six river reaches between Amistad Dam and Falcon Reservoir, with each reach having a theoretical travel time equal to one day. These reaches are identified and described in Table 3.2. By knowing the number of days typically required for released water from either Amistad or Falcon Reservoirs to flow (travel) to the individual reaches under normal flow conditions, the Watermaster can schedule releases from the reservoirs in the proper amounts and on the proper days in response to the requested demands. To aid in the operation of the delivery system, the IBWC provides the Watermaster instantaneous data pertaining to streamflow rates at various locations along the river and preliminary estimates of the United States' share of these flows and of the water stored in Anzalduas Reservoir.

3.2.1.6 Rio Grande Water Allocations

3.2.1.6.1 United States - Mexico Treaties

Two treaties between the United States and Mexico contain basic provisions regarding the development and use of Rio Grande waters by the two countries. The 1906 Treaty[5] provides for delivery to Mexico by the United States of 60,000 acre-feet of water annually in the El Paso-Juarez Valley upstream from Fort Quitman, Texas. If shortages occur in the water supply for United States, then deliveries to Mexico are to be reduced in the same proportion as deliveries to the United States. The 1906 Treaty also includes a provision whereby Mexico "waives any and all claims to the waters of the Rio Grande for any purpose whatever between the head of the present Mexican Canal and Fort Quitman, Texas".

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[5] Convention between the United States and Mexico, Equitable Distribution of the Waters of the Rio Grande; Proclaimed January 16, 1907; Washington, D. C.

Table 3.2 – River Reaches Used by Rio Grande Watermaster for Facilitating Water Deliveries From Amistad and Falcon Reservoirs to Downstream Users

Middle Rio Grande

Reach 1	Amistad Dam (RM 571.8)* to the IBWC streamflow gage at Del Rio, Texas (RM 561.2)
Reach 2	IBWC streamflow gage at Del Rio, Texas (RM 561.2) to IBWC streamflow gage at Eagle Pass, Texas (RM 497.0)
Reach 3	IBWC streamflow gage at Eagle Pass, Texas (RM 497.0) to IBWC streamflow gage near El Indio, Texas (RM 460.4)
Reach 4	IBWC streamflow gage at El Indio, Texas (RM 460.4) to IBWC streamflow gage at Laredo, Texas (RM 359.8)
Reach 5	IBWC streamflow gage at Laredo, Texas (RM 359.8) to San Ygnacio, Texas (at the headwaters of Falcon Reservoir)
Reach 6	San Ygnacio, Texas (at the headwaters of Falcon Reservoir) to Falcon Dam (RM 274.8)

Lower Rio Grande

Reach 1	Falcon Dam (RM 274.8) to the IBWC streamflow gage at Rio Grande City, Texas (RM 235.0)
Reach 2	IBWC streamflow gage at Rio Grande City, Texas (RM 235.0) to Anzalduas Dam (RM 170.3)
Reach 3	Anzalduas Dam (RM 170.3) to Retamal Dam (RM 132.5)
Reach 4	Retamal Dam (RM 132.5) to the IBWC streamflow gage at San Benito, Texas (RM 96.8)
Reach 5	IBWC streamflow gage at San Benito, Texas (RM 96.8) to Cameron County WCID No. 6 river diversion point (RM 68.4)
Reach 6	Cameron County WCID No. 6 river diversion point (RM 68.4) to IBWC streamflow gage near Brownsville, Texas (RM 48.7)
Reach 7	IBWC streamflow gage near Brownsville, Texas (RM 48.7) to the Gulf of Mexico (RM 0.0)

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* "RM" refers to river miles upstream from the mouth of the Rio Grande at the Gulf of Mexico

The 1944 Treaty between the United States and Mexico[6], which is administered by the IBWC, contains provisions relating to the reach of the Rio Grande between Fort Quitman and the Gulf of Mexico, which includes the RGRWPA. This treaty provides for the allocation of all waters within this reach of the Rio Grande between the two countries and for the joint construction of as many as three major international reservoirs on the mainstem of the river for water supply and flood control purposes. Development of hydroelectric power at the reservoirs is also authorized under the treaty, with any hydropower generated divided equally between the two countries. Article 4 of the 1944 Treaty allocates the waters in the Rio Grande below Fort Quitman, Texas, between the United States and Mexico as follows:

A. To Mexico:

(a) All of the waters reaching the main channel of the Rio Grande (Rio Bravo) from the San Juan and Alamo Rivers, including the return flow from the lands irrigated from the latter two rivers.

(b) One-half of the flow in the main channel of the Rio Grande (Rio Bravo) below the lowest major international storage dam, so far as said flow is not specifically allotted under this Treaty to either of the two countries.

(c) Two-thirds of the flow reaching the main channel of the Rio Grande (Rio Bravo) from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vacas Arroyo, subject to the provisions of subparagraph (c) of Paragraph B of this Article.

(d) One-half of all other flows not otherwise allotted by this Article occurring in the main channel of the Rio Grande (Rio Bravo), including the contributions from all the unmeasured tributaries, which are those not named in this Article, between Fort Quitman and the lowest major international storage dam.

B. To the United States:

(a) All of the waters reaching the main channel of the Rio Grande (Rio Bravo) from the Pecos and Devils Rivers, Good-enough Spring, and Alamito, Terlingua, San Felipe and Pinto Creeks.

(b) One-half of the flow in the main channel of the Rio Grande (Rio Bravo) below the lowest major international storage dam, so far as said flow is not specifically allotted under this Treaty to either of the two countries.

(c) One-third of the flow reaching the main channel of the Rio Grande (Rio Bravo) from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vacas Arroyo, provided that this third shall not be less, as an average amount in cycles of five consecutive years, than 350,000 acre-feet (431,721,000 cubic meters) annually. The United States shall not acquire any right by the use of the waters of the tributaries named in this subparagraph, in excess of the said 350,000 acre-feet (431,721,000 cubic meters) annually, except the right to use one-third of the flow

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[6] "Treaty Between the United States and Mexico, Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande"; February 3, 1944; Washington, D. C.

> *reaching the Rio Grande (Rio Bravo) from said tributaries, although such one-third may be in excess of that amount.*
>
> *(d) One-half of all other flows not otherwise allotted by this Article occurring in the main channel of the Rio Grande (Rio Bravo), including the contributions from all the unmeasured tributaries, which are those not named in this Article, between Fort Quitman and the lowest major international storage dam.*
>
> *In the event of extraordinary drought or serious accident to the hydraulic systems on the measured Mexican tributaries, making it difficult for Mexico to make available the run-off of 350,000 acre-feet (431,721,000 cubic meters) annually, allotted in subparagraph (c) of paragraph B of this Article to the United States as the minimum contribution from the aforesaid Mexican tributaries, any deficiencies existing at the end of the aforesaid five-year cycle shall be made up in the following five-year cycle with water from the said measured tributaries.*
>
> *Whenever the conservation capacities assigned to the United States in at least two of the major international reservoirs, including the highest major reservoir, are filled with waters belonging to the United States, a cycle of five years shall be Considered as terminated and all debits fully paid, where upon a new five-year cycle shall commence.*

These treaty provisions are routinely applied by the IBWC to determine the ownership of waters between the United States and Mexico in the lower and middle Rio Grande. Historical data are available from the IBWC indicating the monthly quantities of each country's water that have flowed into the Rio Grande, that have been stored in Amistad and Falcon Reservoirs on the Rio Grande and in tributary reservoirs in each country, that have been released from the mainstem impoundments, that have been diverted from the Rio Grande, and that have passed the Brownsville streamflow gage and flowed to the Gulf of Mexico.

With regard to the repayment of deficits that may be incurred by Mexico under paragraph B(c) of Article 4 of the 1944 Treaty, the United States and Mexican Sections of the IBWC conducted investigations in 1969 that culminated in the joint issuance of Minute No. 234. This Minute established the starting date for water accounting pursuant to paragraph B(c) and outlined procedures and methods for making up deficiencies in the actual amounts of water delivered by Mexico to the United States under the terms of Article 4. Specifically, Mexico and the United States agreed to the following provisions as stated in Minute No. 234:

> 1. *That accounting of the waters of the Rio Grande allotted to the United States from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vacas Arroyo shall begin October 1, 1953.*
>
> 2. *That in the event of a deficiency in a cycle of five consecutive years in the minimum amount of water allotted to the United States from the said tributaries, the deficiency shall be made up in the following five-year cycle, together with any quantity of water which is needed to avoid a deficiency in the aforesaid following cycle, by one or a combination of the following means:*

a. *With water of that portion of the said tributary contributions to the Rio Grande allotted to the United States in excess of the minimum quantity guaranteed by the Water Treaty.*

b. *With water of that portion of the said tributary contributions to the Rio Grande allotted to Mexico, when Mexico gives advance notice to the United States and the United States is able to conserve such water; and*

c. *By transfer of Mexican waters in storage in the major international reservoirs, as determined by the Commission, provided that at the time of the transfer, United States storage capacity is available to conserve them.*

3. *That the provisions of Article 4 of the Water Treaty relating to the waters of the Rio Grande from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vacas Arroyo allotted to the United States be considered satisfied to September 30, 1968.*

It is important to note here that the minimum inflow requirements stipulated in paragraph B(c) above for the United States from the six Mexican tributaries has not been satisfied by Mexico since October, 1992 (see Section 3.8.3 of this report). The total deficit as of September 2000 was approximately 1,400,000 acre-feet, and Mexico's ability to repay this deficit within the terms of the 1944 Treaty now is questionable. The uncertainty related to the availability, or unavailability, of this water from Mexico obviously has a direct bearing on water supply planning for the RGRWPA.

3.2.1.6.2 Rio Grande Valley Water Case

The United States' share of water stored in Amistad and Falcon Reservoirs and diverted from the lower and middle Rio Grande for domestic, municipal, industrial, and irrigation purposes is administered by the TNRCC in compliance with the decision of the Thirteenth Court of Civil Appeals in the landmark case styled *"State of Texas, et al. vs. Hidalgo County Water Control and Improvement District No. 18, et al."* and commonly referred to as the Rio Grande Valley Water Case. The original suit was filed by the State of Texas in 1956 to restrain the diversion of water from the Rio Grande for irrigation when the share of water due the United States from water impounded in Falcon Reservoir was 50,000 acre-feet or less. The storage amount of 50,000 acre-feet was the quantity of water that the Texas Board of Water Engineers (predecessor agency to the TNRCC) had determined at that time to be necessary to meet municipal, domestic and livestock demands for a three-month period without additional inflows into Falcon Reservoir. Earlier efforts to apply voluntary restrictions on diversions of water had collapsed due to severe drought conditions and the consequent shortage of water supplies.

The original trial of the Valley Water Case lasted from January 1964 to August 1966, and the final judgment of the appellate court was entered in 1969. In 1971, the Texas Water Rights Commission (predecessor agency to the TNRCC) adopted rules and regulations implementing the court decision. According to the judgment rendered in this case, a storage reserve in Falcon Reservoir equal to 60,000 acre-feet was established to meet municipal and industrial demands, and a total of approximately 155,000 acre-feet of water rights (annual usage) were allocated for municipal, industrial and domestic uses. Irrigation water from the Rio Grande was allocated for 742,808.6 acres of agricultural land below Falcon Dam. Of this amount, 641,221 acres were assigned Class A irrigation rights, and the remaining acres were awarded Class B irrigation rights.

Whereas municipal uses, which includes uses for domestic, industrial, manufacturing, and steam electric power generation purposes, were granted the highest water supply priority, the result of the Valley Water Case was to establish a weighted priority system along the lower Rio Grande for allocating the remaining surface water supply to irrigation (and mining) uses. The two classes of irrigation water rights that were established, (Class A and Class B) today provide a means for differentiating the rates at which water is credited to individual irrigation storage accounts in Amistad and Falcon Reservoirs. The Class A water right accrues water at a rate 1.7 times greater than the Class B water right. Although this weighted priority system for irrigation water users generally has little significance during years when water is abundant, its effect in water-short years is to distribute the shortage among all users, with the greater shortages occurring on lands with the Class B water rights.

In 1982, water rights in the Middle Rio Grande Basin; i.e., from Amistad Dam downstream to Falcon Reservoir, were adjudicated pursuant to Title 2, Subtitle B, Chapter 11, Subchapter G of the Texas Water Code. As a result of these proceedings, those water users located along the middle Rio Grande that were dependent upon water stored in Amistad or Falcon Reservoirs were assigned water rights based on the same allocation and accounting principles established in the Valley Water Case. Water users located on tributaries within the Middle Rio Grande Basin were assigned water rights based on the Prior Appropriation Doctrine.

Today, the Texas Rio Grande Watermaster is responsible for allocating the amount of water that can be diverted by each Class A and Class B irrigator and for supervising all use of water in the Lower and Middle Rio Grande Basins.

3.2.1.6.3 TNRCC Rio Grande Operating Rules

As a result of the Lower Rio Grande Valley Water Case, rules have been adopted by the State's water agencies, now the TNRCC, that regulate the operation of lower and middle Rio Grande system and the allocation of water among all users[7]. The rules applied by the TNRCC in administering mainstem water rights in the Lower and Middle Rio Grande Basins affect not only the amount of water that can be diverted from the Rio Grande and its tributaries, but also the operation of the storage pools in Amistad and Falcon Reservoirs. The current rules provide a reserve of 225,000 acre-feet of storage in Amistad and Falcon Reservoirs for domestic, municipal, and industrial uses, which is referred to as the "DMI pool", and an operating reserve that fluctuates between 380,000 acre-feet and 150,000 acre-feet, depending on the amount of water in conservation storage in the reservoirs. The stated purpose of the operating reserve in the TNRCC rules is to provide for: (1) loss of water by seepage, evaporation and conveyance; (2) emergency requirements; and, (3) adjustments of amounts in storage, as may be necessary by finalization of IBWC provisional United States-Mexico water ownership computations. The operating reserve is calculated monthly by multiplying the percentage of total United States conservation storage in the Amistad-Falcon system times the maximum operating reserve of 380,000 acre-feet. The calculated reserve cannot be less than 275,000 acre-feet, unless there is insufficient water stored in the reservoirs, in which case, the balance of the water in storage, after allocations for the DMI pool and irrigation account balances, is assigned to the operating reserve. Under no circumstances can the operating reserve be less than 150,000 acre-feet.

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[7] "Chapter 303: Operation of the Rio Grande"; 31 Texas Administrative Code, §§ 303.1-303.73; Texas Water Commission Rules; August 26, 1987; Austin, Texas.

Today, consideration is being given to revising the TNRCC's Rio Grande operating rules by altering the storage amounts for the DMI reserve and the operating reserve. Investigations of the impacts of different reserve amounts on overall water availability and the yield of the Amistad-Falcon Reservoir System are being undertaken as part of this Region M water supply planning study.

The TNRCC Rio Grande Watermaster administers the water allocations to municipal/domestic, industrial, agricultural and other user storage accounts. Such allocations are based on the available water in storage in Falcon and Amistad Reservoirs, as reported by the IBWC on the last Saturday of each month, less dead storage. To determine the amount of water to be allocated to various accounts, the Watermaster makes the following computations at the beginning of each month:

1. From the amount of water in usable storage, 225,000 acre-feet are deducted to re-establish the reserve; i.e., the DMI pool, for domestic, municipal and industrial uses; hence, these uses are given the highest priority;
2. From the remaining storage, the total end-of-month account balances for all lower and middle Rio Grande irrigation and mining allottees are deducted; and,
3. From the remaining storage, the operating reserve is deducted.

After the above computations are made, the remaining storage, if any, is allocated to the irrigation and mining accounts. The allotment for irrigation and mining uses is divided into the Class A and Class B water rights categories. Class A rights (allottees) receive 1.7 times as much water as that allotted to Class B rights. An irrigation allottee cannot accumulate in storage more than 1.41 times its annual authorized diversion right, and, if an allottee does not use water for two consecutive years, its account is reduced to zero. If there is not sufficient water in storage to fully restore the operating reserve in Step 3 above, then the TNRCC rules authorize the Watermaster to make negative allocations of water from the irrigation and mining accounts in sufficient amounts to provide the minimum 150,000 acre-feet of operating reserve capacity.

Generally, under the current rules and regulations of the TNRCC, all United States water that is diverted from the lower and middle Rio Grande by authorized diverters is accounted for by the Rio Grande Watermaster with appropriate charges against annual authorized diversion accounts in accordance with existing individual water rights and against individual storage accounts in Falcon and Amistad Reservoirs. The rules specify that an allottee is charged for water requested and released as follows:

1. A diverter is charged with the actual amount diverted if the total diversion is within plus or minus 10 percent of the amount requested;
2. A diverter is charged with 90 percent of the certification (requested) amount, if the total diversion is less than 90 percent of the amount requested; and,
3. If the quantity of water diverted is more than 110 percent of the amount requested, the diverter is charged with the actual amount of water diverted.

The Rio Grande Watermaster maintains records of daily, weekly and monthly diversions made by all existing water rights along the lower and middle Rio Grande. Monthly and annual reports are provided to all users.

3.2.1.6.4 No Charge Pumping

There are some circumstances, however, when the water use and storage accounts of water rights holders along the lower and middle Rio Grande are not charged for water diverted from the river. These are referred to as "no charge pumping" periods, and diversions during such periods are authorized by an Order issued by the Texas Water Commission on August 4, 1981[8].

Generally no charge pumping is allowed by the Rio Grande Watermaster when there are substantial flows in the river due to high runoff conditions or when there are flood spills or releases from Amistad and/or Falcon Reservoirs. When no-charge pumping is declared by the Rio Grande Watermaster, water from the Rio Grande can be diverted by authorized water rights holders in unlimited quantities, to the extent it is available, without their respective annual water use and storage accounts being charged. For the lower Rio Grande below Falcon Dam, the Rio Grande Watermaster makes a determination regarding no-charge pumping conditions taking into account the quantity of flow passing Anzalduas Dam, the amount of United States water stored in Anzalduas Reservoir, any anticipated stormwater inflows from Mexico, and whether or not spills or flood releases are occurring at Falcon Dam.

3.2.1.7 Rio Grande Hydrology

Because of the international significance of the Rio Grande and the various treaties and agreements between the United States and Mexico regarding the ownership and use of the waters in the basin, extensive efforts have been undertaken by both countries, through their respective sections of the IBWC, to monitor and measure the flows in the Rio Grande, as well as, the inflows to and diversions from the river system. As such, a network of streamflow gages has been in operation for many years, with daily flow records available from most gages since the early 1950s. Some older records date back to the 1930s, and flow measurements for the gage on the Rio Grande at El Paso have been available since 1889. Most of these records are published in IBWC's annual Water Bulletins[9].

3.2.1.7.1 Historical Reservoir Inflows (Upper Rio Grande)

Based on historical streamflow gage records and water balance calculations, the IBWC has determined the historical monthly inflows of United States water and Mexican water into Amistad Reservoir from the upper Rio Grande watershed and into Falcon Reservoir from the intervening watershed between Amistad Dam and Falcon Dam. A listing of these annual inflows is presented in Table 3.3 for the period 1945-1998[10]. Total annual inflows into both reservoirs for each country are listed by year and then by rank in descending order based on magnitude.

Over the 54-year period of available inflow data, the total amount of United States water that has flowed into Amistad and Falcon Reservoirs has averaged about 1,790,000 acre-feet per year, and the total amount

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[8] Order issued pursuant to §11.0871 of the Texas Water Code.

[9] International Boundary and Water Commission, United States Section and Mexico Section; "Flow of the Rio Grande and Related Data From Elephant Butte Dam, New Mexico to the Gulf of Mexico, 1997"; Water Bulletin No.67 and other previous Water Bulletins; El Paso, Texas.

[10] The historical 1945-1998 reservoir inflow data base as used in this study includes the revised estimates of monthly historical inflows to Amistad and Falcon Reservoirs for the United States and Mexico as derived by Perez-Freese & Nichols during Phase II of the previous Lower Rio Grande Integrated Water Resource Planning Study that was undertaken by the Lower Rio Grande Valley Development Council in association with the Valley Water Policy and Management Council of the Lower Rio Grande Water Committee, Inc. in 1999. The historical inflows for 1998 have been compiled during the current Region M water supply planning study.

of inflow to the reservoirs from Mexico has averaged about 1,350,000 acre-feet per year. In the wettest years, the reservoir inflows for each of the countries have approached four million acre-feet. As indicated, the lowest quantity of United States water that has flowed into the reservoirs is 708,265 acre-feet, which occurred in 1956. For Mexico, the lowest annual inflow is 450,154 acre-feet, also in 1956. Both of these inflow amounts reflect, of course, the 1950's drought, which generally has been considered to be the most severe drought of record for the lower and middle Rio Grande. For comparison purposes, the annual inflows to the reservoirs during the current drought period for the years 1993 through 1998 are highlighted. Certainly, as shown, the inflows that occurred during 1995 for the United States and during 1998 for Mexico were some of the lowest experienced during the last fifty years, but they still are not quite as low as those, which occurred during the 1950's drought. As will be discussed later relative to the firm annual yield of the Amistad-Falcon Reservoir System, the 1950s drought continues to be the critical drought of record for the United States; however, for Mexico, it may be the current 1990s drought.

3.2.1.7.2 Historical Rio Grande Streamflows (Middle and Lower Rio Grande)

Historical monthly and annual mean and median flow rates for several gaging stations on the Middle and lower Rio Grande are summarized in Table 3.4. These mean and median flow values have been derived using daily streamflow data compiled by the IBWC and presented in the annual Rio Grande Water Bulletins for the period 1960-1997 for stations on the lower Rio Grande and for the period 1968-1997 for the middle Rio Grande. These timeframes reflect the most recent periods for which published data are available since the currently existing reservoirs on the Rio Grande have been in place and operating. For the lower Rio Grande, 1960 is when Anzalduas Reservoir was constructed. Amistad Reservoir was constructed on the middle Rio Grande in 1968.

As expected, the average flows in the Rio Grande below Amistad Dam gradually increase from station to station in the downstream direction as influenced by tributary inflows from both the United States and Mexico. The effects of significant diversions into the Maverick Canal in Maverick County are evident by the reduction in flow at the Jimenez gage. The most prominent reductions in flow in the Rio Grande occur below Falcon Dam where significant diversions are made by water users in the United States at numerous locations and in Mexico through the Anzalduas Canal. The effects of inflows from the Rio San Juan are apparent in the Rio Grande flows measured at the gage at Rio Grande City.

Table 3.3 - Historical Annual United States and Mexican Inflows to the Rio Grande Above Amistad Reservoir and Between Amistad and Falcon Reservoirs

	UNITED STATES INFLOWS (ac-ft)			MEXICAN INFLOWS (ac-ft)			INFLOWS RANKED IN DESCENDING ORDE				
Year	Above Amistad Reservoir	Below Amistad Reservoir	Total Annual Inflows	Above Amistad Reservoir	Below Amistad Reservoir	Total Annual Inflows	Year	Total U.S. Inflows (ac-ft)	RANK	Year	Total Mexican Inflows (ac-ft)
1945	1,163,203	285,000	1,448,203	883,389	278,000	1,161,389	1971	3,984,106	1	1971	3,794,270
1946	1,212,854	506,000	1,718,854	909,841	521,000	1,430,841	1954	3,970,792	2	1958	3,501,723
1947	973,130	426,000	1,399,130	669,063	371,000	1,040,063	1974	3,317,228	3	1981	2,668,850
1948	1,454,024	595,000	2,049,024	507,768	702,000	1,209,768	1958	3,257,139	4	1976	2,467,178
1949	1,666,097	783,000	2,449,097	1,042,898	442,000	1,484,898	1981	2,882,903	5	1978	2,318,497
1950	1,093,569	248,000	1,341,569	786,227	128,000	914,227	1976	2,669,234	6	1990	2,226,809
1951	743,512	371,000	1,114,512	404,486	326,000	730,486	1990	2,495,386	7	1991	2,215,339
1952	644,293	92,000	736,293	428,901	64,000	492,901	1949	2,449,097	8	1987	1,952,463
1953	505,469	380,000	885,469	222,231	1,003,000	1,225,231	1987	2,428,644	9	1992	1,906,695
1954	3,764,424	206,368	3,970,792	788,961	325,559	1,114,520	1991	2,336,391	10	1988	1,761,635
1955	1,161,083	262,728	1,423,811	677,209	344,411	1,021,620	1957	2,304,200	11	1986	1,748,591
1956	562,134	146,131	708,265	296,764	153,390	450,154	1978	2,299,662	12	1975	1,662,148
1957	1,670,650	633,550	2,304,200	564,144	727,886	1,292,030	1986	2,264,727	13	1979	1,566,850
1958	1,969,349	1,287,790	3,257,139	1,567,841	1,933,882	3,501,723	1992	2,220,265	14	1974	1,517,152
1959	1,400,966	413,263	1,814,229	667,730	489,555	1,157,285	1964	2,152,091	15	1949	1,484,898
1960	1,183,084	304,220	1,487,304	848,707	307,596	1,156,303	1948	2,049,024	16	1972	1,473,295
1961	1,173,210	438,643	1,611,853	624,584	583,960	1,208,544	1988	2,009,094	17	1967	1,467,261
1962	906,681	222,588	1,129,269	511,070	240,095	751,165	1975	1,974,648	18	1946	1,430,841
1963	770,142	259,995	1,030,137	481,290	307,161	788,451	1972	1,876,700	19	1973	1,420,827
1964	1,673,626	478,465	2,152,091	672,900	548,188	1,221,088	1979	1,839,699	20	1966	1,420,305
1965	1,039,969	334,430	1,374,399	489,720	350,059	839,779	1959	1,814,229	21	1980	1,361,638
1966	1,318,285	391,422	1,709,707	1,003,086	417,219	1,420,305	1980	1,738,551	22	1957	1,292,030
1967	954,207	713,220	1,667,427	523,436	943,825	1,467,261	1946	1,718,854	23	1953	1,225,231
1968	991,330	294,637	1,285,967	841,232	382,091	1,223,323	1966	1,709,707	24	1968	1,223,323
1969	843,864	346,676	1,190,540	705,083	382,759	1,087,842	1967	1,667,427	25	1964	1,221,088
1970	844,695	297,120	1,141,815	620,385	283,218	903,603	1977	1,627,565	26	1948	1,209,768
1971	1,783,089	2,201,017	3,984,106	692,998	3,101,272	3,794,270	1973	1,625,856	27	1961	1,208,544
1972	1,307,088	569,612	1,876,700	802,803	670,492	1,473,295	1961	1,611,853	28	1945	1,161,389
1973	918,028	707,828	1,625,856	679,907	740,920	1,420,827	1960	1,487,304	29	1959	1,157,285
1974	3,029,423	287,805	3,317,228	1,211,470	305,682	1,517,152	1998	1,478,242	30	1960	1,156,303
1975	1,284,972	689,676	1,974,648	748,604	913,544	1,662,148	1985	1,467,746	31	1985	1,146,181
1976	1,607,050	1,062,184	2,669,234	773,967	1,693,211	2,467,178	1982	1,458,930	32	1954	1,114,520
1977	1,163,283	464,282	1,627,565	550,896	554,875	1,105,771	1945	1,448,203	33	1977	1,105,771
1978	1,743,638	556,024	2,299,662	1,517,216	801,281	2,318,497	1993	1,431,890	34	1969	1,087,842
1979	1,275,063	564,636	1,839,699	878,202	688,648	1,566,850	1955	1,423,811	35	1947	1,040,063
1980	1,329,313	409,238	1,738,551	817,103	544,535	1,361,638	1947	1,399,130	36	1955	1,021,620
1981	1,888,274	994,629	2,882,903	1,238,430	1,430,420	2,668,850	1965	1,374,399	37	1984	1,018,808
1982	1,118,780	340,150	1,458,930	664,349	338,840	1,003,189	1950	1,341,569	38	1993	1,018,709
1983	910,765	342,907	1,253,672	497,472	291,291	788,763	1989	1,333,316	39	1982	1,003,189
1984	1,086,407	234,142	1,320,549	775,321	243,487	1,018,808	1984	1,320,549	40	1950	914,227
1985	1,043,484	424,262	1,467,746	682,379	463,802	1,146,181	1968	1,285,967	41	1970	903,603
1986	1,887,478	377,249	2,264,727	1,208,462	540,129	1,748,591	1983	1,253,672	42	1989	874,095
1987	1,797,750	630,894	2,428,644	1,203,973	748,490	1,952,463	1994	1,219,854	43	1965	839,779
1988	1,469,121	539,973	2,009,094	929,864	831,771	1,761,635	1969	1,190,540	44	1983	788,763
1989	1,055,062	278,254	1,333,316	589,071	285,024	874,095	1996	1,184,139	45	1963	788,451
1990	2,076,817	418,569	2,495,386	1,728,668	498,141	2,226,809	1997	1,177,454	46	1962	751,165
1991	2,027,658	308,733	2,336,391	1,892,590	322,749	2,215,339	1970	1,141,815	47	1994	744,394
1992	1,702,861	517,404	2,220,265	1,283,085	623,610	1,906,695	1962	1,129,269	48	1951	730,486
1993	1,181,767	250,123	1,431,890	788,586	230,123	1,018,709	1951	1,114,512	49	1996	701,431
1994	924,654	295,200	1,219,854	488,813	255,581	744,394	1995	1,113,964	50	1997	641,400
1995	895,126	218,838	1,113,964	387,891	240,841	628,732	1963	1,030,137	51	1995	628,732
1996	956,466	227,673	1,184,139	441,577	259,854	701,431	1953	885,469	52	1998	628,128
1997	951,291	226,163	1,177,454	398,567	242,833	641,400	1952	736,293	53	1952	492,901
1998	1,141,780	336,462	1,478,242	314,958	313,171	628,128	1956	708,265	54	1956	450,154
AVG	1,319,266	466,503	1,785,769	776,411	569,083	1,345,493	- -	- -	- -	- -	- -

Table 3.4 - Historical Monthly and Annual Mean and Median Flows in the Middle and Lower Rio Grande

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
<u>MIDDLE RIO GRANDE</u>													
Rio Grande below Amistad Dam - RM 571.8													
Mean, Acre-Feet	94,363	125,037	150,948	158,291	220,980	168,307	139,925	150,728	188,867	171,750	99,198	86,320	1,754,714
Mean, cfs	1,535	2,233	2,455	2,660	3,594	2,828	2,276	2,451	3,174	2,793	1,667	1,404	2,424
Median, cfs	1,374	1,709	1,929	1,977	2,682	2,226	1,560	1,676	1,722	1,429	1,340	1,263	1,588
Rio Grande at Del Rio – RM 561.2													
Mean, Acre-Feet	99,095	128,328	154,427	163,195	225,239	171,580	143,093	155,336	195,630	178,007	105,620	91,145	1,810,695
Mean, cfs	1,612	2,292	2,512	2,743	3,663	2,883	2,327	2,526	3,288	2,895	1,775	1,482	2,501
Median, cfs	1,445	1,819	1,956	2,021	2,501	2,185	1,619	1,701	1,704	1,492	1,397	1,320	1,665
Rio Grande near Jimenez - RM 530.3													
Mean, Acre-Feet	50,474	79,923	96,013	107,630	166,241	116,475	98,569	106,128	149,857	145,887	65,404	46,605	1,229,206
Mean, cfs	821	1,429	1,562	1,809	2,704	1,957	1,603	1,726	2,518	2,373	1,099	758	1,698
Median, cfs	457	762	981	892	1,563	1,350	607	780	809	704	533	466	722
Rio Grande at Piedras Negras - RM 497.0													
Mean, Acre-Feet	121,157	147,033	161,765	170,478	236,281	192,030	189,965	176,421	231,267	227,241	139,143	120,400	2,113,181
Mean, cfs	1,970	2,626	2,631	2,865	3,843	3,227	3,089	2,869	3,887	3,696	2,338	1,958	2,919
Median, cfs	1,735	2,225	2,126	2,011	2,948	2,558	1,798	1,867	2,199	2,068	1,812	1,788	2,022
Rio Grande near El Indio - RM 460.4													
Mean, Acre-Feet	129,375	151,628	168,508	180,021	251,674	208,296	201,553	187,652	242,767	237,608	150,076	126,891	2,236,049
Mean, cfs	2,104	2,707	2,741	3,025	4,093	3,501	3,278	3,052	4,080	3,864	2,522	2,064	3,089
Median, cfs	1,851	2,270	2,306	2,221	3,094	2,596	1,969	2,038	2,353	2,208	1,877	1,775	2,175
Rio Grande at Laredo – RM 359.8													
Mean, Acre-Feet	133,643	158,052	173,886	186,210	271,920	238,186	208,544	196,051	252,826	268,538	153,709	130,334	2,371,899
Mean, cfs	2,173	2,822	2,828	3,129	4,422	4,003	3,392	3,188	4,249	4,367	2,583	2,120	3,276
Median, cfs	1,876	2,333	2,324	2,214	3,385	2,846	2,079	1,982	2,480	2,417	1,924	1,772	2,224

Table 3.4 Historical Monthly and Annual Mean and Median Flows in the Middle and Lower Rio Grande, cont'd.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
LOWER RIO GRANDE													
Rio Grande below Falcon Dam - RM 274.8													
Mean, Acre-Feet	214,578	144,439	131,955	331,045	379,817	253,518	162,480	217,840	149,329	161,985	81,498	84,796	2,313,280
Mean, cfs	3,490	2,577	2,146	5,563	6,177	4,261	2,642	3,543	2,510	2,634	1,370	1,379	3,195
Median, cfs	2,725	1,873	1,778	4,900	5,895	3,575	2,364	2,566	1,170	1,517	1,005	1,071	2,101
Rio Grande at Rio Grande City - RM 235.0													
Mean, Acre-Feet	217,888	157,792	134,706	325,269	386,338	281,883	194,117	241,498	300,138	247,334	108,054	101,013	2,696,030
Mean, cfs	3,544	2,815	2,191	5,466	6,283	4,737	3,157	3,928	5,044	4,022	1,816	1,643	3,724
Median, cfs	2,946	2,040	1,813	4,724	5,955	3,737	2,706	2,777	1,964	2,206	1,336	1,282	2,396
Rio Grande Below Anzalduas Dam - RM 169.8													
Mean, Acre-Feet	92,874	71,633	78,838	126,681	159,747	192,148	145,593	141,468	220,094	194,540	87,213	77,425	1,588,253
Mean, cfs	1,510	1,277	1,282	2,129	2,598	3,229	2,368	2,301	3,699	3,164	1,466	1,259	2,194
Median, cfs	1,215	998	1,109	1,884	2,315	2,702	1,829	1,329	1,131	1,110	856	789	1,315
Rio Grande near San Benito - RM 96.8													
Mean, Acre-Feet	41,297	39,243	32,946	47,200	74,948	83,922	72,439	75,623	128,922	139,104	60,104	50,550	846,298
Mean, cfs	672	698	536	793	1,219	1,410	1,178	1,230	2,167	2,262	1,010	822	1,169
Median, cfs	354	336	290	380	603	625	423	322	375	292	267	265	372
Rio Grande near Brownsville - RM 48.7													
Mean, Acre-Feet	33,203	33,893	27,531	33,976	59,986	67,278	61,622	64,553	116,336	134,571	59,106	48,581	740,636
Mean, cfs	540	602	448	571	976	1,131	1,002	1,050	1,955	2,189	993	790	1,023
Median, cfs	167	223	164	154	310	272	202	152	258	222	225	201	202

Source: 1968-1997 Historical data reported by IBWC for the Middle Rio Grande
1960-1997 Historical data reported by IBWC for the Lower Rio Grande

3.2.1.7.3 Historical Lower and Middle Rio Grande Water Balances

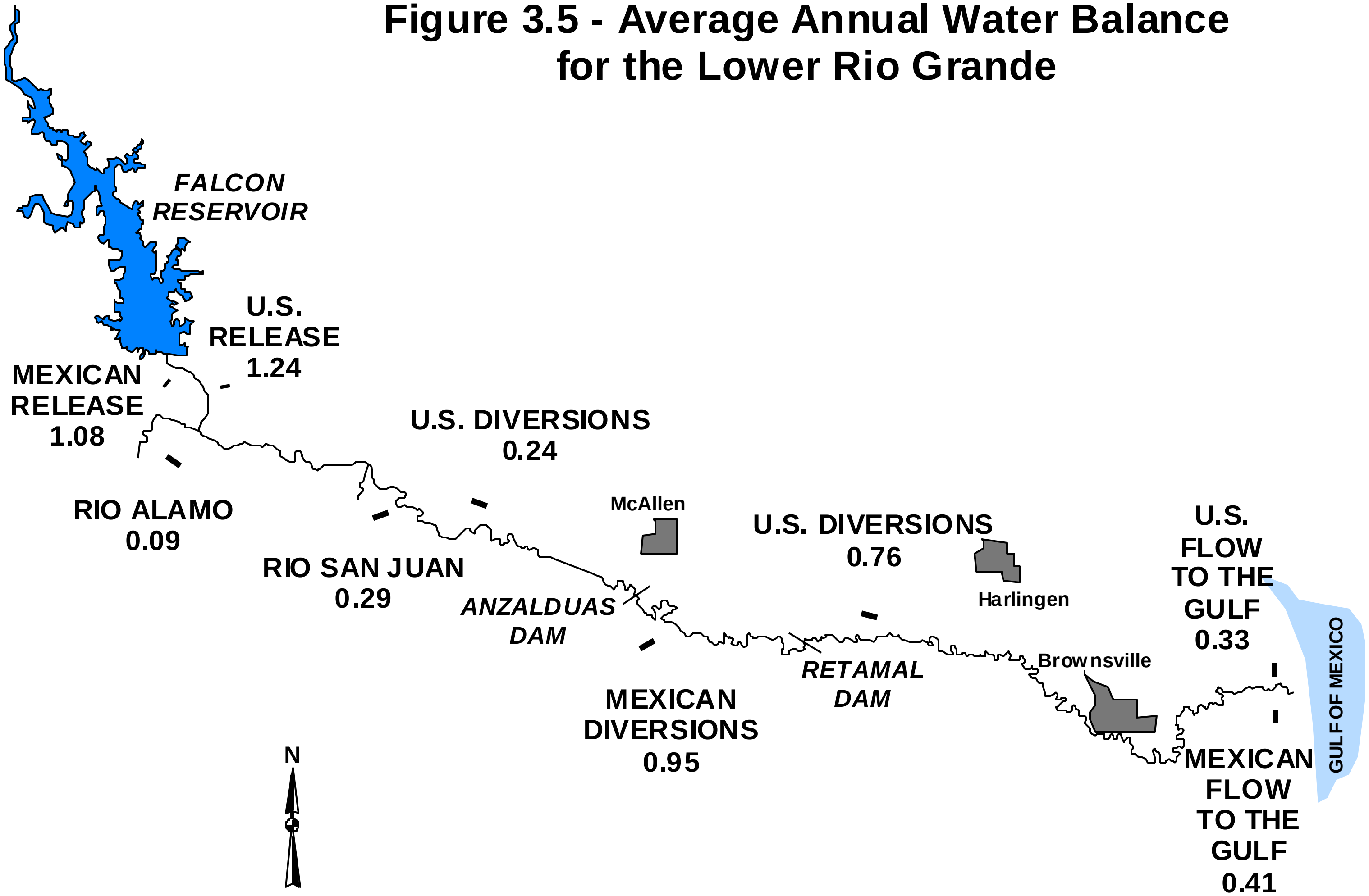
To provide an overview of hydrologic conditions in the lower and middle Rio Grande in terms of the inflows to the system and the various diversions and outflows from the system, the available IBWC flow records have been reviewed and analyzed to establish general trends and average flow values. Using data from IBWC's published annual Water Bulletins, together with information obtained from IBWC regarding the historical monthly quantities of United States and Mexican water released from Amistad and Falcon Reservoirs and flowing to the Gulf of Mexico, average annual inflows to, and outflows from, the lower Rio Grande have been determined for the period 1960-1997. These results are displayed on the conceptual drawing presented in Figure 3.5. Similar inflow and outflow values also have been determined for the middle Rio Grande between Amistad and Falcon Reservoirs for the period 1968-1997, and these results are presented in Figure 3.6. The timeframes used to develop the average flow values for these water balances also reflect the most recent periods for which data are available since the currently existing reservoirs on the Rio Grande have been in place and operating.

As shown in Figure 3.5, an average of about 1.24 million acre-feet per year of United States water has been released (or spilled during flood periods) from Falcon Reservoir, while Mexico has released (or spilled) an average of approximately 1.08 million acre-feet per year during the period 1960 through 1997. Mexico also has received significant inflows of water from Rio Alamo and Rio San Juan, all of which has been allocated to Mexico under the terms of the 1944 Treaty between Mexico and the United States. Inflows from the Rio Alamo and the Rio San Juan historically have averaged about 380,000 acre-feet per year; however, much of this water has occurred as flood flows and, without any means to capture and store the water, it has flowed to the Gulf. As shown on the diagram, an average of 410,000 acre-feet per year of Mexican water has flowed to the Gulf of Mexico since 1960.

On the United States side, of the average amount of water that has been released (or spilled) from Falcon Reservoir (1.24 million acre-feet per year) and that has flowed into the river as runoff from the ungaged watershed below Falcon Dam, an average of 1.00 million acre-feet per year have been diverted by United States users along the lower Rio Grande. During the period between 1960-1997, the United States share of water flowing to the Gulf of Mexico averaged about 330,000 acre-feet per year.

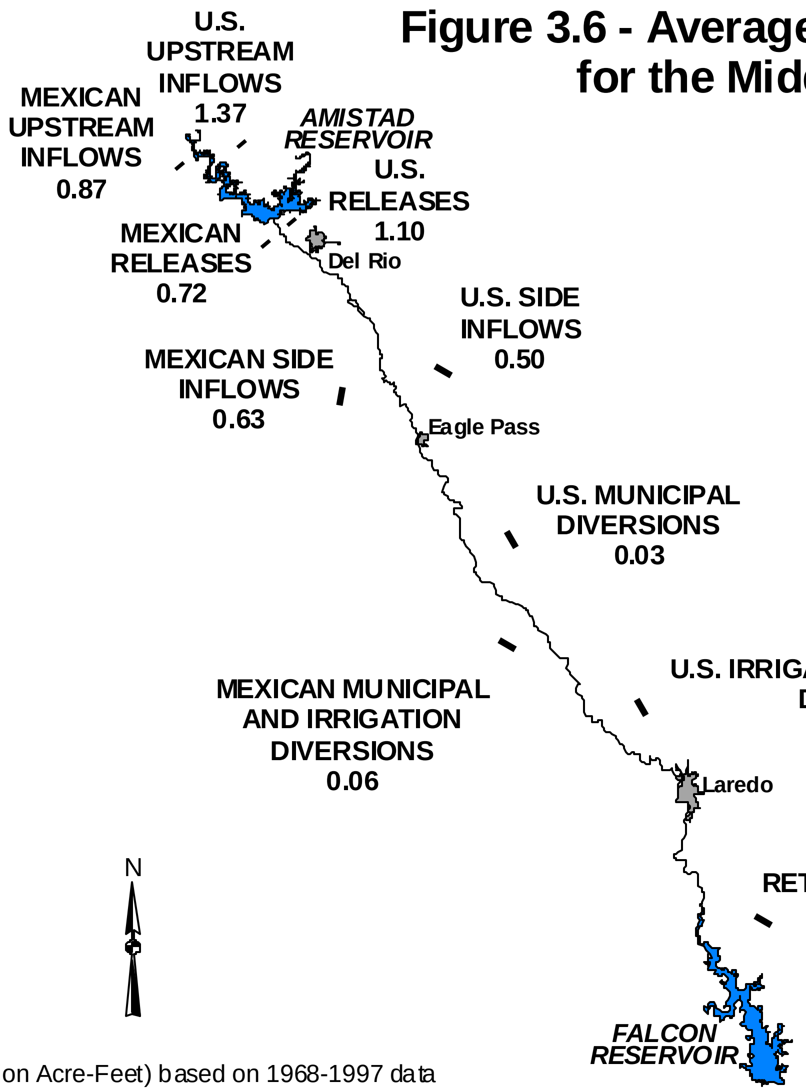
For the middle Rio Grande, as shown in Figure 3.6, the amounts of water that have been released from Amistad Reservoir have averaged about 1.10 million acre-feet per year for the United States and about 0.72 million acre-feet per year for Mexico. The corresponding inflows to Falcon Reservoir from the intervening watershed below Amistad Reservoir have been 0.50 million acre-feet per year for the United States and 0.63 million acre-feet per year for Mexico. As shown, most of the diversions from the river along this reach of the Rio Grande have been from the United States side.

Figure 3.5 - Average Annual Water Balance for the Lower Rio Grande



Averages (Million Acre-Feet) based on 1960-1997 data

Figure 3.6 - Average Annual Water Balance for the Middle Rio Grande



Averages (Million Acre-Feet) based on 1968-1997 data

3.2.1.7.4 Historical Storage in Amistad and Falcon Reservoirs

The monthly variations in the quantities of water stored in Amistad and Falcon Reservoirs since they were constructed are illustrated on the graphs in Figures 3.7 and 3.8, respectively. On each graph, the amounts of water in storage owned by the United States and by Mexico are indicated, along with the total storage values. The maximum conservation storage capacity of each of the reservoirs also is delineated. As shown, the level of storage in Amistad Reservoir typically has been higher relative to its maximum storage capacity than that in Falcon Reservoir. Similarly, Amistad Reservoir has spilled more often than Falcon Reservoir. This trend is consistent with the operating procedures for the two reservoirs whereby Amistad Reservoir is maintained as full as possible to more effectively conserve water with minimal evaporation losses, while releases from Falcon Reservoir are used primarily to meet the water demands of downstream users.

As illustrated, the lowest storage level to which Amistad Reservoir has ever fallen, since it was initially filled, was about 950,000 acre-feet in July 1996. Since the initial filling of Falcon Reservoir, the lowest level that it has dropped to was 286,600 acre-feet, also in July 1996. Hence, the severity of the current drought on the lower and middle Rio Grande, which began in late 1992, is evident from the low storage levels experienced in Amistad and Falcon Reservoirs.

3.2.1.7.5 Historical Storage in Mexican Tributary Reservoirs

The historical monthly variations in the quantities of water stored in the reservoirs located on tributaries of the Rio Grande in Mexico since 1950 are illustrated on the graphs in Figures 3.9 and 3.10. Figure 3.9 shows the historical combined storage in the major reservoirs located on tributaries that flow into the Rio Grande upstream of Falcon Dam. This includes the twelve reservoirs located on streams in the Rio Conchos, Rio San Diego, Rio San Rodrigo, and Rio Salado Basins as listed in Table 3.1. The historical combined storage in the reservoirs located on tributaries that enter the Rio Grande downstream from Falcon Dam, i. e. in the three reservoirs on the Rio San Juan as listed in Table 3.1, is illustrated by the graph in Figure 3.10.

As indicated by the plots, Mexico typically has had two to four million acre-feet of water stored in these tributary reservoirs. Since the beginning of the current drought in the Rio Grande Basin, the least amount of water stored in these reservoirs was approximately 822,000 acre-feet in May of 1995. Further discussion of storage in the Mexican tributary reservoirs and the current deficit accrued by Mexico with respect to its 1944 Treaty obligation to deliver minimum amounts of water to the United States from its tributaries is presented in Section 3.8.3 of this report.

3.2.1.8 Rio Grande Drought of Record

As illustrated by the historical annual inflows to Amistad and Falcon Reservoirs listed in Table 3.3 for the period 1945 through 1998, the flows in the Rio Grande during the 1950s appear to have been the lowest experienced during the last half century. Another analysis of long-term inflows of only United States water into Amistad and Falcon Reservoirs is presented by the graph in Figure 3.11. This plot shows the monthly variation of the 12-month and the 60-month running-average annual inflows for the period from 1900 through 1999. These historical reservoir inflows have been obtained from data originally developed

Figure 3.7 - Monthly Variations in Storage in Amistad Reservoir Since Its Closure

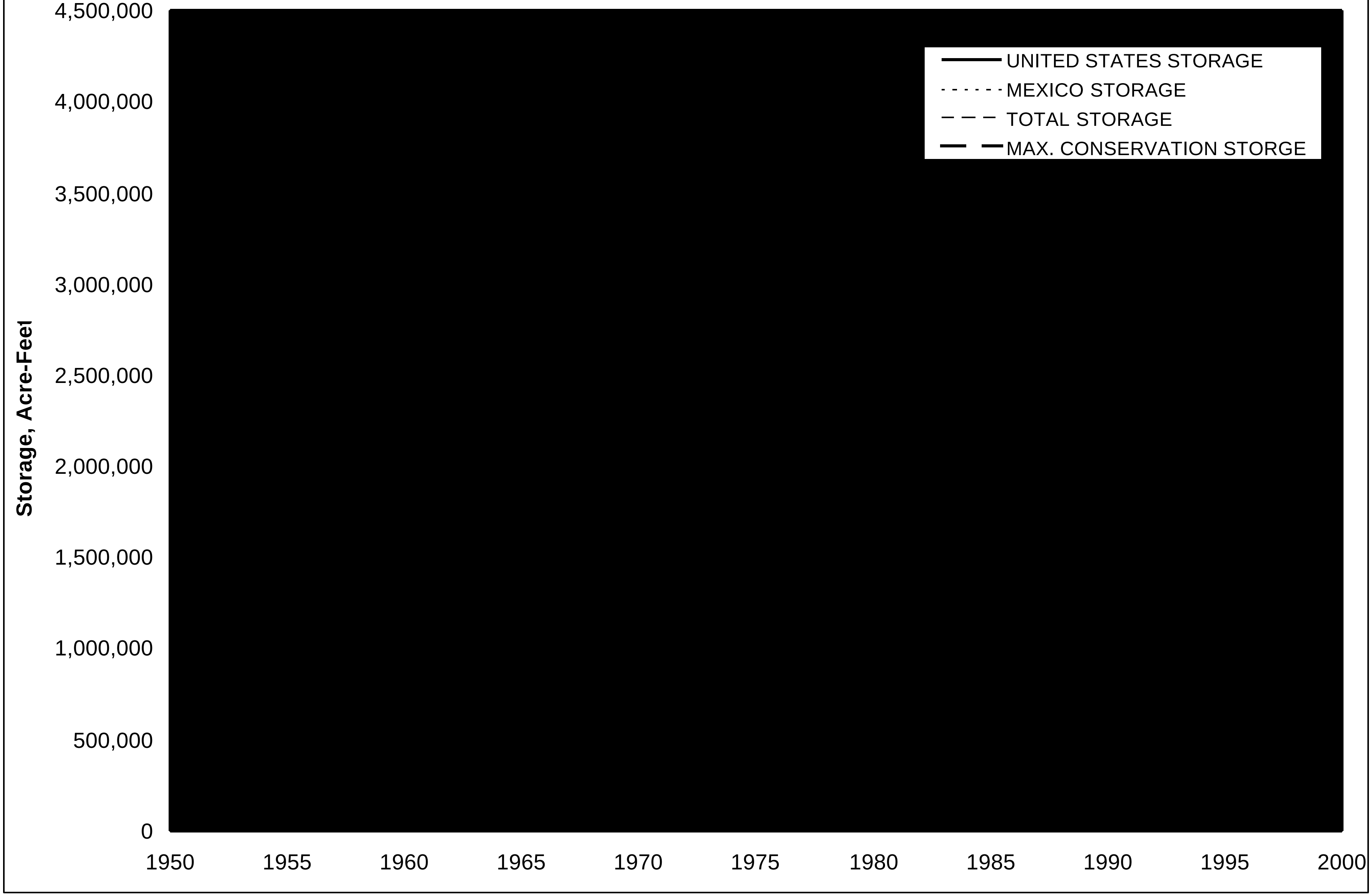


Figure 3.8 - Monthly Variations in Storage in Falcon Reservoir Since Its Closure

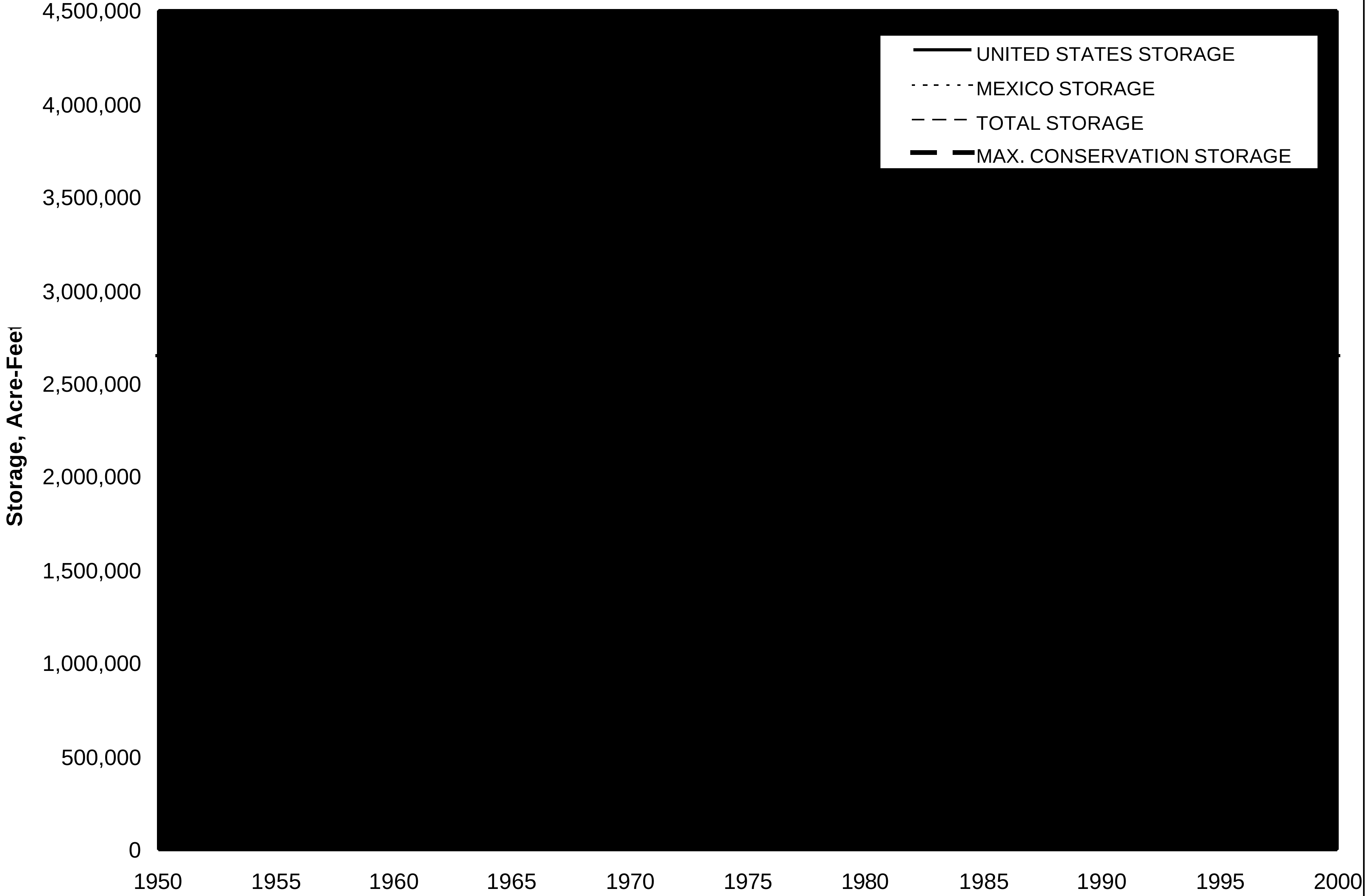


Figure 3.9 - Monthly Variations in Combined Storage in Mexican Reservoirs Located on Tributaries of the Rio Grande Upstream of Falcon Dam

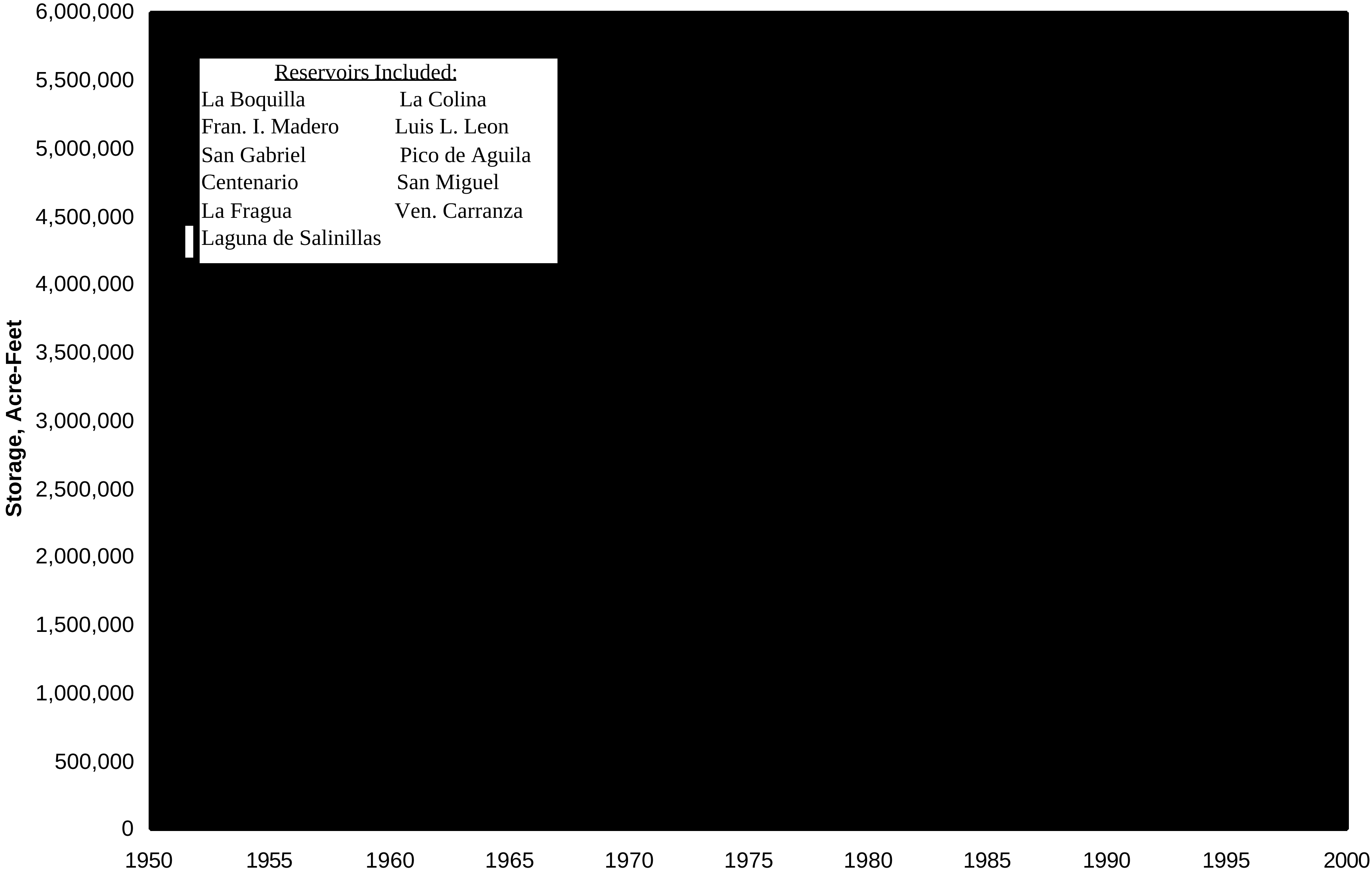
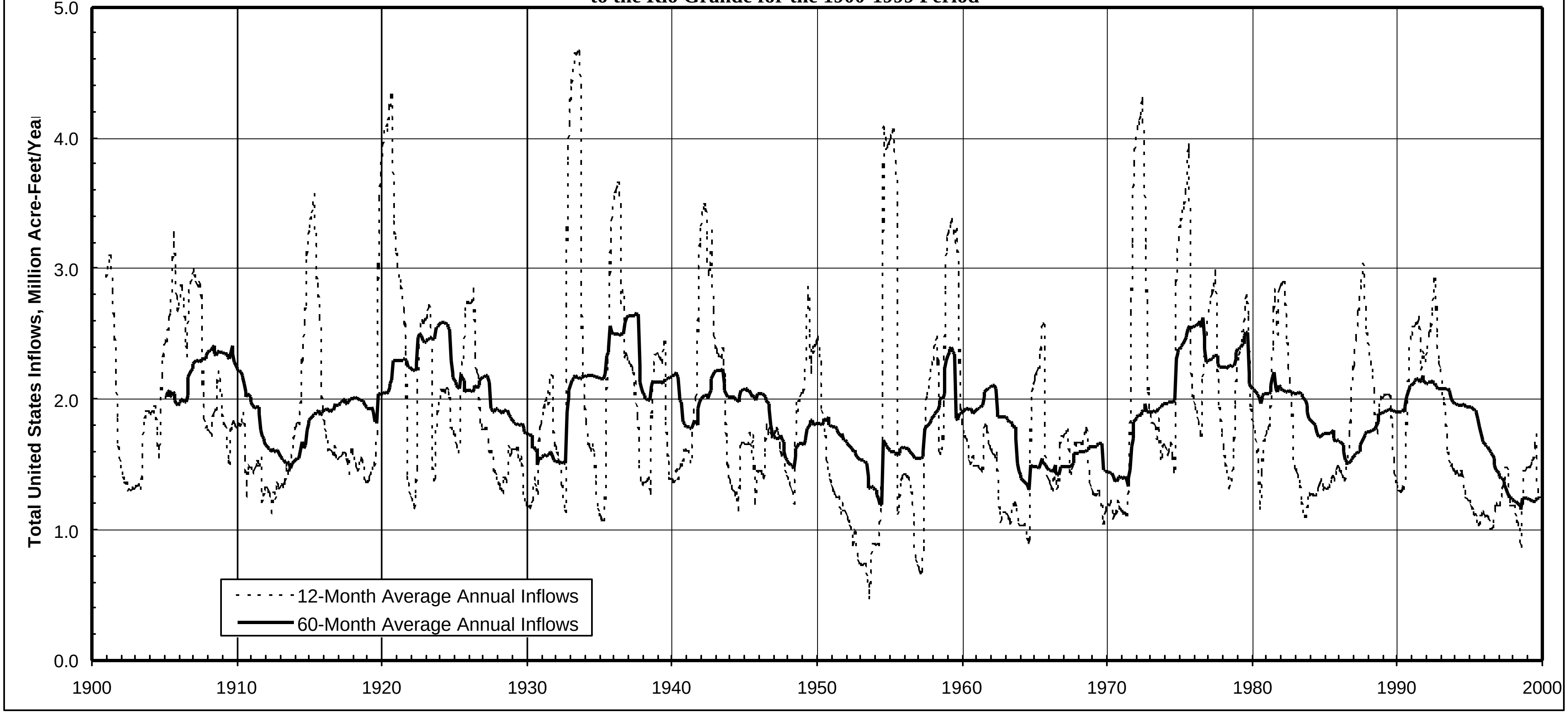


Figure 3.10 - Monthly Variations in Combined Storage in Mexican Reservoirs Located on Tributaries of the Rio Grande Downstream from Falcon Dam

Reservoirs Included:
Rodrigo Gomez
El Cuchillo
Marte R. Gomez

Note: Flows from these reservoirs are dedicated to Mexico by treaty.

Figure 3.11 - Variations in 12-Month and 60-Month Average Annual Total Inflows to the Rio Grande for the 1900-1999 Period



by the IBWC for the period 1900 through 1944[11], and from inflows provided directly by the IBWC for the period from 1945 through October 1999, with some modifications to adjust for revised gage data[12].

As indicated by the curves in Figure 3.11, even over the longer 100-year period, the drought of the 1950s appears to be the most severe; although, the lowest 60-month average inflow for the current drought of the 1990s is almost as low as that which occurred during the drought of the 1950s. The lowest value of the 12-month average annual inflow occurred during the period August 1952 through July 1953 (473,644 acre-feet), and the lowest 60-month average annual inflow occurred during the period from June 1949 through May 1954 (1,185,777 acre-feet). The 60-month lowest average annual inflow value is indicative of the average amount of annual water usage that might be sustained over the duration of a multi-year critical drought, with adequate storage in Amistad and Falcon Reservoirs.

3.2.2 Other Rio Grande Tributaries

In the RGRWPA counties outside of the Lower Rio Grande Basin, there are some existing water rights that authorize diversions from tributaries of the Rio Grande. As stated in the water rights permits, these diversions are for irrigation and mining uses. The tributaries of the Rio Grande with water rights include Javalin Creek in Zapata County; the North Branch of Manadas Creek, Chacon Creek, Becerro Creek and Salado Creek in Webb County; Los Olmos Creek in Starr County; and Rosita Creek in Maverick County. Streamflows in these tributaries typically are intermittent and occur only after rainfall periods. Hence, the water supplies provided by these tributaries also are not continuous and dependent upon local runoff conditions. No future development of the water resources, such as with on-channel or off-channel reservoirs, of these tributaries, or any other tributaries of the Rio Grande, is likely to occur because of the over-appropriated nature of the Rio Grande itself, particularly Amistad and Falcon Reservoirs. Although the reliability and availability of the water supplies from these tributaries as authorized by the existing water rights are questionable, particularly during drought of record conditions, it is possible that some water supplies could be provided from these sources. As described later in this report, only portions of the authorized diversion amounts of these Rio Grande tributary water rights have been accounted for in estimating the available current water supplies for the affected counties.

3.2.3 Arroyo Colorado

The Arroyo Colorado is an ancient channel of the Rio Grande that extends eastward for about 90 miles from near the City of Mission through southern Hidalgo County to the City of Harlingen in Cameron County, eventually discharging into the Laguna Madre near the Cameron-Willacy county line. The watershed of the Arroyo Colorado drains approximately 700 square miles and generally consists of coastal plain that slopes gently toward the Gulf of Mexico. Figure 3.12 presents a map showing the Arroyo Colorado and its watershed.

Flows in the Arroyo Colorado are sustained by treated wastewater discharges from cities in the region, irrigation return flows (tailwater), other agricultural runoff, stormwater runoff from urban areas, and base

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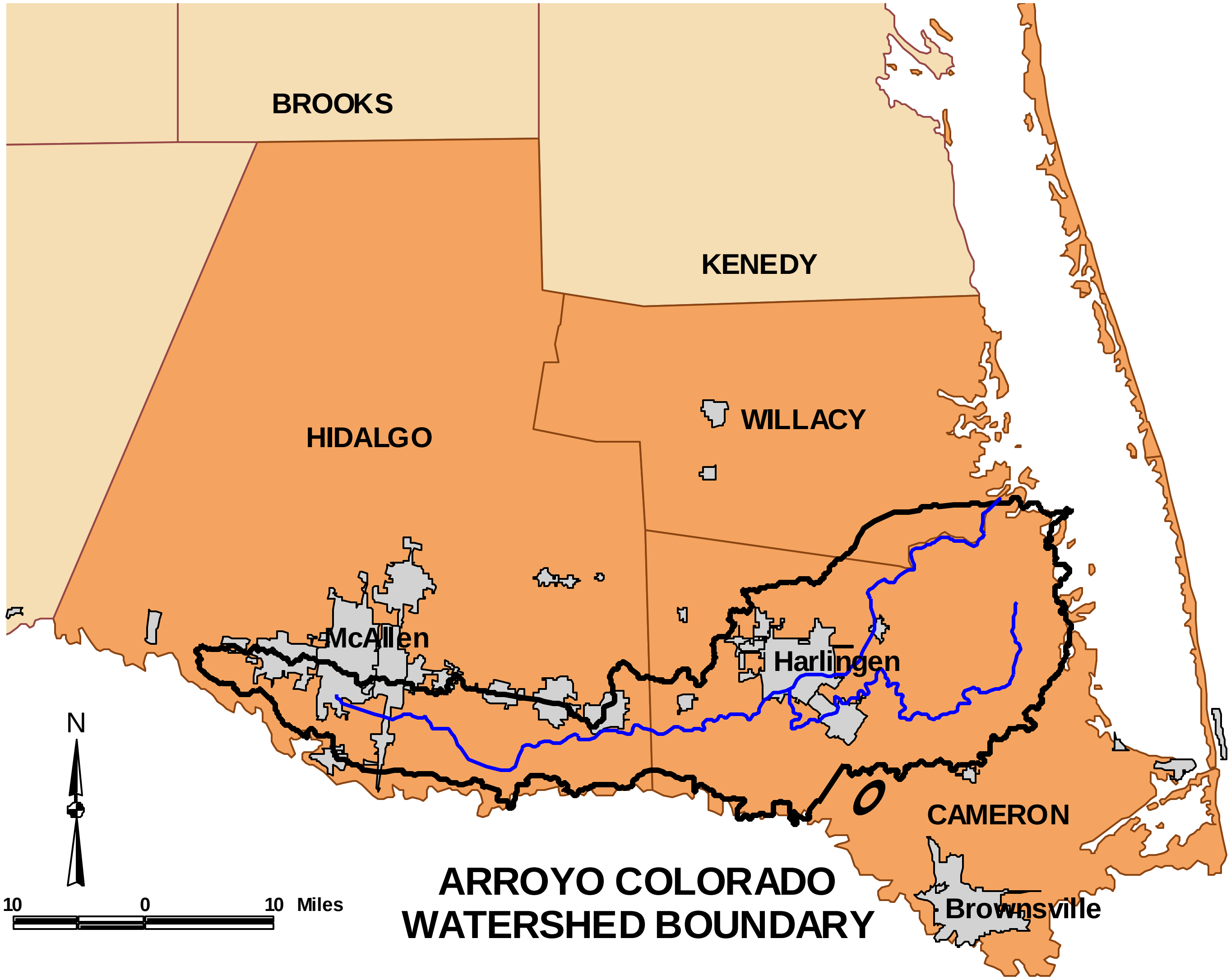
[11] Unpublished computer simulations of the operation of Amistad and Falcon Reservoirs.

[12] Revised estimates of monthly inflows to Amistad and Falcon Reservoirs for the United States and Mexico were derived by Perez-Freese & Nichols during Phase II of the previous Lower Rio Grande Integrated Water Resource Planning Study in 1999.

Figure 3.12 - Arroyo Colorado and its Watershed



flows from groundwater. Water also is occasionally diverted into portions of the Arroyo Colorado from the Rio Grande during major flood events on the river.

The Laguna Atascosa National Wildlife Refuge and several county and city parks are located along the banks of the Arroyo Colorado. The lower one-third of the watercourse is used for commercial shipping from the Gulf Intracoastal Waterway in the Laguna Madre upstream to the Port of Harlingen. Probably the most important use of the Arroyo Colorado, however, is as a source of freshwater inflows to the lower Laguna Madre. This portion of the Laguna Madre serves as an economically and ecologically important coastal water body in the region and the availability of freshwater inflows from the Arroyo Colorado is critical to maintaining its biological resources.

Use of the water in the Arroyo Colorado for municipal, industrial or irrigation purposes is severely limited because of poor quality conditions. Salinity concentrations in the Arroyo typically exceed the limits considered desirable for human consumption, as well as, those acceptable for irrigation of crops. Furthermore, water quality and fish tissue testing have found that: (1) low dissolved oxygen levels have impaired the fish community and other aquatic life downstream from the Port of Harlingen; (2) elevated levels of pesticides (chlordane, toxaphene and DDE) have resulted in a fish consumption advisory upstream from the Port of Harlingen; and, (3) bacteria levels are occasionally elevated indicating a potential health risk to people who swim or wade in the Arroyo upstream from the Port of Harlingen. In response to these use impairments, the TNRCC has initiated a Total Maximum Daily Load (TMDL) study to assess the specific causes of the observed water quality problems and to determine the pollution controls necessary to restore water quality in the Arroyo Colorado.

Because of the severe water quality problems that exist in the Arroyo Colorado, it has been assumed for purposes of this water planning study that there is no water currently available in the Arroyo Colorado for municipal, industrial, or irrigation uses within the RGRWPA. Some limited use of the water in the lower reach of the Arroyo Colorado occurs for aquaculture operations (shrimp farming), and this type of use may be expanded in the future. However, because of the importance of the freshwater inflows from the Arroyo Colorado to the biological resources of the Laguna Madre, future efforts to divert additional water from the Arroyo may be strongly resisted.

3.2.4 Nueces-Rio Grande Resacas

In the Lower Rio Grande Valley, particularly in Cameron County, there are a number of existing water rights that authorize surface water diversions from small isolated lakes referred to as resacas. For the most part, these resacas are old abandoned channels of the Rio Grande that now receive inflows from local runoff, irrigation return flows, groundwater, and, in some cases, diversions from the Rio Grande, and they normally are relatively full. Because the topography along the Rio Grande in this area generally slopes away from the river, these resacas actually are located outside of the Rio Grande watershed and are in the Nueces-Rio Grande Coastal Basin. The resacas in Cameron County with authorized diversions include Resaca Quates, Resaca Fresnos, Resaca De Los, and Resaca Del Ran.

The water rights permits for diversions from these resacas authorized 225 acre-feet of water per year for municipal use and 13,684 acre-feet per year for irrigation use. Although the reliability and availability of the permitted water supplies from these resacas during drought of record conditions have not been analyzed in detail, it appears that these resacas are capable of serving as effective sources of water for meeting localized demands. As such, it has been assumed that the authorized diversion amounts of these resaca water rights will be available as part of the overall water supply for Cameron County.

3.2.5 Springs

According to available publications and literature[13,14], existing springs within the Region M portions of the Rio Grande Basin and the Nueces-Rio Grande Coastal Basin are not numerous and small in terms of their discharge quantities. Much of the area is underlain by shales and marls which cannot store or transmit much water. Typically, the flow rate of the existing springs is less than 20 gallons per minute, with most springs flowing at a rate of only a few gallons per minute. There are no major springs that are extensively relied upon for water supply purposes. Many of the small springs do provide water for livestock and wildlife when they are flowing.

3.3 SURFACE WATER RIGHTS

In general, all users of surface water in Texas are required to possess a water right that authorizes, as necessary, a specified amount of surface water that can be diverted from a particular stream or reservoir, the maximum rate of diversion, the maximum storage capacity for a reservoir, and, in the case of irrigation, the location of the fields that are to be irrigated. The TNRCC is the State agency responsible for issuing and administering water rights in Texas.

For the RGRWPA, the water rights master file of the TNRCC, current as of 4 March 1999, has been reviewed and analyzed, and all water rights authorizing surface water diversions and use within the planning region have been identified and summarized. A compilation of these individual water rights according to owner, grouped by basin, county and type of use, is contained in Appendix 3A located in Volume II, Technical Appendix, of this report. For each county in the region, the water rights are listed separately for the Rio Grande Basin and for the Nueces-Rio Grande Coastal Basin according to source location. The water rights are further categorized according to type of use; i.e., municipal, industrial (manufacturing), irrigation, and mining.

Table 3.5 presents a summary of the surface water rights in each of the eight counties in the RGRWPA. The values contained in the table represent the maximum amounts of water that can be diverted annually under the authority of the existing water rights, expressed in acre-feet. As shown, a total of 2,262,683 acre-feet per year of surface water diversion rights currently exist within the region. Of this amount, about 13 percent (283,581 acre-feet per year) is for municipal uses and about two percent (55,788 acre-feet per year) is for industrial uses. The vast majority of the surface water rights in the region (1,919,979 acre-feet per year or about 85%) are authorized for irrigation.

Most of the surface water rights in the region are located in Hidalgo County (1,438,052 acre-feet of diversions per year or about 63%) and in Cameron County (499,599 acre-feet of diversions per year or about 22%). Approximately 96 percent of the total diversions authorized by the water rights in the RGRWPA are in the Rio Grande Basin, and practically all of these are associated with Amistad and Falcon Reservoirs.

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[13] Gunnar Brune; "Springs of Texas: Vol. 1; Branch-Smith, Inc.; Fort Worth, Texas; 1981.

[14] Gunnar Brune; "Major and Historical Springs of Texas"; Texas Water Development Board; Report 189; Austin, Texas; 1975.

Table 3.5 - Surface Water Rights by County (AF/Yr)

Basin / Type of Use	CAMERON	HIDALGO	JIM HOGG	MAVERICK	STARR	WEBB	WILLACY	ZAPATA	REGION M
RIO GRANDE BASIN									
Municipal	91,815	121,069	-	9,578	7,470	43,931	7,085	2,395	**283,343**
Industrial	3,754	8,080	-	-	-	2,195	-	-	**14,028**
Irrigation	334,396	1,298,176	-	138,661	51,612	29,771	5,525	10,386	**1,868,527**
Mining	112	767	-	88	78	1,925	-	366	**3,335**
COUNTY TOTAL	**430,076**	**1,428,092**	-	**148,327**	**59,160**	**77,821**	**12,610**	**13,146**	**2,169,233**
NUECES-RIO GRANDE BASIN									
Municipal	238	-	-	-	-	-	-	-	**238**
Industrial	38,210	300	-	-	-	-	3,250	-	**41,760**
Irrigation	31,075	9,660	-	-	-	-	10,717	-	**51,452**
Mining	-	-	-	-	-	-	-	-	**-**
COUNTY TOTAL	**69,523**	**9,960**	-	-	-	-	**13,967**	-	**93,450**
REGION M TOTAL									
Municipal	92,053	121,069	-	9,578	7,470	43,931	7,085	2,395	**283,581**
Industrial	41,964	8,380	-	-	-	2,195	3,250	-	**55,788**
Irrigation	365,471	1,307,836	-	138,661	51,612	29,771	16,242	10,386	**1,919,979**
Mining	112	767	-	88	78	1,925	-	366	**3,335**
COUNTY TOTAL	**499,599**	**1,438,052**	-	**148,327**	**59,160**	**77,821**	**26,577**	**13,146**	**2,262,683**

3.4 AMISTAD-FALCON RESERVOIR SYSTEM

As noted previously, the vast majority of the water used in the RGRWPA is diverted from the Rio Grande. For the most part, this water originates as releases from Amistad and Falcon Reservoirs, both of which are located on the mainstem of the river. For this reason, it is important to understand the operation of the Amistad-Falcon Reservoir System and to quantify the amount of water that potentially could be provided by these reservoirs during the drought of record.

3.4.1 Reservoir Operations Model

Because of the importance of Amistad and Falcon Reservoirs for supplying water to the region, previous studies have been undertaken by local water interests in the Lower Rio Grande Valley, with funding support from the TWDB and the Texas Governor's Office, to develop computer models with capabilities for simulating the operation and behavior of the reservoirs15. As the basis for developing and structuring the reservoir operations model (ROM) for the Amistad-Falcon Reservoir System, the existing SIMYLD-II reservoir system model, or computer program, has been used[16]. The original version of this program was formulated and coded by the TWDB in the early 1970s as part of that agency's overall mathematical simulation capabilities for analyzing water resources systems. Extensive modifications of the original SIMYLD-II program were made to adapt the program to the specific features and characteristics of the Amistad-Falcon system that otherwise could not have been described with either the existing program or the normal SIMYLD-II input data.

The basic SIMYLD-II program, as applied to the Amistad-Falcon system, provides a multi-reservoir simulation model capable of describing the movement and storage of water through a system of river reaches, canals, reservoirs and non-storage river junctions over a specified period of time. The Amistad-Falcon ROM utilizes a monthly time step to perform time-varying reservoir storage and river flow simulations subject to a specified sequence of water demands, river inflows, and reservoir evaporation losses. During the simulation process, the model strives to meet a set of specified demands and target reservoir storage conditions in a given order of priority. If shortages occur during the operation, i. e., not all demands or storage conditions can be satisfied for a particular time period, the shortages are spatially located and assigned at the lowest-priority demand or storage nodes.

The SIMYLD-II program is designed to provide flexibility in selecting operating rules for each reservoir in the system being simulated. The operating rules are formulated as the percentage of each reservoir's capacity (either total or conservation) that is desired to be held in storage at the end of each computational time step (each month). The operating rules provide flexibility by allowing the desired reservoir storage levels and the priorities for allocating water between satisfying demands and maintaining storage in the reservoirs to be varied by month during the year. Furthermore, these priorities can be changed during a simulation according to the hydrologic state of the system being modeled; i.e., dry, normal, or wet conditions based on system storage.

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[15] R. J. Brandes Company and Michael Sullivan & Associates, Inc.; "The International Reservoirs Operations and Drought Contingency Planning Study for the Middle and Lower Rio Grande, Phase I - Development, Testing and Application of ROM/CPM Modeling System and Phase II - Extension of ROM/CPM Modeling System to Include Individual Municipal and Irrigation Water Rights Accounts"; prepared for Valley Water Policy and Management Council of the Lower Rio Grande Water Committee, Inc.; submitted to Texas Water Development Board, Contract No. 95-483-143; Austin, Texas; August, 1998.

[16] Texas Water Development Board; "Economic Optimization & Simulation Techniques for Management of Regional Water Resource Systems, River Basin Simulation Model, SIMYLD-II Program Description"; July, 1972; Austin, Texas.

The fundamental concept in applying the SIMYLD-II program is that the physical reservoir system must be transformed into a capacitated network flow problem. In making this transformation, the real system's physical elements are represented as a combination of two possible network components - nodes and links. Given the proper parametric description of these two network components, it becomes a straightforward task to develop the necessary network. Once properly developed, the network system can be analyzed as a direct analog of the real system.

As the nomenclature implies, a node is a connection and/or branching point within the network. Therefore, a node is analogous to a reservoir or a non-storage junction; e.g., a canal junction, major river confluence, etc., in the physical system. Additionally, a node is a network component that is considered to have the capacity to store a finite and bounded amount of the water moving within the network. In the case of SIMYLD-II, reservoirs are represented by nodes, which have storage capacity, as well as, the ability to serve as branching points. A non-storage capacitated junction is handled similarly to a capacitated junction (reservoir) except that its storage capacity is always zero. Demands placed on the system must be located at nodal points. Also, any water entering the system, such as might occur naturally from upstream river inflows or artificially by import, must be introduced at nodal points.

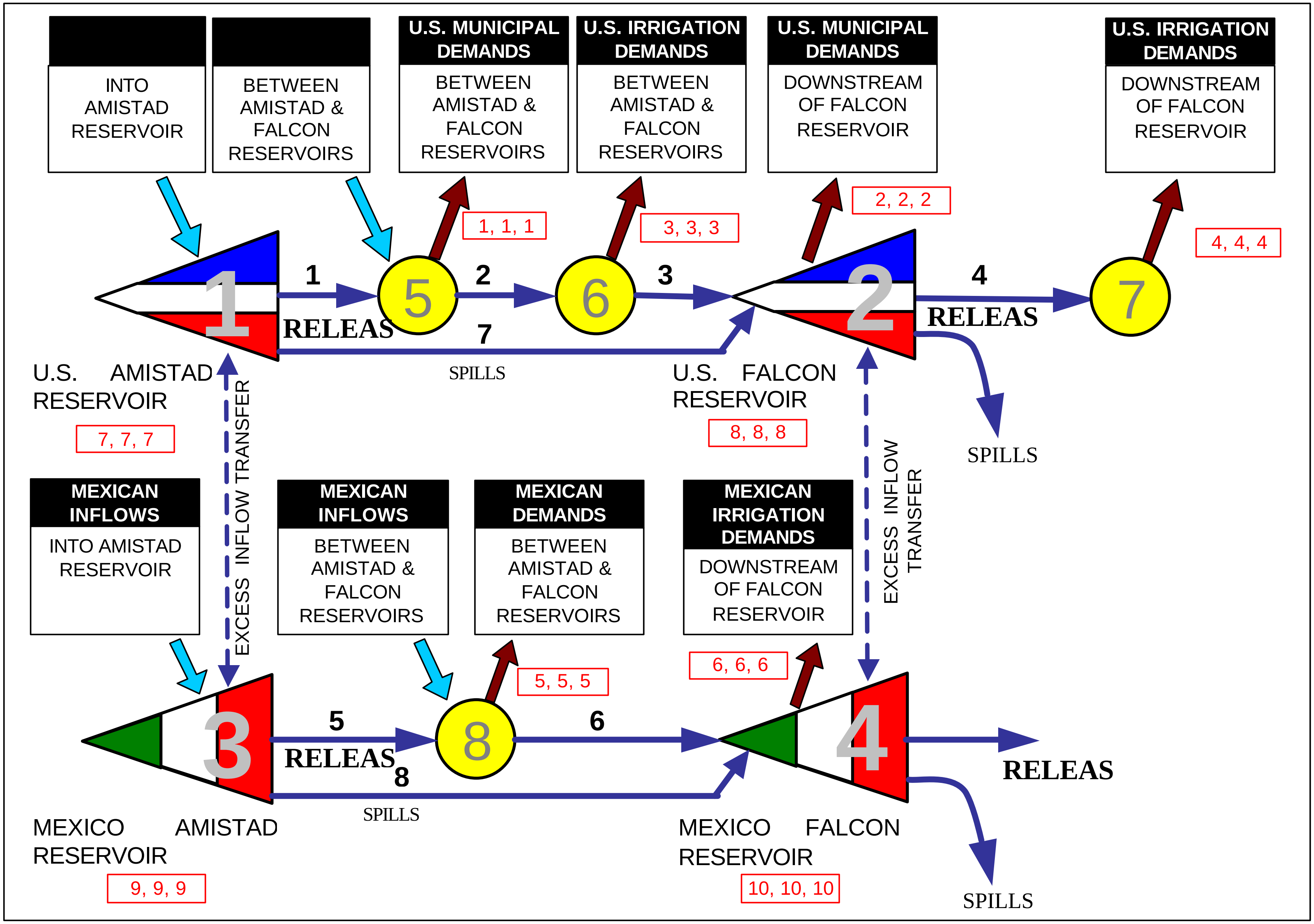
The transfer of water among the various network nodes is accomplished by transfer components called links. Typically, a link is a river reach, canal or closed conduit with a specified direction of flow and a fixed maximum and minimum capacity. The specified maximum capacity represents the upper limit on the amount of water that can be conveyed through a link. The minimum capacity establishes a required minimum flow that must be conveyed through a link at all times.

The SIMYLD-II link-node network used for representing the various components of the Amistad-Falcon system in the ROM is shown in Figure 3.13. As illustrated by this diagram, the Amistad-Falcon ROM consists basically of two separate water storage and conveyance systems; one for the United States and one for Mexico. In this network, the physical system elements for each of the two countries are represented by the network elements in the following manner:

For the United States:

1. The portions of Amistad and Falcon Reservoirs used to store United States water are represented by triangles identified as Nodes 1 and 2, respectively;
2. The United States total municipal water demand between Amistad and Falcon Reservoirs is specified at a non-storage junction identified as Node 5;
3. The United States total irrigation water demand between Amistad and Falcon Reservoirs is specified at a non-storage junction identified as Node 6;
4. The United States total municipal water demand below Falcon Reservoir, including channel losses, is specified at the United States Falcon Reservoir storage junction identified as Node 2;
5. The United States total irrigation water demand below Falcon Reservoir, including channel losses, is specified at a non-storage junction identified as Node 7; and,
6. River reaches between the United States Amistad and Falcon Reservoir storage nodes and the various United States demand nodes are represented by solid lines showing the direction of flow and numbered 1, 2, 3, and 4.

Figure 3.13 – Link-Node Network For Amistad-Falcon Reservoir Operations Model



For Mexico:

1. The portions of Amistad and Falcon Reservoirs used to store Mexican water are represented by triangles identified as Nodes 3 and 4, respectively;
2. The Mexican total municipal and irrigation water demand between Amistad and Falcon Reservoirs is specified at a non-storage junction identified as Node 8;
3. The Mexican total municipal and irrigation water demand below Falcon Reservoir, including channel losses, is specified at the Mexican Falcon Reservoir storage junction identified as Node 4; and,
4. River reaches between the Mexican Amistad and Falcon Reservoir storage nodes and the various Mexican demand nodes are represented by solid lines showing the direction of flow and numbered 5 and 6.

The inflows to the reservoir system, which are comprised of Rio Grande inflows to Amistad Reservoir and tributary inflows to the Rio Grande from the watershed between Amistad and Falcon Reservoirs (referred to as side inflows or incremental inflows), for both the United States and Mexico are indicated on the network diagram by inward arrows at Nodes 1, 3, 5, and 8. Flood spills from Amistad Reservoir are allowed in the model at the Amistad Reservoir storage nodes; i.e., at Node 1 for the United States and Node 3 for Mexico. These flood spills enter each country's respective storage pool in Falcon Reservoir through Link 7 for the United States and Link 8 for Mexico. Spills from the system into the lower Rio Grande can occur at the Falcon Reservoir storage nodes; i.e., at Node 2 for the United States and Node 4 for Mexico. The dashed lines with double arrows between Nodes 1 and 3 (Amistad Reservoir) and Nodes 2 and 4 (Falcon Reservoir) indicate the capability of the model for transferring one country's excess inflows to the other country's conservation pool when the first country's conservation pool is full. This feature is provided for in the 1944 Treaty between the United States and Mexico.

Each of the storage nodes and the demand nodes in the Amistad-Falcon ROM network has been assigned a set of priority numbers that establish the relative priorities among nodes for either storing water or meeting specified water demands during the simulation process. The highest priority for storing water and/or meeting a demand is assigned the lowest number; i.e., a value of one. Sequential higher-value priority numbers then are assigned in accordance with the order in which storage and/or demands at specific nodes are to be shorted, or left unsatisfied, in the event there is not sufficient water in the system to satisfy all desired storage and demand requirements. The specific priorities assigned to the individual nodes and their respective storage/demand activities in the Amistad-Falcon ROM are indicated on the link-node diagram in Figure 3.13.

The definition of the storage/demand priorities for the nodes in the Amistad-Falcon ROM generally reflect current operating procedures for the reservoir system and current demand priorities established by both the United States and Mexico. For example, both countries recognize the higher priority of meeting human water needs; i.e., municipal demands, before irrigation water needs. Hence, all of the municipal demands for each country that are included in the ROM are assigned a higher priority (lower priority number) than the irrigation demands. The use of higher priorities for water demands below Falcon Reservoir in the Lower Rio Grande Basin than those specified for demands along the middle Rio Grande is purely arbitrary and actually makes little difference with regard to the ability of the reservoirs to supply water to users in either the Lower or the Middle Rio Grande Basins. The higher priority assigned to the storage of river inflows in Amistad Reservoir, rather than in Falcon Reservoir, is consistent with accepted water conservation and reservoir system operation practices in that it results in less overall evaporation losses from the reservoirs and tends to optimize the river flow capture ability of the two impoundments. Furthermore, Article 8, §(a), of the 1944 Treaty between the United States and Mexico[17] stipulates that "storage in all major international reservoirs above the lowest shall be maintained at the maximum possible water level, consistent with flood control, irrigation use and power requirements". According to IBWC, Falcon Reservoir is the "lowest international reservoir" on the Rio Grande for purposes of the treaty; therefore, it is the policy of IBWC to maximize the storage of water in Amistad Reservoir upstream.

As indicated on the diagram in Figure 3.13, three priority assignments are specified for each node in the ROM with regard to storage/demand activities. The three priority assignments reflect the priorities that are active in the model under three different prescribed hydrologic conditions which are defined based on the amount of water in reservoir storage; i.e., a "Mod" (Moderate) storage condition, a "Low" storage condition, and a "High" storage condition. As the Amistad-Falcon ROM is presently structured, the particular hydrologic state of the reservoir system for either the United States or Mexico is determined by the amount of water stored *only* in Falcon Reservoir; i.e., the most-downstream reservoir. Since the normal reservoir operation practice is to maintain Amistad Reservoir as full as possible, the hydrologic state of the system at any point in time is better reflected by the amount of water stored in Falcon Reservoir, since its storage tends to fluctuate more directly with variations in inflows and demands. For most simulations with ROM, no changes are made among the various priorities in accordance with the hydrologic state of the system; hence, all of the priorities at each of the nodes are set equal to the same value.

With the model network defined to approximate the components and physical features of the Amistad-Falcon system, the solution procedure in the ROM progresses stepwise in moving from a known set of state variables; i.e., nodal storage volumes and link flow values, at the beginning of a time step (end of Month J), to the solution for the required set of state variables at the end of the time step (end of Month J+1). The four-step solution process that is repeated each month during a simulation period is as follows:

1. The present status of the network is evaluated, and all system elements are given an appropriate parametric description;

2. All specified hydraulic and hydrologic inputs and demands are accounted for, and the mass balance for the entire network system is determined. Bounds are placed on system demands, spills and storage levels;

3. The flows necessary to meet the levels required by Step 2 and, at the same time, to minimize the system's total cost of water transport are determined through the application of an optimization procedure; and,

4. All necessary state variables have now been determined, and the status of the system at the conclusion of the current time step becomes the status at the beginning of the next time step.

This solution procedure is repeated in a stepwise fashion until the specified simulation period has been spanned. The resulting outputs from the SIMYLD-II program, when operated in this manner, are the time variations in reservoir storage and channel or conduit flow for all of the network elements over the duration of the simulation period. Hence, the basic simulated results from the ROM for the Amistad-

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[17] "Treaty Between the United States and Mexico, Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande"; February 3, 1944; Washington, D. C.

Falcon Reservoir System are: (1) the end-of-month values of storage in the United States and the Mexican portions of Amistad and Falcon Reservoirs; (2) the monthly volumes of United States and Mexican water released from Amistad Reservoir to meet downstream demands or Falcon storage requirements; (3) the monthly volumes of United States and Mexico water spilled from Amistad Reservoir when the conservation storage of both countries is full; (4) the monthly volumes of United States and Mexican water released from Falcon Reservoir to meet downstream demands; and, (5) the monthly volumes of United States and Mexico water spilled from Falcon Reservoir when the conservation storage of both countries is full.

One important aspect of the Amistad-Falcon ROM is its ability to also simulate the storage and allocation of United States water among the various pools and accounts specified in the TNRCC's Rio Grande operating rules as described in Section 3.2.1.6.3 above. In this regard, the ROM determines each month during the simulation the quantities of United States water allocated to the DMI pool, the operating reserve, and the irrigation accounts. Irrigation accounts also are debited and credited each month according to specified irrigation demands, inflows to the reservoir system, and the requirements for maintaining the higher-priority operating reserve. Finally, the ROM also has the capability to simulate the accounting for three individual water rights holders, with each having specified amounts of municipal, Class A irrigation and Class B irrigation rights.

3.4.2 Projected Reservoir Sedimentation Effects

Fundamental to properly simulating the storage behavior of Amistad and Falcon Reservoirs and to effectively accounting for evaporation losses is an accurate description of the relationships between the water surface elevation of each of the reservoirs and surface area and storage volume. These relationships, often referred to as "elevation-area-capacity" relationships, typically are derived from topographic maps of the reservoir sites before they were constructed or from bathymetric surveys of the reservoir bottoms after they have been impounded. As the reservoirs have aged over time, their elevation-area-capacity relationships have changed primarily due to sediment loadings that have been discharged into the reservoirs with inflows from their respective watersheds. Typically, the bottom contours of the reservoirs have been altered as sediment has been deposited, and the storage volume of the reservoirs has been reduced. The reduced storage volume of the reservoirs, in turn, can result in corresponding reductions in the firm annual yield of the reservoirs. Hence, for water supply planning purposes, it is important to project the degree to which future sediment loadings may further reduce the storage capacity of the reservoirs and how these storage reductions may impact the yield of the reservoirs.

The IBWC has developed elevation-area-capacity relationships for both Amistad and Falcon Reservoirs at different times since they were initially impounded. The most recent relationships were based on bathymetric surveys conducted in 1992 for both reservoirs. Prior to 1992, elevation-area-capacity relationships were determined in 1980 for Amistad Reservoir and in 1972 for Falcon Reservoir. Comparison of these sets of relationships for each of the reservoirs provides insight regarding the most recent sedimentation rates that have been effective in reducing the storage volumes of the reservoirs. Figure 3.14 presents a plot of the variation of storage volume in Amistad Reservoir with water surface elevation for the 1980 and the 1992 sedimentation conditions. A similar graph for Falcon Reservoir is presented in Figure 3.15 for the 1972 and the 1992 sedimentation conditions.

Examination of the storage-versus-elevation graphs indicates that Amistad Reservoir experienced moderate storage volume reductions due to sedimentation during the period between 1980-1992, whereas

Figure 3.14 - Elevation-Storage Relationships for Amistad Reservoir Based on 1980 and 1992 Bathymetric Surveys

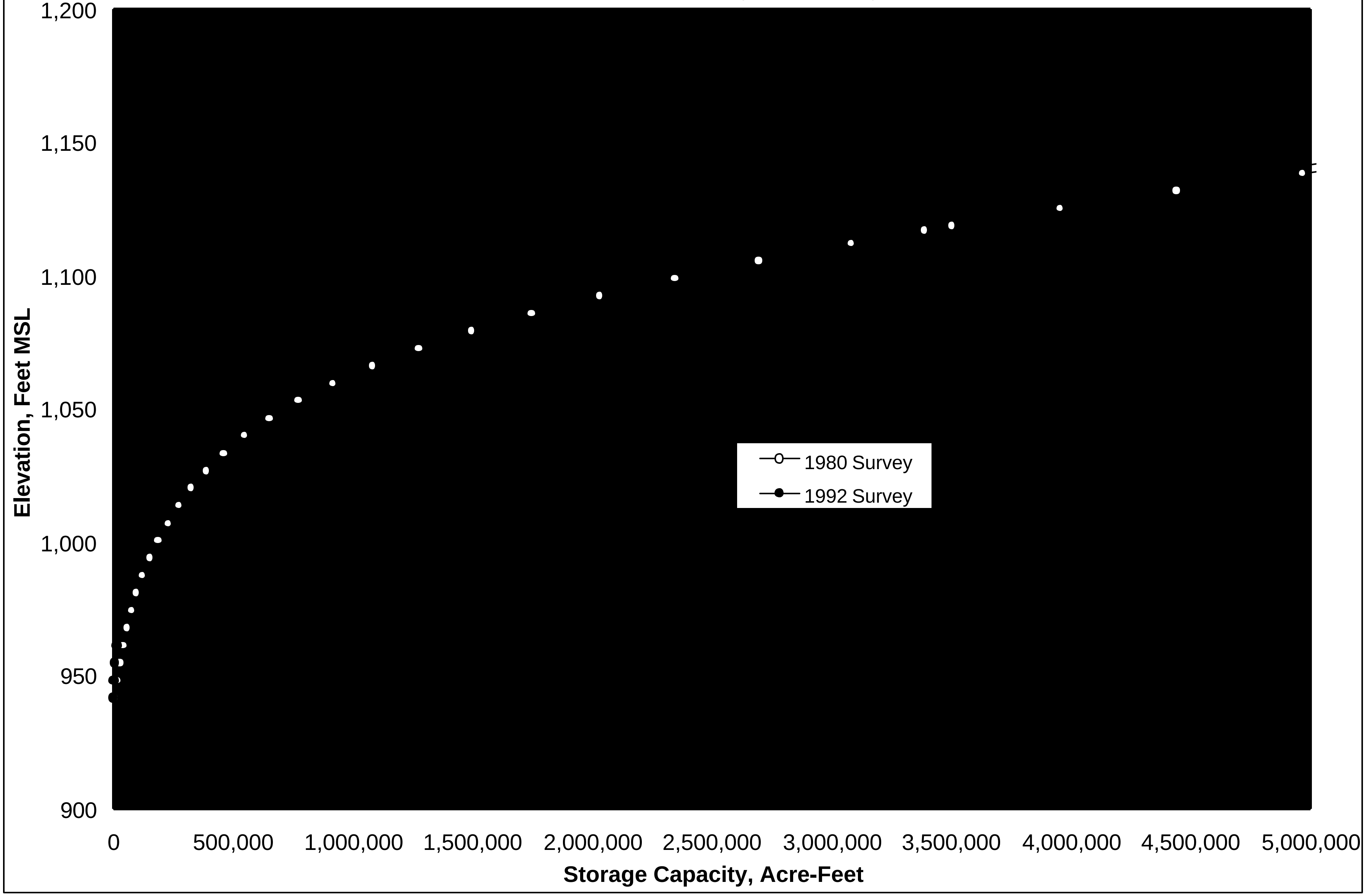
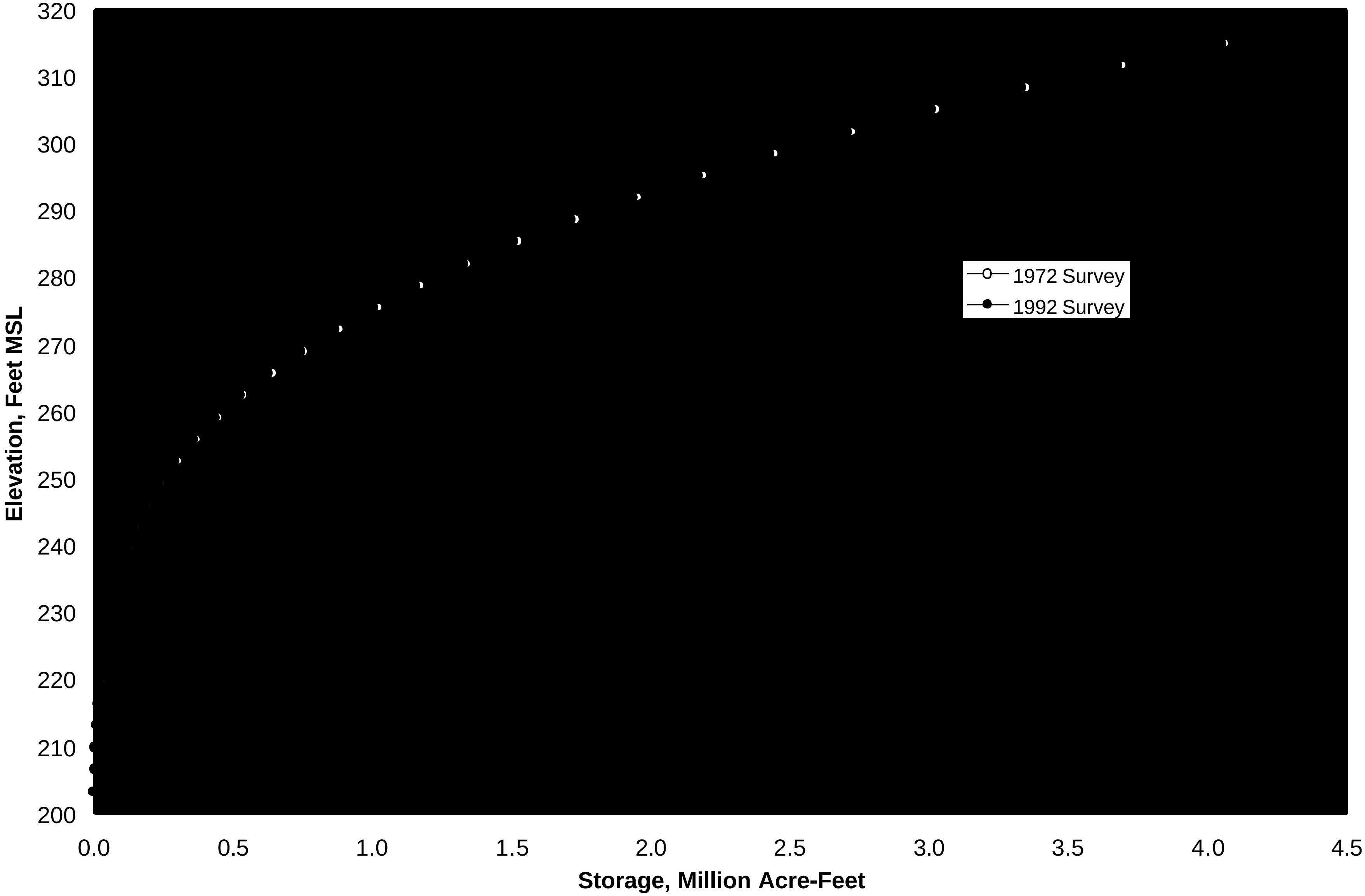


Figure 3.15 - Elevation-Storage Relationships For Falcon Reservoir Based on 1972 and 1992 Bathymetric Surveys



the reduction in the storage volume of Falcon Reservoir during the 1972-1992 period appears to have been minimal. One reason for these differences in sedimentation rates is that Amistad Reservoir is located upstream of Falcon Reservoir and, in effect, captures sediment loadings carried by the Rio Grande before they can enter Falcon Reservoir. Another possible cause is that the average inflows to Amistad Reservoir from its upstream watershed are about twice the average inflows into Falcon Reservoir from the intervening watershed between Amistad and Falcon Reservoirs. Hence, sediment loadings into Amistad Reservoir should be somewhat greater.

The average reservoir sedimentation rates exhibited by the changes in storage volume of Amistad and Falcon Reservoirs shown on the graphs in Figures 3.14 and 3.15 provide a means for projecting future sedimentation conditions in the reservoirs for water supply planning purposes. For Amistad Reservoir, the average sedimentation rate between 1980 and 1992 was on the order of 19,400 acre-feet per year, whereas for Falcon Reservoir between 1972 and 1992, the average sedimentation rate was only about 700 acre-feet per year. These rates of sedimentation in the reservoirs represent corresponding annual reductions in their conservation storage capacities equal to about 0.6 percent for Amistad and about 0.03 percent for Falcon.

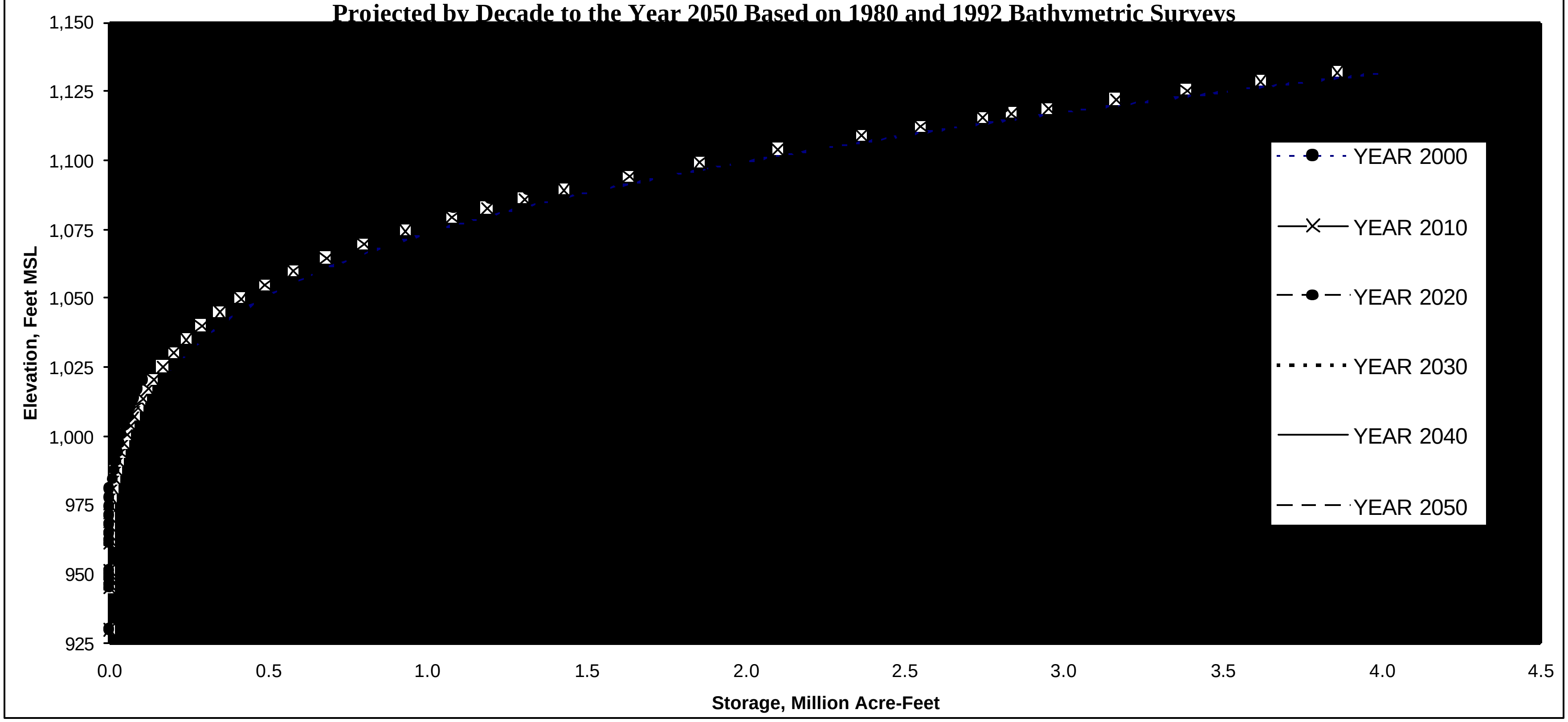
During previous water planning efforts for the Lower Rio Grande Valley, the above observed sedimentation rates for Amistad and Falcon Reservoirs also were examined for purposes of projecting the effects of future sedimentation in the reservoirs on their respective elevation-area-capacity relationships and firm annual yields over the next 50 years. The results from these earlier investigations have been adopted for use in this water supply planning study for the RGRWPA. For Amistad Reservoir, the observed sedimentation rate during the 1980-1992 period was applied to develop adjusted elevation-area-capacity relationships for each decade through the year 2050. The resulting storage-versus-elevation curves for each decade between the year 2000 and 2050 are plotted in Figure 3.16. As expected, these curves gradually shift over time in the direction of lesser amounts of available conservation storage in the reservoir. The corresponding maximum amounts of conservation storage available to the United States and to Mexico in Amistad Reservoir by decade based on these curves are listed below in Table 3.6.

Table 3.6: Projected Maximum Conservation Storage Available in Amistad Reservoir

Year	United States Conservation Storage Acre-Feet	Mexico Conservation Storage Acre-Feet
2000	1,673,055	1,303,912
2010	1,594,648	1,242,804
2020	1,516,541	1,181,696
2030	1,437,833	1,120,588
2040	1,359,425	1,059,481
2050	1,281,018	998,373

For Falcon Reservoir, the historical volume reduction due to sedimentation that occurred during the 1972-1992 period (0.03 % per year) was considered to be negligible; therefore, no adjustments in the elevation-area-capacity relationships were considered necessary to reflect future reservoir sedimentation effects. Consequently, the 1992 storage-versus-elevation curve presented in Figure 3.15 has been used in this study for all analyses of the future operation and yield of Falcon Reservoir.

Figure 3.16 - Elevation-Storage Relationships for Amistad Reservoir
Projected by Decade to the Year 2050 Based on 1980 and 1992 Bathymetric Surveys



3.4.3 Reservoir System Firm Annual Yield

The firm annual yield of a reservoir or system of reservoirs is defined as the maximum amount of water that can be withdrawn from the reservoir(s) each year during the occurrence of the drought of record without causing the reservoir(s) to go dry. For water supply planning purposes, the TWDB requires that no more than this amount of surface water be considered as available from a reservoir, or reservoir system, for meeting future water demands. Hence, for purposes of the Rio Grande water supply planning effort, it is has been necessary to develop projections of the future firm annual yield of the Amistad-Falcon Reservoir System since this system currently supplies and will continue to supply over the 50-year planning horizon the vast majority of the water used in the region. As described in the following sections, firm annual yield amounts have been determined under two conditions of inflow: (1) actual historical inflows as they have occurred during the 1945-1998 period; and, (2) adjusted historical inflows as they might recur in the future without the minimum inflow requirement of 350,000 acre-feet per year for the United States from the Mexican tributaries identified in the 1944 Treaty.

3.4.3.1 Actual Historical Inflows

The determination of the firm annual yield of Amistad and Falcon Reservoirs has been accomplished by operating the Amistad-Falcon ROM under long-term historical hydrologic conditions that are known to include the drought of record. Specifically, simulations have been made with the ROM using historical reservoir inflows for the United States and for Mexico as they occurred during the period from 1945 through 1998. For these simulations, water demands for the United States and for Mexico have been specified in the ROM at the demand nodes previously identified on the ROM link-node diagram in Figure 3.13 in accordance with current demand distributions (geographically and by type of use) and use patterns (by month of the year). The total demands for each country have been successively adjusted through an iterative process of ROM simulations until the firm annual yield condition (minimal non-zero reservoir storage) for both countries has been achieved. The resulting total demand for each country as specified in the ROM then has been considered to be each country's share of the firm annual yield of the Amistad-Falcon system.

This procedure has been applied for each of the projected elevation-area-capacity relationships for the reservoirs as described above for the years 2000, 2010, 2020, 2030, 2040, and 2050. As the available conservation storage capacity in the reservoirs has been reduced over time due to sedimentation effects, the resulting firm annual yield of the system also has decreased.

Results from the firm annual yield analyses using historical reservoir inflows are presented in Table 3.7. Values of the firm annual yield of the Amistad-Falcon Reservoir System are listed for both the United States and Mexico by decade for the period 2000 through 2050. As expected, the firm yield of the system for both countries gradually decreases in the future as sedimentation of the reservoirs is projected to occur over time. The United States' share of the firm annual yield of the reservoir system decreases from 1,166,939 acre-feet per year in the year 2000 to 1,052,483 acre-feet per year in the year 2050, a reduction of about ten percent. Again, these yield values represent the maximum amount of water that can be withdrawn from the reservoirs on a continual basis by the United States should conditions similar to the drought of record recur.

For Mexico, the firm annual yield of the reservoir system is projected to decrease from about 988,200 acre-feet per year in the year 2000 down to about 924,300 acre-feet per year in 2050. Mexico's yield from the reservoirs is different from that of the United States because each country receives different amounts of inflows to the reservoirs in accordance with actual historical hydrologic conditions and the terms of the 1944 Treaty and because the amounts of conservation storage owned by each of the countries in the reservoirs are different.

Table 3.7 - Projected Firm Annual Yields of the Amistad-Falcon Reservoir System For the United States and Mexico by Decade Through the Year 2050 Based on Actual Historical Inflows

Year	United States	Mexico	Total
2000	1,166,939	988,198	2,155,137
2010	1,150,078	972,332	2,122,410
2020	1,128,879	971,876	2,100,755
2030	1,106,110	954,132	2,060,242
2040	1,077,718	942,111	2,019,829
2050	1,052,483	924,332	1,976,815

The simulated monthly storage levels for the United States and for Mexico in Amistad and Falcon Reservoirs combined from the firm annual yield analysis for year-2000 reservoir sedimentation conditions are plotted on the graph in Figure 3.17 for the entire 1945-1998 simulation period. As illustrated, the minimum storage level in the reservoirs for United States water occurs during the 1950s drought; i.e., the drought of record for the Rio Grande. However, it is important to note that the United States minimum storage level during the current drought of the 1990s also is relatively low and, indeed, if the current drought continues, could drop to or below the level indicated for the 1950s drought. In effect, if the current drought persists and inflows to the reservoirs continue to be low, the drought of record for the United States portion of the reservoir system could shift to the current drought and the firm annual yield of the reservoirs for the United States could be reduced. For Mexico, it appears that the current drought of the 1990s may already be more severe than the 1950s drought. While the firm annual yield amounts for Mexico as presented in Table 3.7 are based on the 1950s drought, these levels of demand on the reservoirs for Mexico actually result in shortages during the 1990s. Hence, the actual firm annual yield amounts for Mexico probably are somewhat less than those reported herein.

Another point to note with regard to the storage plot in Figure 3.17 is that the minimum amount of water stored by the United States in the reservoirs during the critical drought period (1950s) is about 650,000 acre-feet, and not zero as typically is required for a firm annual yield analysis. This level of minimum storage occurs because of the provisions in the TNRCC's Rio Grande operating rules18 that require the DMI pool (225,000 acre-feet) and the operating reserve (150,000 to 380,000 acre-feet) to be fully restored and maintained each month and because at least one month's irrigation supply must always be available in storage in the Amistad-Falcon ROM to avoid an irrigation shortage. The minimum United States storage amount that is simulated for the reservoirs during the critical drought period because of the minimum reserve requirements, in effect, provides an additional water supply beyond the firm annual yield of the

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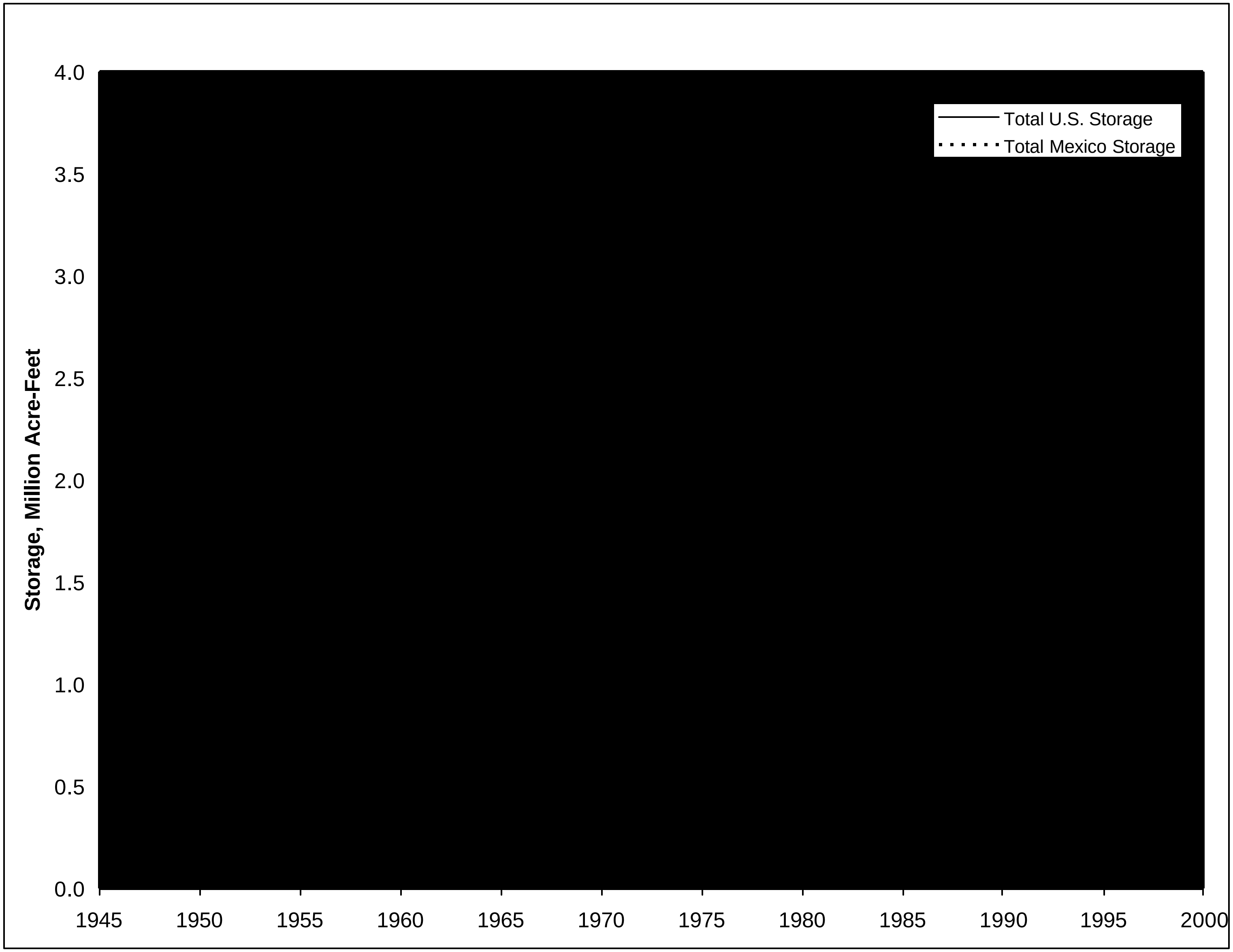
[18] "Chapter 303: Operation of the Rio Grande"; 31 Texas Administrative Code, §§ 303.1-303.73; Texas Water Commission Rules; August 26, 1987; Austin, Texas.

Figure 3.17: Simulated Monthly Storage Levels for the US and Mexico in Amistad and Falcon Reservoirs Combined From the Firm Annual Yield Analysis for Year-2000 Sedimentation Conditions



reservoir system that serves as a factor of safety with regard to supplying domestic, municipal and industrial (DMI) water demands.

3.4.3.2 Adjusted Historical Inflows

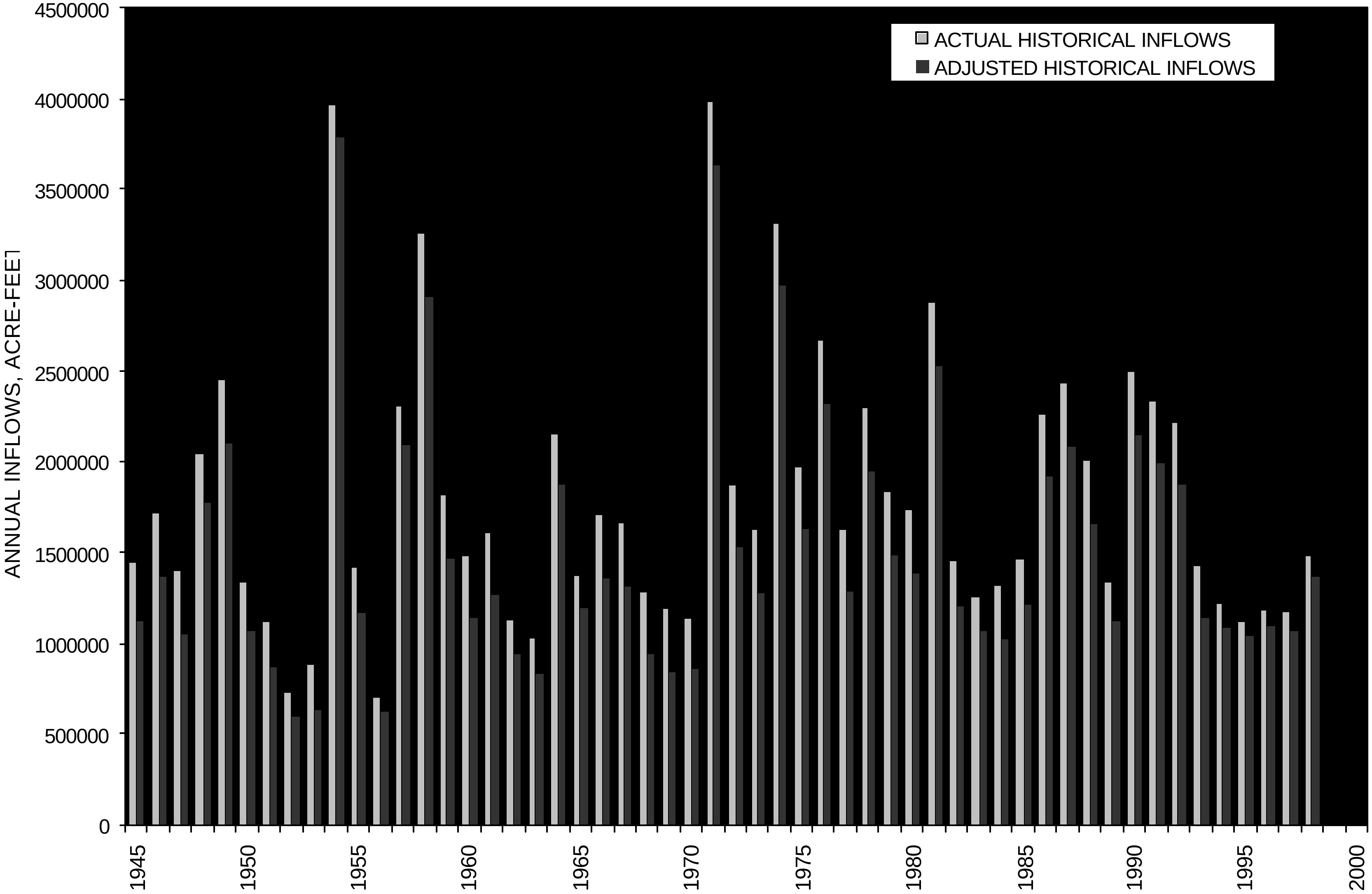
The above analyses of the firm annual yield of the Amistad-Falcon Reservoir System have been performed using the 1945-1998 *historical* monthly inflows to the reservoirs. These inflows, which are listed as annual values in Table 3.3, reflect watershed runoff conditions and water resource development within the contributing watersheds of Amistad and Falcon Reservoirs as they actually occurred over time during the 1945-1998 period. The resulting firm annual yield amounts, by definition, are representative of conditions during the 1950s since this is the period when the historical drought of record occurs with respect to United States water in the reservoirs.

Because watershed runoff conditions and water resource development in the Lower and Middle Rio Grande Basins have continually changed over time since the 1950s; e.g., altered land use conditions, additional tributary reservoir storage, increased tributary water use, etc., the reservoir inflows that actually occurred during the drought of record of the 1950s could be different today or in the future if similar climatic and hydrologic conditions were to recur. For this reason, firm annual yield analyses for the Amistad-Falcon system also have been undertaken using adjusted reservoir inflows that, in part, reflect current hydrologic conditions as they have been influenced by historic reservoir development that has occurred on tributaries to the Rio Grande in Mexico and as they may be influenced by Mexico's inability to deliver the minimum amounts of water to the Rio Grande for the United States pursuant to the terms of the 1944 Treaty.

For these analyses, it has been assumed that the minimum inflow requirement of 350,000 acre-feet per year for the United States from the six Mexican tributaries named in the 1944 Treaty would not be satisfied by Mexico. Hence, the historical annual inflows of United States water to the Rio Grande from the six Mexican tributaries have been reduced by up to a total of 350,000 acre-feet per year, provided they actually were at least this amount historically. Since, under the 1944 Treaty, the United States receives one-third of the total inflows from these Mexican tributaries, Mexico's historical inflows to the Rio Grande from these tributaries also have been reduced correspondingly to account for the other two-thirds of the water. Hence, Mexico's inflows from the six tributaries have been reduced up to 700,000 acre-feet per year, provided they actually were at least this amount historically. While the assumption that potentially none of the 350,000 acre-feet per year of Mexican tributary water will be provided to the United States in the future may be ultra-conservative with respect to the actual water supply that is likely to be available to the RGRWPA from the Mexican tributaries (reported inflows from the six Mexican tributaries have never been zero), it nonetheless provides a worst case scenario that represents the minimum amount of United States water that might be expected to be available.

Figure 3.18 presents a bar chart that provides a comparison of the total historical United States annual inflows to the Rio Grande as listed in Table 3.3 with the corresponding adjusted United States annual inflows after removing up to 350,000 acre-feet per year to reflect the reduced inflows from the Mexican tributaries. The average annual historical inflow for the 1945-1998 period is 1,785,769 acre-feet, whereas the average annual adjusted inflow is 1,504,198 acre-feet, reflecting a reduction of about 16 percent. The firm annual yield amounts for the United States and for Mexico corresponding to the adjusted inflow conditions are listed in the following table.

Figure 3.18 - Comparison of Actual and Adjusted Historical United States Inflows to Amistad and Falcon Reservoirs as Used in Firm Annual Yield Analyses



The firm annual yield values shown in Table 3.8 have been determined with the Amistad-Falcon ROM using the same procedures and reservoir sedimentation conditions as those described above for the firm annual yield analyses based on historical inflows to the Amistad-Falcon system. As expected, these yields are somewhat less than those based on the historical inflow conditions as presented in Table 3.7.

Table 3.8: Projected Firm Annual Yields of the Amistad-Falcon Reservoir System For the United States and Mexico by Decade Through the Year 2050 Based on Historical Inflows Adjusted for Reduced Tributary Inflows From Mexico

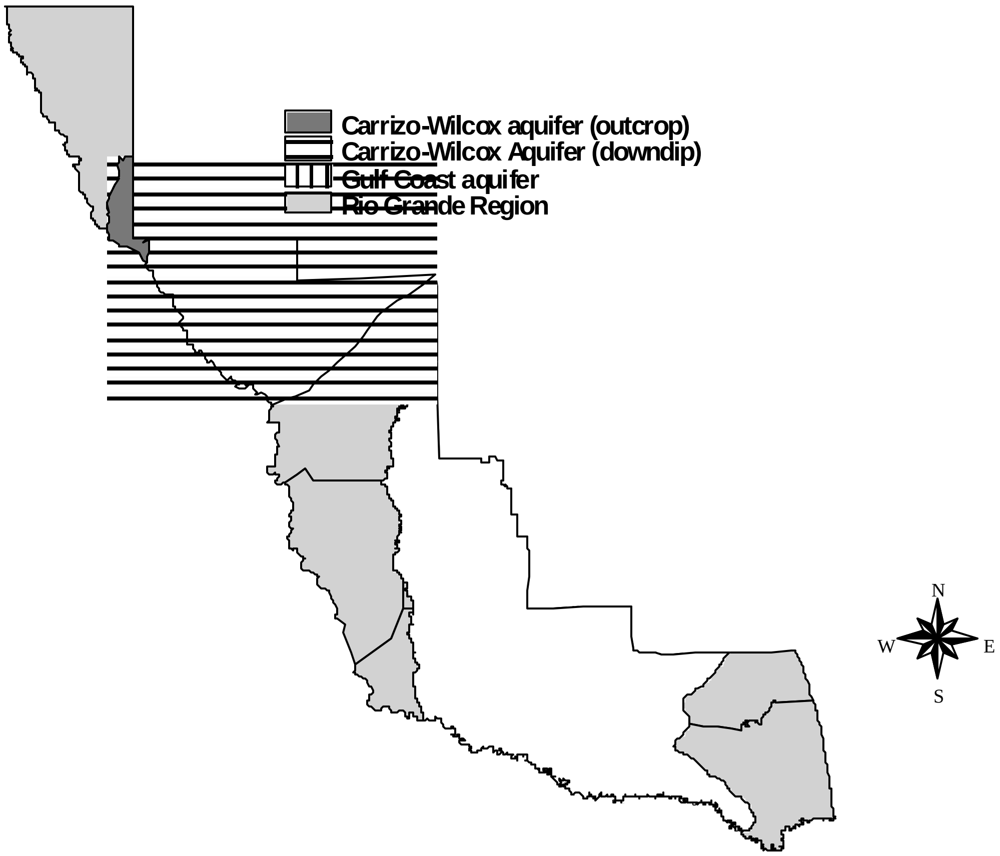
Year	United States	Mexico	Total
2000	850,848	519,506	1,370,354
2010	834,519	519,807	1,354,326
2020	818,739	517,870	1,336,609
2030	803,725	514,547	1,318,272
2040	788,134	511,477	1,299,611
2050	772,562	508,227	1,280,789

The reduction in the United States yield amounts ranges from about 280,000 acre-feet per year up to about 316,000 acre-feet per year. That these yield reductions are not exactly 350,000 acre-feet per year reflects the fact that in some years the historical United States inflows from the Mexican tributaries were less than 350,000 acre-feet per year (hence, these flows could not be reduced the full amount) and also reflects the reduced evaporation losses that occur with less water stored in the reservoirs. As noted above, the firm annual yield values based on the reduced inflow conditions probably represent a lower bound on the actual amount of water that will be available for the United States from the reservoirs even with reduced inflows from the Mexican tributaries.

3.5 GROUNDWATER SOURCES

Throughout the RGRWPA, groundwater has provided water supplies that range from sustainable municipal supplies to quantities of water suitable for irrigation, livestock, and industrial supplies. The major aquifers that exist within the region include the Gulf Coast aquifer, which underlies the entire coastal region of Texas, and the Carrizo aquifer that exists in a broad band that sweeps across the state beginning at the Rio Grande north of Laredo, then continuing northeasterly in an arc south and then east of San Antonio before continuing on to the northeastern corner of the state near Tyler. These aquifers are delineated on the map in Figure 3-19 (“major aquifers” in the Rio Grande Water Planning Region). Less significant aquifers that exist within the region have not been identified in prior water planning studies by the TWDB as “minor aquifers,” but they may produce significant quantities of water supplying relatively small areas. In the RGRWPA, the minor aquifers include the Rio Grande Alluvium, which is also called the Rio Grande aquifer, and the Laredo Formation

Figure 3.19 - Major Aquifers in the Rio Grande Water Planning Region



3.5.1 Gulf Coast Aquifer

3.5.1.1 Location and Use

The Gulf Coast aquifer exists in an irregular band along the Texas coast from the Texas-Louisiana border to Mexico. Historically the Gulf Coast aquifer has been used to supply varying quantities of water in Cameron, Hidalgo, Jim Hogg, eastern Starr, southeastern Webb, and southern Willacy counties as shown in Figure 3.20 (Approximate Productive Areas of Groundwater in the Lower Rio Grande Valley) as derived from McCoy, 1990[19] and Baker, 1979[20].

Total groundwater pumpage was approximately 22,770 acre-feet in 1997. In 1997, municipal pumpage accounted for 11,665 acre-feet, irrigation for 6,550 acre-feet, manufacturing use for 850 acre-feet, electric power generation for 720 acre-feet, mining for 2,410 acre-feet, and livestock use for 575 acre-feet. The greatest total groundwater use in recent years was estimated at 37,990 acre-feet in 1991, primarily driven by irrigation demands of 26,540 acre-feet. The largest volume of groundwater used to meet municipal demands was 11,685 acre-feet in 1996. Because groundwater is usually considered as a secondary source, the higher demand for groundwater has usually coincided with times when there was less surface water available.

3.5.1.2 Hydrogeology

The Gulf Coast aquifer consists of interbedded clays, silts, sands, and gravels, which are hydrologically connected to form a leaky aquifer system. In general, there are four components of this system: the deepest zone is the Catahoulla; above the Catahoulla is the Jasper aquifer located within the Oakeville Sandstone; the Evangeline aquifer contained within the Fleming and Goliad sands is separated from the Jasper by the Burkeville confining layer; and the uppermost aquifer—the Chicot—consists of the Lissie, Willis, Bentley, Montgomery, Beaumont, and overlying alluvial deposits. In the RGRWPA, these overlying alluvial deposits include portions of the Rio Grande alluvium. These zones extend into Zapata and Webb counties, but produce smaller quantities of water in these areas. Figure 3.21 provides a stratigraphic cross-section of the Gulf Coast aquifer system in the Lower Rio Grande Valley.

The primary water-producing zone varies from one area of the region to another. The Chicot aquifer is the primary water-producing zone in western Cameron and eastern Hidalgo counties. The Evangeline aquifer produces significant quantities of water in Cameron, Hidalgo, and Willacy counties. The Oakville Sandstone produces significant quantities of water in northeastern Starr County, northwestern Hidalgo County, and a portion of Jim Hogg County. The Catahoula formation produces small to moderate quantities of water in Webb County.

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[19] T. Wesley McCoy; Texas Water Development Board; "Evaluation of Ground-Water Resources In The Lower Rio Grande Valley, Texas"; Report 316; January, 1990; Austin Texas.

[20] E. T. Baker, Jr.;Texas Department of Water Resources; "Stratigraphic and Hydrogeologic Framework of Part of the Coastal Plain of Texas";Report 236; July 1979;Austin, Texas.

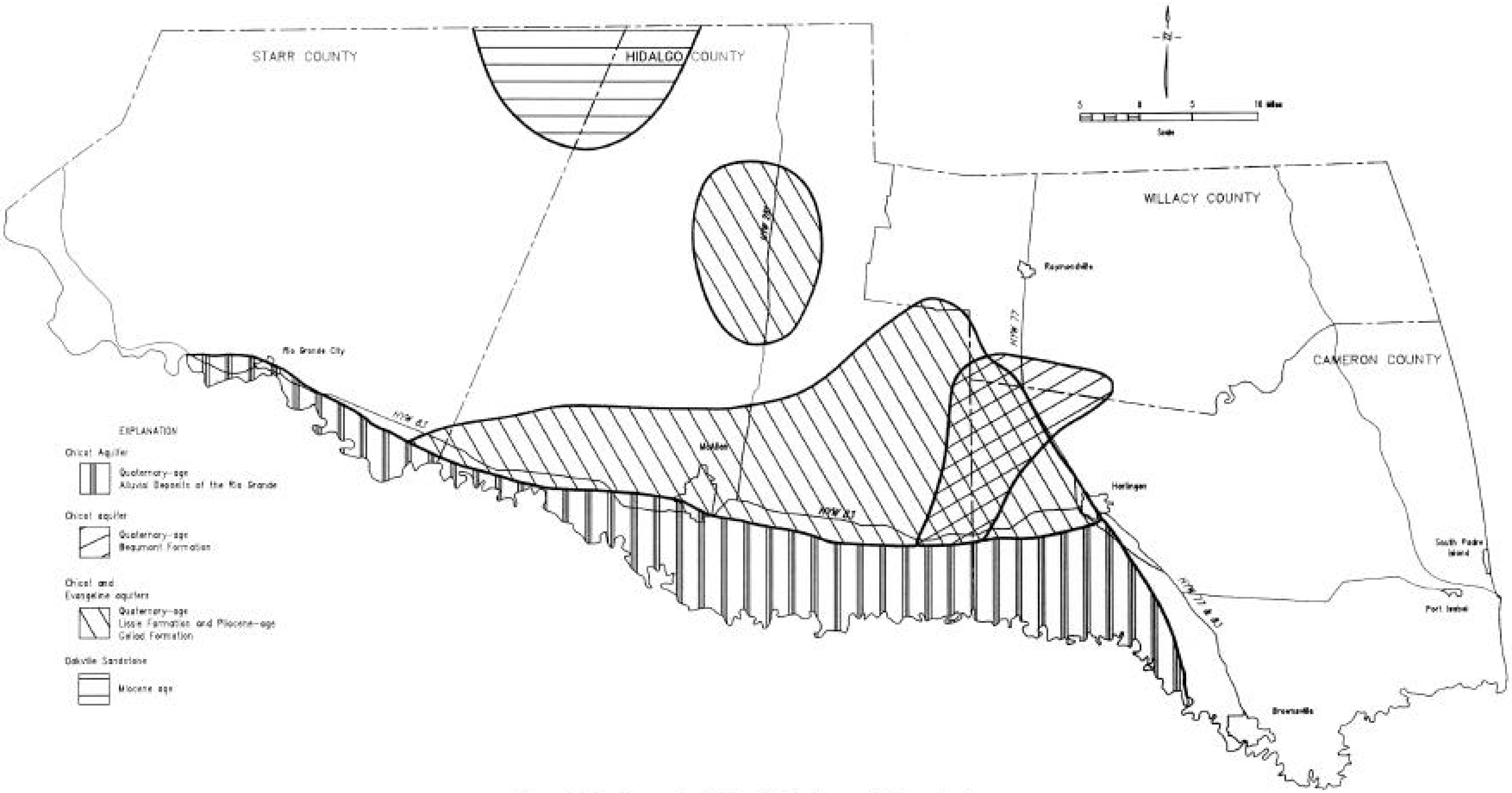
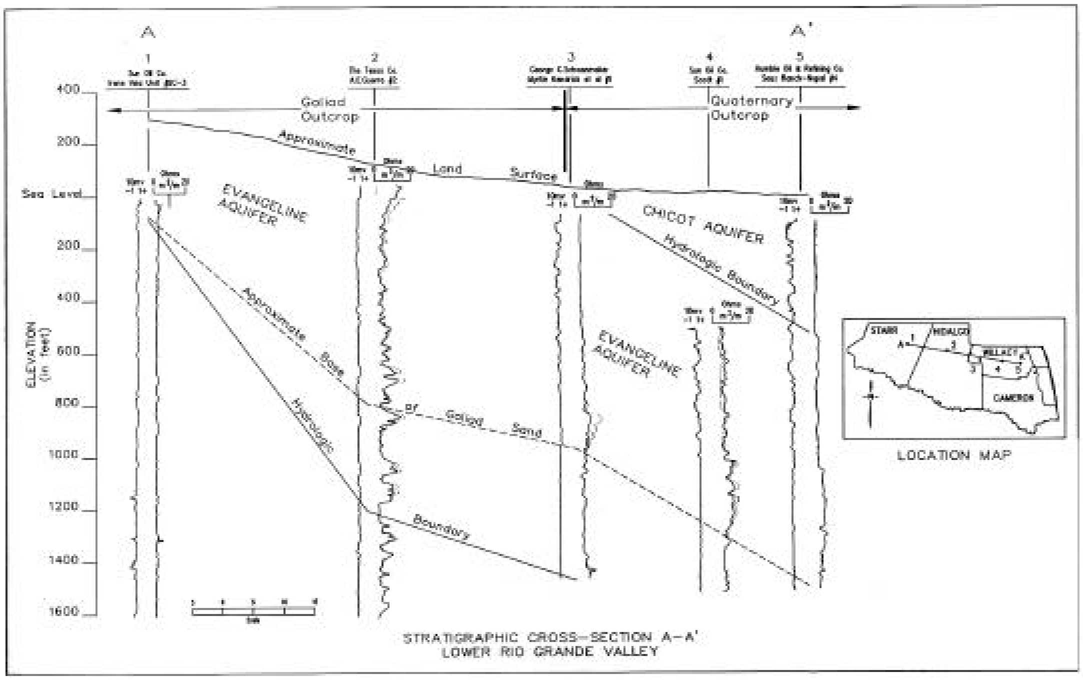


Figure 3.20 - Approximate Productive Areas of Groundwater in the Lower Rio Grande Valley

Figure 3.21: A Stratigraphic Cross-Section of the Gulf Coast Aquifer System in the LRGV



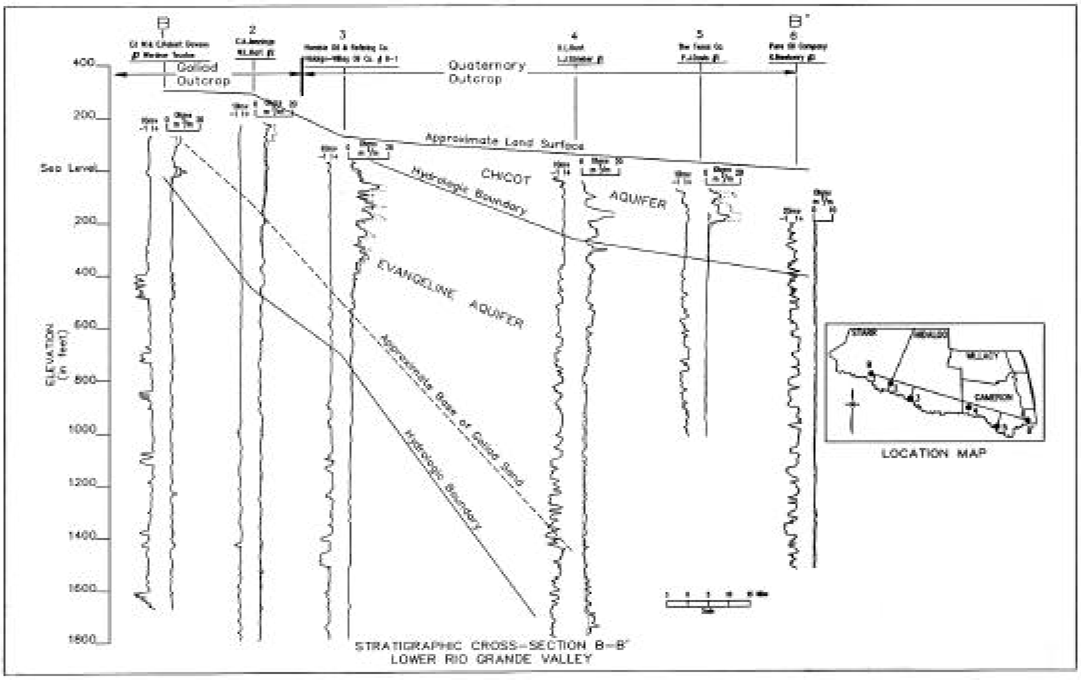


Figure 3.21 - Stratigraphic Cross-Section of the Gulf Coast Aquifer System in the Lower Rio Grande Valley

Recharge to the Gulf Coast aquifer occurs primarily through percolation of excess precipitation, which is precipitation that does not run off of the land surface or is not lost through evapotranspiration. This may be supplemented in some areas by the addition of irrigation water from the Rio Grande. In some areas recharge may be limited by shallow subsurface drainage systems designed to control the buildup of salts resulting from continued irrigation operations.

Although there are significant quantities of groundwater available, groundwater has not been heavily used and water levels have remained relatively stable over the years. The Gulf Coast aquifer is basically considered to be full. Well yields can vary significantly. In the Oakville Sandstone, average production is about 120 gallons per minute (gpm), while in the Chicot aquifer the average well yield is about 10 times this rate, or 1,200 gpm. In the Catahoula formation, yields range from 30 to 150 gpm.

3.5.1.3 Water Availability

The estimated volumes of groundwater available for development from the Gulf Coast aquifer are provided in Table 3.9 below.

Table 3.9: Projected Water Availability From the Gulf Coast Aquifer for Each County by Decade through the Year 2050

	WATER AVAILABLE (acre-feet/year)					
County	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	7,158	7,158	7,158	7,158	7,158	7,158
Hidalgo	15,392	15,392	15,392	15,392	15,392	15,392
Jim Hogg	15,122	15,122	15,122	15,122	15,122	15,122
Starr	7,742	7,742	7,742	7,742	7,742	7,742
Webb	3,984	3,984	3,984	3,984	3,984	3,984
Willacy	300	300	300	300	300	300
Zapata	224	224	224	224	224	224

These quantities of available groundwater have been obtained from the TWDB's estimates and evaluated based on historic water use. If larger quantities of water were known to be produced and used previously, then those larger annual use amounts were applied. This is only the case for Hidalgo County in which 27,902 acre-feet was used in 1991.

3.5.2 Carrizo-Wilcox Aquifer

3.5.2.1 Location and Use

The Carrizo Sand outcrops in a very small area in northwest Webb County, approximately 60 miles to the north-northwest of Laredo (see Figure 3.19, above). The formation continues north into Dimmit, Zavala, and Maverick counties, roughly parallel in orientation to those formations occurring to the east and south.

The reported total groundwater pumpage was only 806 acre-feet in 1997. In 1997, municipal pumpage accounted for 431 acre-feet, irrigation for 187 acre-feet, mining for 117 acre-feet, and livestock use for 71 acre-feet, while manufacturing and electric power generation did not use measurable quantities of groundwater. The greatest total groundwater use in recent years was estimated at 6,561 acre-feet in 1991, primarily driven by irrigation demands of 5,960 acre-feet, with 3,867 acre-feet applied for irrigation in Maverick County and 2,093 acre-feet applied for irrigation in Webb County. The largest volume of groundwater used to meet municipal demands was 512 acre-feet in 1995. Because groundwater is usually considered as a secondary source, the higher demand for groundwater has usually coincided with times when there was less surface water available.

3.5.2.2 Hydrogeology

The Carrizo Sand is the principal and most prolific aquifer within the northern portion of the RGRWPA. The Carrizo Sand is a coarse to fine grained, massive, loosely cemented, cross-bedded sandstone with some interbedded thinner sandstones and shales. It yields moderate to large quantities of groundwater, but the yield decreases with distance from the outcrop as the formation dips southeastward. Figure 3.22 provides a hydrogeologic section of the Carrizo Sand formation[21] across portions of Maverick, Zavala, Dimmit, LaSalle, and Webb counties. Recharge occurs primarily through exposure of the Carrizo Sand to precipitation at the outcrop and where the outcrop is incised by creeks or streams. A groundwater model has recently been developed for the Carrizo aquifer and further study is underway by the TWDB to fully assess the recharge and potential yield of this aquifer.

3.5.2.3 Water Availability

The projected quantities of water available from the Carrizo aquifer are presented in Table 3.10 below. These estimates are primarily derived from TWDB estimates and pumping records. The total estimates of water available from this system may be revised as further evaluation using the Carrizo groundwater model is completed by the TWDB.

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[21] William Klempt, et. al.; Texas Water Development Board; “Groundwater Resources of the Carrizo Aquifer in the Winter Garden Area of Texas, Volume 1”; Report 210; September 1976; Austin, Texas.

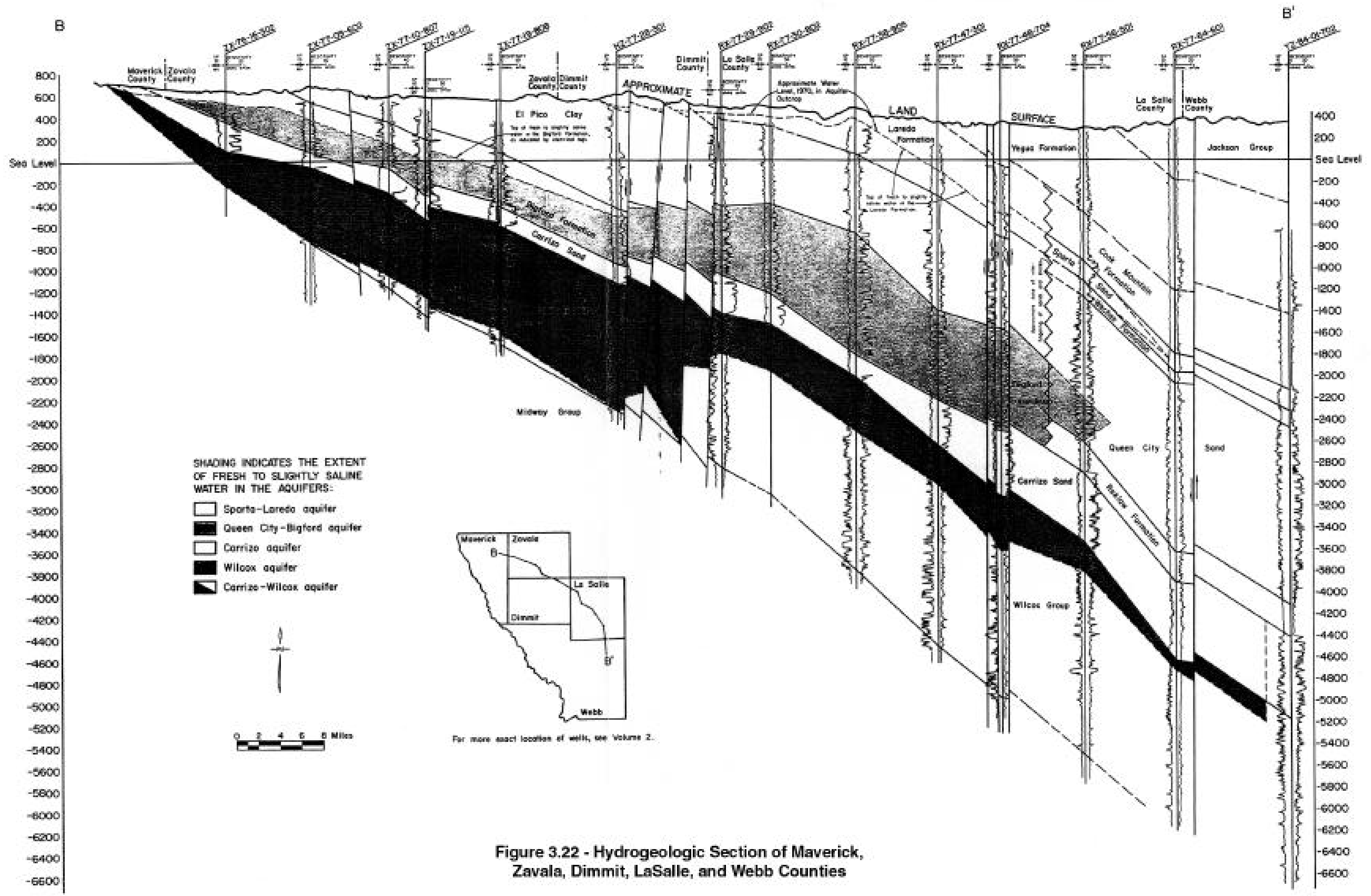

Figure 3.22 - Hydrogeologic Section of Maverick, Zavala, Dimmit, LaSalle, and Webb Counties

Table 3.10: Projected Water Availability From the Carrizo Aquifer for Each County by Decade Through the Year 2050

	WATER AVAILABLE (acre-feet/year)					
County	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Maverick	4,140	4,140	4,140	2,705	2,705	2,705
Webb	29,768	29,768	29,768	16,987	16,987	16,987

3.5.3 Other Aquifers

Other aquifers included in the RGRWPA that are known to supply fairly significant volumes of water include the Rio Grande Alluvium and the Laredo Formation. Although the Rio Grande Alluvium exists in the northern portion of the RGRWPA, most of the production from this formation occurs in the three most southern counties - Cameron, Hidalgo, and Starr. The Laredo Formation is primarily utilized in Webb County.

3.5.3.1 Location and Use

The Rio Grande Alluvium primarily provides water in Hidalgo and Starr counties within about five miles of the Rio Grande. The quantities of water produced from this formation are probably included in the estimates of pumpage from the Gulf Coast aquifer by the TWDB because it is difficult to separate the surface deposits of the Rio Grande Alluvium from those of the Gulf Coast aquifer. The main differentiating characteristic is that the Rio Grande Alluvium is considered to be more permeable. The Laredo Formation is located in southeastern Webb County and northern Zapata County.

The estimates of past groundwater use from "other aquifers" in the RGRWPA includes four counties: Maverick, Webb, Zapata, and Starr. The aquifers that may be included in these estimates of use are the Rio Grande Alluvium, Laredo Formation, and the Catahoula Formation in Webb County. The total estimated groundwater use for 1997 was 1,172 acre-feet. The estimate of use from the "other aquifers" has been as high as 3,048 acre-feet in 1991, consisting of almost equal volumes of municipal and irrigation use.

3.5.3.2 Hydrogeology

The Rio Grande Alluvium exists in Hidalgo County as a river alluvium, but transitions in Cameron County to a more deltaic type of deposit. The material composing the alluvium is highly variable from one location to another. The alluvium has generally been divided into three layers: shallow (less than 75 feet), middle (75 to 150 feet), and deep (150 to 225 feet). Yields are generally higher in the deeper zone and closer to the Rio Grande. Recharge is primarily through interaction with the river, with some surface recharge. Water levels have generally been stable. There is currently additional research being done by the TWDB to further identify the thickness and properties of this groundwater source.

The Laredo Formation is composed of a thick, fine- to very fine-grained sandstone and clay. It yields small to moderate quantities of water to wells in Webb County. The Cook Mountain Formation and

Sparta Sand are generally equivalent to the Laredo Formation in the northeast portion of Webb County and have similar yields.

3.5.3.3 Water Availability

The TWDB has arbitrarily set a limit of 10,000 acre-feet per year for “other aquifers” in each county. This may exceed what can actually be produced in many cases, and in some cases may be much less than actual production. It is beneficial to note that the total historical use for all “other aquifers” in all counties has not exceeded 5,000 acre-feet per year. The existing TWDB estimates of water availability have been adopted.

3.6 AVAILABLE CURRENT WATER SUPPLIES

The development of estimates of the current water supplies that are available for meeting projected future water demands in the RGRWPA has been accomplished through two separate, but interrelated activities; one for surface water and one for groundwater. Both of these activities have proceeded in generally the same fashion, i. e., they both have examined existing sources of water for the region with regard to the maximum supply available under drought of record conditions, taking into consideration other supply restrictions such as the current capacity of existing groundwater well fields; the hydrogeologic properties of aquifers in the region; the quality of existing water supplies with regard to usability; current water rights, permits and other regulatory restrictions; the hydraulic capacity of existing conveyance infrastructure; current contracts and/or option agreements; and obligations that a water user group (WUG) may have in terms of contracts or direct/indirect water sales to other WUGs. In some instances, one or more of these factors have determined the available water supply for individual water users.

Presented in the following sections are the specific steps and procedures that have been undertaken in arriving at the estimated quantities of surface and ground water that are considered to be available from currently existing sources for meeting future water demands in the RGRWPA.

3.6.1 Surface Water Supply Analysis

The analysis of available surface water supplies for the RGRWPA has focused, of course, on the Rio Grande, primarily on Amistad and Falcon Reservoirs. Other lesser sources of surface water such as tributaries of the Rio Grande in Maverick, Webb, Zapata, and Starr counties; the Arroyo Colorado which flows through southern Hidalgo County and northern Cameron County to the Laguna Madre; the pilot channels within the floodways that convey local runoff and floodwaters from the Rio Grande through the Lower Rio Grande Valley to the Laguna Madre; and isolated lakes and resacas in Hidalgo and Cameron counties also have been considered in this investigation.

The existing priorities for allocating the United States’ share of surface water stored in Amistad and Falcon Reservoirs as set forth in the TNRCC Rio Grande operating rules[22] have provided the primary means for determining how the firm annual yield supply of the reservoir system would be apportioned

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[22] "Chapter 303: Operation of the Rio Grande"; 31 Texas Administrative Code, §§ 303.1-303.73; Texas Water Commission Rules; August 26, 1987; Austin, Texas.

among the various water user groups in the RGRWPA. In essence, these rules stipulate that during drought periods when water shortages may occur, domestic, municipal and industrial water uses must be supplied first, followed by irrigation and mining water uses. This is the general allocation procedure that has been used in this study.

Following is a description of the step-by-step procedures and analyses that have been undertaken in determining the quantities of surface water available for meeting future needs in the RGRWPA for specific categories of water use:

Step 1 Municipal/Manufacturing Surface Water Supply – Amistad-Falcon Reservoir System: All of the existing water rights[23] authorizing municipal and/or industrial (manufacturing) uses of water from Amistad and Falcon Reservoirs have been assumed to be fully supplied through the year 2050 by the firm annual yield of the reservoir system. These are the water rights with the highest priority for being allocated water stored in Amistad and Falcon Reservoirs under the TNRCC rules; therefore, they would be entitled first to the United States' share of the firm annual yield of the reservoir system. As indicated in Table 3.5, the total amount of annual diversions that are authorized by existing water rights within the Rio Grande Basin for municipal and/or industrial uses, including water from the Amistad-Falcon system, is less than 300,000 acre-feet per year. Hence, with the United States' share of the firm annual yield of the Amistad-Falcon system projected to be greater than 1,000,000 acre-feet per year over the next 50 years, the supply of water represented by the municipal and industrial (manufacturing) water rights that are dependent upon the reservoir system have been assumed to be fully available.

Step 2 Municipal Surface Water Supply – Amistad-Falcon Reservoir System: The supply of water represented by the municipal water rights dependent upon the Amistad-Falcon Reservoir System, which totals 283,343 acre-feet per year (Table 3.5), has been distributed to individual WUGs (cities, water districts, water supply corporations, irrigation districts, etc.) based either on the actual water rights owned by these entities or on agreements between these entities and other water rights owners. The amounts and sources of actual municipal water used by the WUGs during calendar year 1995, as reflected in records reported to the Rio Grande Watermaster's Office, have been examined to establish water supply relationships between the water rights owners and the WUGs. In the event that the entire amount of a particular water right's authorized annual diversion from the reservoir system for municipal use was not fully utilized in 1995, it has been assumed that the full amount would be available for such use in the future, and the full amount has been distributed proportionally, based on 1995 actual usage, to those WUGs that did use the municipal water authorized by the water right in 1995[24]. In this manner, the entire authorized diversion amounts of all municipal water rights that use water from Amistad and Falcon Reservoirs have been fully allocated for planning purposes.

It is important to recognize that municipal water suppliers in Rio Grande Region that are dependent upon the Amistad-Falcon Reservoir System for their water supplies operate under rules and regulations that originate from the 1969 final judgment of the Thirteenth Court of Civil Appeals in the water dispute commonly referred to as the "Rio Grande Valley Water Case". Among other things, this judgment allocated specific amounts of water in the Lower Rio Grande Valley to individual domestic, municipal and industrial (DMI) water users (typically cities) that

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[23] Based on the water rights master file of the TNRCC as of March 4, 1999.

[24] Excluding the WUG's that were one-time users of contract water from the water rights holders in 1995.

were in existence at the time and had documented historical water usage, and it assigned these DMI water rights to specific irrigation districts, which had pumping facilities on the river, for subsequent diversion and delivery to the DMI users. In effect, the irrigation districts were assigned municipal water rights that were specifically designated for certain individual domestic, municipal and industrial water users.

Today, most of the DMI water users in the Lower Rio Grande Valley continue to obtain their water supplies from the irrigation districts under the original water rights that are owned by the irrigation districts but that have specific assignments to the DMI users. In this regard, the irrigation districts request releases from Falcon Reservoir, pump this water from the Rio Grande into their own distribution systems, and ultimately deliver the water, less losses, to the DMI users. In some cases, there are written contracts between the DMI users and the irrigation districts for water delivery; however, often there are only general agreements between the DMI users and the irrigation districts that water will be delivered pursuant to the requirements of the original water rights that specifically assign water to the DMI users. When these delivery contracts or agreements expire, they normally are simply extended with revised rates to cover pumping costs. Sometimes when the annual allotment for DMI water as stipulated in a water right is exceeded by an individual DMI water user, the irrigation district will continue to supply DMI water to the DMI user under the district's own water right and then charge the DMI user for this additional water. This one-time delivery of water is referred to as "contract water", but it really has nothing to do with a formal long-term contractual agreement. It simply means that water is being delivered to a DMI user on a short-term contract basis.

What is most important from a water supply perspective with regard to these water supply arrangements between individual DMI users and irrigation districts in the Lower Rio Grande Valley is the total amount of DMI water that is available under the existing water rights, not whether or not there is a formal contract in place to guarantee the delivery of the water. The DMI water users are guaranteed the water because of the water rights themselves, and it these water rights that determine the extent of the overall DMI supply. Since DMI water was assigned the highest priority relative to other types of uses; e.g., irrigation and mining, as a result of the Rio Grande Valley Water Case, the DMI water supply is guaranteed, as noted above, by the firm yield of the Amistad-Falcon Reservoir System.

For these reasons, the currently available DMI water supplies for individual WUGs have been determined based primarily on allotments specified in existing water rights. It is these allotments that are of most importance to the WUG's with respect to their future water supplies, not the terms of any contract or other agreement. It is only when the projected municipal water usage by a WUG approaches the annual allotment for DMI water that is specified in the WUG's existing water rights that the WUG should be concerned with obtaining an additional water supply. Otherwise, its water supply will be provided in accordance with existing water rights. This is the procedure that has been applied herein, and it is considered to be the most appropriate for projecting currently available municipal water supplies.

It should be recognized, however, that there are some municipal water users that do have their own water rights, which they have acquired (usually purchased) from the irrigation districts. As with all municipal water rights, the projected water supplies associated with these municipal user-owned water rights have been set equal to their authorized annual diversion amounts since, because of their priority, they are fully protected by the firm yield of the Amistad-Falcon

Reservoir System. There also are some municipal water users that have specific contracts for DMI water from the irrigation districts under the districts' water rights (exclusive of the original allotments from the Rio Grande Valley Water Case). For these municipal water users with identifiable and known contracts, the projected water supplies that have been considered to be available for future use have been those specified in the contracts, with the term of the existing contracts taken into account.

The specific amounts of available current municipal water supplies that have been projected for the individual WUGs within the RGRWPA are presented by county in Table 5 of the TWDB Exhibit B tables section of Volume II, Technical Appendix, of this report. The balance of the available current municipal water supplies from Amistad and Falcon Reservoirs based on existing DMI water rights has been assigned to the municipal use category referred to by the TWDB as "County-Other". These amounts, as totals for each county, also are presented in Table 5 TWDB Exhibit B tables, Volume II, Technical Appendix, of this report[25].

Step 3 <u>Municipal Surface Water Supply – Amistad-Falcon Reservoir System:</u> To verify the accuracy of the available current water supplies as derived in Step 2 above, letters have been sent to specific municipal WUGs[26] summarizing their water supply sources and available amounts and requesting any additional information considered necessary to refine or update the water supply data. Of the 45 letters sent, seven responses were received with revised information. This revised information has been incorporated into the estimates of available current water supplies as appropriate.

Step 4 <u>Municipal Surface Water Supply – Amistad-Falcon Reservoir System:</u> To verify the accuracy of information regarding water supply agreements between specific water users and specific water suppliers as developed in Step 2 above, letters also have been sent to 14 irrigation districts that are believed to supply surface water from the Rio Grande to individual cities in the Lower Rio Grande Valley. Twelve responses were received with revised information, and several of the irrigation districts also were contacted directly to clarify water supply data and information. This revised information also has been incorporated into the estimates of available current water supplies as appropriate.

Step 5 <u>Municipal Surface Water Supply – Amistad-Falcon Reservoir System:</u> In subsequent analyses of supply and demand for specific types of water use in individual counties in the RGRWPA as described in Chapter 4, some small amounts of supply shortages have been identified with respect to the projected demands for manufacturing and livestock uses in certain counties within the RGRWPA as set forth in Chapter 2. It is known, however, that surplus water from the Amistad-Falcon municipal water supplies as derived in Steps 2 through 4 above, in reality, would be used to meet these demands if shortages actually occurred in the future.

Hence, for these isolated cases, specific amounts of the Amistad-Falcon "County-Other" municipal water supplies have been transferred to supplement the available supplies for the other

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[25] Those specifically named cities within the RGWPR for which projected water demand information is available from the Texas Water Development Board.

[26] The same specifically named cities within the RGWPR for which projected water demand information is available from the Texas Water Development Board. These are the named cities identified by county in Table 5 in Appendix 3-B.

water use categories in order to meet these potential demand shortages. For example, over the period from the year 2000 to the year 2050, between 779 and 2,368 acre-feet per year have been transferred to the Amistad-Falcon "Manufacturing" water supply category in Hidalgo County, 43 acre-feet per year have been transferred to the Amistad-Falcon "Manufacturing" water supply category in Webb County, and 73 acre-feet per year have been transferred to the Amistad-Falcon "Livestock" water supply category in Cameron County. These transfers are reflected in Table 5, TWDB Exhibit B tables, Volume II, Technical Appendix.

Step 6 Municipal Surface Water Supply – Nueces-Rio Grande Resacas: As described in Section 3.6.4 above, the surface water supplies associated with water rights that authorize diversions from certain resacas in Cameron County have been assumed to be available for localized municipal use. Hence, a total of 225 acre-feet of water per year have been included in the "Municipal" water use category for Cameron County in Table 5.

Step 7 Manufacturing Surface Water Supply – Amistad-Falcon Reservoir System: As with the available current supplies of water from the Amistad-Falcon system for municipal uses, the available supplies for the "Manufacturing" (industrial) water use category also have been established based on the fully authorized diversion amounts of the existing Amistad-Falcon water rights that are designated for industrial purposes. As indicated in Table 3.5, the total amount of annual diversions within the Rio Grande Basin that are authorized by existing water rights for industrial uses is 14,028 acre-feet per year. Since industrial water rights include water that is used for steam electric power generation, a portion of the total authorized diversion amount for industrial use has been transferred to the "Steam Electric" water use category in accordance with existing water rights ownership and supply agreements. The water rights holders and the amounts of diversions transferred are summarized below by county:

Cameron County		
Central Power & Light	2,400	acre-feet/year
Hidalgo County		
Central Power & Light	2,475	acre-feet/year
Webb County		
Central Power & Light	2,195	acre-feet/year
Total Steam Electric Transfers	***7,070***	***acre-feet/year***

With these transfers, the total available supply for the "Manufacturing" water use category based on existing Amistad-Falcon water rights (industrial) is reduced to 4,292 acre-feet per year. Adjusting this amount of available manufacturing supply for the transfers from the "County Other" municipal water use category as described above in Step 5 to offset isolated manufacturing demand shortages over the next 50 years (between 779 and 2,368 acre-feet per year in Hidalgo County and 43 acre-feet per year in Webb County), the resulting amounts of available current water supplies for the "Manufacturing" water use category based on existing Amistad-Falcon water rights is projected to range from 5,115 acre-feet in the year 2000 up to 6,704 acre-feet in the year 2050. These total amounts of available supply are distributed by county in Table 5 (TWDB Exhibit B tables, Volume II, Technical Appendix).

Step 8 Manufacturing Surface Water Supply – Reuse: In addition to the firm supplies available for manufacturing uses from the Amistad-Falcon system as described in Step 7 above, there also is projected to be a certain amount of water available for manufacturing through reuse of treated wastewater effluent. Based on information from the TWDB[27], 2,239 acre-feet per year of treated wastewater are being supplied by the City of Harlingen to Fruit of the Loom. For planning purposes, this amount has been assumed as the available current supply of reuse water for the "Manufacturing" water use category within the RGRWPA, and it is listed under Cameron County in Table 5 (TWDB Exhibit B tables, Volume II, Technical Appendix).

Step 9 Steam Electric Surface Water Supply – Amistad-Falcon Reservoir System: As noted in Step 7 above, 7,070 acre-feet of water per year from the Amistad-Falcon Reservoir System are available for use for steam electric generation purposes as a result of the supply transfers from the "Manufacturing" water use category. In addition, there are other sources of Amistad-Falcon water that are currently used for steam electric generation through agreements with individual water rights holders. In Hidalgo County, the Hidalgo County Irrigation District No. 6 supplies 1,102 acre-feet of water per year to Central Power & Light, and it also has an agreement with CSW Energy in Hidalgo County for supplying 2,666 acre-feet of water per year for steam electric generation purposes. Considering both water rights and agreements, the available current water supply for steam electric generation in the RGRWPA totals 10,838 acre-feet per year, and this amount is distributed among the individual counties in Table 5 in accordance with the locations where it is used.

Step 10 Steam Electric Surface Water Supply - Reuse: Reuse of treated municipal wastewater effluent also provides an additional source of water for steam electric generation. Currently, the City of McAllen has agreements to supply 4.8 million gallons of wastewater effluent per day (5,376 acre-feet/year) to the Duke Energy plant and 4.0 million gallons of wastewater effluent per day (4,480 acre-feet/year) to the Calpine plant. Hence, for planning purposes, the total water supply currently available through reuse of treated municipal wastewater effluent within the RGRWPA has been assumed to be 9,856 acre-feet per year, and this amount is included in TWDB Exhibit B Table 5 under Hidalgo County.

Step 11 Irrigation and Mining Surface Water Supply – Amistad-Falcon Reservoir System: As noted in Table 3.5, the existing water rights in the Rio Grande Basin authorize the use of water from Amistad and Falcon Reservoirs for irrigation and mining purposes up to 1,871,862 acre-feet per year. This amount of usage far exceeds the projected firm annual yields of the reservoir system as indicated by the yield amounts presented in Table 3.7. Hence, the reservoir system is over-appropriated with regard to the total diversion amount authorized in existing water rights for irrigation and mining uses. In accordance with the water allocation priorities set forth in TNRCC's Rio Grande operating rules, water stored in Amistad and Falcon Reservoirs is available for irrigation and mining uses only after the demands for domestic, municipal and industrial uses (including manufacturing and steam electric uses) have been supplied (to the extent authorized by existing water rights) and after the DMI pool and the operating reserve in the reservoirs have been fully restored. In effect, for purposes of water supply planning in accordance with TWDB guidelines, this means that the available water supply from Amistad and Falcon Reservoirs for irrigation and mining uses is represented by the balance of the firm annual yield of the reservoir system after the domestic, municipal and industrial (including

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[27] Texas Water Development Board Web Site; "Municipal Wastewater Reuse in Texas - 1997"; Austin, Texas.

manufacturing and steam electric) water demands have been satisfied and after the DMI pool and the operating reserve in the reservoirs have been fully restored.

Therefore, in this study, the available water supply from Amistad and Falcon Reservoirs for irrigation and mining uses has been determined by operating the Amistad-Falcon ROM in a manner that apportions the remaining firm annual yield of the reservoir system to irrigation and mining uses after first satisfying the municipal, manufacturing and steam electric surface water demands that are projected to occur in the future. For these analyses, which have been performed for each of the future decades through the year 2050, the portions of the projected municipal, manufacturing and steam electric water demands set forth in Chapter 2 of this report that are expected to be satisfied with surface water from Amistad and Falcon Reservoirs have been specified in the ROM and assigned the highest demand priority. These reservoir-dependent demands have been derived by subtracting from the projected total municipal, manufacturing and steam electric water demands for the region the quantities of water that are expected to be supplied for these uses from groundwater, by reuse of surface water, or from resacas or other local water bodies as specified in Table 5 (TWDB Exhibit B tables, Volume II, Technical Appendix). With these municipal, manufacturing and steam electric reservoir-dependent demands specified, the ROM then has been operated using the 1945-1998 historical inflows to the reservoirs to determine the remaining yield of the reservoirs that would be available for irrigation and mining uses. These remaining yield amounts for each decade represent the available current water supplies from Amistad and Falcon Reservoirs for irrigation and mining uses, and they have been apportioned among the counties of the RGRWPA based on the projected future demands for these uses as specified in Tables 2.8 and 2.12 of Chapter 2. The resulting available current water supplies for irrigation and mining uses in each county within the RGRWPA are listed in Table 3.11 and in Table 5 for each decade through the year 2050.

Step 12 Irrigation and Mining Surface Water Supply – Rio Grande Tributaries: As described in Section 3.2.2 above, the surface water supplies that are available for irrigation and mining uses under existing water rights on some of the tributaries of the Rio Grande are not continuous and are dependent upon local runoff conditions. Although the reliability and availability of the water supplies from these tributaries as authorized by the existing water rights are questionable, particularly during drought of record conditions, specific diversion amounts for these surface water sources have been included in the available current water supplies for irrigation and mining uses. These diversion amounts have been established by assuming that the actual diversions that could be realized from these tributary water rights would be subject to the same level of reductions as the Amistad-Falcon irrigation and mining water rights based on the ROM yield analyses as described in Step 11 above. In effect, this means that the available supplies have been assumed to be equal to the authorized diversion amounts specified in these existing

Table 3.11: Projected Firm Annual Yield Amounts for Irrigation and Mining Uses From the Amistad-Falcon Reservoir System After Satisfying Future Reservoir-Dependent Municipal, Industrial, and Steam Electric Water Demands

IRRIGATION USES

County	2000	2010	2020	2030	2040	2050
Cameron	264,570	251,678	238,914	220,105	199,964	174,869
Hidalgo	512,683	469,823	423,658	358,040	325,277	284,456
Jim Hogg	0	0	0	0	0	0
Maverick	74,469	73,091	70,657	66,647	60,549	52,950
Starr	27,379	25,260	24,252	22,888	20,793	18,184
Webb	3,402	3,195	3,025	2,817	2,559	2,238
Willacy	36,928	37,174	37,984	37,768	34,312	30,006
Zapata	1,210	1,135	1,074	995	892	762
TOTAL	920,641	861,356	799,565	709,261	644,346	563,465

MINING USES

County	2000	2010	2020	2030	2040	2050
Cameron	7	5	2	1	0	0
Hidalgo	416	403	427	447	431	402
Jim Hogg	0	0	0	0	0	0
Maverick	70	35	17	9	3	2
Starr	775	652	631	601	541	486
Webb	295	235	188	160	134	121
Willacy	0	0	0	0	0	0
Zapata	12	4	2	1	0	0
TOTAL	1,575	1,333	1,269	1,218	1,109	1,011

IRRIGATION AND MINING USES

County	2000	2010	2020	2030	2040	2050
All Counties	922,216	862,689	800,834	710,479	645,455	564,476

water rights reduced by the following factors in accordance with the reductions experienced by the Amistad-Falcon irrigation and mining water rights each decade:

Year	Diversion Reduction Factor
2000	59.3 %.
2010	59.2 %
2020	59.2 %
2030	58.4 %
2040	51.6 %
2050	46.1 %

The resulting available current water supplies from these Rio Grande tributary water rights are listed in Table 5 for each of the counties in which the tributaries are located.

Step 13 Irrigation Surface Water Supply – Reuse: In addition to the supplies available for irrigation from the Amistad-Falcon system and from certain Rio Grande tributaries, there also is surface water available for irrigation through reuse of treated wastewater effluent. Most of this water is currently used for irrigating golf courses in the region. Based on information from the TWDB[28], 1,320 acre-feet per year of treated wastewater are being supplied within the RGRWPA for irrigation purposes. Specific users of this reuse water and the annual amounts used are listed below by county:

Cameron County	
City of Brownsville	75acre-feet/year
Harlingen Country Club	161acre-feet/year
Hidalgo County	
City of Mission	166acre-feet/year
Maverick County	
Eagle Pass Grass Farm	123acre-feet/year
Webb County	
Laredo - Laredo Golf Course & Casa Blanca Golf Course	795acre-feet/year
Total Amount of Irrigation Reuse	***1,320acre-feet/year***

For planning purposes, 1,320 acre-feet of reuse water per year have been assumed to be available for irrigation purposes within the RGRWPA, and this amount is distributed to the individual counties in Table 5 (TWDB Exhibit B tables, Volume II, Technical Appendix) in accordance with the above usage.

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[28] Texas Water Development Board Web Site; "Municipal Wastewater Reuse in Texas - 1997"; Austin, Texas.

Step 14 Livestock Surface Water Supply – Amistad-Falcon System: In accordance with the adjustments made in Step 5 above to provide available current water supplies for certain types of uses to offset apparent water shortages identified during the supply and demand analyses described in Chapter 4, an amount equal to 73 acre-feet per year of Amistad-Falcon water has been assigned to the "Livestock" water use category for Cameron County for each decade through the year 2050. This amount is listed in Table 5.

Step 15 Livestock Surface Water Supply – Other Local Supply: Projected demands for livestock watering have been made for the RGRWPA, and these are described in Chapter 2. While water supplies for domestic and livestock demands sometimes are provided under existing water rights that are designated for municipal or irrigation uses, these types of demands typically are supplied using groundwater or surface water from local unpermitted sources such as small streams and stock ponds.

In this study, it has been assumed that the projected livestock water demands would be satisfied first using available groundwater supplies, to the extent they are available within each county. However, in the event of shortages, rather than allocate portions of the available current water supplies associated with existing water rights, such as Amistad-Falcon municipal or irrigation water or Rio Grande tributary water, it has been assumed that the projected livestock demand shortages would be supplied from the local unpermitted sources referred to as "Other Local Supply". Hence, in developing the available current water supplies for the "Livestock" water use category, specific amounts of supply have been assigned under the heading "Other Local Supply" to offset the demand shortages that are projected to occur when the available groundwater supplies are not sufficient to fully meet the future livestock water demands. For the RGRWPA, these additional amounts of livestock water supply range from 4,600 acre-feet in the year 2000 up to 4,524 acre-feet in the year 2050.

3.6.2 Groundwater Supply Analysis

The analysis of groundwater supplies available to users throughout the RGRWPA has been based on information from a variety of sources. The general steps used in developing the groundwater supply quantities presented in Table 5 (TWDB Exhibit B tables, Volume II, Technical Appendix) are described below.

Step 1 A list of user groups for the RGRWPA was compiled based on information listed in water supply allocation tables provided by the TWDB. The allocation tables indicate which water supplies are available to a user and how much of each supply is potentially to be allocated to that user. The amount of water that is available to each user is either listed as a limited quantity (acre-feet/year) or as a percentage value of the total supply.

Step 2 As indicated above, each user listed in Exhibit B Table 5 was assigned to a water supply. The various water supplies available in the RGRWPA are listed in Table 4 (TWDB Exhibit B tables, Volume II, Technical Appendix) of this report. A groundwater supply has been defined as that portion of an aquifer within each basin of each county. Therefore, the total water available from an aquifer within the area of the RGRWPA has been divided among the counties of the region crossed by that aquifer and split between the basins within that portion of each county. Some water users, particularly municipalities, draw water from wells located in more than one basin of a county. These wells, however, may or may not tap separate aquifers. A separate entry has been included in Table 5 for each groundwater supply allocated to a user.

Step 3 Each entry in Table 5 (Exhibit B tables, Volume II) has been allocated a volume of water (acre-feet/year). This amount was calculated based on the water available as shown in Table 4 and the allocation tables from the TWDB. Where the allocation tables indicated a limit value, that volume was entered in Table 5. The allocation limit may be based on the user's pumping capacity during a drought, on an established legal limit, or on other information obtained from the individual user. Individual users were contacted by telephone to obtain additional information regarding system, pumping, and/or well limitations. Where the allocation tables indicated that a user was allocated a percentage of the available supply, that percent value was multiplied times the total available supply listed in Table 4.

Step 4 After allocation values were established for each user listed, the total amount allocated from each groundwater supply was totaled and compared with actual groundwater availability provided in Table 4 (Exhibit B tables, Volume II). Cases of over allocations were resolved by reducing the allocation percentages (some supplies were distributed among several users with each allocated 100 percent of the available supply) and the allocation limits. The highest priority was given to municipalities and users listed as "County-Other". Other information such as a user's pumping capacity during drought (for municipalities) and whether a user also had surface water supplies available were taken into consideration. Where necessary to further resolve over-allocations, the tables of user demand information from the TWDB and from Chapter 2 of this report were also considered.

3.6.3 Summary of Water Supply Results

Table 3.12 provides a summary of the total amounts of available current water supplies for the entire RGRWPA by water use category and by source of supply for each decade through the year 2050. This table is a regional summary of the county data that are presented in Table 5 (TWDB Exhibit B tables, Volume II, Technical Appendix), of this report.

As shown at the bottom of Table 3.12, the total available current water supply for the RGRWPA ranges from 1,339,343 acre-feet in the year 2000 down to 963,857 acre-feet in the year 2050. This reduction in the total water supply for the region is caused, of course, primarily by the decrease in the firm annual yield of the Amistad-Falcon Reservoir System during this period as sedimentation in the reservoirs reduces their available conservation storage capacity. Some of the reduction also is due to gradually declining groundwater supplies. In accordance with the priorities for allocating water within the Rio Grande Basin as stipulated in the TNRCC's Rio Grande operating rules, the projected reduction in the water supply for the region is translated directly to irrigation and mining uses. Hence, the projected water supplies for these uses exhibit declines similar to those for the region. The projected water supplies for municipal, manufacturing and steam electric uses generally remain fairly level over the next 50 years as these supplies are provided for, to a large extent, from the firm annual yield of the Amistad-Falcon system.

An indication of the water supplies available to each of the counties within the RGRWPA over the next 50 years by decade is provided by the bar charts in Figures 3.23 through 3.30. These charts have been developed from the water supply data presented in Table 5 (Exhibit B tables, Volume II). On each of these charts, the quantities of supplies available by type of use are shown. Also shown are the portions of the total supplies for each county that are projected to be from surface water and from groundwater.

3.7 LOWER RIO GRANDE MUNICIPAL DELIVERIES DURING SEVERE DROUGHTS

One of the concerns regarding the availability of water in the Lower Rio Grande Valley pertains to the delivery of water to municipal users during severe drought periods when irrigation water use may be curtailed or ceased all together as the total supply of United States water stored in Amistad and Falcon Reservoirs falls to low levels. Under the current Rio Grande operating rules, the available supply of water in the reservoirs for irrigation use is gradually depleted as irrigation diversions are made during periods when the inflows to the reservoirs are low. During extended periods of continued irrigation use and low reservoir inflows, the available quantity of irrigation water stored in the reservoirs can be reduced to zero. Should such conditions occur, no releases of irrigation water would be able to be made from Falcon Reservoir. This would mean that deliveries of municipal water from the reservoir to entities in the Lower Rio Grande Valley would have to be made without the normal carrying water provided by the irrigation water deliveries. Under these circumstances, the water losses, due to such factors as seepage and evaporation, that may be experienced either along the river channel or within the irrigation district delivery systems that are used to convey raw water from the river to the municipal water users could be substantial. Also of concern under these conditions is whether or not the existing diversion facilities on the lower Rio Grande would be able to physically withdraw water from the river because of the potentially lower river levels.

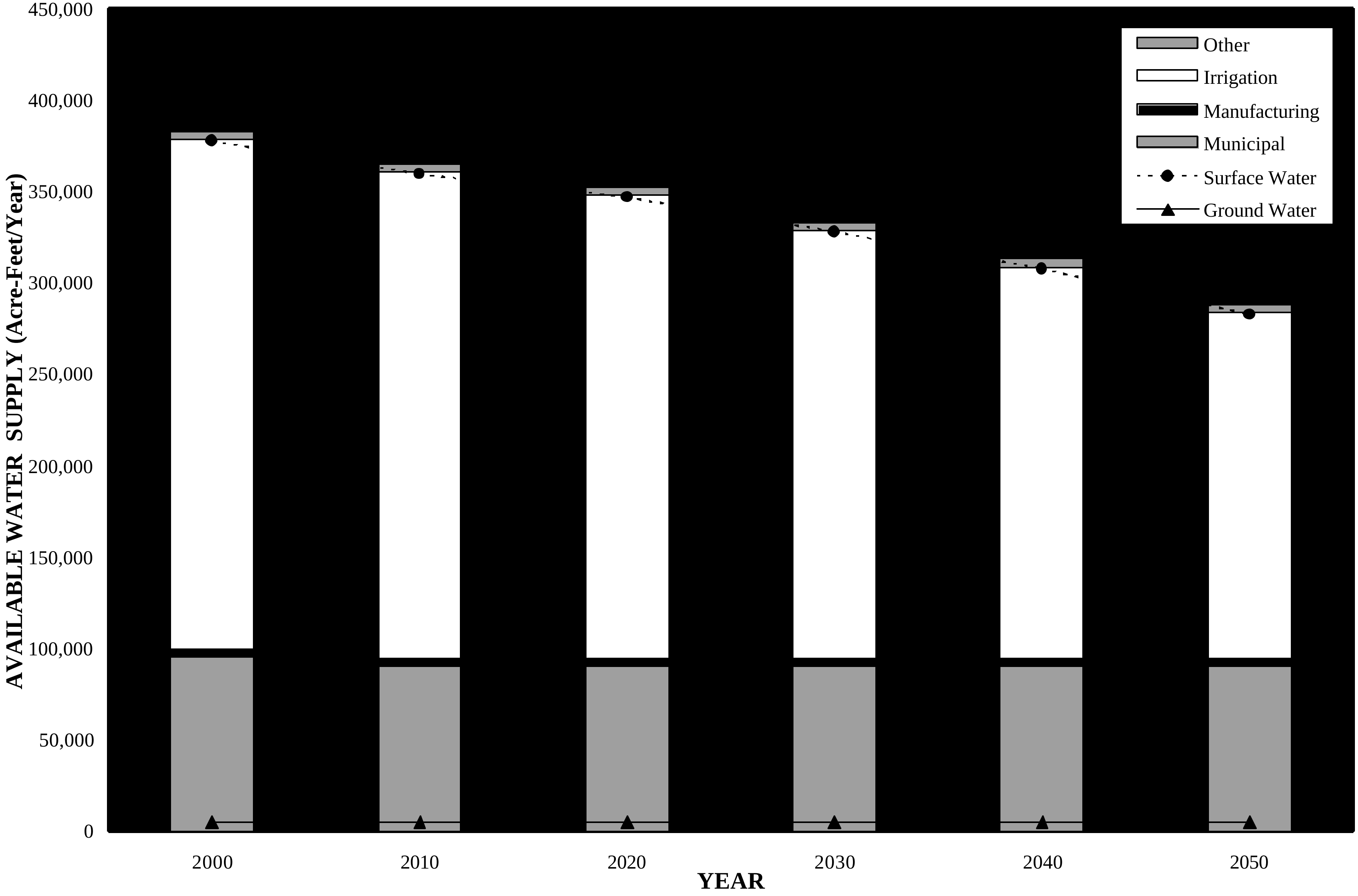
Table 3.12 - Summary of Total Amounts of Currently Available Water Supplies for the RGWPR by Water Use Category and by Source of Supply

Water Use Category / Source of Supply	2000	2010	2020	2030	2040	2050
MUNICIPAL						
Water User Groups						
Surface Water - Amistad/Falcon System	223,091	219,048	219,164	219,323	219,431	219,578
Surface Water - Other Local Supply	0	0	0	0	0	0
Surface Water - Rio Grande Tributaries	0	0	0	0	0	0
Surface Water - Reuse	0	0	0	0	0	0
Surface Water - Nueces/Rio Grande Resacas	0	0	0	0	0	0
Ground Water - Gulf Coast	7,528	7,528	7,528	7,528	7,528	7,528
Ground Water - Carrizo-Wilcox	200	200	200	200	200	200
Ground Water - Other Aquifer	232	232	232	232	232	232
Water User Groups - TOTAL	**231,051**	**227,008**	**227,124**	**227,283**	**227,391**	**227,538**
County Other Municipal						
Surface Water - Amistad/Falcon System	61,853	61,456	61,197	61,030	60,644	60,266
Surface Water - Other Local Supply	0	0	0	0	0	0
Surface Water - Rio Grande Tributaries	0	0	0	0	0	0
Surface Water - Reuse	0	0	0	0	0	0
Surface Water - Nueces/Rio Grande Resacas	225	225	225	225	225	225
Ground Water - Gulf Coast	8,706	8,714	8,724	8,731	8,735	8,737
Ground Water - Carrizo-Wilcox	552	552	552	495	495	495
Ground Water - Other Aquifer	550	550	550	550	550	550
County Other Municipal - TOTAL	71,886	71,497	71,248	71,031	70,649	70,273
MUNICIPAL - TOTAL	**302,938**	**298,506**	**298,373**	**298,315**	**298,041**	**297,812**
MANUFACTURING						
Surface Water - Amistad/Falcon System	5,115	5,512	5,771	5,938	6,324	6,704
Surface Water - Other Local Supply	0	0	0	0	0	0
Surface Water - Rio Grande Tributaries	0	0	0	0	0	0
Surface Water - Reuse	2,239	2,239	2,239	2,239	2,239	2,239
Surface Water - Nueces/Rio Grande Resacas	0	0	0	0	0	0
Ground Water - Gulf Coast	77	77	77	77	77	77
Ground Water - Carrizo-Wilcox	0	0	0	0	0	0
Ground Water - Other Aquifer	86	101	118	137	158	181
MANUFACTURING - TOTAL	**7,517**	**7,929**	**8,205**	**8,391**	**8,798**	**9,201**
STEAM ELECTRIC						
Surface Water - Amistad/Falcon System	10,837	10,837	10,837	10,837	10,837	10,837
Surface Water - Other Local Supply	0	0	0	0	0	0
Surface Water - Rio Grande Tributaries	0	0	0	0	0	0
Surface Water - Reuse	9,856	9,856	9,856	9,856	9,856	9,856
Surface Water - Nueces/Rio Grande Resacas	0	0	0	0	0	0
Ground Water - Gulf Coast	1,190	1,190	1,190	1,190	1,190	1,190
Ground Water - Other Aquifer	0	0	0	0	0	0
Ground Water - Carrizo-Wilcox	0	0	0	0	0	0
STEAM ELECTRIC - TOTAL	**21,883**	**21,883**	**21,883**	**21,883**	**21,883**	**21,883**

Table 3.12 - Summary of Total Amounts of Currently Available Water Supplies for the RGWPR by Water Use Category and by Source of Supply, cont'd.

Water Use Category / Source of Supply	2000	2010	2020	2030	2040	2050
MINING						
Surface Water - Amistad/Falcon System	1,582	1,338	1,272	1,220	1,109	1,011
Surface Water - Other Local Supply	0	0	0	0	0	0
Surface Water - Rio Grande Tributaries	356	355	356	350	310	277
Surface Water - Reuse	0	0	0	0	0	0
Surface Water - Nueces/Rio Grande Resacas	0	0	0	0	0	0
Ground Water - Gulf Coast	5,042	5,042	5,042	5,042	5,042	5,042
Ground Water - Carrizo-Wilcox	9,284	9,284	9,284	5,308	5,308	5,308
Ground Water - Other Aquifer	2,462	2,462	2,462	2,443	2,443	2,443
MINING - TOTAL	**18,726**	**18,481**	**18,415**	**14,363**	**14,212**	**14,080**
IRRIGATION						
Surface Water - Amistad/Falcon System	920,641	861,356	799,565	709,261	644,346	563,465
Surface Water - Irrigation Local Supply	0	0	0	0	0	0
Surface Water - Rio Grande Tributaries	5,020	5,005	5,005	4,918	4,346	3,868
Surface Water - Reuse	1,320	1,320	1,320	1,320	1,320	1,320
Surface Water - Nueces/Rio Grande Resacas	13,684	13,684	13,684	13,684	13,684	13,684
Ground Water - Gulf Coast	13,535	13,535	13,535	13,535	13,535	13,535
Ground Water - Carrizo-Wilcox	4,384	4,384	4,384	2,618	2,618	2,618
Ground Water - Other Aquifer	5,107	5,107	5,107	5,107	5,107	5,107
IRRIGATION - TOTAL	**963,691**	**904,390**	**842,600**	**750,442**	**684,956**	**603,597**
LIVESTOCK						
Surface Water - Amistad/Falcon System	73	73	73	73	73	73
Surface Water - Livestock Local Supply	4,520	4,520	4,520	4,551	4,551	4,551
Surface Water - Rio Grande Tributaries	0	0	0	0	0	0
Surface Water - Reuse	0	0	0	0	0	0
Surface Water - Nueces/Rio Grande Resacas						
Ground Water - Gulf Coast	2,545	2,545	2,545	2,545	2,545	2,545
Ground Water - Carrizo-Wilcox	17,120	17,120	17,120	9,785	9,785	9,785
Ground Water - Other Aquifer	330	330	330	330	330	330
LIVESTOCK - TOTAL	**24,588**	**24,588**	**24,588**	**17,284**	**17,284**	**17,284**
REGION M - TOTAL	**1,339,343**	**1,275,777**	**1,214,064**	**1,110,678**	**1,045,173**	**963,857**

Figure 3.23 - Currently Available Water Supplies for Cameron County by Type of Use and from Surface Water and Ground Water



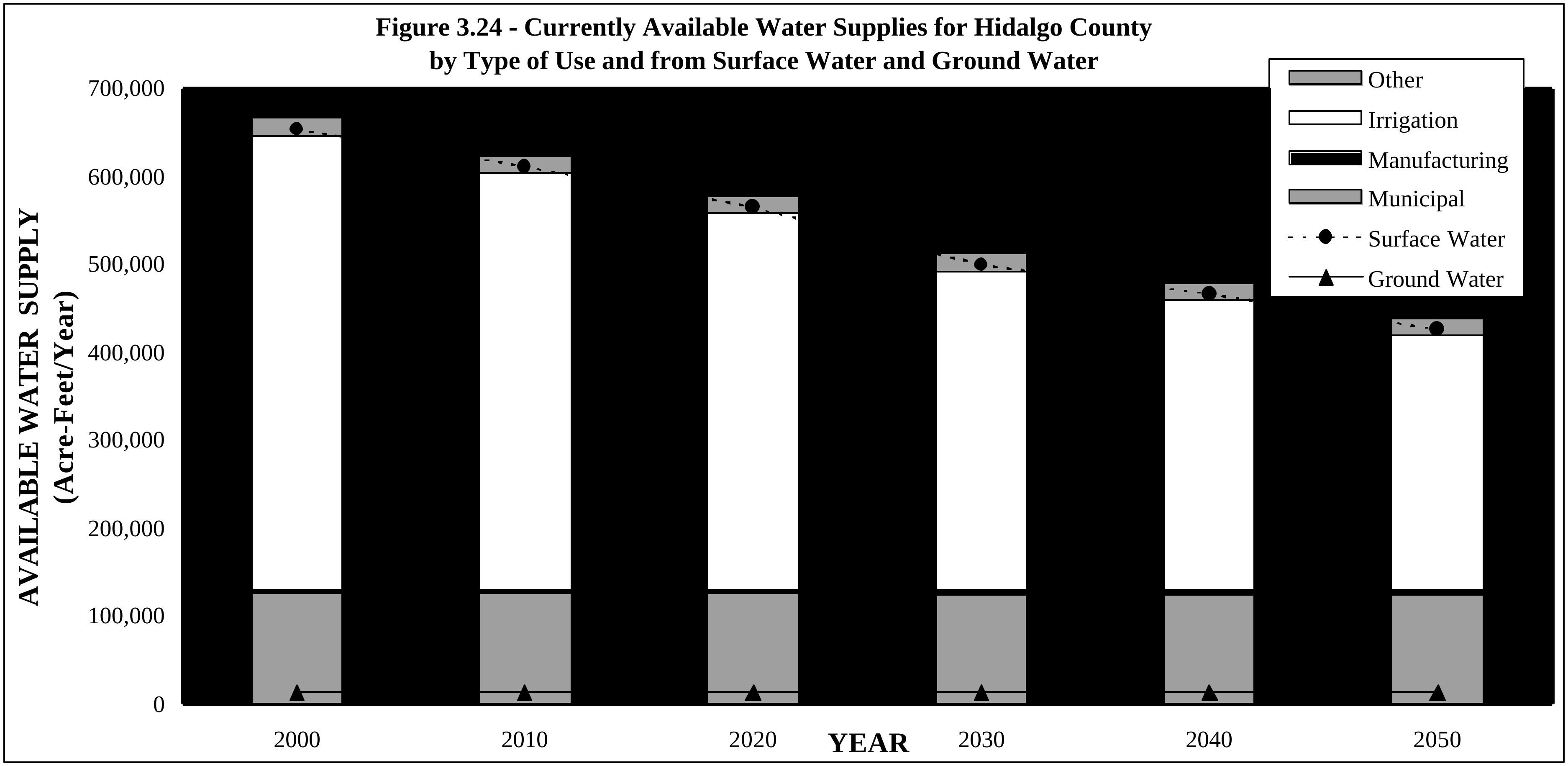


Figure 3.24 - Currently Available Water Supplies for Hidalgo County by Type of Use and from Surface Water and Ground Water

Figure 3.25 - Currently Available Water Supplies for Jim Hogg County by Type of Use and from Surface Water and Ground Water

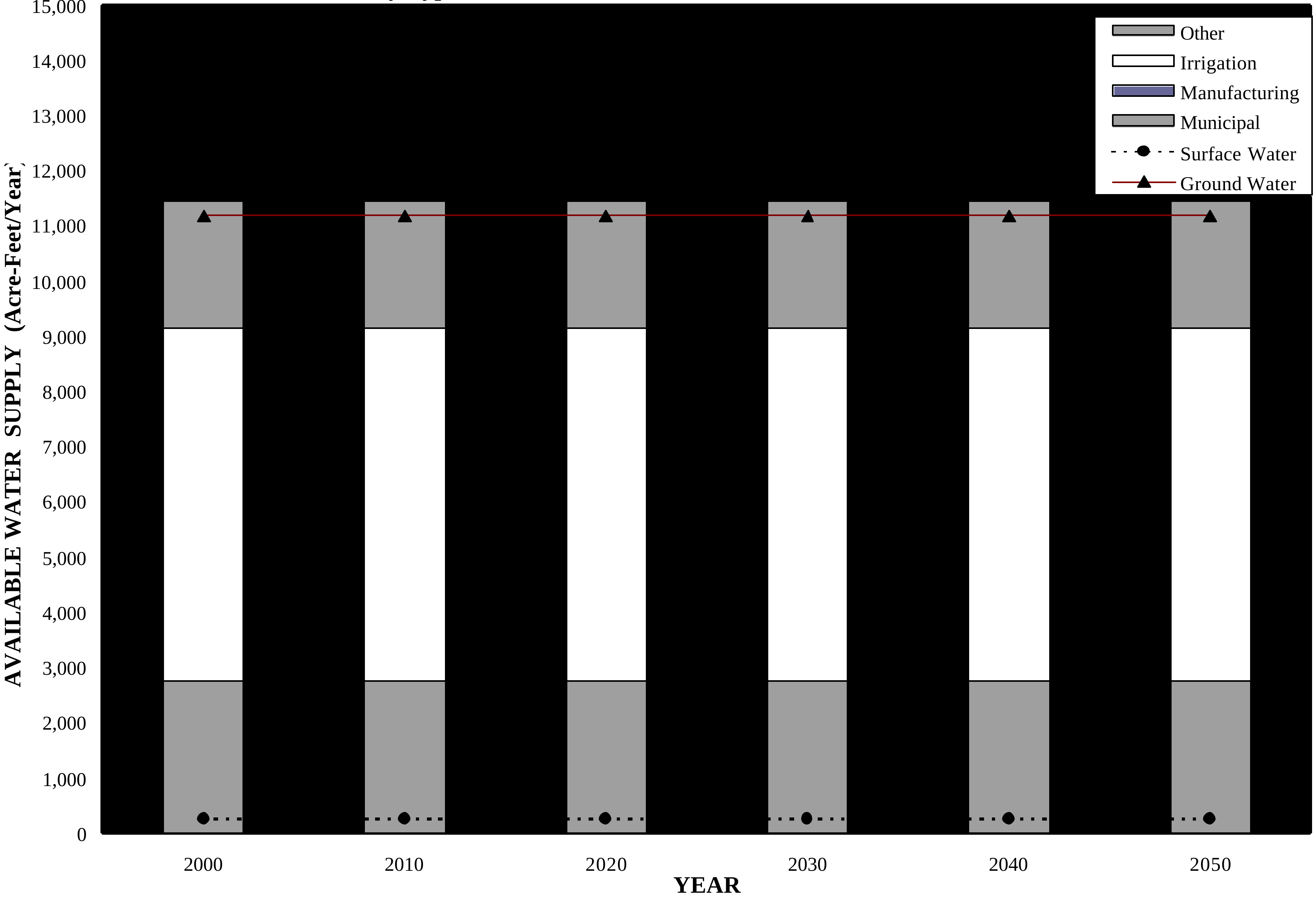


Figure 3.26 - Currently Available Water Supplies for Maverick County by Type of Use and from Surface Water and Ground Water

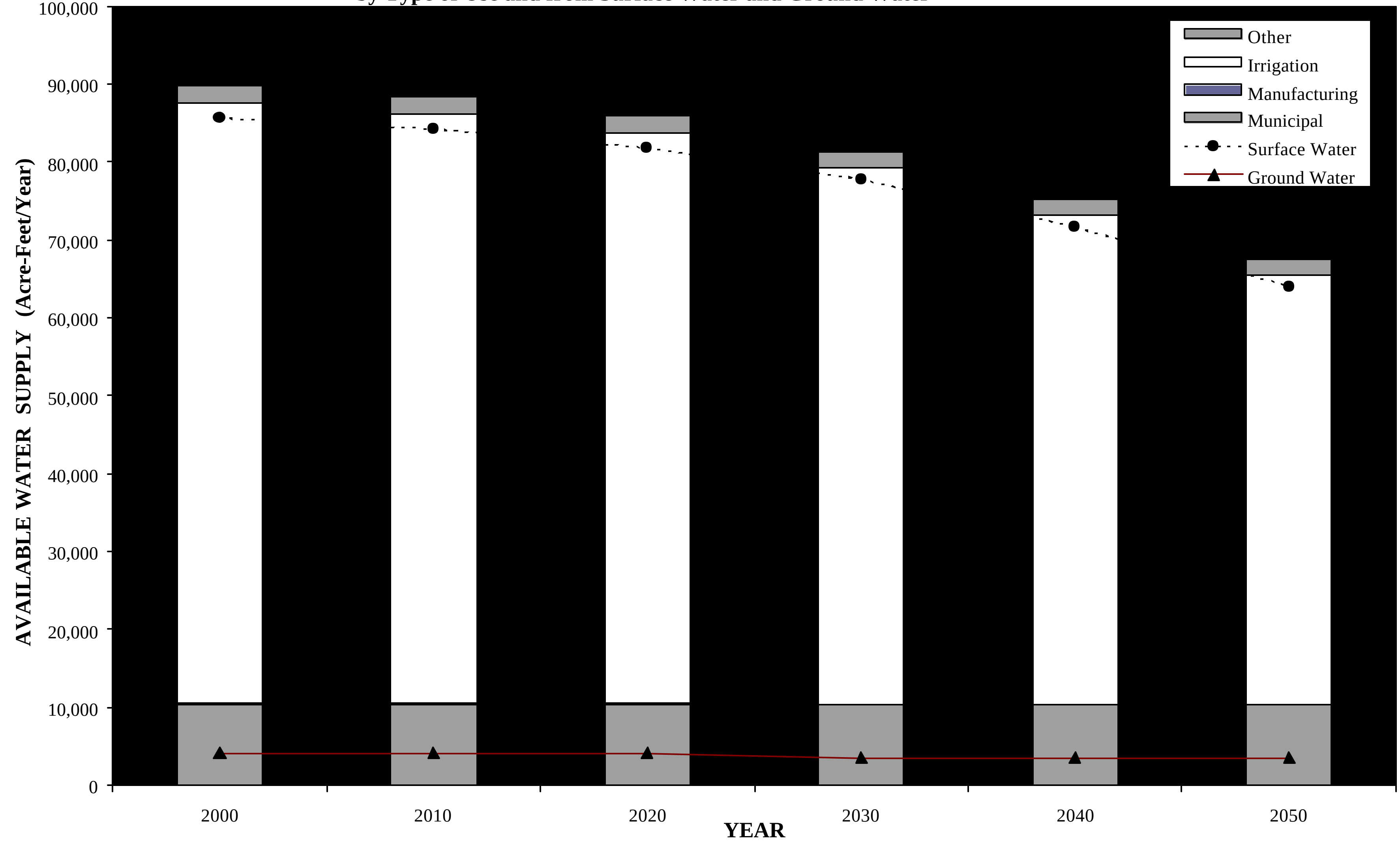


Figure 3.27 - Currently Available Water Supplies for Starr County by Type of Use and from Surface Water and Ground Water

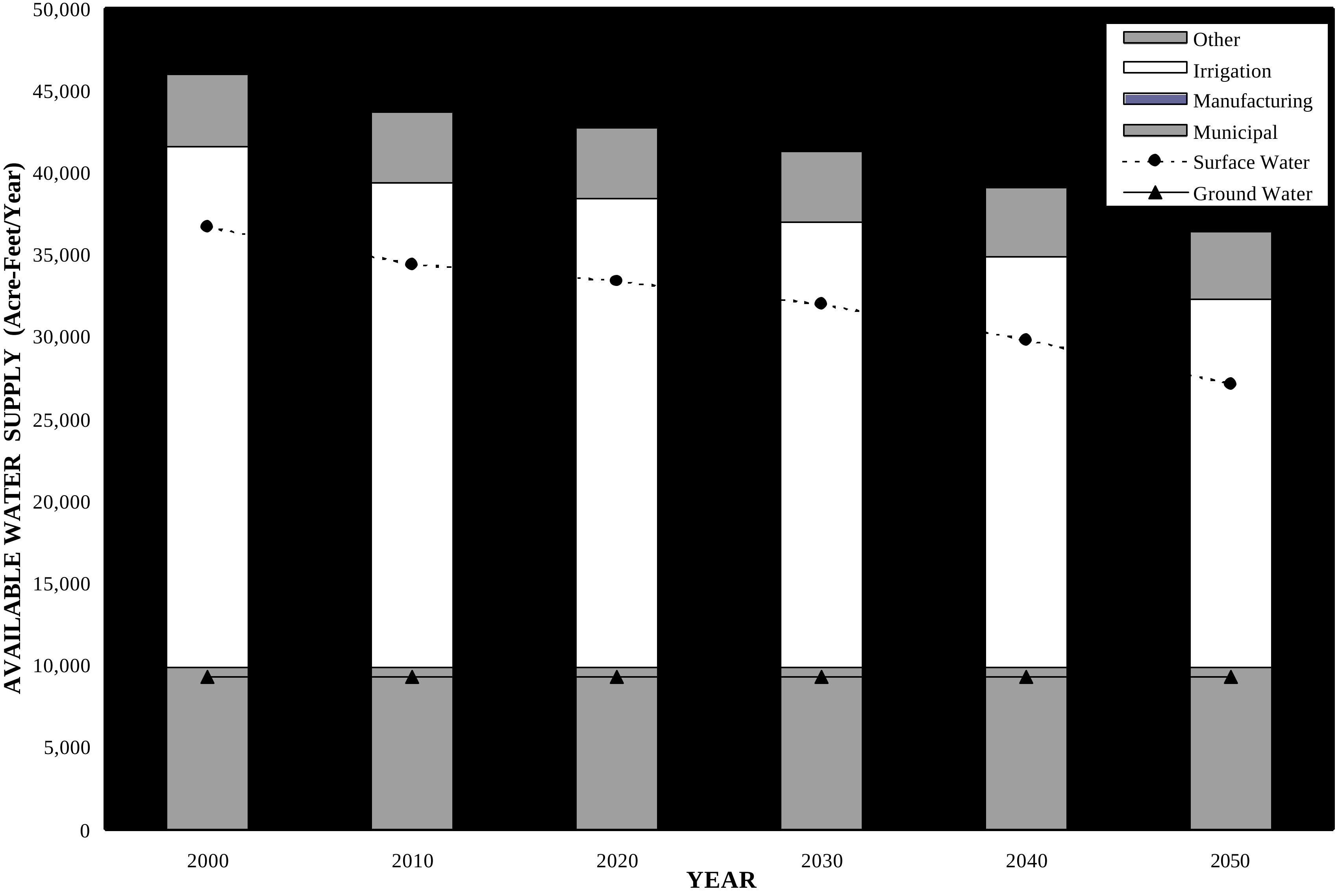


Figure 3.28 - Currently Available Water Supplies for Webb County by Type of Use and from Surface Water and Ground Water

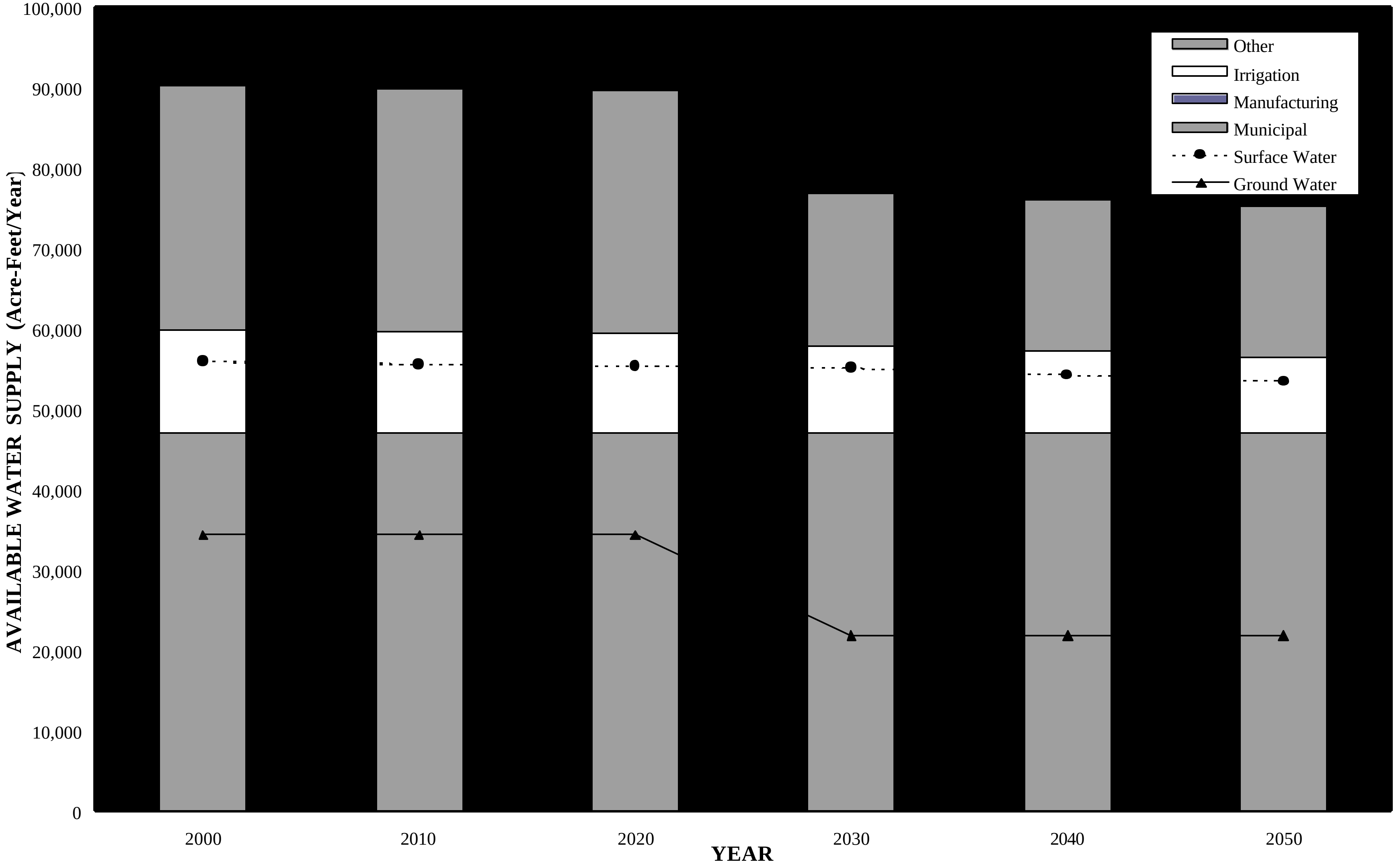


Figure 3.29 - Currently Available Water Supplies for Willacy County by Type of Use and from Surface Water and Ground Water

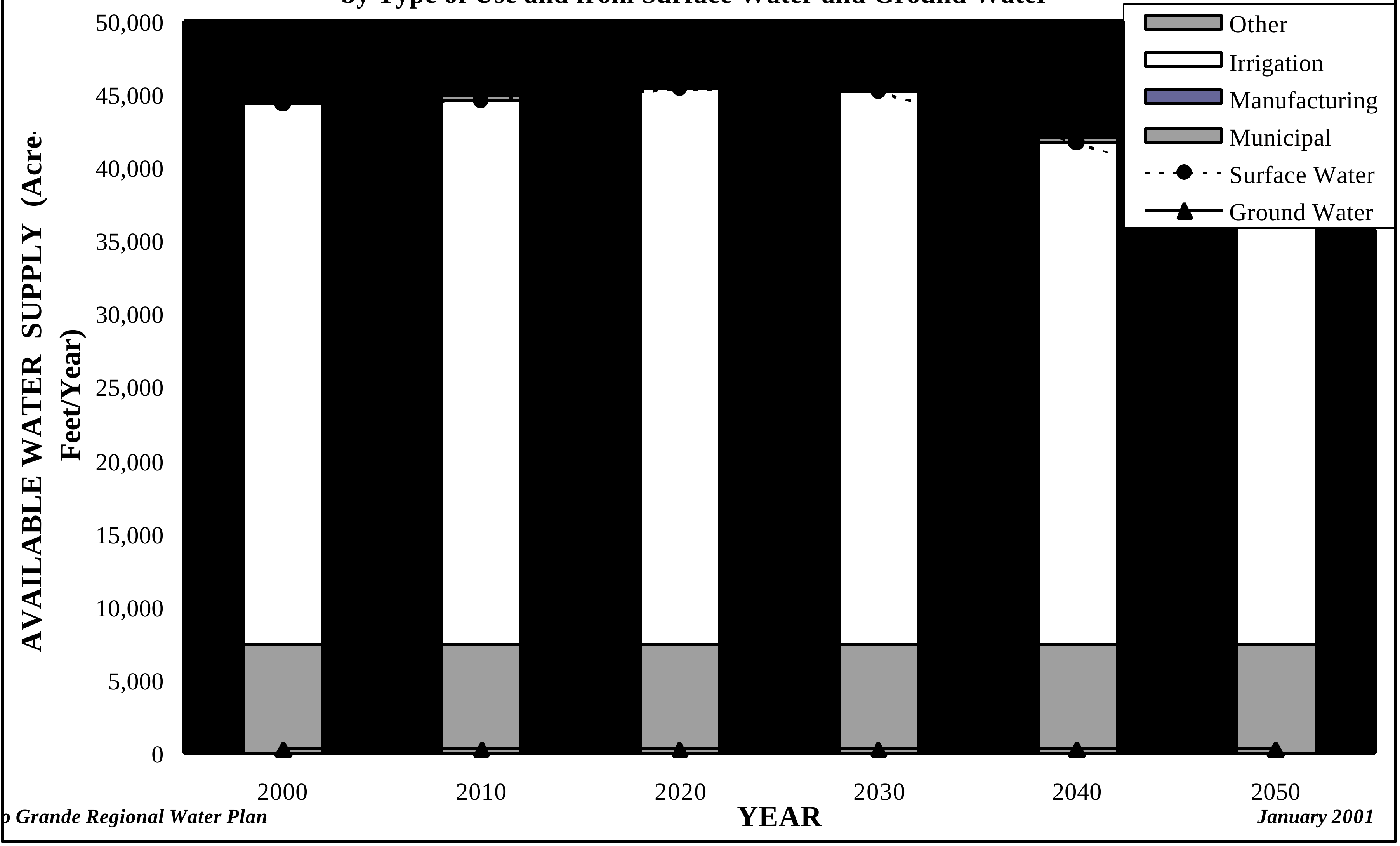
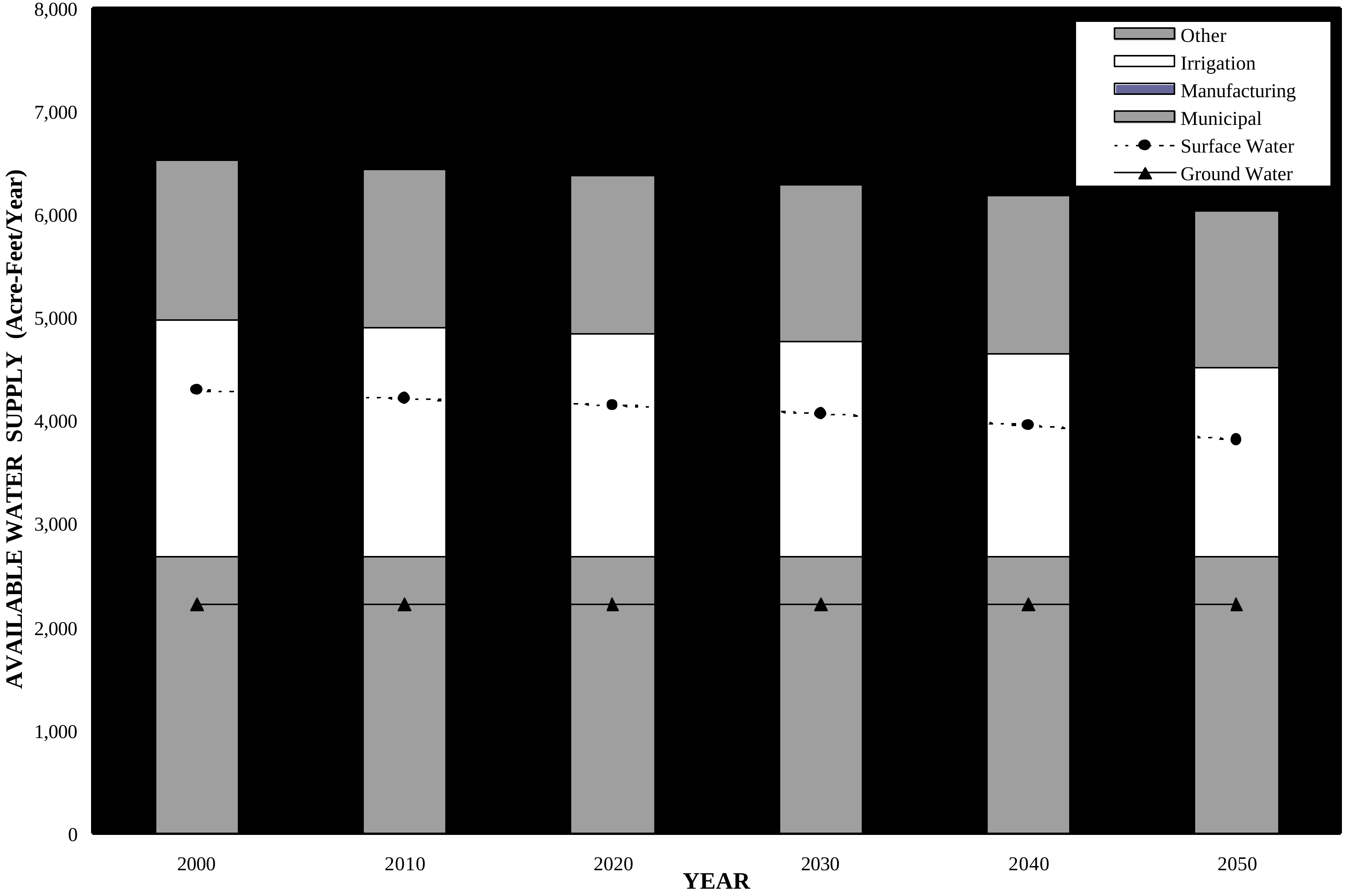


Figure 3.30 - Currently Available Water Supplies for Zapata County by Type of Use and from Surface Water and Ground Water



3.7.1 River Channel and Irrigation District Delivery System Water Losses

Preliminary estimates of the potential water losses that could be experienced when only municipal water is released from Falcon Reservoir during critical drought periods have been made in previous investigations that were undertaken as part of Phase II of the Lower Rio Grande Valley Regional Integrated Water Resources Planning Study (LRGIWRP-II Study) conducted by the Lower Rio Grande Valley Development Council[29]. In these investigations, the Amistad-Falcon ROM was modified and operated to evaluate the extent of the water losses that could be experienced along the lower Rio Grande and within the irrigation district water delivery systems during drought periods with only municipal water being released for the United States from Falcon Reservoir. Simulations were made with the ROM for a hypothetical period between 1995-2000, which was based on actual historical hydrologic and demand conditions through March 1998, and on assumed 1995 critical drought hydrologic conditions and year 2000 municipal demands for the period from April 1998 through December 2000[30]. With routines incorporated into the ROM to describe the channel losses along the lower Rio Grande and the anticipated losses within the irrigation district water delivery systems, the results from the ROM simulations provide an indication of the total quantities of water losses that could be experienced with only municipal water deliveries made in the Lower Rio Grande Valley without the benefit of irrigation carrying water.

For these simulations, the original Amistad-Falcon ROM link-node network as previously illustrated on the diagram in Figure 3.13 was extended downstream to include specific river reaches and water demand and loss centers along the lower Rio Grande. For the United States portion of the model, five reaches of the river were delineated for describing river channel losses between Falcon Dam and the City of Brownsville. These reaches are identified on the map of the four-county Lower Rio Grande Valley in Figure 3.31, and they are the same as those used by the Rio Grande Watermaster for facilitating water deliveries to the Lower Rio Grande Valley as previously described in Table 3.2. In addition, six additional nodes were defined in the ROM for describing the geographical distribution of United States municipal demands along the river downstream of Falcon Dam. For Mexico, two additional nodes were defined in the ROM network to account for the water demands associated with Mexico's Anzalduas Canal (at Anzalduas Dam) and the City of Matamoros. The expanded link-node network for the Amistad-Falcon ROM, including the additional links and nodes along the lower Rio Grande, is shown on the schematic in Figure 3.32.

The projected year-2000 municipal demands for the United States water users in the Lower Valley were distributed among the different nodes in the revised ROM based on geographical location and available information regarding which cities divert water directly from the river and which irrigation districts deliver river water to which cities. Table 3.13 summarizes the distribution of the year-2000 United States municipal water demands among the different river reaches and model nodes (Nodes 9, 11, 14, 16, 18, and 20). The various cities assigned to specific reaches and nodes in the ROM are listed in the table, and the corresponding sums of the year-2000 municipal water demands associated with each node are indicated. The locations of these cities within the four-county Lower Rio Grande Valley also are shown on the map in Figure 3.31.

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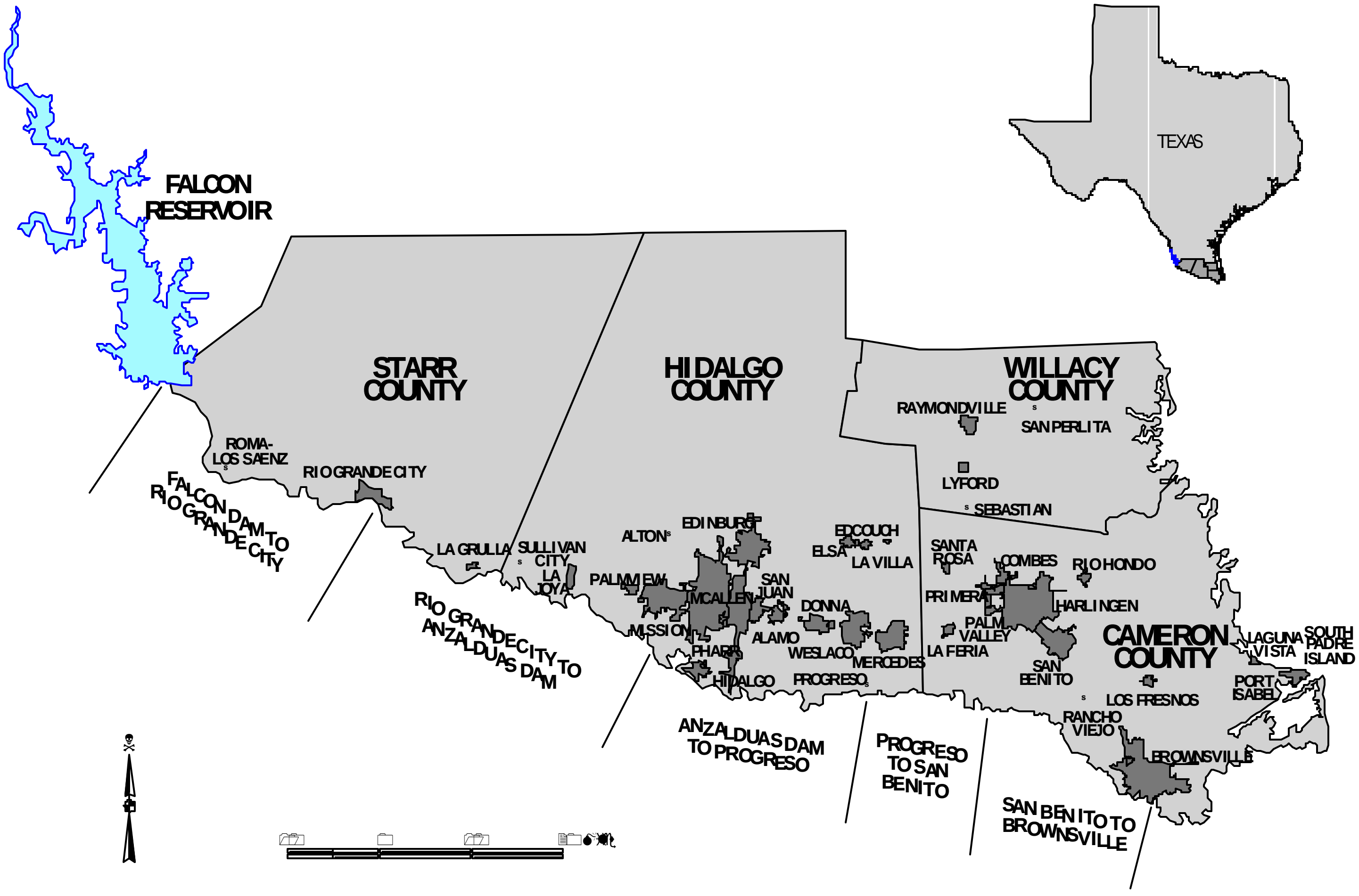
[29] R. J. Brandes Company; "Evaluation of Amistad-Falcon Water Supply Under Current and Extended Drought Conditions"; Phase II, Lower Rio Grande Valley Regional Integrated Water Resources Planning Study; Lower Rio Grande Valley Development Council and the Valley Water Policy and Management Council of the Lower Rio Grande Water Committee, Inc.; Austin, Texas; March, 1999.

[30] Actual hydrologic and demand conditions were used only for the period extending through March, 1998 because March, 1998 was the last month for which these data were available from the International Boundary and Water Commission at the time this investigation was undertaken.

Figure 3.31 - Designated River Reaches Along the Rio Grande



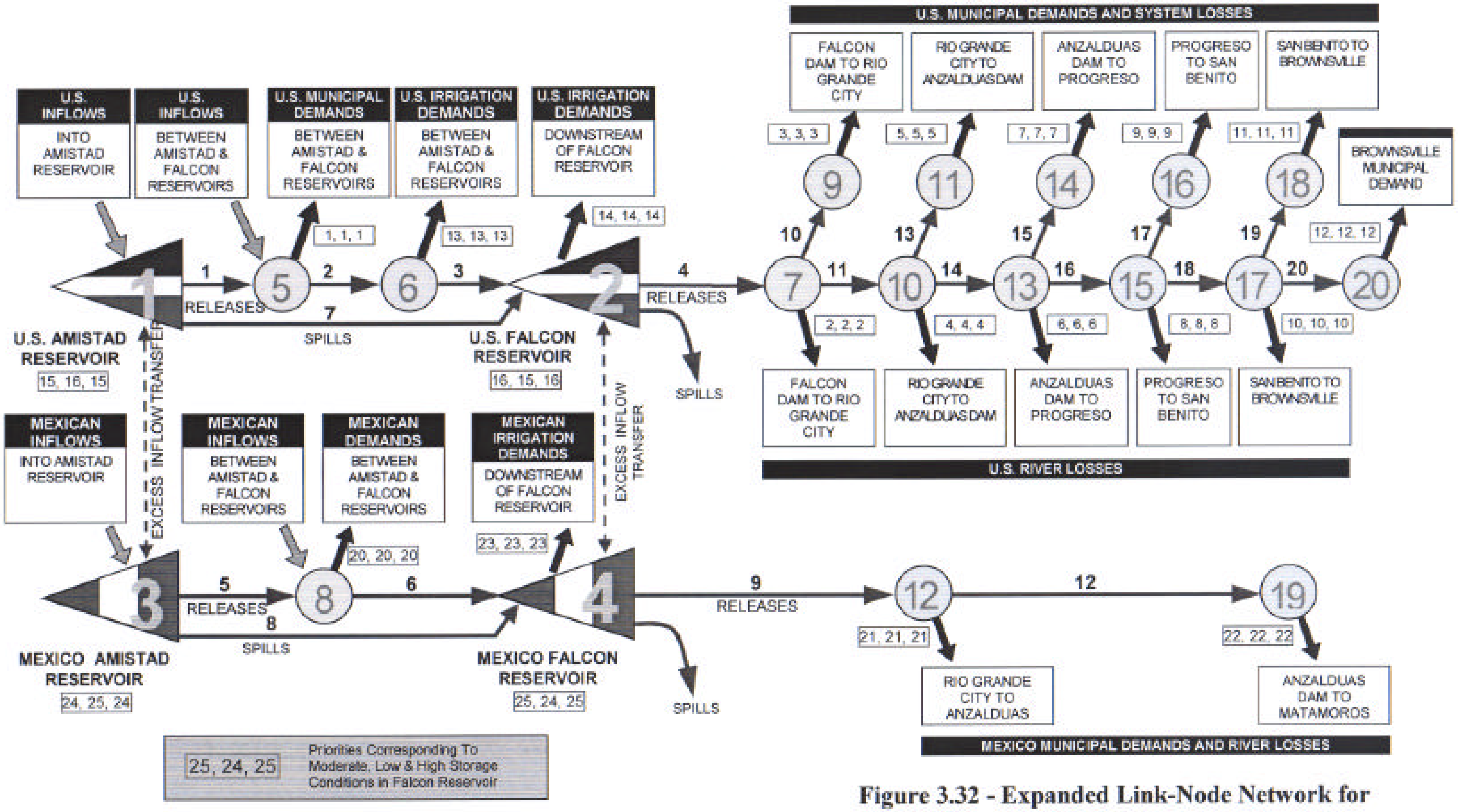


Figure 3.32 - Expanded Link-Node Network for Amistad-Falcon Reservoir Operations Model

Table 3.13 - Distribution of Projected Water Demands and Associated Irrigation District Delivery System Losses Under Severe Drought Conditions

ROM NODE NO.	REACH / NODE DESCRIPTION	PROJECTED YEAR-2000 WATER DEMANDS Acre-Feet	IRRIGATION DISTRICT DELIVERY SYSTEM CONVEYANCE LOSSES		
			15% Acre-Feet	20% Acre-Feet	25% Acre-Feet
9	Falcon Dam to Rio Grande City	5,032	351	469	586
	Rio Grande City*				
	Roma/Los Saenz				
11	Rio Grande City to Anzalduas Dam	47,997	7,200	9,599	11,999
	La Grulla				
	Starr County - Other				
	Sullivan City				
	La Joya				
	Palmview				
	Alton				
	Mission				
	Hidalgo County - Other				
14	Anzalduas Dam to Progreso	55,698	8,355	11,140	13,925
	Hidalgo				
	McAllen				
	Edinburg				
	Pharr				
	San Juan				
	Alamo				
	Donna				
	Elsa				
	Edcouch				
	La Villa				
	Weslaco				
	Progreso				
16	Progreso to San Benito	31,225	4,684	6,245	7,806
	Mercedes				
	San Perlita				
	Raymondville				
	Lyford				
	Sebastion				
	Willacy County - Other				
	La Feria				
	Santa Rosa				
	Palm Valley				
	Primera				
	Combes				
	Harlingen				
	Rio Honda				
	San Benito				

* Since raw water deliveries to Rio Grande City are diverted directly from the Rio Grande, no conveyance losses have been assigned to its projected year-2000 water demand (2,689 ac-ft).

Table 3.13 - Distribution of Projected Water Demands and Associated Irrigation District Delivery System Losses Under Severe Drought Conditions, cont'd.

ROM NODE NO.	REACH / NODE DESCRIPTION	PROJECTED YEAR-2000 WATER DEMANDS Acre-Feet	IRRIGATION DISTRICT DELIVERY SYSTEM CONVEYANCE LOSSES		
			15% Acre-Feet	20% Acre-Feet	25% Acre-Feet
18	San Benito to Brownsville Rancho Viejo Los Fresnos Laguna Vista Port Isabel South Padre Island Cameron County - Other	19,245	2,887	3,849	4,811
20	Brownsville*	27,000	0	0	0
TOTAL UNITED STATES DEMANDS AND SYSTEM LOSSES		186,198	23,476	31,302	39,127
12	Mexico Anzalduas Canal*	230,051	0	0	0
19	Matamoros and Other Users*	43,447	0	0	0
TOTAL MEXICO DEMANDS AND SYSTEM LOSSES		273,498	0	0	0

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* Since raw water deliveries to Brownsville, the Anzalduas Canal, and Matamoros are diverted directly from the Rio Grande, no conveyance losses have been assigned to their respective water demands.

Also included in Table 3.13 are the water demands for Mexico that were assigned to the nodes representing the Anzalduas Canal (Node 12) and the City of Matamoros and other Mexican water users in the Lower Rio Grande Valley below Anzalduas Dam (Node 19). The annual demand for the Anzalduas Canal node is based on the actual year 1995 canal diversions as reported by the IBWC during periods when irrigation usage by Mexico was minimal. For the City of Matamoros and other lower Rio Grande Mexican water users that divert their water directly from the Rio Grande, the annual demand in Table 3.13 reflects the actual 1995 releases of Mexico's water from Anzalduas Reservoir during non-irrigation periods.

For purposes of estimating seepage, evaporation and other losses that are typically experienced when United States water is conveyed through the irrigation district water delivery systems in the Lower Rio Grande Valley, information compiled and analyzed by other investigators during the LRGIWRP-II Study were used. In those investigations, it was concluded that, as an overall average, about 20 percent of the total amount of water diverted from the river by all of the districts is typically lost and not actually delivered to water users. Hence, the 20-percent loss rate also was assumed to be an appropriate average value for estimating the quantities of municipal water that potentially could be lost through the irrigation district delivery systems without irrigation carrying water. However, in order to provide for some level of variation in the estimated loss quantities, values of 15 percent and 25 percent also were incorporated into the analyses.

It should be noted that these levels of percentage loss rates for the irrigation district delivery systems under conditions with only municipal water being conveyed through the systems are strictly estimates. Values for these loss rates on the order of 20 percent were not verified with any field measurements or actual system data because such data and information are not known to exist for conditions similar to those which would occur with only municipal water being delivered. The historical average values of loss rates on the order of 20 percent for the irrigation district systems very likely were derived from actual data and observations that represent normal conditions when the systems are fully charged with water. Hence, the 20-percent loss rate reflects total seepage and evaporation losses from all components (canals, pipelines, and storage reservoirs) of the district delivery systems when full irrigation and municipal deliveries are being made. With only municipal water being delivered, it is reasonable to expect that only the essential canals and pipelines within each district system would be used to convey the municipal water; hence, the quantities of the associated losses should be less than those that normally would occur if all of the canals and pipelines were being used to convey water. The question that remains unanswered is whether the losses from the essential canals and pipelines that would be used to convey the municipal water would still be on the order of 20 percent of the quantity of municipal water being conveyed. In some cases, these losses certainly could be higher than 20 percent because the essential canals and pipelines would likely include the largest components; i.e., those with the largest surface area and wetted perimeter, that are located nearest the river within a given irrigation district system. However, it is also likely that these largest components of a given irrigation district system would be those that probably have been improved and possibly lined to minimize losses. These offsetting factors suggest that assuming average loss rates on the order of 20 percent for the irrigation district delivery systems may be appropriate even when only municipal water is being conveyed.

The resulting amounts of water losses associated with the conveyance of United States municipal water through the irrigation district delivery systems also are listed in Table 3.13 for each of the nodes in the revised ROM network where the lower Rio Grande municipal water demands are assigned. Three columns of figures are presented corresponding to the three different assumed percentages for conveyance losses (15%, 20%, and 25 %). For those entities that divert water directly from the river (Rio Grande City, Brownsville, Anzalduas Canal and Matamoros), no conveyance losses are indicated.

An analysis of historical monthly streamflow records for gages located along the lower Rio Grande also was made in an attempt to quantify historical channel losses from the river under flow conditions similar to those that might occur during extreme drought periods when only municipal water deliveries would be made from Falcon Reservoir. For this purpose, historical monthly streamflow and diversion data were examined for the period from 1960 through 1997[31] for each of the river reaches as previously identified on the map of the lower Rio Grande in Figure 3.31. Using these data, months during which the historical flows in the lower Rio Grande were of the same general magnitude as those that might be expected during future periods when only municipal water deliveries would be made from Falcon Reservoir were identified. The general ranges of these flow conditions by reach of the river were inferred based the projected demands and the estimated delivery system conveyance losses listed in Table 3.13. For the selected historical monthly data sets, water balance analyses were performed for each of the reaches to quantify monthly losses or gains. For the water balance analyses, the gaged monthly streamflows at the upstream and downstream ends of each reach and the corresponding gaged incremental tributary inflows and reported diversions were used.

The resulting monthly percentage losses and gains, calculated based on the flow at the upstream end of each reach, were plotted versus the flow at the downstream end of each reach. Plots were prepared for each of the five reaches of the lower Rio Grande. While the data shown on these plots does exhibit considerable variations with flow, the indicated loss percentages, nonetheless, do provide general estimates of the level of losses that might be expected, and these values were used to establish the following average and high percentage loss rates for each of the reaches:

River Reach	Average Loss Rate	High Loss Rate
Falcon Dam to Rio Grande City	4 %	7 %
Rio Grande City to Anzalduas Dam	5 %	7 %
Anzalduas Dam to Progreso	2 %	4 %
Progreso to San Benito	2 %	7 %
San Benito to Brownsville	8 %	10 %

Six different operations of the modified ROM were made corresponding to the three sets of irrigation district delivery system loss rates (15%, 20%, and 25%) and the two sets of river channel loss rates (average and high). Results from these simulations indicate that between 13 and 21 percent of the municipal water released from the reservoir for the United States during extreme drought periods without any irrigation carrying water potentially could be lost along the river, with Mexico's losses ranging between 11 and 17 percent. The differences between the river loss rates for the two countries are the result of allocating the total losses in a given reach based on the proportional amount of water that each country has flowing in the reach.

The total amount of water that must be released at any one time from Falcon Reservoir in order to satisfy United States municipal demands in the Lower Rio Grande Valley without the benefit of irrigation carrying water is equal to the sum of the individual demands themselves plus the estimated losses associated with the irrigation district delivery systems plus the estimated losses along the river channel. The resulting total loss rates associated with each of the six combinations of assumed irrigation district delivery system loss rates (15%, 20%, and 25%) and river channel loss rates (average and high) are

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[31] At the time of the studies, this was the last year for which published and unpublished streamflow and diversion records were available from the IBWC.

summarized in Table 3.14 for as percentages of the total municipal demands and as percentages of the corresponding releases from Falcon Reservoir required to meet these demands. These loss rates suggest that between 29 and 52 percent of the total United States municipal demands below Falcon Reservoir can be expected to be lost either along the river channel or through the irrigation district delivery systems, which means that an additional 29 to 52 percent of the municipal demands must be released from Falcon Reservoir in order for the full amount of the municipal demands to be satisfied; i.e., at the water treatment plant headgates. Or stated another way, for every acre-foot of United States water that is released from Falcon Reservoir to meet downstream municipal demands without the benefit of irrigation carrying water, between 22 and 34 percent can be expected to be lost either along the river channel or through the irrigation district delivery systems.

Corresponding results for Mexico based on the ROM simulations also are summarized in Table 3.14. The indicated total loss rates for Mexico (12% to 20% of total demands or 11% to 17% of Falcon releases) are considerably less than those for the United States because they do not reflect any conveyance losses within Mexico's internal water delivery system, for example, along the Anzalduas Canal. These total loss rates reflect only river channel losses. The corresponding river channel loss rates for the United States based on Falcon Reservoir releases are comparable and range between 13 and 21 percent.

3.7.2 Withdrawal Capabilities of Existing Diversion Facilities

Municipal water users in the Lower Rio Grande Valley that rely on irrigation districts to pump and deliver their water from the Rio Grande also have expressed concerns regarding the ability of the districts' pumping facilities on the river to effectively function when flows in the river may become diminished because irrigation water is not being conveyed. As with the loss analysis described in the previous section, under these conditions, it is conceivable that if only municipal water is being released from Falcon Reservoir and conveyed in the river, then the river levels may be so low that the pump intakes could be physically above the level of the river and, therefore, unable to withdraw water from the river.

To investigate this potential problem, the Lower Rio Grande Development Council entered into a Research and Planning Fund Research Grant Contract with the TWDB to assemble data on each irrigation district diversion facility on the lower Rio Grande that delivers water for domestic, municipal, and industrial uses. The objective on the study was to assess the irrigation district diversion facilities on the river to develop an opinion as to whether municipal water supplies could be pumped from the river and delivered under conditions when little or no irrigation water is being used.

To achieve the basic objective of the study, the following specific activities were undertaken:

- Available construction drawings showing the general plan and capacity of each diversion facility, including existing weirs, were assembled;
- A committee of three irrigation district representatives and three municipal representatives was established to review the assembled drawings;
- Each critical diversion facility was reviewed and discussed to evaluate its capabilities for delivering municipal water in the absence of irrigation water in the river; and,
- A written summary report was prepared.

Table 3.14 - Summary of Total Losses Associated with Municipal Water Deliveries in the Lower Rio Grande Valley Under Severe Drought Conditions

UNITED STATES WATER DELIVERIES

Irrigation District System Loss and River Loss Condition Demands	Based On Municipal Releases	Based On Falcon
15% Irrigation System Loss, Average River Loss	29 %	22 %
20% Irrigation System Loss, Average River Loss	34 %	25 %
25% Irrigation System Loss, Average River Loss	38 %	28 %
15% Irrigation System Loss, High River Loss	42 %	29 %
20% Irrigation System Loss, High River Loss	47 %	32 %
25% Irrigation System Loss, High River Loss	52 %	34 %

MEXICAN WATER DELIVERIES

River Loss Condition	Based On	Based On
Total Falcon		
Demands	Releases	
Average River Loss	12 %	11 %
High River Loss	20 %	17 %

Based on past history of operations, it was verified during the study that the irrigation districts can divert, and have diverted, water from the Rio Grande when there is no irrigation water being released from Falcon Reservoir; although, pumping efficiencies are negatively affected and the overall volumes capable of being pumped are limited. There are documented data from the Rio Grande Watermaster and the IBWC that indicate the historical periods of time when little or no irrigation water was being released from Falcon Reservoir. The water diverted from the river during these periods was only municipal water. Based on this historical data, the study concluded that irrigation districts would be able to physically pump water from the river even if the only water flowing in the Rio Grande is water that has been released from Falcon Reservoir for municipal uses.

The study also noted that the major water diverters (irrigation districts) along lower Rio Grande, below Anzalduas Dam, have weirs constructed across the river downstream of their respective diversion points. These weirs are effective in maintaining a minimum river elevation at the districts pumping facilities and creating a pool of water that facilitates the diversion of water during low flow conditions. Irrigation districts with their river pumping facilities located upstream of Anzalduas Dam utilize the reservoir created by the dam itself; therefore, their ability to divert water for municipal use generally is not affected when there is no irrigation water flowing in the river.

In conclusion, the study made the following recommendations:

> *All cities and/or water purveyors must be required to have control of, or contract to an irrigation district for, raw water storage for at least 20 to 30 days of supply. Raw water storage requirements should meet the maximum daily demand from the water treatment facility. The 20 to 30-day storage requirement should be a firm storage requirement and not be based on total volume of storage. If cities had a requirement to have 20 to 30 days of water storage, it would greatly increase the efficiency in how the irrigation districts divert water. This would be the responsibility of the city and not the district since it would only benefit the city.*
>
> *Several cities rely on the irrigation districts' canal system as their reservoir. This practice places an unnecessary burden on the irrigation districts. Cities should not take into account canals as storage facilities unless there are no taps to the canal prior to the cities' diversion points. In other words, they can use that portion of the canal that serves solely their water treatment facility, if and only if, the irrigation district agrees to the concept. The storage could be contained through weirs or gates to meet that storage requirement. If an irrigation district has a storage structure at the present time, the district might explore to determine if the structure can be reworked to provide more storage, or to determine if there is a way that the city can put their own storage facility into operation. If the district has a storage structure presently, the district could work with the city to fund the needed repairs of the facility.*

In addition, the study also made the following specific recommendations to insure the continued pumping ability of the districts under low flow conditions:

1. *A study should be made on all existing Rio Grande weirs (and future installations) that could determine their positive impact on pumping conditions during low flows. Also, to determine what could be done to increase the positive results of the weirs now in place;*

2. *Further study should be done on the aquatic weed infestation and its impact on low Rio Grande flows.*

3. *The water ordering mechanism now being used between the irrigation districts and the Rio Grande Watermaster needs to be investigated to determine what would best enhance the efficient delivery of water from the Falcon Lake if the situation ever arose where only municipal water was remaining in the reserves.*

4. *Additional measuring or gauging stations along the river could better monitor the river flow and could provide a higher level of operation. Efforts should be made to coordinate the activities of all the agencies to assist in the funding of such a program.*

5. *Negative environmental effects resulting from the low flows, such as potential fish or wildlife damage, need to be addressed by those water right holders (Texas Parks & Wildlife, U.S. Fish and Wildlife, etc.) who have the water reserves that could possibly alleviate these conditions. No other water right allocation holders should use their reserves for this purpose.*

6. *The cities can help themselves by either studying their water supply system themselves or hiring someone to assess their needs and provide an answer for them. Many of the smaller towns have let their treatment and distribution systems and their water supply sources to their system deteriorate for so many years. These cities are in an almost impossible situation money-wise to be able to provide any type of fix to these facilities.*

3.8 COORDINATION WITH MEXICO

3.8.1 Border Region Population and Water Demands

The population of cities and towns within the border region of Mexico along the RGRWPA[32] increased by about two-thirds over the last 20 years, and it is expected to double in the next 20 years. Historical and projected population figures for cities and towns in this area are summarized by state in Table 3.15. As shown, the total population for this border region of Mexico is expected to increase from about 1,800,000 in the year 2000 to over 3,700,000 by the year 2020, with most of this growth occurring in the states of Coahuila and Tamaulipas.

Projected municipal water demands for the cities and towns listed in Table 3.15 have been estimated based on recent per capita water usage figures for selected cities located along the Rio Grande within the states of Coahuila and Tamaulipas for which data are readily available (see Table 3.16, Historical Annual Per Capita Water Usage for Mexican Border Cities). Using the average daily per capita water use figure of 88 gallons, the total municipal water demands for the projected border region populations within each of the Mexican states have been calculated. These projected municipal water demands also are presented in Table 3.15. As indicated, by the year 2020, a total of approximately 365,000 acre-feet of water per year is projected to be needed for municipal uses in the designated four-state border region of Mexico. Assuming that the existing sources of supply will continue to be relied upon in the future, about 90

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[32] For purposes of this report, the border region within Mexico extends approximately 100 miles into Mexico from the Rio Grande.

Table 3.15 - Population and Municipal Water Demands for Mexican Border Region

Historical and Projected Population[1]

State Community	1980	1990	2000	2010	2020
Chihuahua	68,121	71,451	79,630	92,069	106,798
Janos	8,904	10,896	10,767	10,706	10,384
Asencion	11,985	16,360	23,765	34,592	49,062
Praxedis G Guerrero	7,774	8,439	9,548	10,757	11,764
Guadalupe	8,874	9,053	10,199	11,451	12,521
Ojinaga	26,420	23,909	23,391	23,170	22,163
Manuel Benavides	4,164	2,794	1,960	1393	904
Coahuila[2]	151,623	191,135	301,256	493,352	834,135
Ocampo	9,000	7,853	7,234	6,842	6,482
Acuna	41,947	56,335	107,167	241,466	492,484
Jimenez	8,636	8,254	10,507	13,354	16,672
Piedras Negras	80,291	98,184	125,956	192,069	262,996
Nava	8,684	16,916	24,840	36,435	52,355
Guerrero	2,314	2,373	1,950	1,611	1,303
Hidalgo	751	1,220	1,342	1,575	1,843
Nuevo Leon	16,475	17,312	19,465	22,072	24,596
Tamaulipas[2]	849,417	1,015,562	1,411,397	1,969,848	2,734,972
Nuevo Laredo	203,285	219,465	308,852	536,784	828,248
Guerrero	4,191	4,510	3789	3,339	3,145
Mier	6,382	6,242	6,632	6,682	6,977
Miguel Aleman	19,600	21,323	19,421	25,812	28,183
Camargo	16,014	15,042	15,561	16,075	16,302
Gustavo Diaz Ordaz	17,830	17,704	13,878	10,827	8,246
Reynosa	211,411	282,666	399,108	563,994	774,085
Rio Bravo	83,523	94,010	107,428	122,296	135,912
Valle Hermosa	48,342	51,305	59,785	69,636	79,658
Matamoros	238,839	303,295	370,954	614,403	854,216
Total Border Region	1,085,636	1,295,460	1,811,748	2,577,341	3,700,501

Projected Municipal Water Demands[3]

State	- -	- -	2000	2010	2020
Chihuahua	- -	- -	7,850	9,076	10,528
Coahuila	- -	- -	29,698	48,634	82,229
Nuevo Leon	- -	- -	1,919	2,176	2,425
Tamaulipas	- -	- -	139,135	194,186	269,612
Total Border Region	- -	- -	178,601	254,073	364,793

[1] Source: Instituto Nacional de Estadstica Geografia e Informatica of Mexico, 1996; as presented by J. Peach and J. Williams, New Mexico University, "Population and Economic Dynamics on the U.S.-Mexico Border: Past, Present and Future", SCERP-EPA Border Institute, Rio Rico, Arizona, December 7-9, 1998.

[2] Source: Jose Maria Hinojosa, Comision Nacional Del Agua, fax transmitted on August 28, 2000

[3] Based on 88 gallons per capita per day (See Table 3.16 in this report).

Table 3.16: Calculation of Average Daily Per Capita Municipal Water Usage for Mexican Border Region

State Community	Year	Population	Rio Grande Diversions Acre-Feet	Per Capita Water Usage Gallons/Day
Coahuila				
Cd. Acuna	1990	56,336	2,910	46
Cd. Acuna	1996	81,577	3,087	34
Cd. Acuna	1997	81,577	3,107	34
Piedras Negras	1990	98,185	7,315	67
Piedras Negras	1996	116,097	8,806	68
Piedras Negras	1997	116,097	12,791	98
Tamaulipas				
Nuevo Laredo	1990	219,468	20,606	84
Nuevo Laredo	1996	274,913	46,018	149
Nuevo Laredo	1997	274,913	40,458	131
Nvo. Cd. Guerrero	1996	4,007	548	122
Nvo. Cd. Guerrero	1997	4,007	579	129
Cd. Mier	1996	6,270	600	85
Cd. Mier	1997	6,270	554	79
Cd. Miguel Aleman	1996	22,363	2,440	97
Cd. Miguel Aleman	1997	22,363	2,384	95
Cd. Diaz Ordaz	1996	15,685	1,338	76
Cd. Diaz Ordaz	1997	15,685	1,231	70
Reynosa	1996	336,732	39,358	104
Reynosa	1997	336,732	35,619	94
Matamoros	1997	363,236	40,480	99
		Average Daily Per Capita Water Usage:		88

NOTE:
Historical data for population figures and corresponding Rio Grande diversions have been obtained from the International Boundary and Water Commission, United States Section and Mexico Section; "Flow of the Rio Grande and Related Data From Elephant Butte Dam, New Mexico to the Gulf of Mexico, 1997"; Water Bulletin No.67 and other previous Water Bulletins; El Paso, Texas.

percent of these projected municipal water demands will be satisfied with surface water from the Rio Grande; i.e., from Amistad and Falcon Reservoirs.

Most of the water used by Mexico in the border states is for irrigation of crops. Information supplied by Mexico pursuant to bi-national meetings and discussions regarding Mexico's tributary inflow deficits under the 1944 Treaty (see Section 3.8.3) provides insight with regard to Mexico's irrigation activities and water usage in the Rio Grande border region[33]. The historical annual usage of water for irrigation by Mexico in three different portions of the Rio Grande Basin is illustrated by the bar chart in Figure 3.33. This chart shows the irrigation water usage by year since 1960 as reported by Mexico for eight individual irrigation districts according to their location in either the Rio Conchos Basin, which is upstream of Amistad Reservoir, the Middle Rio Grande Basin between Amistad and Falcon Reservoirs, or the Lower Rio Grande Basin below Falcon Reservoir[34]. Practically all of the water used by Mexico for irrigation in the Rio Conchos and Middle Rio Grande Basins is diverted from tributaries, whereas most of the water used in the Lower Rio Grande Basin comes from releases from Falcon Reservoir that are subsequently diverted into Mexico's Anzalduas Canal.

As shown by the annual irrigation water use amounts in Figure 3.33, since 1980, Mexico has used on the order of 1.5 to 3.0 million acre-feet of water per year for irrigation within the Rio Grande Basin, most of which has occurred below Falcon Dam, with the Rio Conchos Basin being the next area of significant irrigation water use. Since 1980, Mexico has averaged about 2,000,000 acre-feet per year of irrigation water use, including the relatively low usage during the current 1990's drought. On the chart in Figure 3.33, the effect of the reduced water supply available from Amistad and Falcon Reservoirs during the current 1990's drought on Mexico's irrigation water use is evident after 1994 (for the 1995-1999 period, Mexico averaged about 1,000,000 acre-feet of irrigation water use per year). The variations in the annual amounts of irrigation water usage from year to year probably reflect corresponding variations in local rainfall and climatic conditions, crop acreage, cropping patterns, and the availability of water stored either in Mexico's tributary reservoirs or in Amistad and Falcon Reservoirs. However, it does appear that Mexico's overall demand for irrigation water significantly increased around the early 1980's. In the future, it is reasonable to expect Mexico to continue to use generally the same amounts of water for irrigation within the Rio Grande Basin that it has used since the early 1980's, with the same types of variations as dictated by climatic and hydrologic conditions.

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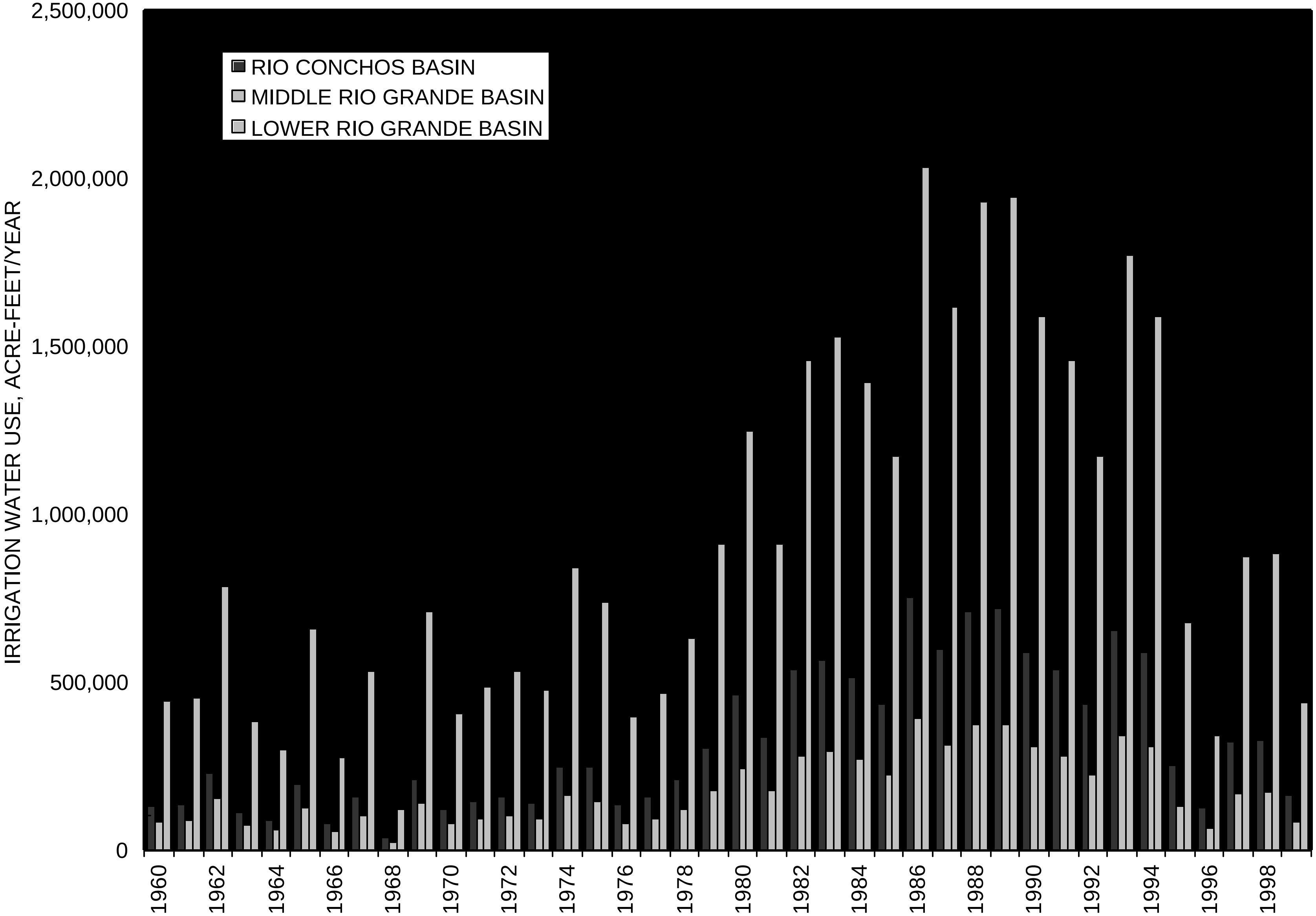
[33] Mexico Comision Nacional Del Agua; "Comentarios al Documento Estadounidense: 'Analisis Preliminar del Deficit Mexicano de Las Aguas del Rio Bravo, Bajo el Tratado de 1944'"; Mexico, D. F.; February 8, 2000.

[34] It should be noted that, since Mexico provided only total quantities of water used for irrigation each year in all eight of the irrigation districts, the distribution of these total amounts to the individual districts has been made based on the average number of acres irrigated in each of the districts since they have been in operation as reported by Mexico. This procedure may not have produced the actual amount of irrigation water used in each district in each year, but it is believed to provide a meaningful indication of the distribution of irrigation water use among the three different subbasins within the Rio Grande Basin.

Figure 3.33 - Historical Annual Irrigation Water Usage by Mexico



3.8.2 Mexican Amistad-Falcon Reservoir System Release Patterns

One of the tasks included in the water supply planning effort for the RGRWPA relates to developing an understanding of Mexico's planned municipal and irrigation release patterns for Amistad and Falcon Reservoirs such that any potential impacts on the availability of water for Rio Grande water users might be identified. As a first step in examining these releases, data describing Mexico's historical monthly releases from Amistad and Falcon Reservoirs have been obtained from the IBWC, and plots of these monthly releases, along with reservoir storage, for the period from 1985 through 1999 have been made.

Figure 3.34 is a graph showing the historical monthly releases, or flood spills, of Mexican water from Amistad Reservoir for the period 1985-1999. The corresponding historical end-of-month storage of Mexican water in Amistad Reservoir also is plotted on the graph. To help in understanding the relationships between Mexican releases and storage as plotted in Figure 3.34, a similar graph of the corresponding inflows of Mexican water into Amistad Reservoir is plotted in Figure 3.35, again with the historical end-of-month Mexican storage in the reservoir. As expected and as illustrated by the curves on the plot in Figure 3.34, when Mexican releases are made from the reservoir, the storage in the reservoir falls. For example, this trend is clearly evident in 1986, 1994, 1998, and 1999 when significant irrigation releases were made each year, resulting obvious declines in reservoir storage.

The reverse trend is evident, of course, when significant inflows to the reservoir cause the storage to increase. In Figure 3.35, such rises in reservoir storage are apparent in the latter part of 1986 and 1990, when substantial amounts of inflow occurred. In the latter part of 1991, significant inflows also occurred (see Figure 3.35), but because the reservoir already was relatively full as a result of the 1990 inflows, significant releases were made and the storage in the reservoir increased only slightly. The only regular pattern of releases that might be discerned from the release curve in Figure 3.34 is that increased releases up to several hundred thousand acre-feet per month typically have been made during the spring and/or early summer of practically every year to provide water for irrigation demands downstream. Otherwise, baseflow releases on the order of about 25,000 acre-feet per month have been made, at least under normal flow and reservoir storage conditions. As can be seen, releases from Amistad Reservoir were significantly reduced from about mid-1995 through early 1998 as inflows to the reservoir were diminished.

The significance of the curves presented in Figures 3.34 and 3.35 with respect to Mexico's historical release patterns for Amistad Reservoir is that they demonstrate that releases are made in response to both downstream demands and inflows to the reservoir depending on current circumstances. This mode of operation is not going to change in the future. Furthermore, the 1944 Treaty between the United States and Mexico stipulates that "storage in all major international reservoirs above the lowest shall be maintained at the maximum possible water level, consistent with flood control, irrigation use and power requirements". At the present time, Amistad Reservoir is the only major international reservoir above the lowest, which is Falcon Reservoir. Hence, Amistad Reservoir is operated by IBWC, in conjunction with Falcon Reservoir, in a manner that maximizes the amount of water stored in Amistad for both countries. This operating requirement obviously influences release patterns for Amistad Reservoir.

A plot of the historical monthly releases of Mexican water from Falcon Reservoir for the period 1985-1999 is presented in Figure 3.36. Because of the greater demand for irrigation water downstream in the Lower Rio Grande Basin and the requirement under the 1944 Treaty for using water first from the lowest major international reservoir, the spring and early summer releases depicted on this plot are more prominent for Falcon Reservoir than they are for Amistad Reservoir (see Figure 3.34). As shown,

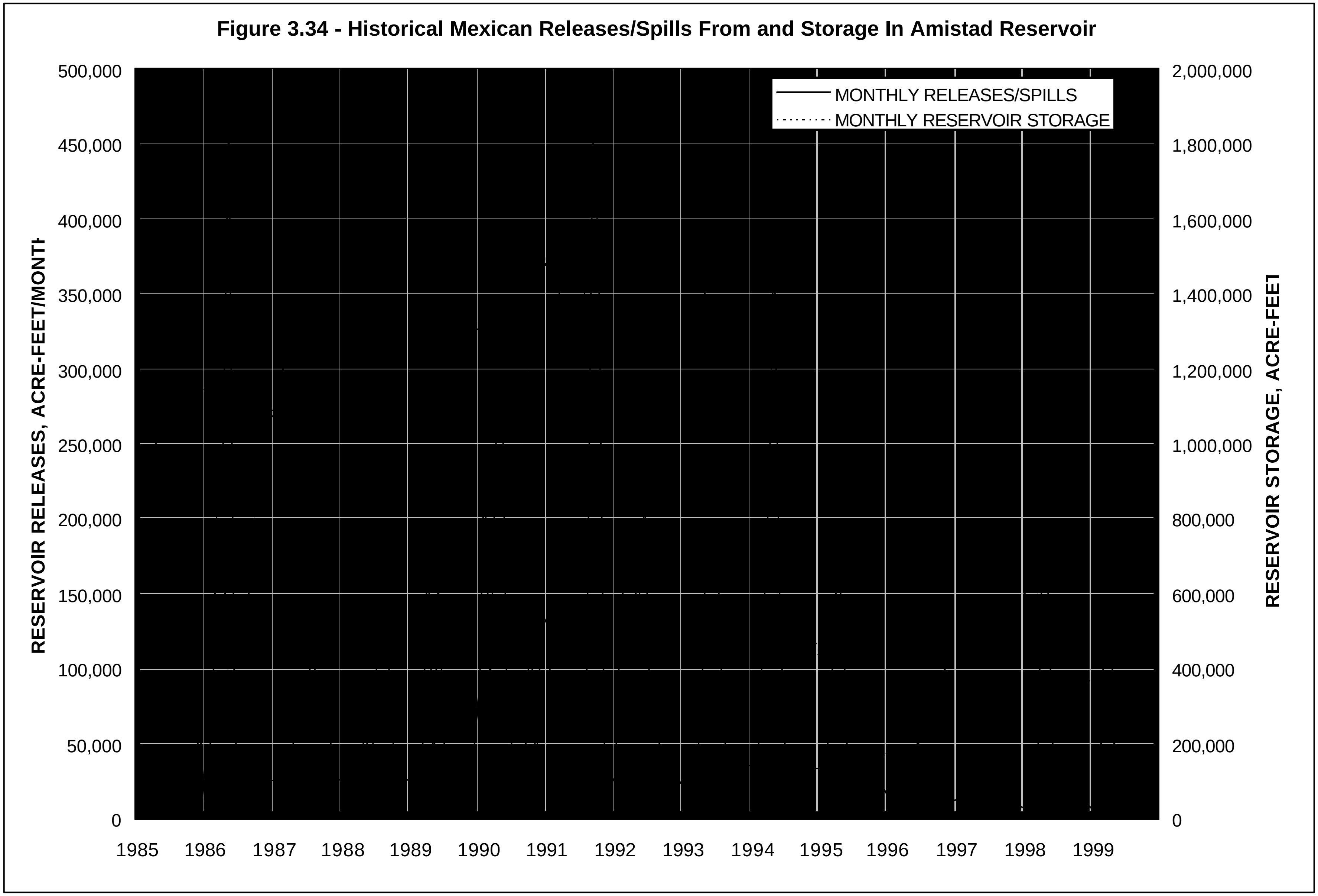


Figure 3.34 - Historical Mexican Releases/Spills From and Storage In Amistad Reservoir
MONTHLY RELEASES/SPILLS
MONTHLY RESERVOIR STORAGE
RESERVOIR RELEASES, ACRE-FEET/MONTH
RESERVOIR STORAGE, ACRE-FEET
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

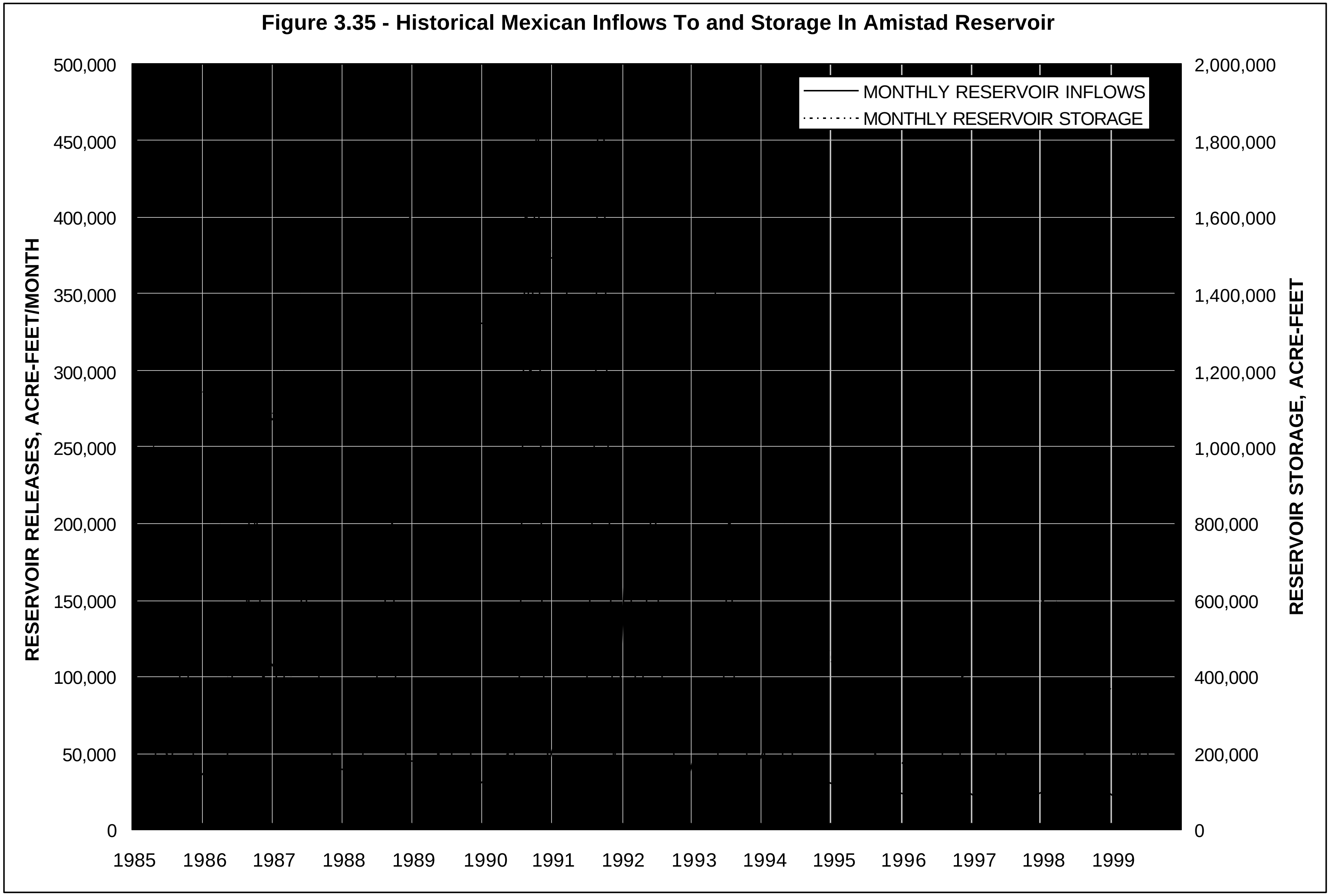
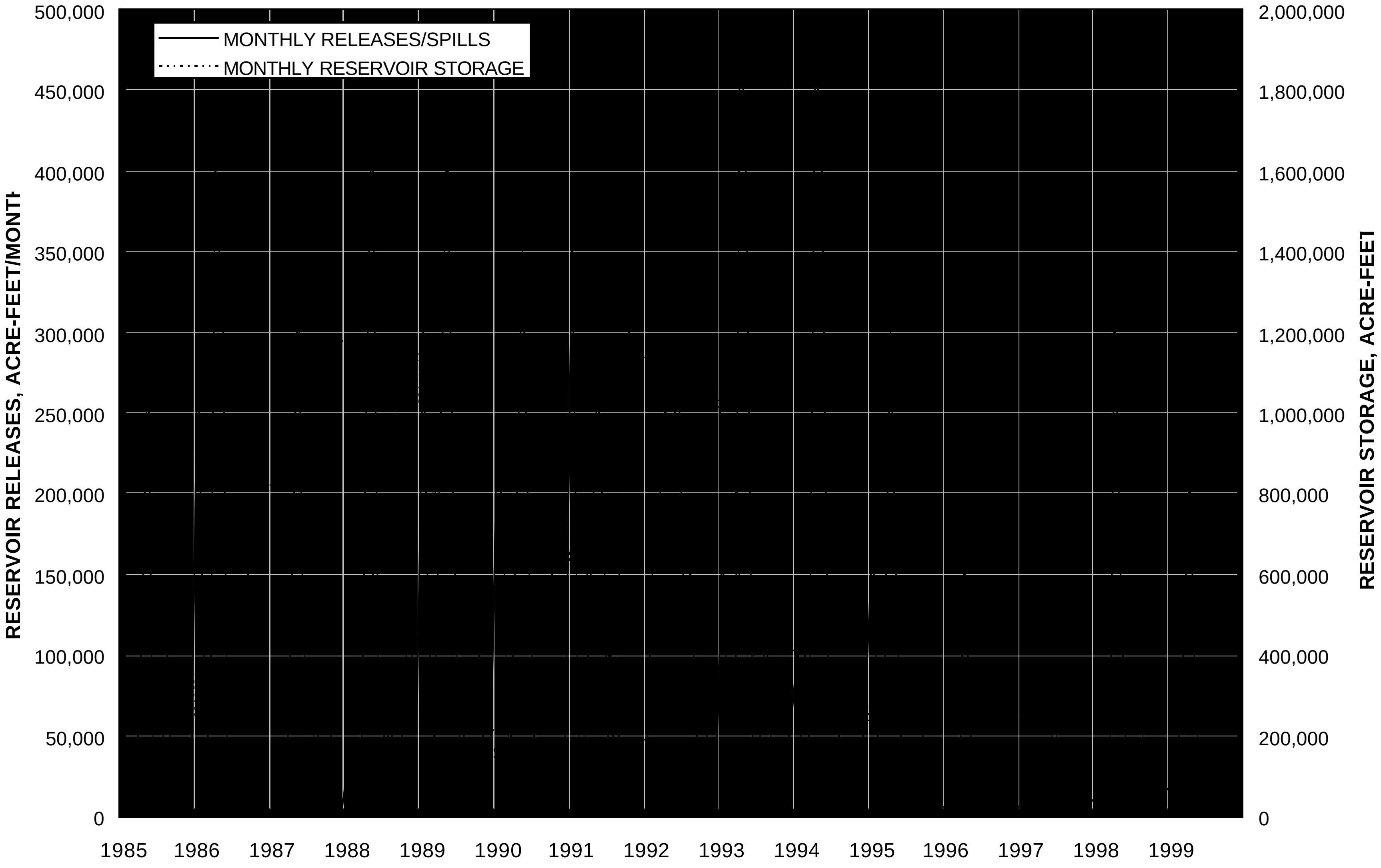


Figure 3.35 - Historical Mexican Inflows To and Storage In Amistad Reservoir
RESERVOIR RELEASES, ACRE-FEET/MONTH
RESERVOIR STORAGE, ACRE-FEET
MONTHLY RESERVOIR INFLOWS
MONTHLY RESERVOIR STORAGE
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

Figure 3.36 - Historical Mexican Releases/Spills From and Storage In Falcon Reservoir



releases on the order of 300,000 to 500,000 acre-feet per month have been released practically every year. Of course, as the supply of stored water in Falcon Reservoir has diminished during the drought of the late 1990's, these releases have been curtailed. Again, no significant changes in this pattern of Mexican releases for Falcon Reservoir are expected.

3.8.3 Mexican Water Deficits Under 1944 Treaty

As discussed earlier in this report (see Section 3.2.1.6.1**)**, the 1944 Treaty between the United States and Mexico contains a provision whereby Mexico is to provide the United States with a minimum of 350,000 acre-feet per year, averaged in five-year cycles, of inflows to the Rio Grande from six named tributaries, all located below Fort Quitman, Texas. The inflows from these tributaries contribute directly to the Amistad-Falcon water supply that is extensively relied upon by water users in the RGRWPA. Hence, when these tributary inflows are reduced, the available water supply for the RGRWPA also is reduced.

The IBWC is responsible for measuring the Mexican tributary inflows and performing the necessary water accounting in accordance with the provisions of the 1944 Treaty. Since October 1992, data reported by the IBWC indicate that Mexico has failed to deliver the required minimum inflows to the United States, and, therefore, Mexico accrued deficits for the five-year accounting cycle that ended on October 2, 1997, amounting to 1,024,000 acre-feet. For the current five-year accounting cycle that will end on October 2, 2002, the deficit owed by Mexico is 384,100 acre-feet, or since October 1992, the total amount of the inflow deficit incurred by Mexico on the six named tributaries identified in the 1944 Treaty was 1,408,100 acre-feet through September 2000.

Because of the substantial amount of the current Mexican water deficits and because agricultural interests in the Lower Rio Grande Valley have been severely impacted during the drought of the 1990's as available water supplies from Amistad and Falcon Reservoirs have diminished, there has been increased concern by all Rio Grande water users regarding the reasons for the deficits and Mexico's ability to repay the deficits in accordance with the terms of the 1944 Treaty and Minute No. 234. To begin to address these issues, special studies have been undertaken as part of this regional water planning effort for the RGRWPA, and preliminary results pertaining to the Mexican water deficits are presented in a separate report[35]. For the purpose of summarizing current results from these ongoing Mexican deficit studies in this Chapter 3 report, please refer to the Summary of Findings and Conclusions found in Chapter 6. For specific details regarding these findings, the Mexican deficit report should be consulted.

More in-depth studies now are being undertaken through the RGRWPG in an attempt to refine the estimates of inflows to the Rio Grande from the Mexican tributaries pursuant to the 1944 Treaty. Progress is limited, however, due to the lack of site-specific information regarding Mexico's tributary reservoirs and their actual historical inflows and the specific demands for water by Mexico from each of the reservoirs. Hopefully, enough data and information can be assembled to allow at least a preliminary reservoir operations model to be developed for Mexico's tributary reservoirs so that simulations of their available supplies can be made under different demand conditions and operating scenarios. Such results could contribute to the development of a long-range operating plan for the reservoirs that would optimize

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[35] R. J. Brandes Company; "Preliminary Analysis of Mexico's Rio Grande Water Deficit Under the 1944 Treaty"; Second Draft Report to the Rio Grande Regional Water Planning Group and the Lower Rio Grande Valley Development Council; Austin, Texas; April 3, 2000.

[36] First paragraph following Paragraph B(d) of Article 4.

the use of Mexico's available water supplies with regard to Mexico's own needs and to its 1944 Treaty obligations. In the short term, such results would useful in formulating a repayment schedule for the Mexico's current deficits.

It should be noted that after February 2000, Mexico transferred approximately 138,000 acre-feet of its water stored in the Amistad-Falcon Reservoir System to the United States in an effort to help offset the deficits under the 1944 Treaty. Mexico also agreed to provide to the United States through September 2000, a portion of the inflows to the Rio Grande that Mexico is entitled to under the provisions of the 1944 Treaty. Through July 2000, this additional water that Mexico allocated to the United States totaled about 110,000 acre-feet. Even with these additional quantities of water from Mexico, however, the deficit owed to the United States under the 1944 Treaty remains at 1,408,100 acre-feet through the end of the accounting year ending September 2000.

3.9 SURFACE WATER QUALITY

Surface water quality is addressed in this section for portions of two basins - the Rio Grande, which flow directly into the Gulf of Mexico; and the Arroyo Colorado, which discharges into the Laguna Madre and then into the Gulf of Mexico. Surface and sub-surface discharges that arise from both natural processes and the activities of man affect the quality of these water resources. In general, the presence of minerals, which contribute to the total dissolved solids concentration in surface water, arise from natural sources, but can be concentrated as flows travel downstream. Return flows from both irrigation and municipal uses can concentrate dissolved solids, but can also add other elements such as nutrients, sediments, chemicals, and pathogenic organisms.

3.9.1 Rio Grande

Water in the Rio Grande normally is of suitable quality for irrigation, treated municipal supplies, livestock, and industrial uses, but salinity, nutrients, and fecal coliform bacteria are concerns identified throughout the basin. Salinity concentrations in the Rio Grande are the result of both human activities and natural conditions: the naturally salty waters of the Pecos River are a major source of the salts that flow into Amistad Reservoir and continue downstream. Untreated or poorly treated discharges from inadequate wastewater treatment facilities, primarily in Mexico, are the principal source for fecal coliform bacteria contamination. A secondary source is from nonpoint source pollution on both sides of the river, including poorly constructed or malfunctioning septic and sewage collection systems and improperly managed animal wastes. Although frequently identified as a concern, nutrient levels do not represent a threat to human health nor have they supported excessive aquatic plant growth and caused widespread depressed dissolved oxygen levels.

Following is a discussion of water quality for each of the following individual river segments:

- Amistad to Falcon Reservoir;
- Falcon Reservoir;
- Below Falcon Reservoir;
- Arroyo Colorado; and,
- Laguna Madre.

Where available, the TNRCC water quality stream segment number corresponding to a particular reach of the river or other stream is noted. In addition, the current water quality standards for each of these stream segments are provided in Table 3.17.

3.9.1.1 Amistad to Falcon Reservoir

In the Rio Grande below Amistad Reservoir (TNRCC Stream Segment No. 2304), the major water quality concern is the occurrence of fecal coliform bacteria (at low-flow conditions) resulting from inadequately treated wastewater discharges. Historically, this has resulted from inadequate wastewater treatment facilities in Mexico, but is also resulting from "Colonia" developments on the United States side of the Rio Grande. Due to the elevated levels of fecal coliform bacteria that have been observed, contact recreation use is not supported. Possible other concerns are nitrogen and phosphorus. This segment of the river was included on the 1999 and prior 303d lists of water quality limited stream segments, but has been proposed for removal from the 303d list in the year 2000. The original basis for listing this segment was the occurrence of sediment toxicity downstream of Laredo and Eagle Pass, but by applying new guidelines, sediment toxicity concentrations are below the aquatic life use criterion, and the 303d listing is no longer valid.

Table 3.17 – Summary of Water Quality Standards for Stream Segments in the Rio Grande Region

		DESIGNATED WATER USES				CRITERIA						
Segment No.	**Segment Name**	**Recreation**	**Aquatic Life**	**Domestic Water Supply**	**Other**	**Cl^{-1} (mg/L)**	**SO_4^{-2} (mg/L)**	**TDS (mg/L)**	**Dissolved Oxygen (mg/L)**	**pH Range (SU)**	**Indicator Bacteria[1] [Fecal Coliform] #/100ml**	**Temperature (°F)**
NUECES-RIO GRANDE COASTAL BASIN												
2201	Arroyo Colorado Tidal	Contact Recreation	High						4.0	6.5-9.0	35/200	95
2202	Arroyo Colorado Above Tidal	Contact Recreation	Inter-mediate			1,200	1,000	4,000	4.0	6.5-9.0	126/200	95
RIO GRANDE BASIN												
2301	Rio Grande Tidal	Contact Recreation	Excep-tional						5.0	6.5-9.0	35/200	95
2302	Rio Grande Below Falcon Reservoir	Contact Recreation	High	Public Supply		270	350	880	5.0	6.5-9.0	126/200	90
2303	International Falcon Reservoir	Contact Recreation	High	Public Supply		200[140]	300	1,000 [700]	5.0	6.5-9.0	126/200	93
2304	Rio Grande Below Amistad Reservoir	Contact Recreation	High	Public Supply		200	300	1,000	5.0	6.5-9.0	126/200	95
2305	International Amistad Reservoir	Contact Recreation	High	Public Supply		150	270	800	5.0	6.5-9.0	126/200	88
BAYS AND ESTUARIES												
2491	Laguna Madre	Contact Recreation	Excep-tional/ Oyster						5.0	6.5-9.0	14	95
2493	South Bay	Contact Recreation	Excep-tional/ Oyster						5.0	5-9.0	4	95
2494	Brownsville Ship Channel	Contact Recreation	Excep-tional						5.0	6.5-9.0	35/200	95

Table 3.17 – Summary of Water Quality Standards for Stream Segments in the Rio Grande Region, cont'd.

		DESIGNATED WATER USES				CRITERIA						
Segment No.	Segment Name	Recreation	Aquatic Life	Domestic Water Supply	Other	Cl^{-1} (mg/L)	SO_4^{-2} (mg/L)	TDS (mg/L)	Dissolved Oxygen (mg/L)	pH Range (SU)	Indicator Bacteria[1] [Fecal Coliform] #/100ml	Temperature (°F)
GULF OF MEXICO												
2501	Gulf of Mexico	Contact Recreation	Exceptional/ Oyster						5.0	6.5-9.0	14	95

[1] The indicator bacteria for freshwater is *E. coli* and Enterococci for saltwater. Fecal coliform is an alternative indicator.

[2] [*] High concentrations of chlorides, sulfates and total dissolved solids in Segment 2204 are due to past brine discharges which were halted effective 1/10/87 by order of the Texas Railroad Commission. Water quality is expected to improve as residual brines are flushed from the system. These estimated criteria are subject to modification as improvement in water quality is documented.

Stream Segment Descriptions

2201 Arroyo Colorado Tidal - from the confluence with Laguna Madre in Cameron/Willacy County to a point 100 meters (110 yards) downstream of Cemetery Road south of Port Harlingen in Cameron County
2202 Arroyo Colorado Above Tidal - from a point 100 meters (110 yards) downstream of Cemetery Road south of Port Harlingen in Cameron County to FM 2062 in Hidalgo County (includes La Cruz Resaca, Llano Grande Lake, and the Main Floodway)
2301 Rio Grande Tidal - from the confluence with the Gulf of Mexico in Cameron County to a point 10.8 kilometers (6.7 miles) downstream of the International Bridge in Cameron County
2302 Rio Grande Below Falcon Reservoir - from a point 10.8 kilometers (6.7 miles) downstream of the International Bridge in Cameron County to Falcon Dam in Starr County
2303 International Falcon Reservoir - from Falcon Dam in Starr County to the confluence of the Arroyo Salado (Mexico) in Zapata County, up to the normal pool elevation of 301.1 feet (impounds Rio Grande)
2304 Rio Grande Below Amistad Reservoir - from the confluence of the Arroyo Salado (Mexico) in Zapata County to Amistad Dam in Val Verde County
2305 International Amistad Reservoir - from Amistad Dam in Val Verde County to a point 1.8 kilometers (1.1 miles) downstream of the confluence of Ramsey Canyon on the Rio Grande Arm in Val Verde County and to a point 0.7 kilometer (0.4 mile) downstream of the confluence of Painted Canyon on the Pecos River Arm in Val Verde County and to a point 0.6 kilometer (0.4 mile) downstream of the confluence of Little Satan Creek on the Devils River Arm in Val Verde County, up to the normal pool elevation of 1117 feet (impounds Rio Grande)
2491 Laguna Madre *
2493 South Bay *
2494 Brownsville Ship Channel *
2501 Gulf of Mexico * - from the Gulf shoreline to the limit of Texas' jurisdiction between Sabine Pass and Brazos Santiago Pass

* The segment boundaries are considered to be the mean high tide line.

3.9.1.2 Falcon Reservoir

In Falcon Reservoir (TNRCC Stream Segment No. 2303), the elevated total dissolved solids have been identified as a concern. Phosphorus is identified as a possible concern. The average concentrations of chlorides and total dissolved solids exceed the criteria established to safeguard general water quality uses.

3.9.1.3 Below Falcon Reservoir

The Rio Grande below Falcon Reservoir (TNRCC Stream Segment No. 2302) is regulated by releases from Falcon Reservoir. Concerns that have been identified include elevated total dissolved solids and fecal coliform bacteria (at low-flow conditions). Possible concerns are nitrogen and phosphorus. Due to elevated levels of fecal coliform bacteria, contact recreation use is not supported. In the lower 25 miles of this reach, bacteria levels sometimes exceed the criterion established to assure the safety of contact recreation. As water levels continue to decline in Amistad and Falcon Reservoirs, the dissolved solids concentrations of the stored water continues to increase. Total dissolved solids concentrations usually range from 400 to 750 mg/L (milligrams per liter), which is considered fresh, but these levels can cause salt accumulation in agricultural soils if excess water is not applied periodically to leach the fields.

Near the mouth of the Rio Grande, which is known as the Rio Grande Tidal segment (TNRCC Classified Stream Segment 2301), the watershed is narrow and flat and extends only a few miles inland on either side of the river. The only significant water quality concern beyond the salinity influence from the Gulf of Mexico is a concern for elevated phosphorus levels.

3.9.2 Arroyo Colorado

The Arroyo Colorado lies in Willacy, Cameron, and Hidalgo counties, and is the major drainageway for approximately two dozen cities in this area, with the notable exception of Brownsville. Almost 500,000 acres in the three counties are irrigated for cotton, citrus, vegetables, grain sorghum, corn, and sugar cane production; and much of the runoff and return flows from these areas is discharged into the Arroyo Colorado. The Arroyo Colorado and the Brownsville Ship Channel both discharge into the Laguna Madre near the northern border of Willacy County.

The Arroyo Colorado includes TNRCC Classified Stream Segment 2201 and 2202. Use of the water in the Arroyo Colorado for municipal, industrial, or irrigation purposes is severely limited because of poor quality conditions. Salinity concentrations in the Arroyo typically exceed the limits considered desirable for human consumption, as well as, those acceptable for irrigation of crops. Water quality and fish tissue testing have found that: (1) low dissolved oxygen levels have impaired the fish community and other aquatic life downstream from the Port of Harlingen; (2) elevated levels of pesticides (chlordane, toxaphene, and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene--DDE) have resulted in a fish consumption advisory upstream from the Port of Harlingen; and, (3) bacteria levels are occasionally elevated indicating a potential health risk to people who swim or wade in the Arroyo upstream from the Port of Harlingen. In response to these use impairments, the TNRCC has initiated a Total Maximum Daily Load (TMDL) study to assess the specific causes of the observed water quality problems and to determine the pollution controls necessary to restore water quality in the Arroyo Colorado. The fish consumption advisory includes Llano Grande Lake and the Main Floodway in Cameron and Hidalgo counties. The Texas Department of Health also issued a fish consumption ban for the Donna Reservoir and the canals that connect to the Rio Grande due to polychlorinated biphenyls (PCBs) found in fish tissue. A TMDL effort is underway for this water body as well.

3.9.3 Laguna Madre

The Lower Laguna Madre (TNRCC Classified Stream Segment 2491), which encompasses the portion of the Laguna Madre south of the land bridge, receives runoff from watersheds in Cameron, Willacy, and Hidalgo counties primarily by way of the Arroyo Colorado. The only concern identified is elevated nitrogen, which results mainly from agricultural runoff and from municipal wastewater discharges. Total dissolved solids concentrations in the range of 35,000 mg/L typically eliminate this water from being considered as a viable source for municipal or industrial uses. However, improvements in technology are continuing to reduce the cost of desalinization, especially where there is a waste heat source available.

Based on Texas Department of Health shellfish maps, 5.2 percent of the Lower Laguna Madre (18.1 square miles near the Arroyo Colorado and along the Intracoastal Waterway) does not support the oyster water use, and 38.8 percent (134.8 square miles) of the bay fully supports the oyster water use. The remaining 56 percent (194.6 square miles) of the Laguna Madre, from Port Mansfield to Corpus Christi, has not been assessed for oyster use. Non-supporting areas are restricted or prohibited for the growing and harvesting of shellfish for direct marketing due to potential contamination by human pathogens.

3.10 GROUND WATER QUALITY

In general, groundwater from the various aquifers in the region has total dissolved solids concentrations exceeding 1,000 mg/L (slightly saline) and often exceeds 3,000 mg/L (moderately saline). The salinity hazard for groundwater ranges from high to very high[37]. Localized areas of high boron content occur throughout the study area.

3.10.1 Gulf Coast Aquifer

The quality of groundwater found in the Gulf Coast aquifer in Starr, Hidalgo, Willacy, and Cameron counties is reviewed in the TWDB's Report No. 316[38]. Water quality is described from the deepest and oldest or Eocene series (as shown in Table 3.18, Stratigraphy of the Lower Rio Grande Valley) to the shallower and younger Pleistocene series. Wells in western Starr County draw from the Eocene-age strata, which lie below the more commonly known Evangeline aquifer, and provide small quantities of slightly to moderately saline water for domestic and livestock use. In many places water drawn from this strata is too mineralized for domestic use and, in some cases, even for livestock watering. The Miocene-age strata overly the Eocene strata, but are still below the Evangeline aquifer. These strata are

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[37] Salinity hazard is a measure of the potential for salts to be concentrated in the soil from high salinity groundwater. Accumulation or buildup of salts in the soil can affect the ability of plants to take in water and nutrients from the soil. Salinity hazard is usually expressed in terms of specific conductance in micromhos per centimeter at 25° C.

[38] Evaluation of Ground-Water Resources In the Lower Rio Grande Valley, Texas; T. Wesley McCoy; Texas Water Development Board Report 316; January 1990.

Table 3.18 – Stratigraphy of the Lower Rio Grande Valley

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

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

characterized as yielding small to moderate quantities of slightly to moderately saline water to wells in the area of northwestern Hildalgo and eastern Starr counties. (See Figure 3.20 above, Approximate Productive Areas of the Major Sources of Groundwater in the Lower Rio Grande Valley)

The Evangeline and Chicot aquifers lie within the Goliad Formation and the younger, Quarternary-age deposits, respectively. Both aquifers yield moderate to large quantities of fresh to moderately saline water in Cameron, Hidalgo, and Willacy counties. (see Figure 3.37, Chemical Quality of Water in the Evangeline and Chicot Aquifers) However, these aquifers are reported as containing high sodium concentrations. In addition, water quality analyses for the Chicot have shown chloride, bicarbonate, and sulfate concentrations in roughly equal proportions, with water quality deteriorating with distance from the Rio Grande. Analyses of water from the Evangeline aquifer indicate higher chloride and sulfate concentrations with respect to that of bicarbonate. Within both the Chicot and Evangeline aquifers there are two small areas yielding fresh-quality groundwater (total dissolved solids less than 1,000 mg/L). One of these areas is located in southeastern Hidalgo and southwestern Cameron counties and occurs in the alluvial and deltaic deposits of the Rio Grande Alluvium, and the other is located in north-central Hidalgo County and occurs in the shallow sediments found between the cities of Linn and Faysville. Scattered throughout the study area, many wells with depths of less than 100 feet have produced water with high nitrate levels. Additionally, wells drawing from the Oakville Sandstone in Starr, Willacy and northern Hidalgo counties can contain levels of sulfate in excess of 300 mg/L.

3.10.2 Carrizo-Wilcox Aquifer

The Carrizo Sand Formation outcrops in a very small area in northwest Webb County and continues north into Dimmit, Zavala, and Maverick counties. It yields moderate to large quantities of fresh to slightly saline water. Groundwater quality and yield decrease with distance from the formation outcrop and are best down-gradient of the outcrop in Dimmit and Zavala counties. The water remains fresh into northern Webb County, but yields decline as the formation dips southeastward. In central Webb County, total dissolved solids levels exceed 1,000 mg/L. Water quality and yield data from a few wells in southern and western Webb County suggest that the groundwater becomes more mineralized down-dip as aquifer permeability and yield decline.

3.10.3 Other Aquifers

The Catahoula Formation has a very narrow outcrop area in southeast Webb County that extends northeast into Duval County. It yields small amounts of highly mineralized water at the outcrop, and moderate quantities of fresh to slightly saline water at confined depths in southeast Webb County. Water quality is a concern in this formation due to the presence of arsenic and other metals in concentrations exceeding the limits for potable water. The Jackson Group has a substantial outcrop area in Webb County, but it is also a minor aquifer. It yields variable amounts of slightly to highly saline water. The Yegua Formation outcrops across Webb and La Salle counties. It is often ferruginous (iron bearing) and yields small to moderate quantities of slightly to moderately saline water.

The Laredo Formation yields small to moderate quantities of fresh to slightly saline water to wells in Webb County and also outcrops across Webb and La Salle counties. The El Pico Clay outcrops in Webb, Dimmit, and Zavala counties, but yields only small amounts of highly mineralized water. The Bigford Formation is a minor aquifer that outcrops in northwestern Webb County and to the north-northeast through Dimmit County. Groundwater from wells in the Bigford Formation is usually highly mineralized.

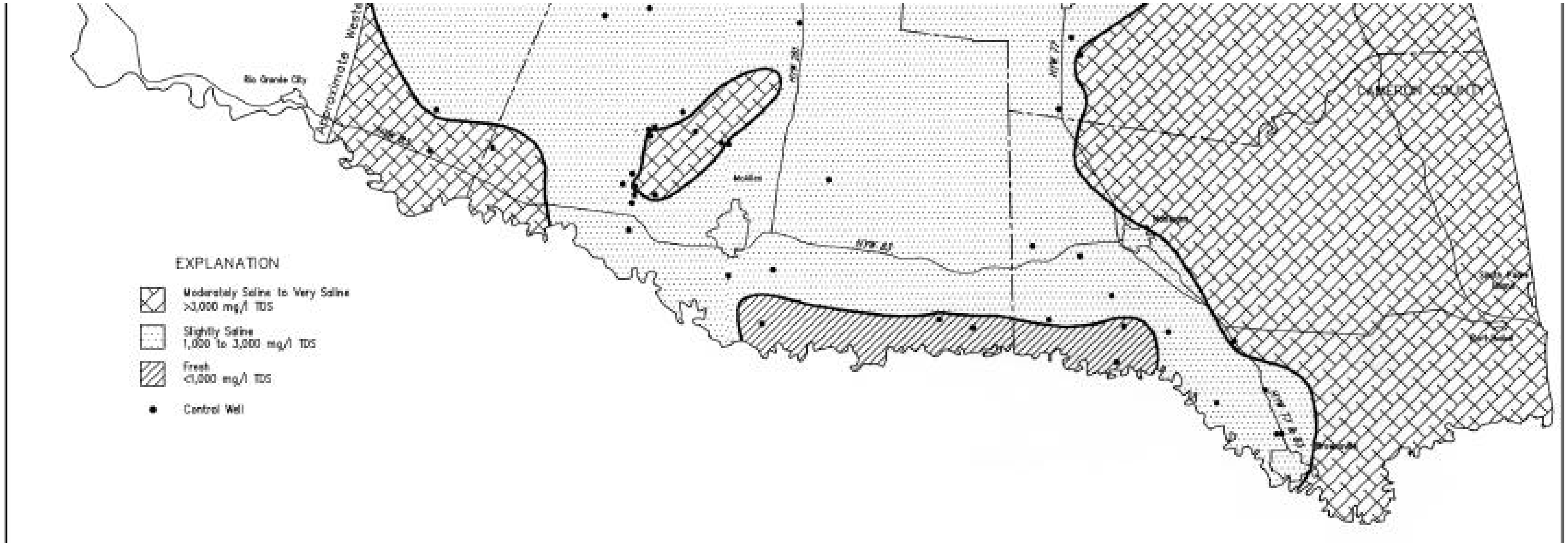
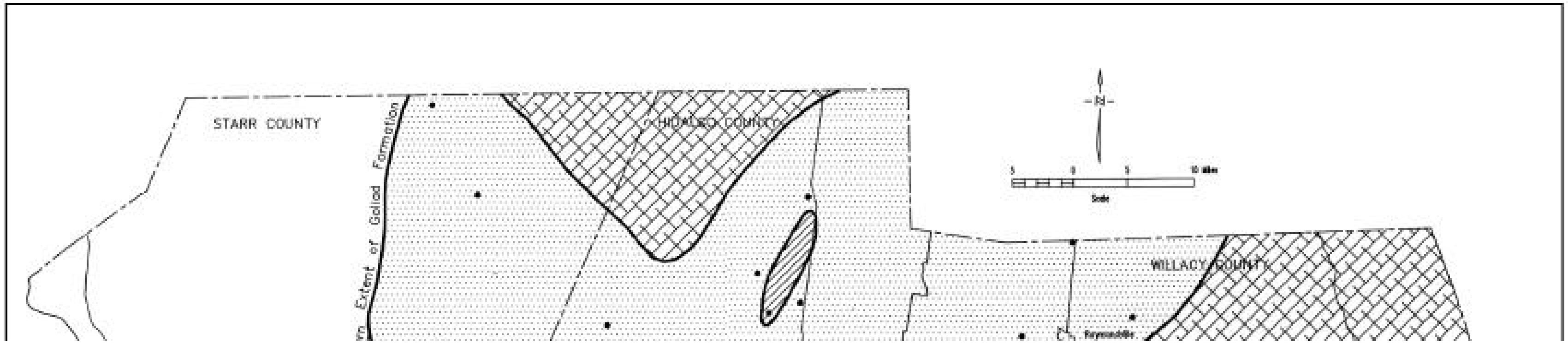


Figure 3.37 - Chemical Quality of Water in the Evangeline and Chicot Aquifers



3.10.3.1 Rio Grande Alluvium

The material composing the Rio Grande alluvium is highly variable from one location to another. The alluvium has generally been divided into three layers or zones: shallow (less than 75 feet), middle (75 to 150 feet), and deep (150 to 225 feet). Yields are generally higher in the deeper zone and closer to the river. Recharge is primarily through interaction with the river, with some surface recharge. Water levels have generally been stable. There is currently additional research being done by the TWDB to further identify the thickness and properties of this groundwater source.

Water quality data is assigned to one of three zones defined by depth: shallow (50-100 feet below the land surface), middle (100 to 300 feet below the land surface) and lower (more than 300 feet below the land surface) for the Lower Rio Grande Valley aquifer (now referred to as the Gulf Coast aquifer).

<u>Shallow Zone</u> - In the area near Mission, the shallow zone is characterized by highly mineralized water that is unsuitable for most uses, except for the southern portion near the Rio Grande. Water samples taken in 1983 from some of the shallow zone wells revealed excessive levels of nitrate. In Cameron County, the shallow zone (depths less than 75 feet) was found to produce limited amounts of very poor quality ground water with dissolved solids ranging from 1,170 to 37,800 mg/L.

<u>Middle Zone</u> - Water samples from the middle zone indicate fresh to slightly saline water, with about 25 percent of the wells sampled also containing excessive nitrate levels in the area near Mission. The middle zone is not considered suitable for irrigation purposes due to its high salinity and sodium (alkali) hazards. Water drawn from this zone has yielded concentrations of dissolved solids and chlorides that appear to increase to the east and southeast in the range of 1,180 to 13,450 mg/L. Water quality data reported for wells in the area just west of Brownsville suggest that the middle zone may be in direct hydraulic contact with the shallow zone as indicated by high mineral concentrations.

<u>Lower Zone</u> - The lower zone is considered to contain better water quality than the other two zones. Water samples have indicated fresh to slightly saline water with nitrate levels found to be within safe limits (<45 mg/L). Nevertheless, this zone is generally considered not to be suitable for irrigation due to its high salinity and sodium (alkali) hazards. A few deep wells have produced groundwater of relatively good quality in an area north of the City of Brownsville along the Rio Grande. From there, the salinity of ground water produced from the deep zone increases steadily toward the southeast, east, northeast, and north, especially in the concentrations of sodium, sulfate, chloride, and dissolved solids.

3.10.3.2 Laredo Formation

The Laredo formation yields small to moderate quantities of fresh to slightly saline water to wells in Webb County. The total dissolved solids concentrations range from 1,000 to 3,000 mg/L. This formation has been identified as one of the potential alternative groundwater supply sources for the City of Laredo.

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CHAPTER 4.0: COMPARISON OF WATER DEMANDS WITH WATER SUPPLIES TO DETERMINE NEEDS

This chapter compares the water demand projections discussed in Chapter 2 with the water supply projections presented in Chapter 3. The objective is to determine which water users within the Rio Grande Region will have more water supplies than they will need during the planning period and which will fall short. As required by the TWDB, this comparison considers each "city, county and portion of a river basin within the regional water planning area for major providers of municipal and manufacturing water, and for categories of water use including municipal, manufacturing, irrigation, steam electric power generation, mining and livestock watering." In this analysis, a water supply "need" means that current or projected demands are greater than supply, producing a water supply "deficit" or shortage. Supply in "excess" of demand, on the other hand, results in a water supply "surplus" for the particular user.

Although the analysis has determined water supply needs by decade through the year 2050, under TWDB guidelines, the Regional Water Planning Group is only required to develop specific plans to meet those needs projected to occur by the year 2030. The group has the option of also developing strategies for meeting long-term needs through 2050 and beyond.

Section 4.7 presents the evaluation of the socio-economic impact of not meeting regional water supply needs, as required by Section 357.7(4) of the rules for implementing Senate Bill 1. The Texas Water Development Board has provided technical assistance, as required, in performing this evaluation.

The Rio Grande region faces significant water supply needs, as indicated in Tables 4.1 and 4.2. Those tables summarize total water supply needs and excess supplies by category of use for the Rio Grande Region for each decade of the planning period. Following are detailed projections of water needs and excess supplies by each category of use: municipal, manufacturing, irrigation, steam electric power generation, mining, and livestock. Projected demands are also provided for each of the two river basins and the one coastal basin partially located within the Rio Grande Region.

Table 4.1: Water Supply Needs for the Rio Grande Region by Category of Use (acre-foot/year)

Category of Use	2000	2010	2020	2030	2040	2050
Municipal	13,257	36,154	69,586	130,330	168,149	214,621
Manufacturing	0	0	0	1	9	17
Irrigation	583,840	551,422	505,154	461,814	525,595	605,140
Steam Electric	0	1,705	1,705	12,805	12,805	12,805
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
TOTAL WATER NEEDS (ac-ft/yr)	**597,097**	**589,281**	**576,445**	**605,950**	**706,558**	**832,583**

Table 4.2: Water Supply Surpluses for the Rio Grande Region by Category of Use (acre-foot/year)

Category of Use	2000	2010	2020	2030	2040	2050
Municipal	63,206	37,646	22,675	15,016	9,493	6,766
Manufacturing	2,433	2,294	2,176	2,047	1,871	1,690
Irrigation	21,329	21,667	22,274	21,339	19,632	17,820
Steam Electric	12,784	12,189	11,689	11,289	10,289	10,289
Mining	16,084	16,246	16,302	12,313	12,161	11,946
Livestock	17,274	17,274	17,274	10,010	10,010	10,010
TOTAL WATER SURPLUS (ac-ft/yr)	**133,110**	**107,316**	**92,390**	**72,014**	**63,456**	**58,521**

4.1 MUNICIPAL WATER NEEDS

Municipal water needs in the Rio Grande Region are projected to increase dramatically over the 50-year planning period, as a growing demand for water outstrips currently available water supplies. As shown in Figure 4.1, below, regional water supply deficiencies are projected to increase from approximately 13,250 acre-feet per year (ac-ft/yr) in the year 2000 to more than 214,000 ac-ft/yr in 2050.

Figure 4.1: Municipal Water Needs Summary

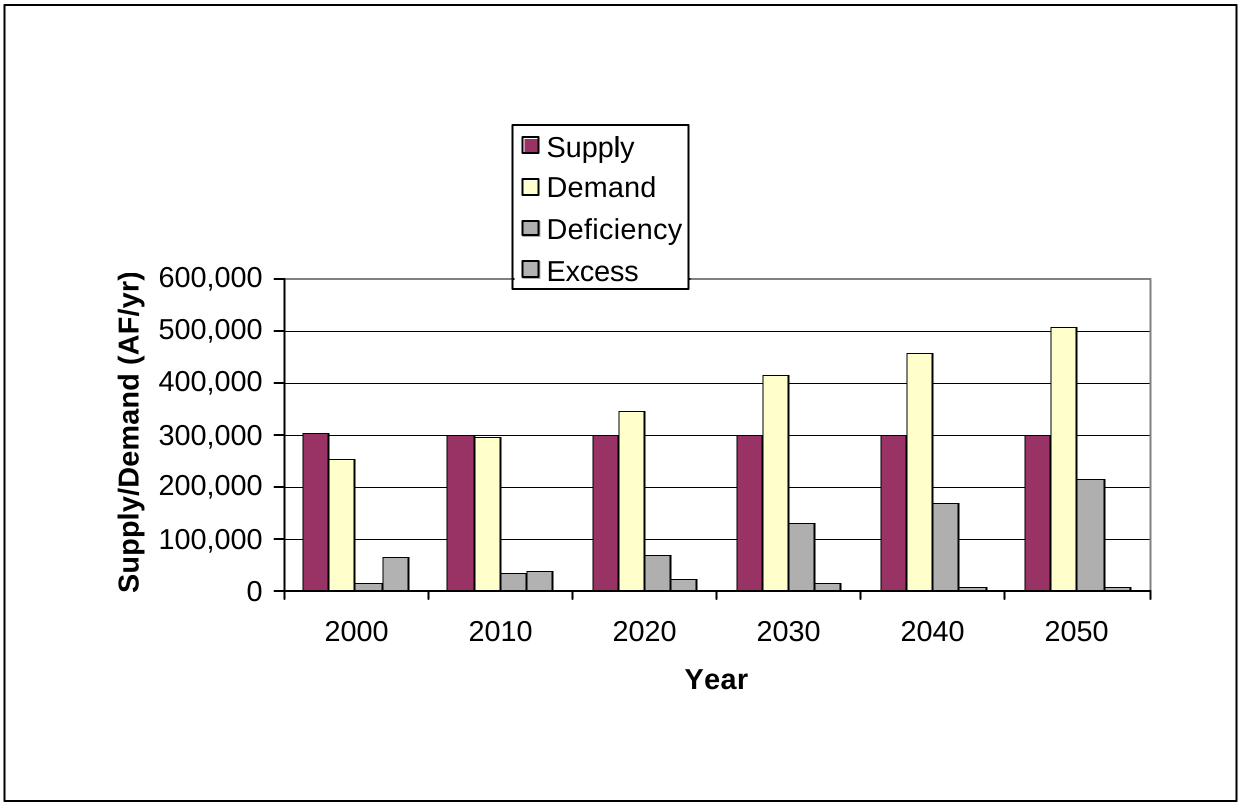


Figure 4.1 shows that total municipal demand will exceed total supplies beginning around the year 2010. However, this regional summary does not reflect the fact that some entities have secured water supplies in excess of projected demand for the entire planning period while others already are facing deficiencies. A county-by-county summary of the region's municipal water needs follows.

4.1.1 Cameron County - Municipal Summary

Currently, only a small portion of Brownsville and rural areas of the county that lie within the Rio Grande basin are experiencing water supply deficits. By 2030, five additional cities in the county are projected to have deficits, as shown in Table 4.3.

Table 4.3: Municipal Water Surplus/Needs for Cameron County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Brownsville	Nueces-Rio Grande	-1,514	-5,065	-8,945	-15,104	-17,162	-19,611
Brownsville	Rio Grande	4994	-11	-16	-23	-26	-30
Combes	Nueces-Rio Grande	38	31	19	-4	-2	-17
Harlingen	Nueces-Rio Grande	5,474	3,960	2,782	414	-324	-1,223
La Feria	Nueces-Rio Grande	1,016	933	832	700	517	283
Laguna Vista	Nueces-Rio Grande	113	106	100	82	66	48
Los Fresnos	Nueces-Rio Grande	190	-16	10	-153	-332	-528
Palm Valley	Nueces-Rio Grande	61	23	-12	-70	-115	-144
Port Isabel	Nueces-Rio Grande	1,374	1,045	761	248	69	-129
Primera	Nueces-Rio Grande	330	283	229	145	68	-27
Rancho Viejo	Nueces-Rio Grande	288	278	273	266	264	260
Rio Hondo	Nueces-Rio Grande	437	382	329	255	200	163
San Benito	Nueces-Rio Grande	139	-407	-841	-1,789	-2,078	-2,436
Santa Rosa	Nueces-Rio Grande	464	430	344	338	330	298
South Padre Island	Nueces-Rio Grande	976	691	416	11	-297	-653
County-Other	Nueces-Rio Grande	11,784	9,737	7,410	6,145	2,604	1,512
County-Other	Rio Grande	-66	-97	-132	-151	-205	-222
SUM OF DEFICITS		**1,580**	**5,596**	**9,946**	**17,294**	**20,541**	**25,020**
SUM OF EXCESS SUPPLIES		**27,678**	**17,899**	**13,505**	**8,604**	**4,118**	**2,564**

NOTE: Cities and County-Other area located in more than one river basin are divided as separate entries, per TWDB requirements.

4.1.2 Hidalgo County - Municipal Summary

Nine cities in Hidalgo County already have a need for additional water supply. By 2030, seventeen of the county's eighteen cities plus its rural areas will experience deficits. Water needs for the county are projected to increase more than 15-fold in 50 years, from approximately 5,000 ac-ft/yr in 2000 to more than 99,900 ac-ft/yr in 2050, as shown in Table 4.4.

Table 4.4: Municipal Water Surplus/Needs for Hidalgo County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Alamo	Nueces-Rio Grande	-265	-629	-824	-1,137	-1,297	-1,524
Alton	Nueces-Rio Grande	0	0	0	0	0	0
Donna	Nueces-Rio Grande	-195	-997	-1,840	-3,032	-4,090	-5,353
Edcouch	Nueces-Rio Grande	577	524	478	370	265	136
Edinburg	Nueces-Rio Grande	-1,121	-2,658	-4,230	-6,499	-8,529	-10,987
Elsa	Nueces-Rio Grande	32	-98	-225	-475	-731	-1,032
Hidalgo	Nueces-Rio Grande	765	539	303	-3	-269	-615
La Joya	Rio Grande	-43	-219	-380	-544	-663	-817
La Villa	Nueces-Rio Grande	59	-26	-117	-241	-350	-462
McAllen	Nueces-Rio Grande	3,413	2,167	1,060	-1,965	-6,742	-12,701
Mercedes	Nueces-Rio Grande	649	326	-37	-619	-1,162	-1,817
Mission	Nueces-Rio Grande	-46	-2,438	-6,490	-9,908	-12,804	-16,331
Palmview	Nueces-Rio Grande	-216	-310	-404	-550	-679	-844
Pharr	Nueces-Rio Grande	2,032	576	-928	-2,908	-4,705	-6,925
Progresso	Nueces-Rio Grande	-81	-105	-115	-136	-157	-194
San Juan	Nueces-Rio Grande	-2,502	-2,874	-3,193	-3,675	-4,018	-4,440
Sullivan City (CDP)	Rio Grande	-570	-618	-645	-688	-739	-804
Weslaco	Nueces-Rio Grande	986	-92	-1,308	-3,014	-4,563	-6,406
County-Other	Nueces-Rio Grande	14,078	6,593	-751	-11,668	-20,049	-27,960
County-Other	Rio Grande	453	254	21	-308	-537	-736
SUM OF DEFICITS		**-5,039**	**-11,064**	**-21,487**	**-47,370**	**-72,084**	**-99,948**
SUM OF EXCESS SUPPLIES		**23,044**	**10,725**	**1,862**	**370**	**265**	**136**

NOTE: Cities and County-Other area located in more than one river basin are divided as separate entries, per TWDB requirements.

4.1.3 Jim Hogg County - Municipal Summary

Jim Hogg County currently shows no water supply shortages, as shown in Table 4.5. In fact, the city of Hebbronville and the portion of the County-Other area in the Nueces-Rio Grande basin have excess supplies totaling nearly 2,000 ac-ft/yr. The portion of the County-Other area in the Rio Grande basin does not show an excess or a shortage throughout the planning period.

Table 4.5: Municipal Water Surplus/Needs for Jim Hogg County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Hebbronville	Nueces-Rio Grande	1,754	1,685	1,613	1,544	1,503	1,447
County-Other	Nueces-Rio Grande	227	214	199	187	181	177
County-Other	Rio Grande	0	0	0	0	0	0
SUM OF DEFICITS		**0**	**0**	**0**	**0**	**0**	**0**
SUM OF EXCESS SUPPLIES		**1,981**	**1,899**	**1,812**	**1,731**	**1,684**	**1,624**

NOTE: Cities and County-Other area located in more than one river basin are divided as separate entries, per TWDB requirements.

4.1.4 Maverick County - Municipal Summary

The only significant municipal water supply need in Maverick County occurs in the Rio Grande basin portion of the County-Other area. This need, currently estimated to be 523 ac-ft/yr, is projected to increase to over 1,800 ac-ft/yr in 2050. Table 4.6 presents the water surplus or deficit for each city or County-Other area in Maverick County.

Table 4.6: Municipal Water Surplus/Needs for Maverick County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Eagle Pass	Rio Grande	2,985	2,320	1,867	1,415	754	-40
County-Other	Nueces	388	382	379	319	313	302
County-Other	Rio Grande	-523	-758	-910	-1,073	-1,328	-1,782
SUM OF DEFICITS		**523**	**758**	**910**	**1,073**	**1,328**	**1,822**
SUM OF EXCESS SUPPLIES		**3,373**	**2,702**	**2,246**	**1,734**	**1,067**	**302**

NOTE: Cities and County-Other area located in more than one river basin are divided as separate entries, per TWDB requirements.

As indicated in Chapter 2, current information presented by the City of Eagle Pass and approved by the Rio Grande RWPG indicates substantially higher water demands, both for the City and for the portion of the County-Other WUG located in the Rio Grande Basin. Also as described in Chapter 2, the City of Eagle Pass is expected to become a regional water supplier through the absorption of the El Indio WSC service area, which represents the Rio Grande Basin portion of the County-Other WUG in Maverick County. While the TWDB approved demand projections are not being formally amended at this time pending completion of a regional water and wastewater facility plan, the following table provides an "alternative" water supply and demand analysis that has been proposed for inclusion in the Rio Grande Regional Water Plan.

Table 4.7: "Alternative" Water Supply and Demand Analysis for the City of Eagle Pass

Water User Group	River Basin		2000	2010	2020	2030	2040	2050
Eagle Pass	Rio Grande	Demand	5,772	6,615	7,190	7,765	8,604	9,611
Eagle Pass	Rio Grande	Supply	7,553	7,538	7,521	7,502	7,481	7,458
Eagle Pass	Rio Grande	Surplus/Shortage	1,781	923	331	-263	-1,123	-2,153
County-Other	Rio Grande	Demand	1,645	2,416	3,154	3,859	4,531	5,171
County-Other	Rio Grande	Supply	0	0	0	0	0	0
County-Other	Rio Grande	Surplus/Shortage	-1,645	-2,416	-3,154	-3,859	-4,531	5,171
Regional System	**Rio Grande**	**Surplus/Shortage**	**136**	**-1,493**	**-2,823**	**-4,122**	**-5,654**	**-7,324**

NOTE: Water supply for manufacturing provided by the City of Eagle Pass has been excluded from this scenario. It is assumed that all manufacturing water demands in Maverick County will be supplied by Eagle Pass such that there are no shortages for the manufacturing WUG.

As indicated, this alternative water supply/demand scenario for Eagle Pass as a regional water supplier paints a significantly different picture from that portrayed in Table 4.6. Together the combined service areas of the City of Eagle Pass and the Rio Grande Basin portion of the County-Other WUG are projected to require additional water supply by 2010 and will experience growing supply shortages through the planning period. Although the alternative scenario does not reflect the official TWDB-approved demand projections, recommended strategies for meeting the projected water needs under the alternative scenario are included in Chapter 5. As previously indicated, the City of Eagle Pass intends to request formal amendment of the Rio Grande Regional Water Plan once it completes its regional water and wastewater facility plan.

4.1.5 Starr County - Municipal Summary

Total municipal water supply deficits in Starr County are projected to increase from 2,144 ac-ft/yr in 2000 to approximately 16,700 ac-ft/yr in 2050. During this period, excess supplies are projected to decrease from 2,780 ac-ft/yr to 1,226 ac-ft/yr. Table 4.8 presents the water surplus or deficit for each city or County-Other area in Starr County.

Table 4.8: Municipal Water Surplus/Needs for Starr County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
La Grulla	Rio Grande	-395	-511	-831	-1,377	-1,654	-1,986
Rio Grande City	Rio Grande	-221	-974	-2,038	-3,862	-4,806	-5,891
Roma Los-Saenz	Rio Grande	1,068	582	-84	-1,267	-1,832	-2,566
County-Other	Nueces-Rio Grande	1,712	1,613	1,492	1,370	1,263	1,226
County-Other	Rio Grande	-1,528	-2,497	-3,681	-4,871	-5,911	-6,273
SUM OF DEFICITS		**2,144**	**6,126**	**6,634**	**11,377**	**14,203**	**16,716**
SUM OF EXCESS SUPPLIES		**2,780**	**2,195**	**1,492**	**1,370**	**1,263**	**1,226**

NOTE: Cities and County-Other area located in more than one river basin are divided as separate entries, per TWDB requirements.

4.1.6 Webb County - Municipal Summary

Webb County currently has water supply needs of approximately 3,400 ac-ft/yr. By 2050, these needs are projected to nearly reach 61,000 ac-ft/yr. Webb County, as the utility service provider for the City of El Cenizo, has secured water supplies to meet projected demand through the entire planning period, Laredo and portions of the County-Other have, or will have, shortages over the planning period. Table 4.9 presents the water surplus or deficit for each city or County-Other area in Webb County.

Table 4.9: Municipal Water Surplus/Needs for Webb County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
El Cenizo (Webb Co.)	Rio Grande	269	221	173	97	108	119
Laredo	Rio Grande	1,338	-9,391	-22,354	-40,998	-44,766	-48,910
County-Other	Nueces	67	-5	-87	-201	-226	-383
County-Other	Nueces-Rio Grande	632	456	258	-18	-80	-462
County-Other	Rio Grande	-3,448	-3,959	-5,455	-7,548	-8,017	-10,899
SUM OF DEFICITS		**3,448**	**13,355**	**27,896**	**48,765**	**53,089**	**60,654**
SUM OF EXCESS SUPPLIES		**2,306**	**677**	**431**	**97**	**108**	**119**

NOTE: Cities and County-Other area located in more than one river basin are divided as separate entries, per TWDB requirements.

4.1.7 Willacy County - Municipal Summary

In Willacy County, water shortages have been identified in the city of San Perlita and the county's rural area beginning in 2010. Other cities in the county have no projected water supply needs over the 50-year planning period. Table 4.10 presents the water surplus or deficit for each city or County-Other area in Willacy County.

Table 4.10: Municipal Water Surplus/Needs for Willacy County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Lyford	Nueces-RioGrande	346	292	250	217	186	151
Raymondville	Nueces-Rio Grande	1,383	1,120	957	780	695	539
San Perlita	Nueces-Rio Grande	0	-16	-31	-48	-63	-80
Sebastian	Nueces-Rio Grande	119	122	120	113	107	105
County-Other	Nueces-Rio Grande	0	-61	-70	-70	-48	-25
SUM OF DEFICITS		**0**	**77**	**101**	**118**	**111**	**105**
SUM OF EXCESS SUPPLIES		**1,848**	**1,534**	**1,327**	**1,110**	**988**	**795**

4.1.8 Zapata County - Municipal Summary

By 2020 all of Zapata County is projected to have a municipal water supply need. The total county deficit is projected to increase from 523 ac-ft/yr in 2000 to more than 10,000 ac-ft/yr in 2050. Table 4.11 presents the water surplus or deficit for each city or County-Other area in Zapata County

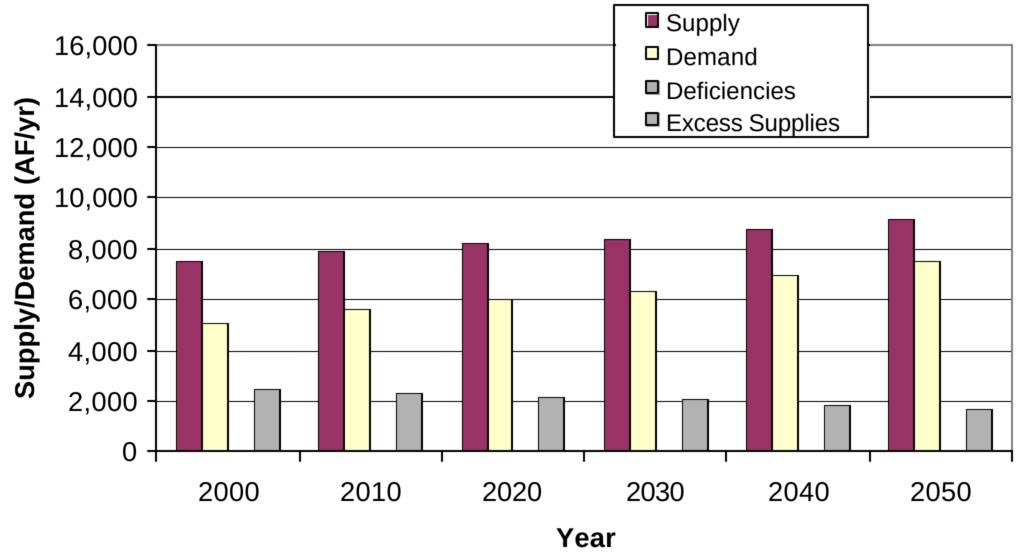
Table 4.11: Municipal Water Surplus/Needs for Zapata County

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Zapata	Rio Grande	-523	-1,321	-2,374	-3,653	-5,484	-8,036
County-Other	Rio Grande	196	15	-237	-680	-1,309	-2,320
SUM OF DEFICITS		**523**	**1,321**	**2,611**	**4,333**	**6,793**	**10,356**
SUM OF EXCESS SUPPLIES		**196**	**15**	**0**	**0**	**0**	**0**

4.2 MANUFACTURING WATER NEEDS

The Rio Grande Region, for the most part, has adequate supplies to meet manufacturing water demands. In fact, throughout the planning period currently available water supply for manufacturing exceeds projected water demand. However, certain local areas do have small manufacturing water supply deficits. Figure 4.2, below, presents a region-wide summary of manufacturing water supplies as compared to demand. In addition, this figure presents a summary of water needs (deficiencies) and excess supplies for the region.

Figure 4.2: Manufacturing Water Needs Summary



The majority of excess manufacturing water supplies are located in Cameron County. There are currently no manufacturing water supply deficits in the Region. Table 4.12 presents manufacturing water surplus/deficit by county and portion of a river basin.

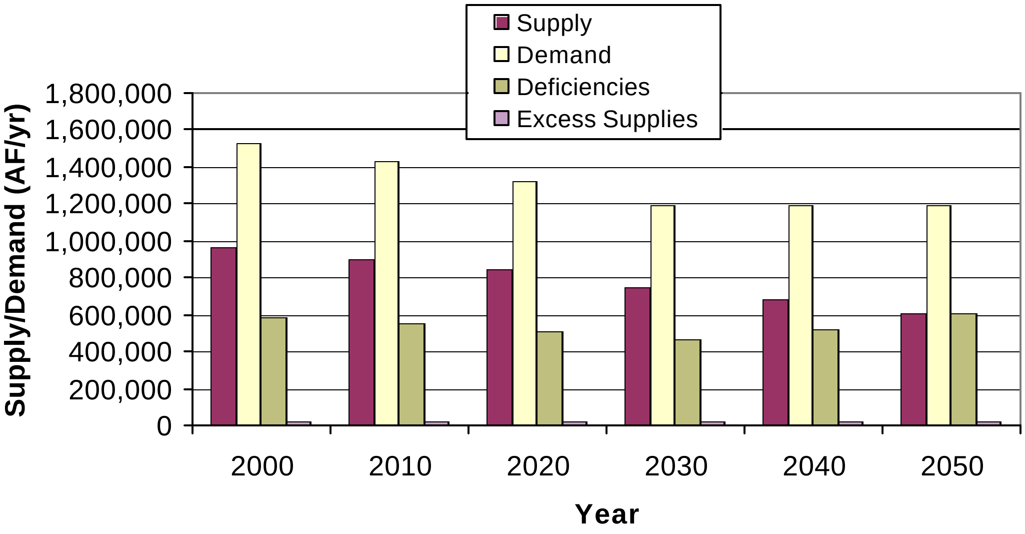
Table 4.12: Manufacturing Water Surplus/Needs for the Rio Grande Region

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
County	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	Nueces-Rio Grande	2,336	2,202	2,089	1,965	1,789	1,608
Cameron	Rio Grande	0	0	0	0	0	0
Hidalgo	Nueces-Rio Grande	60	60	60	60	60	60
Hidalgo	Rio Grande	17	17	17	17	17	17
Jim Hogg	Nueces-Rio Grande	0	0	0	0	0	0
Jim Hogg	Rio Grande	0	0	0	0	0	0
Maverick	Nueces	0	0	0	0	0	0
Maverick	Rio Grande	0	0	0	0	0	0
Starr	Nueces-Rio Grande	0	0	0	0	0	0
Starr	Rio Grande	0	0	0	0	0	0
Webb	Nueces	4	4	4	4	4	4
Webb	Nueces-Rio Grande	1	1	1	1	1	1
Webb	Rio Grande	15	10	5	-1	-9	-17
Willacy	Nueces-Rio Grande	0	0	0	0	0	0
Zapata	Rio Grande	0	0	0	0	0	0
SUM OF DEFICITS		**0**	**0**	**0**	**-1**	**-9**	**-17**
SUM OF EXCESS SUPPLIES		**2,433**	**2,294**	**2,176**	**2,045**	**1,863**	**1,656**

4.3 IRRIGATION WATER NEEDS

The Rio Grande Region does not have enough irrigation water supplies to meet irrigation water demand. At present, total water supply deficiencies are estimated to be nearly 584,000 ac-ft/yr. While the overall volumes of these water supply shortages are projected to remain relatively constant, the deficit as a percent of total demand is projected to increase over the planning period, from 38 percent to 51 percent, as irrigation water demand declines over the next 30 years due to improved irrigation efficiency. It should be noted that these deficits are based on high levels of projected irrigation demand and water availability under extreme drought conditions. Figure 4.3, below, presents a region-wide summary of irrigation water supplies as compared to demand, along with water needs (deficiencies) and excess supplies.

Figure 4.3: Irrigation Water Needs Summary



Cameron, Hidalgo, Maverick, Starr, Willacy, and Zapata counties have identified irrigation water supply needs, while Jim Hogg and Webb counties have irrigation water supply surpluses. Table 4.13 presents irrigation water surplus/deficit by county and portion of a river basin.

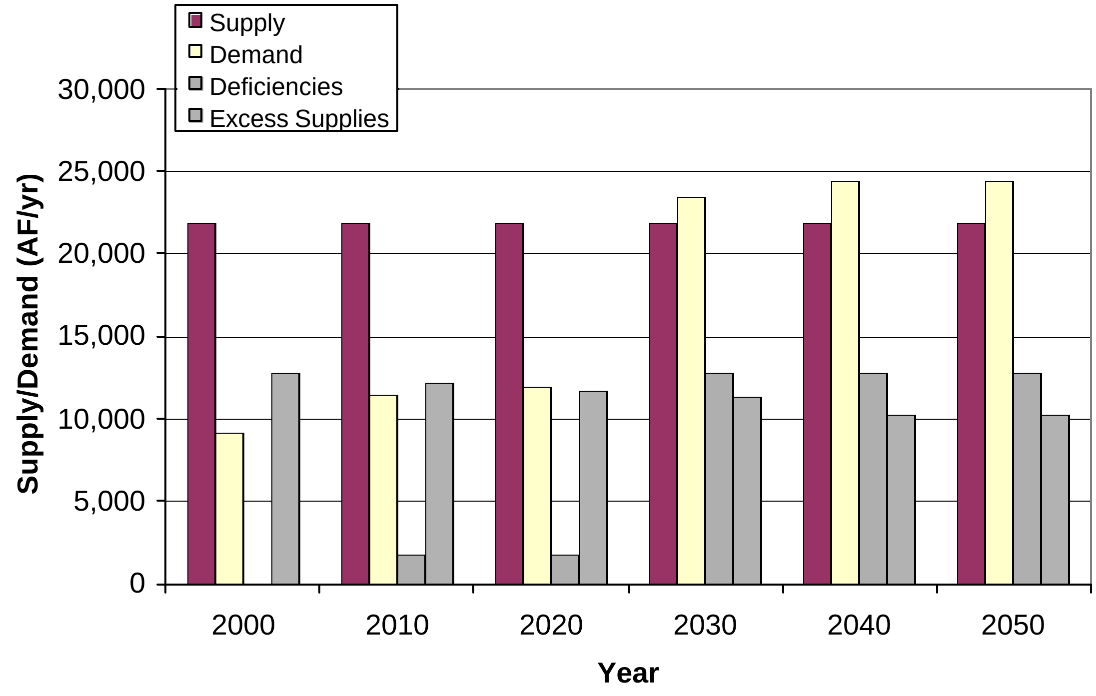
Table 4.13: Irrigation Water Surplus/Needs for the Rio Grande Region

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	Nueces-Rio Grande	-166,554	-160,080	-150,273	-142,902	-162,238	-186,329
Cameron	Rio Grande	7,053	7,241	7,651	7,957	7,152	6,148
Hidalgo	Nueces-Rio Grande	-319,739	-295,888	-263,434	-229,287	-260,772	-300,001
Hidalgo	Rio Grande	-12,593	-11,652	-10,351	-8,991	-10,269	-11,861
Jim Hogg	Nueces-Rio Grande	4,654	4,658	4,663	4,667	4,667	4,667
Jim Hogg	Rio Grande	1,614	1,614	1,614	1,614	1,614	1,614
Maverick	Nueces	-4,148	-3,952	-3,763	-3,595	-3,595	-3,595
Maverick	Rio Grande	-42,127	-41,945	-40,002	-39,445	-45,566	-53,183
Starr	Nueces-Rio Grande	699	699	699	699	699	699
Starr	Rio Grande	-14,434	-13,231	-12,394	-11,996	-14,101	-16,732
Webb	Nueces	2,415	2,415	2,415	1,572	1,572	1,572
Webb	Nueces-Rio Grande	90	90	90	90	90	90
Webb	Rio Grande	4,749	4,855	4,997	4,569	3,780	3,030
Willacy	Nueces-Rio Grande	-24,245	-24,674	-24,937	-25,598	-29,054	-33,360
Zapata	Rio Grande	55	95	145	171	58	-79
SUM OF DEFICITS		**583,840**	**551,422**	**505,154**	**461,814**	**525,595**	**605,140**
SUM OF EXCESS SUPPLIES		**21,329**	**21,667**	**22,274**	**21,339**	**19,632**	**17,820**

4.4 STEAM ELECTRIC WATER NEEDS

The Rio Grande Region is projected to have steam electric water supplies in excess of demand through the year 2020. After that point, demand will be slightly greater than supply, and relatively large steam electric water supply deficits will occur due to the location of available supply. Figure 4.4, below, presents a region-wide summary of steam electric water supplies as compared to demand, along with water needs (deficiencies) and excess supplies for the region.

Figure 4.4: Steam Electric Water Needs Summary



Although the Rio Grande Region currently has no identified steam electric water demand needs, water shortages are projected to occur beginning in 2030 in Cameron County and in 2010 in Webb County. Hidalgo County will have a significant surplus of steam-electric water supply throughout the planning period due to reuse of municipal wastewater. Table 4.14 presents steam electric water surplus/deficit by county and portion of a river basin.

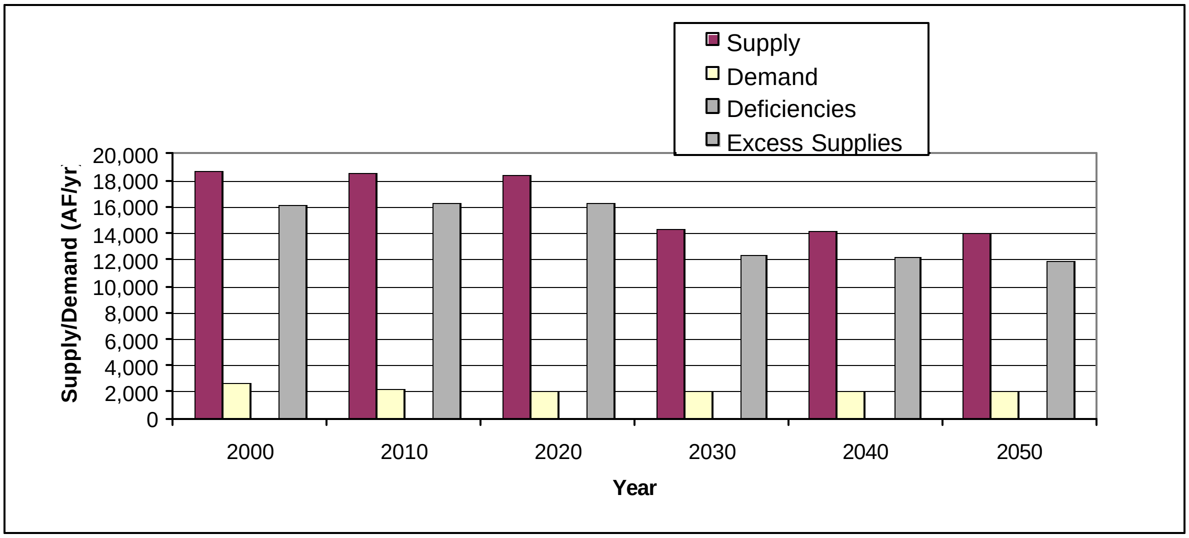
Table 4.14: Steam Electric Water Surplus/Needs for the Rio Grande Region

		Surplus/Deficit (ac-ft/yr) **Deficits are shaded**					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	Nueces-Rio Grande	0	400	400	-9,200	-9,200	-9,200
Cameron	Rio Grande	0	0	0	0	0	0
Hidalgo	Nueces-Rio Grande	12,589	11,789	11,289	11,289	10,289	10,289
Hidalgo	Rio Grande	0	0	0	0	0	0
Jim Hogg	Nueces-Rio Grande	0	0	0	0	0	0
Jim Hogg	Rio Grande	0	0	0	0	0	0
Maverick	Nueces	0	0	0	0	0	0
Maverick	Rio Grande	0	0	0	0	0	0
Starr	Nueces-Rio Grande	0	0	0	0	0	0
Starr	Rio Grande	0	0	0	0	0	0
Webb	Nueces	0	0	0	0	0	0
Webb	Nueces-Rio Grande	0	0	0	0	0	0
Webb	Rio Grande	195	-1,705	-1,705	-3,605	-3,605	-3,605
Willacy	Nueces-Rio Grande	0	0	0	0	0	0
Zapata	Rio Grande	0	0	0	0	0	0
SUM OF DEFICITS		**0**	**-1,705**	**-1,705**	**-12,805**	**-12,805**	**-12,805**
SUM OF EXCESS SUPPLIES		**12,784**	**12,189**	**11,689**	**11,289**	**10,289**	**10,289**

4.5 MINING WATER NEEDS

Total mining water supply is projected to exceed water demand throughout the planning period. Figure 4.5, below, presents a region-wide summary of mining water supplies as compared to demand and water needs (deficiencies) and excess supplies for the region.

Figure 4.5: Mining Water Needs Summary



The following table presents mining water surplus/deficit by county and portion of a river basin. This table shows that the largest surpluses are in Starr, Webb, and Jim Hogg counties.

Table 4.15: Mining Water Surplus/Needs for the Rio Grande Region

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	Nueces-Rio Grande	489	491	492	494	494	494
Cameron	Rio Grande	0	0	0	0	0	0
Hidalgo	Nueces-Rio Grande	693	689	670	645	584	506
Hidalgo	Rio Grande	233	243	249	252	250	247
Jim Hogg	Nueces-Rio Grande	1,121	1,131	1,135	1,137	1,139	1,140
Jim Hogg	Rio Grande	160	160	160	160	160	160
Maverick	Nueces	368	408	428	417	422	424
Maverick	Rio Grande	144	126	118	76	74	73
Starr	Nueces-Rio Grande	679	767	791	793	759	713
Starr	Rio Grande	1,089	1,077	1,071	1,076	1,059	1,023
Webb	Nueces	6,055	6,088	6,134	3,561	3,571	3,565
Webb	Nueces-Rio Grande	492	473	458	444	428	417
Webb	Rio Grande	3,544	3,568	3,569	2,229	2,191	2,154
Willacy	Nueces-Rio Grande	25	27	28	29	30	30
Zapata	Rio Grande	992	998	999	1,000	1,000	1,000
SUM OF DEFICITS		**0**	**0**	**0**	**0**	**0**	**0**
SUM OF EXCESS SUPPLIES		**16,084**	**16,246**	**16,302**	**12,313**	**12,161**	**11,946**

4.6 LIVESTOCK WATER NEEDS

Projections show no identified livestock water supply shortages in the Rio Grande Region during the next 50 years. Livestock water surpluses are estimated to total more than 17,200 ac-ft/yr through the year 2020 and approximately 10,000 ac-ft/yr thereafter. Figure 4.6, below, presents a region-wide summary of livestock water supplies as compared to demand and a summary of water needs (deficiencies) and excess supplies for the region. Webb County accounts for the majority of the livestock water supply surplus. The following table presents livestock water surplus/deficit by county and portion of a river basin.

Figure 4.6: Livestock Water Needs Summary

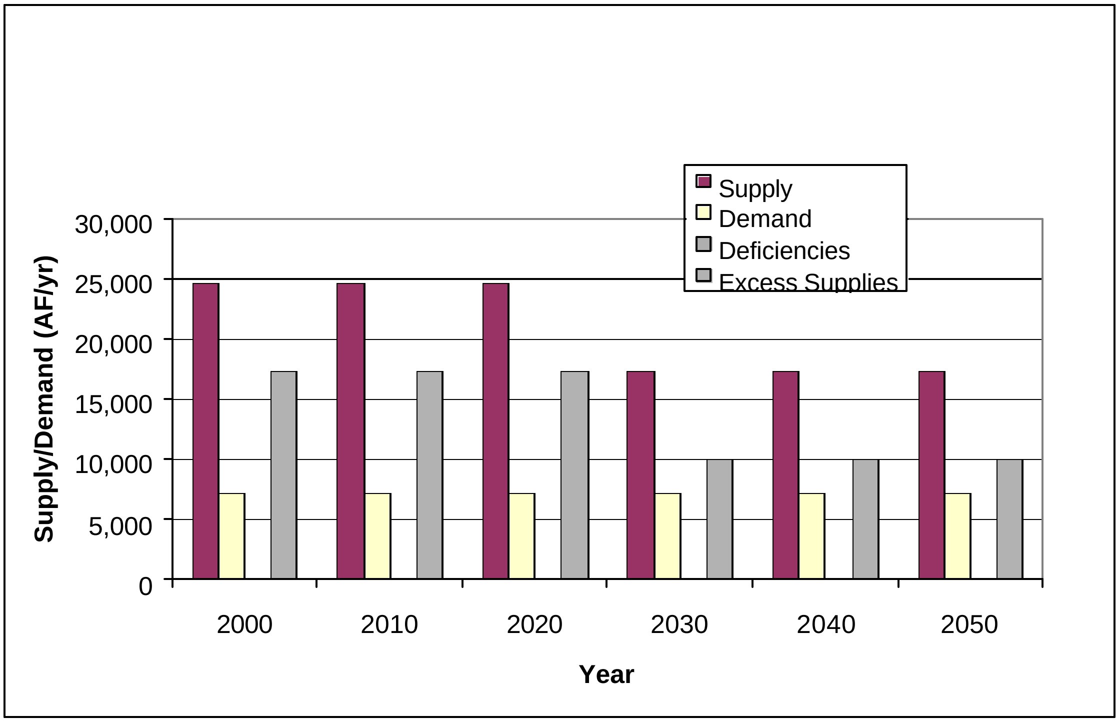


Table 4.16: Livestock Water Surplus/Needs for the Rio Grande Region

		Surplus/Deficit (ac-ft/yr) Deficits are shaded					
City	**River Basin**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Cameron	Nueces-Rio Grande	40	40	40	40	40	40
Cameron	Rio Grande	0	0	0	0	0	0
Hidalgo	Nueces-Rio Grande	71	71	71	71	71	71
Hidalgo	Rio Grande	21	21	21	21	21	21
Jim Hogg	Nueces-Rio Grande	106	106	106	106	106	106
Jim Hogg	Rio Grande	0	0	0	0	0	0
Maverick	Nueces	145	145	145	143	143	143
Maverick	Rio Grande	106	106	106	76	76	76
Starr	Nueces-Rio Grande	164	164	164	164	164	164
Starr	Rio Grande	0	0	0	0	0	0
Webb	Nueces	10,766	10,766	10,766	5,970	5,970	5,970
Webb	Nueces-Rio Grande	414	414	414	414	414	414
Webb	Rio Grande	5,305	5,305	5,305	2,829	2,829	2,829
Willacy	Nueces-Rio Grande	96	96	96	96	96	96
Zapata	Rio Grande	80	80	80	80	80	80
SUM OF DEFICITS		**0**	**0**	**0**	**0**	**0**	**0**
SUM OF EXCESS SUPPLIES		**17,314**	**17,314**	**17,314**	**10,010**	**10,010**	**10,010**

4.7 ECONOMIC AND SOCIAL IMPACT OF NOT MEETING WATER NEEDS

[NOTE: This socio-economic analysis conducted by the TWDB is no longer current. We have recently received revisions that affect the water supply need projections for several water user groups. While these revisions have been incorporated in other places in the plan, we were not able to have the TWDB perform a revised analysis in time for inclusion in this plan. It is anticipated that the TWDB will revise the socioeconomic analysis after the submittal of the Adopted Plan to the TWDB on January 5, 2001, and before the adoption of the Final State Plan on January 5, 2002 .]

Section 357.7(4) of the rules for implementing Senate Bill 1 require that the economic and social impact of not meeting regional water supply needs be evaluated by the Regional Water Planning Groups (RWPG). The purpose of this element of Senate Bill 1 planning is to give the regions an estimate of the potential costs of not acting to meet anticipated needs in each water user group, or conversely, the potential benefit to be gained from devising a strategy to meet a particular need. The summation of all the impacts gives the region a view of the ultimate cumulative effect of not meeting the entire list of needs. These summations should be considered a worst-case scenario for the region, since the likelihood of not meeting the entire list of needs is very small.

The Texas Water Development Board (TWDB) conducted the socio-economic impact analysis for the region, and the results of this analysis are included in the Technical Memoranda appendix, Volume II, of this report. The impacts of unmet water needs summarized for each of the six types of water user groups are presented in Table 2 of the TWDB Technical Memorandum, Volume II, as well as in Table 4.18 of this chapter. The results of the TWDB analysis of the impacts of unmet water needs are presented in Tables 9 and 10 (in the TWDB Exhibit B Tables appendix in Volume II). Each water user group with a need is evaluated in terms of direct and indirect economic and social impact on the region resulting from the shortage. Economic variables chosen for this analysis include gross economic output (sales and business gross income), employment (number of jobs) and personal income (wages, salaries and proprietors net receipts). The effects of shortages on population and school enrollments are the social variables of the analysis. Declining populations indicate a depreciation of social services in most, but not every case, while declining school enrollment indicates loss of younger cohorts of the population and possibilities of strains on the tax bases, when combined with economic losses.

4.7.1 Impacts of Unmet Water Needs for the Region

Sections 4.1 - 4.6 of this chapter identified individual water user groups that showed an unmet need during drought-of-record supply conditions for each decade from 2000 to 2050.

The water shortages of the region amount to about 34 percent of the forecasted demand by 2020, rising to 42 percent of demand in 2040, and to 48 percent of demand in 2050. This means that by 2050 the region would be able to supply only 52 percent of the projected needs unless supply development or other water management strategies are implemented.

4.7.1.1 Economic Growth Limitations

The difference between expected future growth, unrestricted by water shortage, and expected growth restricted by unmet water needs provides the measure of impact.

4.7.1.1.1 Employment

Left entirely unmet, the level of shortage in 2010 results in 59 thousand fewer jobs than would be expected in unrestricted development (without water needs) by 2010. The gap between unrestricted and restricted job growth grows to 221 thousand by 2030, and to 359 thousand jobs that the restricted economy could not create by 2050.

4.7.1.1.2 Population

The forecasted population growth of the region would be economically restricted by curtailed potential job creation. This in turn causes both an out migration of some current population and an expected curtailment of future population growth. Compared to the baseline growth in population, the region could expect 137 thousand fewer people in 2010, growing to 511 thousand fewer in 2030, and 825 thousand fewer in 2050. The expected 2050 population under the severe shortage conditions would be 27 percent lower than projected in the region’s most likely growth forecast.

4.7.1.1.3 Income

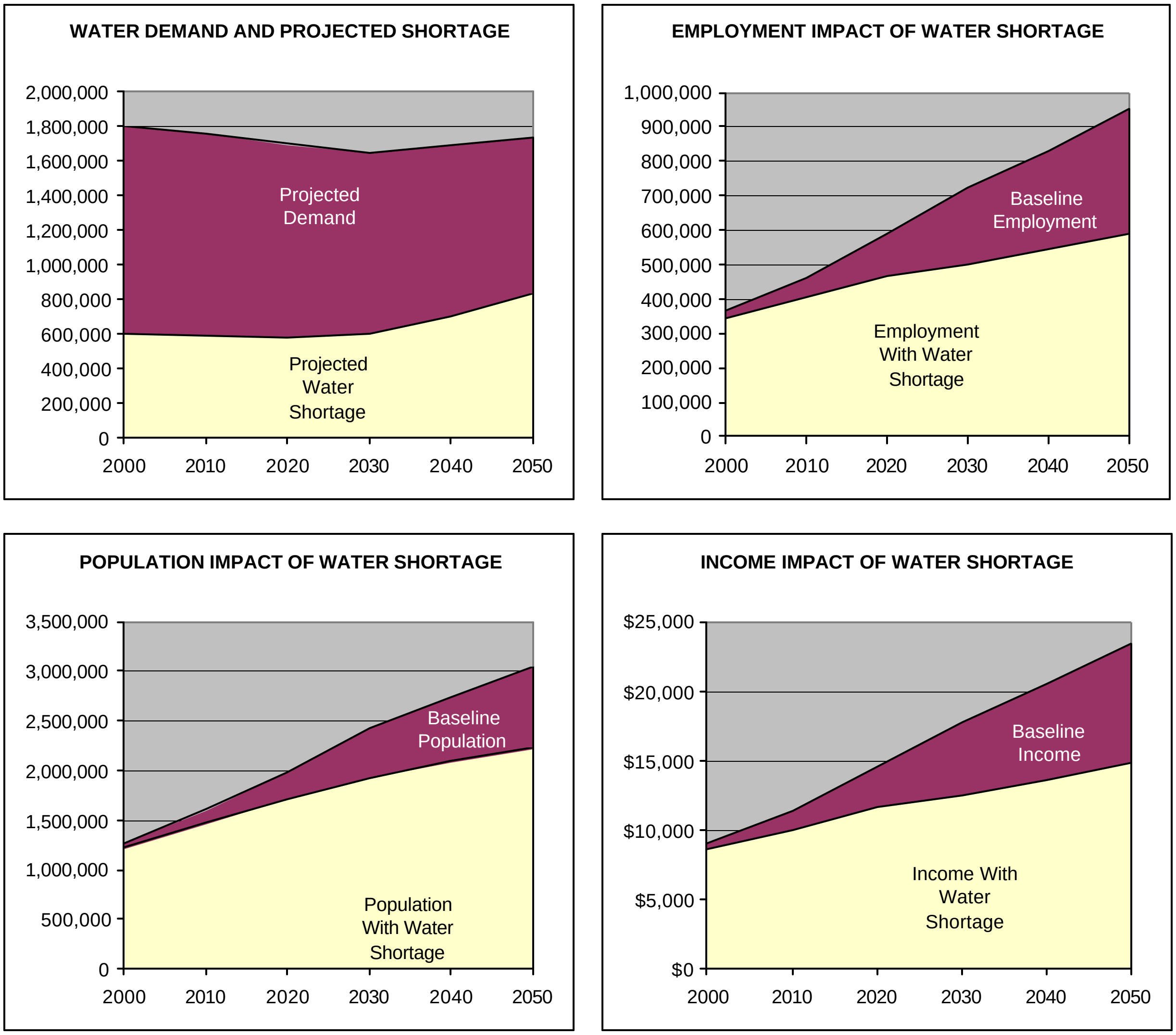
The potential loss of economic development in the region amounts to about 13 percent less income to people in 2010, with the gap growing to 31percent less than expected in 2030. By 2050 the region would have 38 percent less income than is currently projected assuming no water restrictions. (See Table 4.17 and Figure 4.7)

Table 4.17: Relationship of Water Needs and Impacts to Projections Without Constraints, Rio Grande Region, 2000 - 2050

WATER				EMPLOYMENT			
Decade	**Projected Demand**	**Projected Water Shortage**	**Percent Shortage**	**Decade**	**Baseline Employment**	**Employment With Water Shortage**	**Percent Loss**
	(acre-feet)				(FTE jobs)		
2000	1,803,291	599,567	33.2%	2000	366,696	344,741	6.0%
2010	1,757,448	589,304	33.5%	2010	461,302	401,995	12.9%
2020	1,698,077	576,534	34.0%	2020	587,709	468,769	20.2%
2030	1,643,617	605,100	36.8%	2030	721,599	500,227	30.7%
2040	1,688,276	706,764	41.9%	2040	831,667	547,644	34.2%
2050	1,737,924	832,583	47.9%	2050	951,400	592,087	37.8%

POPULATION				INCOME			
Decade	**Baseline Population**	**Population With Water Shortage**	**Percent Loss**	**Decade**	**Baseline Income**	**Income With Water Shortage**	**Percent Loss**
2000	1,264,582	1,213,600	4.0%	2000	9,055	8,584	5.2%
2010	1,600,077	1,463,522	8.5%	2010	11,391	10,001	12.2%
2020	1,976,791	1,702,540	13.9%	2020	14,513	11,671	19.6%
2030	2,425,604	1,914,964	21.1%	2030	17,819	12,433	30.2%
2040	2,735,506	2,084,010	23.8%	2040	20,537	13,640	33.6%
2050	3,046,680	2,222,060	27.1%	2050	23,494	14,782	37.1%

Figure 4.7: Summary of Socio-Economic Impacts of Not Meeting Water Needs, Rio Grande Region



4.7.1.2 Water User Groups with Shortages

The economic and social impact of an unmet water need varies greatly depending on the type of Water User Group for which the shortage is anticipated. On a per acre-foot basis, the largest impacts will generally result from shortages in manufacturing and municipal uses, while shortages for irrigation will typically result in the smallest impact. Table 4.18 (also see the Technical Memoranda appendix in Volume II of this report) presents the impacts of unmet water needs summarized for each of the six types of Water User Groups.

Table 4.18 Summary of Impacts by Decade and Category

RIO GRANDE REGION, 2000 - 2050

Category	Decade	Value of Need (Acre-Feet)	Impact of Need on Employment	Impact of Need on Gross Business Output in 1999 US Dollars (Millions)	Impact of Need on Population	Impact of Need on School Enrollment	Impact of Need on Income in 1999 US Dollars (Millions)	Number of WUGs with Needs
Municipal	2000	-15,661	16,259	1,071.2	37,759	10,285	387.4	21
Manufacturing	2000	-66	315	29.3	734	202	7.7	1
Steam Elec.	2000	0	0	0.0	0	0	0.0	0
Mining	2000	0	0	0.0	0	0	0.0	0
Irrigation	2000	-583,840	5,381	313.7	12,489	3,397	76.3	7
Livestock	2000	0	0	0.0	0	0	0.0	0
TOTAL		**-599,567**	**21,955**	**1,414.2**	**50,982**	**13,884**	**471.4**	
Municipal	2010	-36,096	53,394	3,236.6	122,956	33,157	1,288.9	29
Manufacturing	2010	-81	387	36.0	882	240	9.4	1
Steam Elec.	2010	-1,705	443	70.8	1,010	275	20.0	1
Mining	2010	0	0	0.0	0	0	0.0	0
Irrigation	2010	-551,422	5,082	296.3	11,707	3,192	72.1	7
Livestock	2010	0	0	0.0	0	0	0.0	0
TOTAL		**-589,304**	**59,307**	**3,639.7**	**136,555**	**36,864**	**1,390.4**	
Municipal	2020	-69,577	113,373	6,742.7	261,357	69,697	2,744.4	34
Manufacturing	2020	-98	468	43.5	1,095	295	11.4	1
Steam Elec.	2020	-1,705	443	70.8	1,037	279	20.0	1
Mining	2020	0	0	0.0	0	0	0.0	0
Irrigation	2020	-505,154	4,656	271.4	10,762	2,896	66.1	7
Livestock	2020	0	0	0.0	0	0	0.0	0
TOTAL		**-576,534**	**118,940**	**7,128.5**	**274,251**	**73,167**	**2,841.9**	
Municipal	2030	-130,363	213,221	12,672.0	491,634	130,964	5,162.0	39
Manufacturing	2030	-118	567	52.8	1,354	368	13.8	2
Steam Elec.	2030	-12,805	3,328	532.0	7,762	2,091	150.4	2
Mining	2030	0	0	0.0	0	0	0.0	0
Irrigation	2030	-461,814	4,256	248.1	9,890	2,666	60.4	7
Livestock	2030	0	0	0.0	0	0	0.0	0
TOTAL		**-605,100**	**221,372**	**13,504.9**	**510,640**	**136,089**	**5,386.5**	
Municipal	2040	-168,217	275,116	16,350.7	630,918	168,073	6,660.4	42
Manufacturing	2040	-147	735	68.4	1,717	480	17.9	2
Steam Elec.	2040	-12,805	3,328	532.0	7,682	2,059	150.4	2
Mining	2040	0	0	0.0	0	0	0.0	0
Irrigation	2040	-525,595	4,844	282.4	11,179	2,999	68.7	7
Livestock	2040	0	0	0.0	0	0	0.0	0
TOTAL		-706,764	284,023	17,233.5	651,496	173,611	6,897.4	
Municipal	2050	-214,460	349,495	20,785.3	801,899	213,367	8,460.2	45
Manufacturing	2050	-178	912	84.9	2,143	584	22.2	2
Steam Elec.	2050	-12,805	3,328	532.0	7,701	2,059	150.4	2
Mining	2050	0	0	0.0	0	0	0.0	0
Irrigation	2050	-605,140	5,577	325.1	12,877	3,431	79.1	8
Livestock	2050	0	0	0.0	0	0	0.0	0
TOTAL		**-832,583**	**359,313**	**21,727.2**	**824,620**	**219,441**	**8,711.9**	

The vast majority of the economic and social impacts of unmet water needs in the Rio Grande Region result from municipal water shortages. In 2010, municipalities have unmet needs of 36 thousand acre-feet, 6 percent of the total unmet needs. The economic impacts of this shortage (53 thousand jobs, $3.2 billion in output, and $1.3 billion of income) represent approximately 90 percent of the total impacts. By 2050, unmet municipal needs total 214 thousand acre-feet (26% of the total) resulting in 349 thousand jobs not created, and reductions of $20.8 billion in potential output and $8.5 billion in potential income.

Unmet irrigation needs represent the largest category of need, but, due to the relatively small value of economic output added per acre-foot, the impacts of not meeting irrigation needs are considerably less. In 2010, irrigation has unmet needs of 551 thousand acre-feet, 94 percent of the total. The economic impacts of the shortage (5 thousand direct and indirect jobs, $296 million in output, and $72 million in income) represent less than 10 percent of the total economic impact.

The region also projects unmet water needs for manufacturing and for steam electric power, representing only a very small proportion of both water needs and socio-economic impacts.

4.7.2 Interpretation of the Results

It is not to be assumed that the entire list of needs with impacts is a prediction of future water disasters. These data simply give regional planners one source of information by which to develop efficient and effective means to meet the needs and avoid calamities.

Some clarification is needed to understand the impact numbers. The following points must be kept in mind when using the data:

a) The impacts are expressed in terms of regional impact. Thus, individual water user group shortages are shown as they influence the entire region's economy and not just the limits of the direct impact. The total impact of municipal shortage for a particular city, for example, includes the direct impact within the city limits and the impact indirectly through the region. The indirect linkages were derived from regional economic models. There are no models for individual water user groups.

b) While the entirety of an estimated impact applies to the region as a whole, a significant portion will generally be felt in the local area where the shortage occurs. An impact that is of a small magnitude relative to impacts of other shortages on other areas may be extremely severe if its magnitude is large relative to the size of the local economy. Thus, while the absolute magnitude of agricultural shortages may appear to be small, the true severity of the impact may be much more significant to the surrounding rural area.

c) Water supplies are calculated on drought-of-record levels. Shortages that show up for the 2000 decade and beyond are considered to be mostly the result of severe dry conditions; this contributes to the apparent abnormally large size of some impacts. This approach to supply analysis results in a worst-case scenario. Historically, most water user groups have at least partially met their needs through management of the remaining supplies, either by conservation, limitations on lower-valued uses such as lawn watering, or finding alternative sources of water. The results in this report <u>assume no applied management strategies</u>. The entirety of the needs is not met in any fashion.

d) The analysis begins by calculating water use coefficients–defined as production (dollars of sales to final customers, or final demand) resulting from use of an acre-foot of water. This measure is considered an <u>average, not marginal measure</u> of water use. Thus, the analysis does not attempt to measure the market forces that would tend to drive the price of water higher or reserve limited water for the highest-valued uses, as it becomes scarce. The average value approach was used because the analysis is intended to show the present value in today's regional economies of differing amounts of water use. With this information analysts can answer the question, "How much water does it take to support the current level and structure of economic activity and population"? The baseline projections for the future of regional economies assume a continuation of this known relationship of volumes of water use to economic output, under current structures of use. The models do not attempt to estimate the market allocation of the resource among competing activities because this change in structure is considered a possible management strategy–relying on market forces to work in a water-marketing system. Marginal cost analysis would be necessary for evaluating such an approach.

e) The Municipal water use category includes <u>commercial establishments</u>. The impacts from even small shortages in many such establishments are considerably higher on a per-acre-foot basis than in any other category. Thus, relatively small Municipal shortages can have a very large amount of economic impact, since the analysis assumes a direct relationship between curtailed water use and lost economic production. Since this analysis is intended to provide impacts without assuming any strategies, the normal response of conservation programs is not assumed. The impact data appear to overstate the Municipal category, but the results are consistently measured, since no response to the shortage is assumed that would mitigate loss of critical water used in commercial and residential settings.

f) The sizes of the projected impacts do not represent reductions from the current levels of economic activity or population. That is, the data are a <u>comparison</u> between a <u>baseline forecast</u>, assuming no water shortages, and a <u>restricted forecast</u>, based on the assumption of future water shortages. In some cases, with severe water shortages the regional economy could actually decline, dropping employment below current levels. For most regions, however, the measurement of impact represents an <u>opportunity cost</u>, or lost potential development that would be foregone in the absence of water management strategies.

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CHAPTER 5.0: EVALUATION AND SELECTION OF WATER MANAGEMENT STRATEGIES FOR THE RIO GRANDE REGION

The primary emphasis of the regional water supply planning process established by Senate Bill (SB) 1 is the identification of current and future water needs and the development of strategies for meeting those needs. This chapter presents the results of the evaluation of various water management strategies; a conceptual framework and overview of the water management strategies recommended for implementation within the Rio Grande Region; and specific recommendations to meet the identified water supply shortages of individual water user groups (WUGs).

5.1 TWDB GUIDELINES FOR PREPARATION OF REGIONAL WATER PLANS

By rule, the Texas Water Development Board (TWDB) has set forth specific requirements for the preparation of regional water plans (31 Texas Administrative Code, Chapter 357). With regard to recommendations for meeting identified water supply needs, the regional water plans are to include:

- Specific recommendations for meeting near-terms needs (2000-2030) in sufficient details to allow the TWDB and the Texas Natural Resource Conservation Commission (TNRCC) to make financial assistance or regulatory decisions with regard to the consistency of the proposed action with an approved regional water plan.
- Specific recommendations or alternative scenarios for meeting long-term needs (2030-2050).

It should be noted, however, that TWDB rules provide that a regional water plan may also identify water needs for which no water management strategy is feasible, provided applicable strategies are evaluated and reasons are given as to why no strategies are feasible. For the Rio Grande Region, there are no feasible strategies for meeting a portion of the projected irrigation shortages. This will be explained in detail in subsequent sections of this chapter.

According to TWDB rules, potentially feasible water management strategies are to be evaluated by considering:

- The quantity, reliability, and cost of water delivered and treated for the end user's requirements;
- Environmental factors including effects on environmental water needs, wildlife habitat, cultural resources, and effect of upstream development on bays, estuaries, and arms of the Gulf of Mexico;
- Impacts on other water resources of the state including other water management strategies and groundwater surface water interrelationships;
- Impacts of water management strategies on threats to agricultural and natural resources;
- Any other factors deemed relevant by the regional water planning group including recreational impacts;
- Equitable comparison and consistent application of all water management strategies the regional water planning group determines to be potentially feasible for each water supply need;

- Consideration of the provisions in Texas Water Code, Section 11.085(k)(1) for interbasin transfers; and,
- Consideration of third party social and economic impacts resulting from voluntary redistributions of water.

In January 2000, the Rio Grande RWPG adopted a two-tiered approach to the evaluation of water management strategies. The first tier of criteria focused on the estimated water supply yield, cost, and environmental impact of each water management strategy. According to TWDB guidelines, yield is the quantity of water that is available from a particular strategy under drought-of-record hydrologic conditions. The cost of implementing a strategy includes the estimated capital or construction costs, total annual cost, and the unit cost expressed as dollars per acre-foot of yield. As indicated, cost estimates include the cost of water delivered and treated for end-user requirements. For example, water supplied to a municipal water user would typically include costs for diversion and delivery, as well as capital and O&M costs for treatment to meet current state and federal drinking water standards. Cost estimates were prepared in consideration of TWDB guidelines regarding interest rates, debt service, other project costs (e.g., environmental studies, permitting, and mitigation). In addition to environmental considerations that are included in estimates of cost for each strategy, environmental impacts were considered and assessed at a reconnaissance level.

The second tier of evaluation included consideration, as appropriate, of other factors outlined in TWDB rules, for example, impacts on recreation, third-party impacts, impacts on agricultural and natural resources.

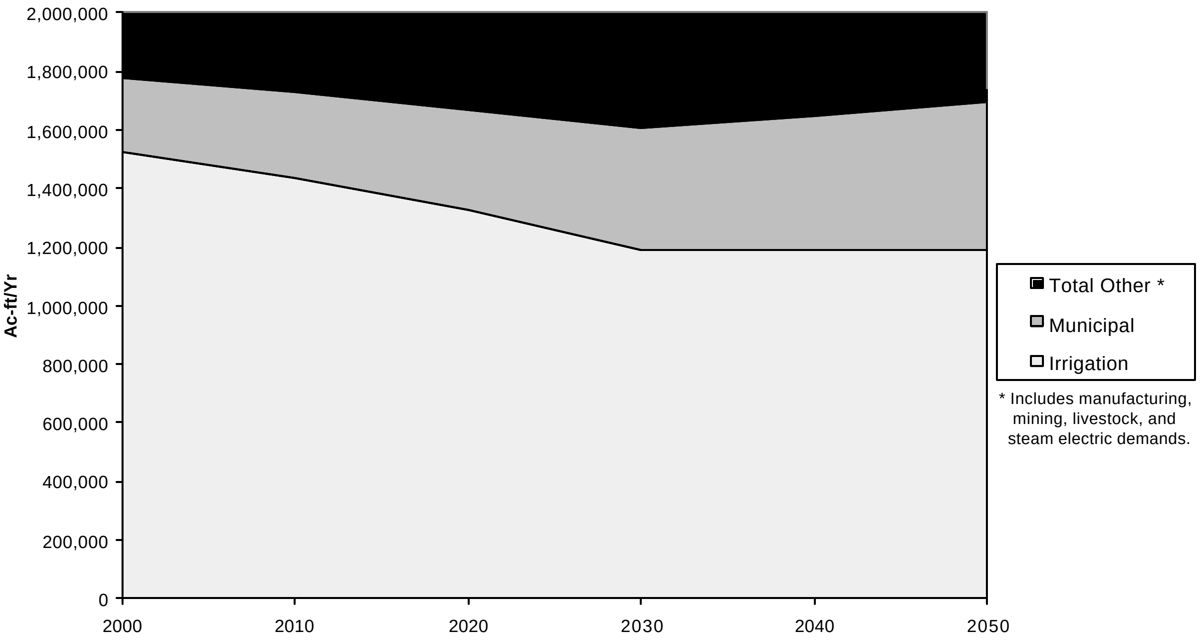
5.2 REGIONAL SUMMARY

A brief review of projected water demands, estimates of currently available water supplies, and current and projected water needs of the Rio Grande Region is presented below.

5.2.1 Current and Projected Water Demands

Current and projected water demands within the Rio Grande Region are presented in Chapter 2 of this plan. As indicated, rapid population growth is expected to continue through the 50-year planning period, with population increasing from approximately 1.2 million at present to over three million in 2050. With rapid population growth and continued urbanization, significant increases in domestic-municipal-industrial (DMI) water demands are projected through the planning period. Also, as a consequence of continued urbanization in Cameron and Hidalgo counties, irrigated acreage and irrigation water demands are projected to decrease substantially during the planning period from approximately 1.5 million acre-feet per year at present to roughly 1.2 million acre-feet per year in 2030 and thereafter. Figure 5.1 below presents the current and projected regional water demands for each of the six major water use categories.

Figure 5.1: Water Demand Projections Summary for the RGRWPA



It is important to note that while DMI water demands are projected to increase substantially and irrigation demands are projected to decrease, as a percentage of total regional water demand, irrigation will remain the dominant water use in the region, accounting for roughly 85 percent of water demand at present and 69 percent of water demand in 2050. Clearly, the irrigation sector will continue to be a vital component of the region's economy for the foreseeable future.

5.2.2 Current and Projected Water Supply Availability

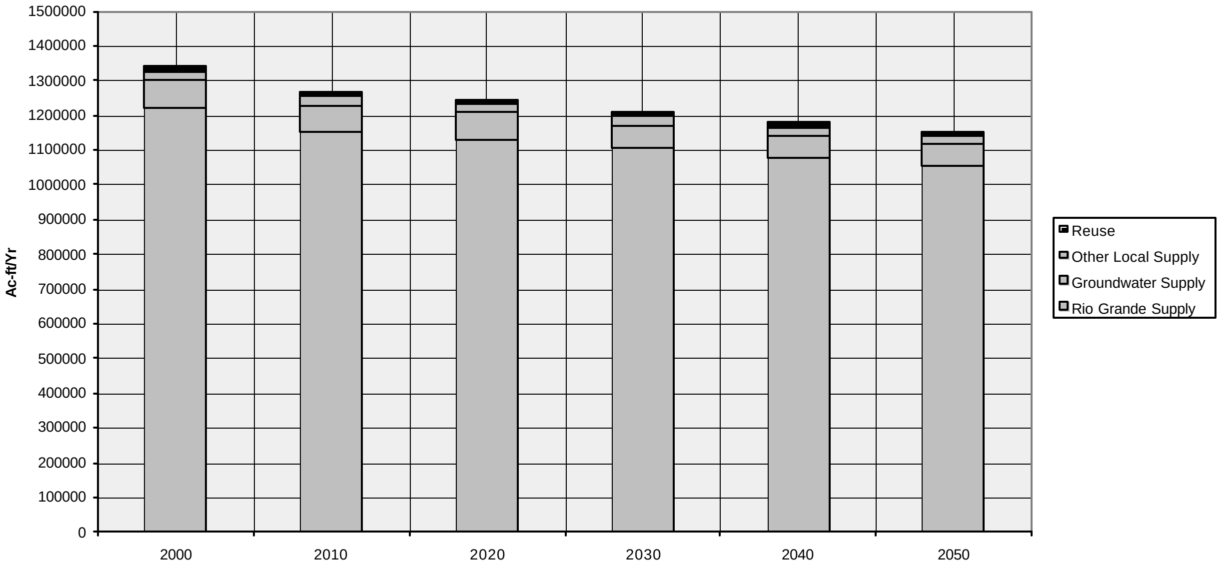
As discussed in Chapter 3 of this plan, the Rio Grande is the primary water source for the Rio Grande Region, now and in the future. At present, the dependable firm water supply available from the Rio Grande (i.e., the Amistad-Falcon Reservoir System) during drought-of-record hydrologic conditions is approximately 1.2 million acre-feet per year. This represents more than 91 percent of the total supply of water currently available to the region from all sources (e.g., groundwater reuse, Rio Grande tributaries, and other local sources). Over time, however, the firm yield of the reservoir system is projected to decrease significantly, largely as a consequence of sedimentation of the Amistad-Falcon Reservoir System. By 2050, it is estimated that the firm yield of the reservoir system will decrease by more than 115,000 acre-feet.

Because of the manner by which Rio Grande water supplies from the Amistad-Falcon reservoir system are managed and allocated, the impact of declining supply availability will be borne directly by irrigation and mining water users. Also, estimates of the amount of supply available for irrigation are based on an assumption that all future needs of DMI users that presently rely on the Rio Grande will be met with additional Rio Grande supplies. Because of these factors, the firm yield of the Rio Grande for irrigation and mining is projected to decrease by approximately 357,000 acre-feet per year (see Table 3.11) or more than 40 percent over the 50-year planning period.

In addition to the water supply available from the Rio Grande, approximately six percent, or nearly 80,000 acre-feet per year, of the region's water supply is estimated to be available from groundwater sources at present. Also, approximately 13,000 acre-feet per year (1%) is available from reuse of reclaimed water for irrigation, manufacturing, and stream electric uses and nearly 24,000 acre-feet per year of supply is estimated to be available from Rio Grande tributaries and other local surface water sources.

Current and projected water supplies available to the Rio Grande region under a scenario of "no new development" of additional water supplies are summarized in Figure 5.2.

Figure 5.2: Current and Projected water supplies for the RGRWPA



5.2.3 Water Supply Needs

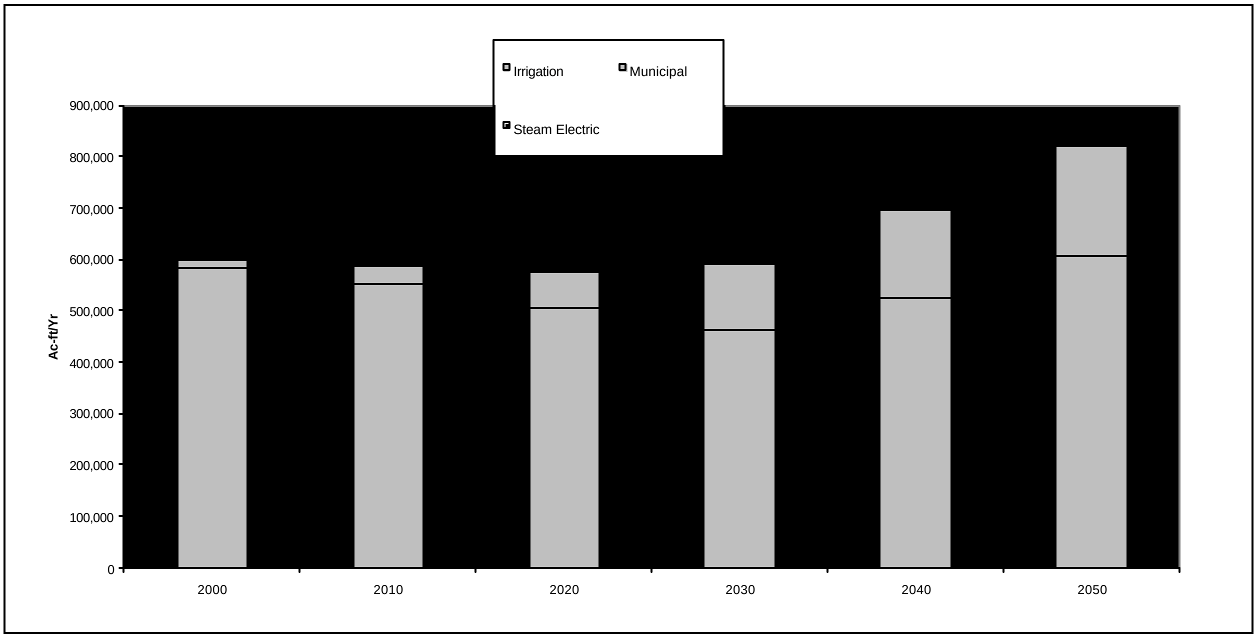
The comparison of projected water demands to estimates of available water supply (presented in Chapter 4) reveals that the Rio Grande Region faces serious challenges in the management of its limited water resources. At present, both DMI and agricultural water users show significant water shortages under drought-of-record conditions, and shortages in both sectors are projected to increase significantly through the planning period. A user-by-user comparison of supply and demand reveals that 48 of the 92 TWDB designated "water user groups" within the Rio Grande Region are projected to experience shortages during the 50-year planning period.

Shortages for DMI users, which include the municipal, manufacturing, and stream electric use categories, are projected to increase from approximately 13,250 acre-feet per year at present to more than 227,443 acre-feet per year by 2050. Projected shortages within the municipal sector are widespread, with 39 of the 52 municipal water user groups in the region showing shortages at some point during the 50-year planning period. Jim Hogg County is the only county without projected municipal water shortages during the planning period. Region-wide, there are only minor water shortages projected for the manufacturing sector. Also, the steam electric water user groups in Cameron and Webb counties are projected to have shortages during the planning period.

Supply shortages in the irrigation sector are particularly acute and are projected to increase from approximately 580,000 acre-feet per year at present to more than 605,000 acre-feet per year by 2050. Decreases in irrigation supply availability are nearly offset by projected decreases in irrigation demand. Six of the eight irrigation "water user groups" in the Rio Grande Region show shortages during the 50-year planning period (i.e., Cameron, Hidalgo, Maverick, Starr, Willacy, and Zapata counties).

No shortages are projected for the mining or livestock category of water use for any of the counties in the region.

Figure 5.3: Regional Shortages for Each Use Sector



Sectors With Significant Shortages From 2000-2050

Note: Manufacturing, mining, and livestock not shown. There are only minor shortages in manufacturing and no shortages in both mining and livestock.

5.3 OVERVIEW OF RECOMMENDED WATER MANAGEMENT STRATEGIES

The Rio Grande RWPG has adopted five basic goals or “pillars” that underlie this regional water plan. These are:

- Optimize the supply of water available from the Rio Grande;
- Reduce projected municipal water supply needs through expanded water conservation programs;
- Diversify water supply sources for DMI uses through the appropriate development of alternative water sources (e.g., reuse of reclaimed water, groundwater); and
- Minimize irrigation shortages through the implementation of agricultural water conservation measures and other measures; and
- Recognize that the acquisition of additional Rio Grande water supplies will be the preferred strategy of many DMI users for meeting future water supply needs.

Consistent with these goals, the Rio Grande RWPG has adopted recommended water management strategies for each water user group (WUG) with identified water needs during the 50-year planning period. It should be noted that **the water management strategies recommended and adopted by the Rio Grande RWPG and presented herein are for the entire 50-year planning period, applicable towards both near-term needs (2000-2030) and long-term needs (2030-2050)**. The sections that follow present a regional overview of recommended water management strategies for each major category of water use. Specific recommendations for each of the eight counties in the Rio Grande Region are presented in Section 5.5. Information for all of the potentially feasible water management strategies that were considered during the planning process is presented in Section 5.6 for meeting DMI needs in Section 5.7 for reducing irrigation shortages, and in Section 5.8 for improving the overall management of the Rio Grande.

5.3.1 Recommended Strategies for Meeting Municipal Water Needs

TWDB rules specify that the regional water plans are to include the evaluation of all water management strategies the RWPG determines to be potentially feasible. For the Rio Grande Region, an initial determination of potentially feasible strategies was made by the Rio Grande RWPG and was incorporated into the approved scope-of-work for preparation of the regional water plan. Additional strategies were added over the course of the planning process.

For DMI users, the strategies evaluated for this plan are:

- Municipal water conservation;
- Reuse of reclaimed water;
- Acquisition of additional Rio Grande water;
- Desalinization of brackish groundwater and sea water;
- Aquifer storage and recovery;
- Development of a third reservoir on the Rio Grande;

- Construction of a gravity canal to deliver water to users in the Lower Rio Grande Valley (LRGV);
- Construction of a pipeline to deliver water from Falcon Reservoir to municipal users in the LRGV;
- Off-channel storage of excess Rio Grande flows;
- Construction of the proposed Brownsville Weir and Reservoir;
- Collection and use of local runoff in the LRGV;
- Interbasin transfer of surface water from Lavaca and Nueces River basins; and,
- Groundwater development.

In addition, reallocation of storage in the Amistad-Falcon Reservoir System, and voluntary redistribution of existing water resources were also evaluated as potentially feasible strategies for meeting DMI needs.

The recommended strategies for meeting current and projected municipal water demands in the Rio Grande Region are presented in Tables 5.1 and 5.2 for years 2030 and 2050 and depicted graphically in Figure 5.4. As indicated, the key strategies are:

- Additional or “advanced” water conservation measures for all municipalities, with a target goal of achieving one to two percent reduction in water demand per decade beginning in 2010, above and beyond the conservation already built in to the demand projections. This would reduce municipal demands 15,100 acre-feet per year in 2030 and 30,200 acre-feet per year in 2050. (This revised strategy was recommended by the Rio Grande RWPG at the planning group meeting on September 27, 2000);
- Reuse of reclaimed water. Non-potable water reuse is recommended for those cities with a potential to have a total of at least 5.0 million gallons per day (mgd) wastewater treatment plant capacity. This criteria was applied to cities with projected population exceeding 50,000 by year 2030, assuming 100 gallons per day (gpd) of wastewater generated per person. For the cities that met the above criteria, the following reduction in water demand per decade was assumed: 5 percent in 2010, 15 percent in 2020, 25 percent in 2030, 2040 and 2050. This strategy will contribute 32,800 acre-feet per year of additional supply 2030 and 43,300 acre-feet by 2050. (This strategy was recommended by the Rio Grande RWPG at the planning group meeting on July 28, 2000);
- Acquisition, by purchase or contract, of an additional 81,400 acre-feet per year of Rio Grande supplies by 2030 and 134,100 acre-feet per year by 2050.
- Construction of the proposed Brownsville Weir and Reservoir, which will provide an additional 20,640 acre-feet of dependable surface water supply for the City of Brownsville by the Year 2010 and thereafter.
- Local groundwater development, which is recommended to provide an additional 11,000 acre-feet per year of supply through the planning period.
- Renewal of existing water supply contracts.

Appendix 5.1 contains a summary of each of the strategies that were evaluated by the Rio Grande RWPG (details are included in the technical appendix to the plan (Volume II).

Table 5.1: Recommended Water Management Strategies to Meet 2030 Regional Municipal

			Water Conservation	Non-Potable Reuse	Conversion from Ag. to Mun. Water	Purchase of RG supply	Brownsville Weir	Groundwater development	Final (Deficit)/ Surplus
	2030	COST	$232	$360	$325	$430	$438	$580	
	Demand	Water Deficit							
Cameron Co.									
Brownsville	43,555	-15,127	0	6,000	131	131	20,643		11,777
Combes	234	-4	7		4	4			10
County Other (R.G)	251	-151	8		136	8			0
County Other (RG-N)	17,070	6,145	512						6,657
Harlingen	17,971	414	539	4,493	270	270			5,985
La Feria	1,100	700	33						733
Los Fresnos	1,003	-153	30		93	30			0
Palm Valley	476	-70	14		41	14			0
Port Isabel	3,613	248	108		54	54			465
Primera	672	145	20		10	10			185
Rio Hondo	635	255	19						274
San Benito	7,289	-1,789	219		1,352	219			0
So. Padre Island	2,988	11	90		45	45			190
County Total	***96,857***	***-17,294***	***1,599***	***10,493***	***2,135***	***783***	***20,643***		18,359
Hidalgo Co.									
Alamo	2,790	-1,137	84		970	84			0
Alton	1,505	0	45						45
County Other	50,893	-11,976	1,527		8,922	1,527			0
Donna	7,222	-3,032	217		2,599	217			0
Edcouch	970	370	29						399
Edinburg	14,480	-6,499	434	3,620	2,010	434			0
Elsa	2,315	-475	69		336	69			0
Hidalgo	1,709	-3	51		26	26			100
La Joya	1,213	-544	36		471	36			0
La Villa	741	-241	22		197	22			0
McAllen	35,514	-1,965	1,380	8,879	1,395	690			10,379
Mercedes	4,446	-619	133		352	133			0
Mission	20,197	-9,908	606		8,696	606			0
Palmview	863	-550	26		498	26			0
Pharr	11,439	-2,908	343	2,860	172	172			638
Progreso	403	-136	12		112	12			0
San Juan	6,021	-3,675	181		3,314	181			0
Sullivan City	701	-688	21		646	21			0
Weslaco	10,990	-3,014	330	2,748	165	165			393
County Total	***174,412***	***-47,370***	***5,547***	***18,106***	***30,880***	***4,421***			11,583
Maverick Co.									
County Other (R.G)	3,552	-1,073	213			860			0
County Other (N)	77	319	2						321
Eagle Pass	6,114	1,415	183			183			1,782
County Total	***9,743***	***-1,073***	***399***	***0***	***0***	***1,043***			369
Starr Co.									
La Grulla	1,844	-1,377	111			1,266			0
Rio Grande City	6,330	-3,862	380			3,482			0
Roma	4,109	-1,267	247			1,020			0
Starr Co Other (R.G.)	6,920	-4,871	415			4,456			0
Starr Co Other (N)	704	1,370	21						1,391
County Total	***19,907***	***-11,377***	***1,173***	***0***	***0***	***10,225***			21
Webb Co.									
Laredo	84,571	-40,998	5,074	4,229		20,745		10,950	0
Webb Co Other	11,347	-7,767	681			7,145			59
County Total	***95,918***	***-48,765***	***5,755***	***4,229***	***0***	***27,890***		***10,950***	59
Willacy Co.									
Lyford	841	217	25						242
Raymondville	4,890	780	147						927
San Perlita	187	-48	6		37	6			0
Willacy Co Other	1,146	-70	34		17	17			-1
County Total	***7,064***	***-118***	***212***	***0***	***54***	***23***			171
Zapata Co.									
Zapata	5,437	-3,653	326			3,327			0
Zapata Co Other	1,590	-680	95			585			0
County Total	***7,027***	***-4,333***	***422***	***0***	***0***	***3,911***			0

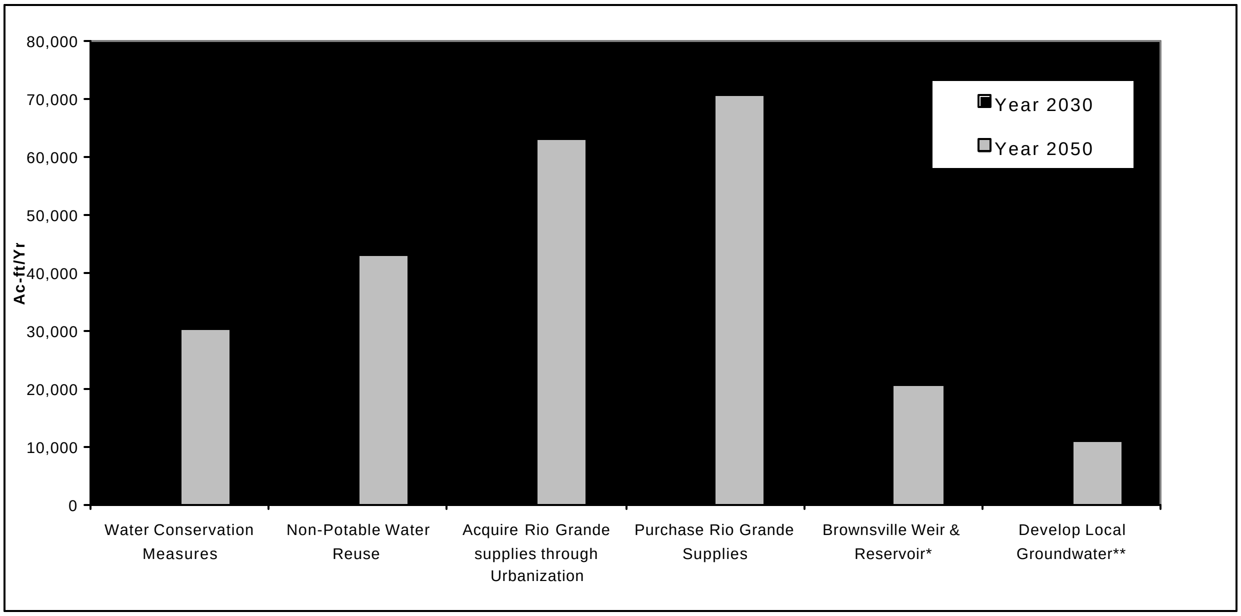
Note: Implementation issues associated with the recommended strategies for DMI use may encourage an individual community to place deferring priorities to its specific solution. However, any combination of the recommended strategies is viewed as a possible solution.

Table 5.2: Recommended Water Management Strategies to Meet 2050 Regional Municipal

			Water Conservation	Non-Potable Reuse	Conversion from Ag. to Mun. Water	Purchase of RG supply	Brownsville Weir	Groundwater development	Final (Deficit)/ Surplus
	2050	COST	232	$360	$325	$430	$438	$580	
	Demand	Water Deficit							
Cameron Co.									
Brownsville**	48,069	-19,641	0	10,000	240	240	20,643		11,483
Combes	247	-17	12		6	6			8
County Other (R.G)	322	-222	16		190	16			0
County Other (RG-N)	21,703	1,512	1,085						2,597
Harlingen	19,608	-1,223	980	4,902	490	490			5,640
La Feria	1,517	283	76						359
Los Fresnos	1,378	-528	69		390	69			0
Palm Valley	550	-144	28		89	28			0
Port Isabel	3,990	-129	200		100	100			270
Primera	844	-27	42		21	21			57
Rio Hondo	727	163	36						199
San Benito	7,936	-2,436	397		1,642	397			0
So. Padre Island	3,652	-653	183		288	183			0
County Total	***110,543***	***-25,020***	***3,124***	***14,902***	***3,457***	***1,549***	***20,643***		18,655
Hidalgo Co.									
Alamo	3,177	-1,525	159		1,207	159			0
Alton	1,760	0	88						88
County Other	66,849	-28,696	3,342		22,011	3,342			0
Donna	9,543	-5,353	477		4,399	477			0
Edcouch	1,204	136	60						196
Edinburg	18,968	-10,987	948	4,742	4,348	948			0
Elsa	2,872	-1,032	144		745	144			0
Hidalgo	2,321	-615	116		383	116			0
La Joya	1,486	-817	74		668	74			0
La Villa	962	-462	48		366	48			0
McAllen	46,250	-12,701	2,300	11,563	2,325	1,150			4,637
Mercedes	5,644	-1,817	282		1,253	282			0
Mission	26,620	-16,331	1,331		13,669	1,331			0
Palmview	1,157	-844	58		728	58			0
Pharr	15,456	-6,925	773	3,864	1,515	773			0
Progreso	461	-194	23		148	23			0
San Juan	6,786	-4,440	339		3,761	339			0
Sullivan City	817	-804	41		722	41			0
Weslaco	14,382	-6,406	719	3,596	1,372	719			0
County Total	***226,715***	***-99,949***	***11,323***	***23,764***	***59,621***	***10,025***		***0***	4,785
Maverick Co.									
County Other (R.G)	4,261	-1,782	426			1,356			0
County Other (N)	94	302	5						307
Eagle Pass	7,569	-40	378			378			717
County Total	***11,924***	***-1,822***	***809***	***0***	***0***	***1,734***		***0***	722
Starr Co.									
La Grulla	2,453	-1,986	245			1,741			0
Rio Grande City	8,359	-5,891	836			5,055			0
Roma	5,408	-2,566	541	0		2,025			0
Starr Co Other (R.G.)	8,322	-6,273	832			5,441			0
Starr Co Other (N)	848	1,226	42						1,268
County Total	***25,390***	***-16,716***	***2,497***	***0***	***0***	***14,262***		***0***	42
Webb Co.									
Laredo	92,483	-48,910	9,248	4,624		24,088		10,950	0
Webb Co Other	15,324	-11,744	1,533			10,212			1
County Total	***107,807***	***-60,654***	***10,781***	***4,624***	***0***	***34,300***		***10,950***	1
Willacy Co.									
Lyford	907	151	45						196
Raymondville	5,131	539	257						796
San Perlita	219	-80	11		58	11			0
Willacy Co Other	1,101	-25	55		28	28			85
County Total	***7,358***	***-105***	***368***	***0***	***86***	***38***		***0***	387
Zapata Co.									
Zapata	9,820	-8,036	982			7,054			0
Zapata Co Other	3,230	-2,320	323			1,997			0
County Total	***13,050***	***-10,356***	***1,305***	***0***	***0***	***9,051***		***0***	0

Note: Implementation issues associated with the recommended strategies for DMI use may encourage an individual community to place deferring priorities to its specific solution. However, any combination of the recommended strategies is viewed as a possible solution.

Figure 5.4: Recommended Strategies for Meeting Municipal Needs in the RGRWPA



It should be noted that a given WUG may implement any combination and/or order of the above mentioned recommended strategies for DMI shortages to meet its specific needs.

The strategies selected for meeting DMI needs generally will not result in adverse impacts to other water resources of the state, will not threaten other natural resources (see Chapter 1), and will not result in significant adverse socio-economic impacts to third parties from voluntary redistributions of water (e.g., contractual water sales).

Because a portion of future DMI needs will be met through the acquisition of additional supply from the Rio Grande, reallocation of water from agricultural to DMI uses will be required, which will have the effect of reducing the availability of water for agricultural use. However, instead of aggravating this "threat to agricultural resources" (see Chapter 1), significant opportunities exist for constructive partnerships between DMI users and agricultural water users that will further the interests of both groups, and the region as a whole.

Desalination of brackish groundwater as a technology should continue to be evaluated as potential strategy for DMI use as cost efficiencies continue to improve and environmental issues can be economically addressed. However, desalination of brackish groundwater could be considered a recommended strategy in a few specific local areas where it already is cost-effective (see Section 5.5.1)

It should be noted that although groundwater development is selected as a recommended water management strategy only for the City of Laredo, the Rio Grande RWPG considers groundwater as a viable alternative to augment supplies in some areas. This is a current practice that is likely to continue.

In addition, the Rio Grande RWPG recognizes that surface water uses that will not have significant impact on the region's water supply may be required above and beyond the recommended strategies even though they are not specifically recommended in the plan. Additionally, the region may also face the need to develop water supply projects that do not involve the development of or connection to a new water source even though such projects are not specifically recommended in the plan.

5.3.2 Recommended Strategies for Meeting Projected Manufacturing Needs

Small manufacturing water shortages are projected for Webb County. It is recommended that these demands be supplied by the City of Laredo.

5.3.3 Recommended Strategies for Meeting Projected Steam Electric Needs

Combined, the county-level steam electric power generation WUGs in Cameron and Webb counties are projected to have shortages of 12,805 acre-feet per year by 2030 and thereafter through 2050. Water management strategies considered potentially applicable to this need include acquisition of additional Rio Grande supplies, use of reclaimed water, and groundwater. It is recommended that all of the projected steam electric demands be met through a combination of the three listed strategies.

5.3.4 Additional Recommended Strategies for Reducing Projected Irrigation Shortages

The economics of the agriculture industry are such that water management strategies considered feasible for the Rio Grande Region are not sufficient to satisfy the projected deficits in their entirety. Consequently, development of new water supply sources for irrigated agriculture – whether surface or groundwater – is not seen as a viable strategy. There nevertheless are strategies that could significantly reduce irrigation demand or increase the available supply of water for irrigation.

For irrigation users, the water management strategies considered for this plan are:

- Agricultural water conservation;
- On-farm water use efficiency;
- Modification of current TNRCC rules for the operation of the Amistad-Falcon Reservoir System;
- Reuse of reclaimed water;
- Brush control;
- Weather modification, and
- Retaining irrigation water rights associated with “excluded” properties.

In addition, because of assumptions made in estimated irrigation water availability during drought-of-record hydrologic conditions (see Chapter 3), additional irrigation supplies are projected to be available as a consequence of recommended strategies for DMI users that will lessen the need for DMI users to acquire additional Rio Grande supplies than would otherwise be the case. In essence, strategies such as municipal water conservation and reuse of reclaimed water for DMI purposes, is a strategy for reducing the magnitude of projected irrigation shortages

At the regional level, irrigation shortages of 461,814 acre-feet per year in 2030 and 605,140 acre-feet per year in 2050 are projected under drought-of-record conditions. However, relative to average irrigation demands over the past decade, a more realistic estimate of irrigation shortages is 200,000 to 400,000 acre-feet per year.

The Rio Grande RWPG believes that investment in agricultural water efficiency is one of the cornerstones of the region's near-term water management plan. Accordingly, the Rio Grande RWPG recommends that there be a comprehensive effort by local, state, and federal agencies to "capture" the maximum amount of water savings from irrigated agriculture over the 50-year planning period. The Rio Grande RWPG recommended the following water management strategies for reducing irrigation shortages:

- Agricultural water conservation;
- On-farm water use efficiency; and,
- Modification of current TNRCC rules for the operation of the Amistad-Falcon Reservoir System.

Specifically, it is recommended that investments be made such that 75 percent of the achievable water savings from efficiency improvements in irrigation water conveyance and distribution are "captured" by 2020. It is further recommended that on-farm water conservation measures be implemented at a rate such that 80 percent of achievable savings are realized by 2050. The resultant water savings to be obtained from these strategies is shown below in Table 5.3.

Table 5.3: Water Supply Yield from Implementation of Recommended Agricultural Water Conservation Strategies Under Drought Conditions (ac-ft/yr)

Strategy	2000	2010	2020	2030	2040	2050
Conveyance Improvements	0	59,862	119,724	119,724	119,724	119,724
On-Farm Measures	0	43,635	87,270	104,722	122,176	139,630
Total	**0**	**103,497**	**206,994**	**224,446**	**241,900**	**259,354**

Note: Estimated water savings are based on reduced irrigation demand during drought conditions.

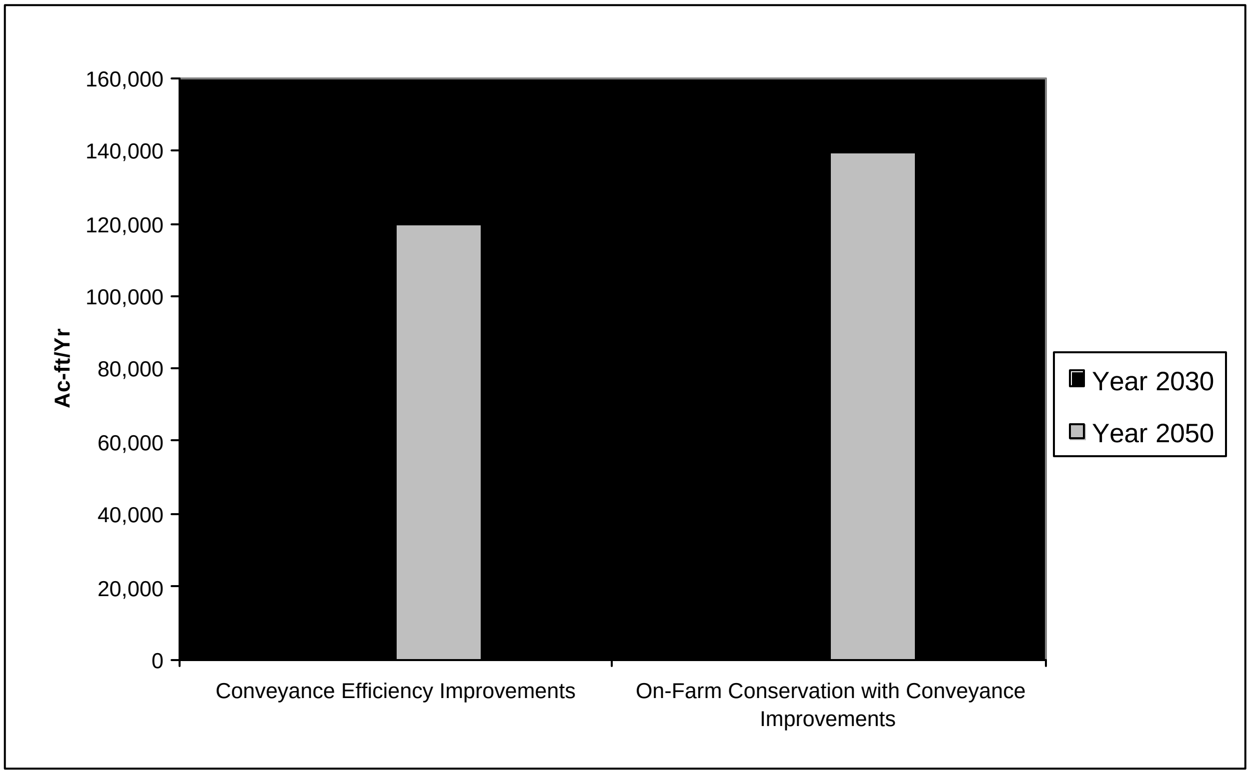
A summary of recommended strategies for reducing irrigation shortages is depicted in Figure 5.5. Additionally, the re-evaluation of irrigation supply availability, in light of reduced DMI needs for additional Rio Grande supplies resulting from advanced water conservation and reuse, will reduce the projected irrigation deficit by 21,700 acre-feet per year (4.7 percent) in 2030 and by 35,300 acre-feet per year (5.8 percent) in 2050.

At a regional level, implementation of the recommended agricultural water conservation strategies will require a total capital investment of approximately $204 million at a total annualized cost of $17.9 million for conveyance improvements and $31.5 million for on-farm conservation measures. At the regional level, the resultant annualized unit costs of water provided by these strategies would be $150 per acre-foot per year for conveyance improvements and $225 per acre-foot per year for on-farm measures.

The remaining supply deficit represents a need for which there are no feasible water management strategies. However, this unmet need could be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that would further increase irrigation water supply availability (See Section 5.7.2).

Furthermore, it is recognized that retaining irrigation water rights associated with "excluded" properties, if implemented, may help further reduce the irrigation shortages. Additionally, weather modification or rainfall enhancement is currently being implemented in certain areas of the Rio Grande Region. The Rio Grande RWPG, therefore, recommends that weather modification programs be continued in future in this region for augmenting water supplies.

Figure 5.5: Recommended Strategies to Meet Regional Irrigation Needs in 2030 and 2050w RGRWPA Irrigation Water Needs



5.3.5 Other Recommended Strategies

Opportunities to increase the available water supply from the Rio Grande are limited. Nonetheless, three management strategies are recommended for implementation or further study that could optimize and increase the dependable water supply from the Rio Grande. These are:

- Improved real-time monitoring of the Rio Grande and major tributaries to minimize river conveyance losses and to maximize utilization of unregulated "excess" river flows (i.e., no-charge pumping).
- On-going control of hydrilla and water hyacinth in the lower portions of the Rio Grande; and,
- Re-channelization of portions of the Rio Grande upstream of Amistad International Reservoir.

The water supply benefits associated with improved real-time monitoring of the Rio Grande and control of exotic plant species cannot be quantified. It is nonetheless believed that these strategies will be of general benefit to water users throughout the region and should be implemented by appropriate state, federal, or regional agencies. Detailed information on these strategies is presented in Section 5.8.

5.4 REGIONAL DROUGHT PREPAREDNESS

Overall, the Rio Grande Region is well prepared for drought, as evidenced by manner in which the region has been able to cope with the current drought. The legal system under which Rio Grande water rights are administered acts like a regional drought contingency plan. DMI users have an assured annual supply of water from the Amistad-Falcon Reservoir System equal to their authorized annual water right. Irrigation and mining water rights accounts, as the "residual" users of water from the reservoir system, bear the entire brunt of water supply shortages during drought as those users only receive new allocations of water when inflows to the reservoir system are in excess of that required to satisfy municipal demands and offset system losses.

In effect, the existing TNRCC rules and regulations for operating the Amistad-Falcon Reservoir System provide the means for initiating a drought response. As the storage in the reservoirs falls during dry periods in response to decreased inflows, the existing rules automatically reduce the available supply of water in the irrigation and mining accounts. This action serves to protect the available supply for DMI users. In essence, this system functions as a drought contingency plan.

Additionally, many irrigation districts have adopted district-level water allocation policies, which provide a market-based mechanism for minimizing the economic impacts of irrigation shortages. Specifically, during periods of shortage, most districts "go on allocation" and allow individual irrigators to sell all or a portion of their water allocations to other irrigators within the district and, in some cases, to irrigators outside the district. The benefit of these agriculture-to-agriculture water transfers is that the producers of higher value and more water-intensive crops, such as citrus and sugar cane, can gain access to additional water over and above their allocations from an irrigation district. The entire region benefits to the extent that these transactions minimize the economic impacts of irrigation shortages by allowing limited water supplies to move from lower to higher value uses. A recent study estimates that about 120,000 acre-feet of water was transferred within the agricultural sector during the 1995-1996 time period.

While DMI water users in the Rio Grande Region are generally afforded a very high degree of water supply reliability during drought, there are circumstances under which drought preparedness is somewhat deficient. One situation that has arisen during the current drought is the potential for interruption of DMI water deliveries by irrigation districts when irrigation water rights accounts are depleted. In many cases in the Lower Rio Grande Valley, DMI water deliveries are dependent upon adequate supplies of irrigation "push water." If irrigation supplies are exhausted, DMI water rights accounts or the reserves may have to be tapped to maintain adequate water flows in the conveyance facilities that deliver DMI water. One potential solution to this problem is to develop more conveyance/distribution interconnections between DMI users and irrigation districts and between DMI users and other DMI users. With state technical and financial assistance, efforts are currently underway to identify and implement such interconnections.

Based on current TNRCC records, it also appears that a significant number of municipal water suppliers have not complied with state requirements to prepare drought contingency plans. While such plans may not be necessary for responding to water supply shortages, there are other conditions, which may from time to time require voluntary or mandatory curtailment of non-essential municipal water uses. For example, local drought can result in elevated peak water demands, which may strain limited water treatment and distribution capacity. Also, it is not uncommon for water utilities to experience outages caused by major equipment failures and natural disasters. Such situations should be addressed in local drought contingency plans.

5.5 COUNTY-LEVEL SUMMARY OF RECOMMENDED STRATEGIES FOR MEETING PROJECTED NEEDS

Provided below is a summary of recommendations for meeting the projected water needs of each category of water users within each county of the Rio Grande Region. For municipal water users, the recommendations are presented in the aggregate. The specific recommendations for each individual water user group (WUG) are presented in "decision documents" (Appendix 5.2) and in TWDB Exhibit B Tables 11, 12, and Summary Tables in Volume II of the plan (Technical Appendix).

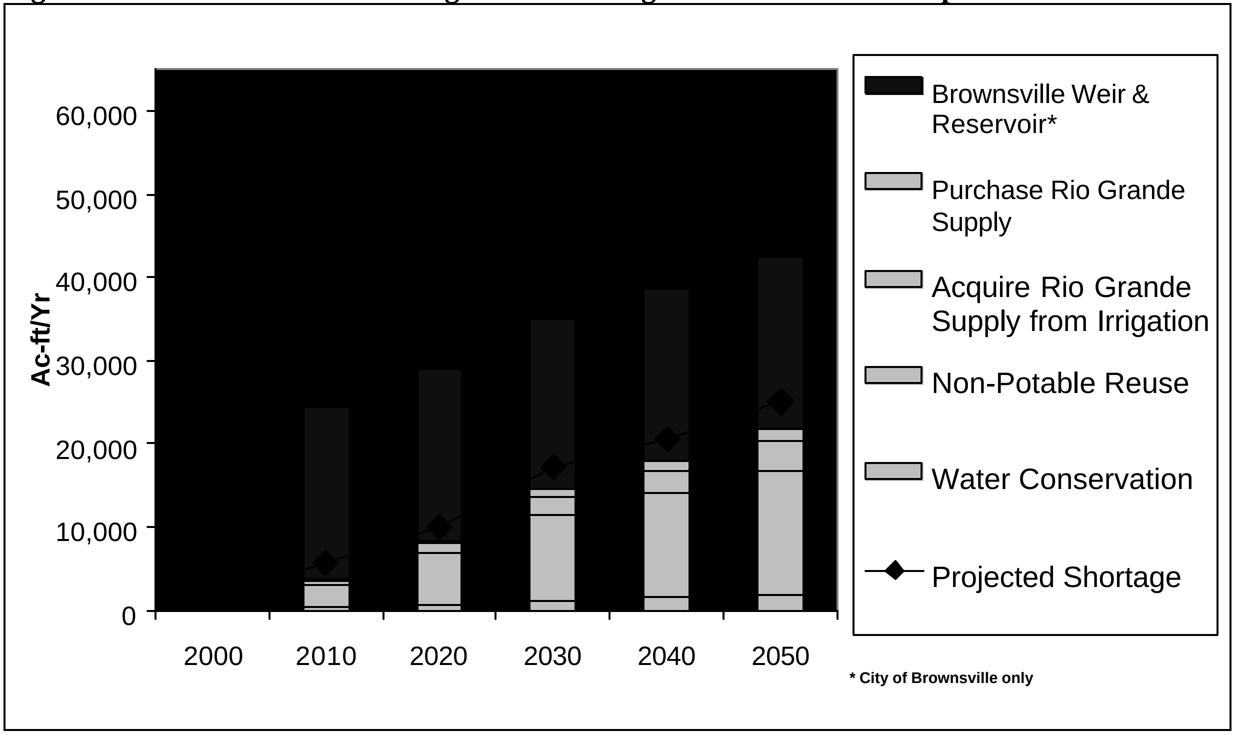
5.5.1 Cameron County

As described in Chapter 4, there are projected water shortages in Cameron County for municipal WUGs and for the county-level stream electric and irrigation WUGs. There are six municipal WUGs with combined shortages of 17,294 acre-feet per year in 2030, increasing to ten WUGs with combined shortages of 25,020 acre-feet per year in 2050. The county-level steam electric WUG in the Nueces-Rio Grande Basin has projected shortages of 9,200 acre-feet per year beginning in 2030 and continuing through 2050. The county-level irrigation WUG for Cameron County in the Nueces-Rio Grande Basin has a current shortage of 166,554 acre-feet per year under drought of record conditions, which is projected to decrease to 142,902 acre-feet per year in 2030 due to reductions in irrigated acreage from urbanization. However, irrigation shortages are projected to increase to 186,329 acre-feet per year in 2050 (see Table 4.13) as a consequence of reduced supply availability from increased DMI demands for Rio Grande supplies and reductions in reservoir system yield due to sedimentation.

The recommended strategies for meeting municipal water needs in Cameron County are displayed graphically in Figure 5.6. As indicated, additional water conservation measures are recommended that will reduce total projected demands by 1,599 acre-feet by year 2030 and by 3,124 acre-feet in 2050. Non-potable reuse of reclaimed water is recommended to provide 10,493 acre-feet per year of additional supply in 2030 and 14,902 acre-feet per year by 2050. It is also recommended that municipal WUGs in Cameron County acquire an additional 2,918 acre-feet per year of Rio Grande supplies by 2030 and an additional 5,006 acre-feet by 2050 (see Tables 5.1 and 5.2).

Additionally, based on input provided by the Brownsville Public Utilities Board (BPUB), Brownsville Weir and Reservoir, when completed, will provide an additional 20,643 acre-feet per year of supply. Considering BPUB's local water supply plans, which also include reuse and acquisition of additional Rio Grande supplies, the City of Brownsville will enjoy water supply surpluses of over 11,000 acre-feet per year through 2050.

Figure 5.6: Recommended Strategies for Meeting Cameron Co. Municipal Water Needs



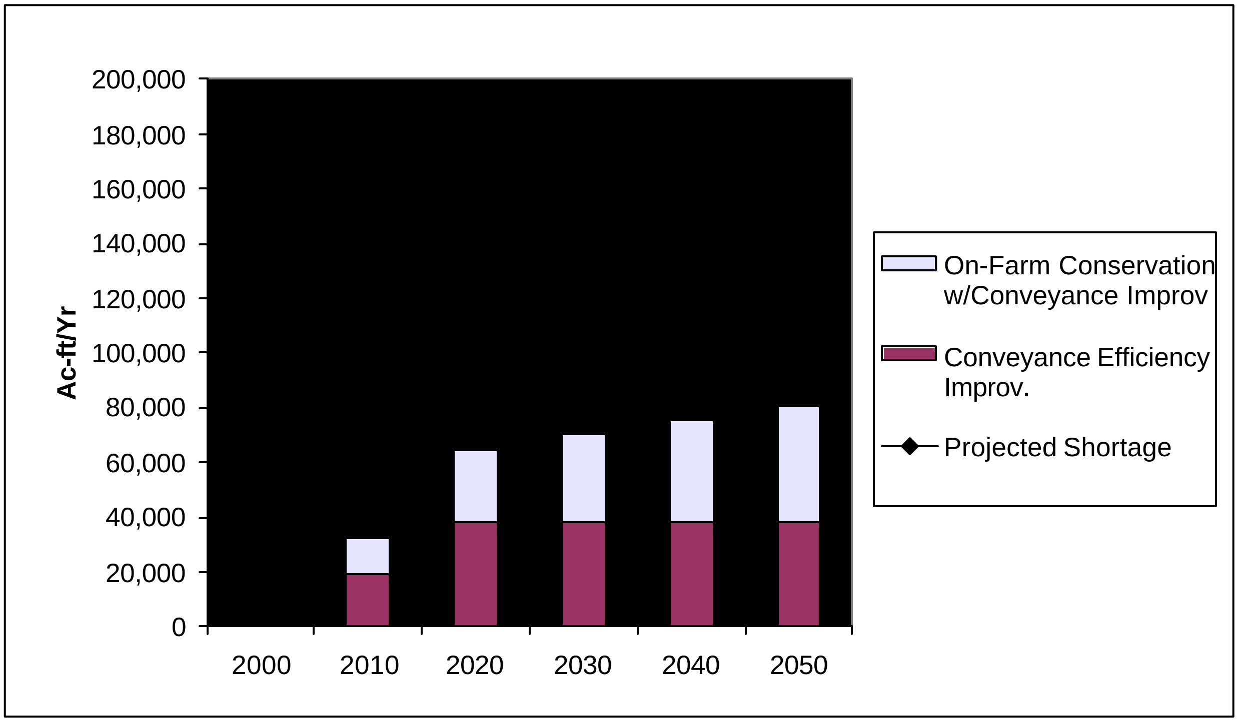
Projections indicate that the county-level steam electric WUG in Cameron County will require an additional 9,200 acre-feet per year of water supply by 2030 and thereafter. It is recommended that this need be met through a combination of reuse of reclaimed water, acquisition of additional Rio Grande supplies and groundwater.

Although not depicted with the large-scale solutions in Figure 5.6, desalination of brackish groundwater should be considered as a recommended strategy in localized areas of Cameron County where it is cost-effective. For example, the Rancho Viejo and River Bend Resorts areas should consider expanding their existing brackish groundwater treatment system from approximately 280 acre-ft/yr to 840 acre-ft/yr. Although this system will not significantly impact the overall needs in the county, it would have a significant local impact. Due to the site-specific nature of this technology and the need for more specific investigations, however, it is not included in Tables 5.1 and 5.2.

Figure 5.7 depicts projected irrigation shortages in Cameron County and the recommended strategies for meeting a portion of those needs. As indicated, implementation of agricultural water conservation measures are recommended ,that will reduce the projected irrigation deficit by 69,931 acre-feet per year (52 percent) in 2030 and by 80,532 acre-feet per year (45 percent) in 2050. Additionally, the re-evaluation of irrigation supply availability, in light of reduced DMI needs for additional Rio Grande supplies, will reduce the projected irrigation deficit by 6,745 acre-feet per year (4.7 percent) in 2030 and by 10,961 acre-feet per year (5.9 percent in 2050).

The remaining supply deficit represents a need for which there are no feasible water management strategies. However, this unmet need could be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that would further increase irrigation water supply availability.

Figure 5.7: Recommended Strategies for Meeting Partial Cameron Co. Irrigation Needs



5.5.2 Hidalgo County

There are projected water shortages in Hidalgo County for municipal WUGs and for the county-level irrigation WUG. At present, nine cities in Hidalgo County have needs for additional water supply. By 2030, 17 of 19 municipal WUGs in the county are projected to have supply deficits totaling 47,370 acre-feet per year, increasing to 99,950 acre-feet by 2050. The county-level irrigation WUG for Hidalgo County has an estimated 332,332 acre-foot per year shortage at present under drought-of-record conditions. This is projected to decrease to 238,278 acre-feet per year in 2030 due primarily to reduced demand associated with the loss of irrigated acreage from urbanization. As a consequence of projected increased DMI demands for Rio Grande supplies and reductions in reservoir system yield due to sedimentation, irrigation shortages are projected to increase to 311,862 acre-feet per year by 2050. There are no projected shortages for the manufacturing, steam electric, mining, or livestock WUGs in Hidalgo County.

The recommended strategies for meeting municipal water needs in Hidalgo County are displayed graphically in Figure 5.8. Acquisition of additional Rio Grande water supplies totaling 35,301 acre-feet in 2030 and 69,646 acre-feet per year in 2050 is also recommended. In combination, the strategies recommended for meeting municipal needs in Hidalgo County would provide surpluses of approximately 11,600 acre-feet per year and 4,800 acre-feet per year in 2030 and 2050, respectively.

Figure 5.8: Recommended Strategies for Meeting Hidalgo Co. Municipal Water Needs

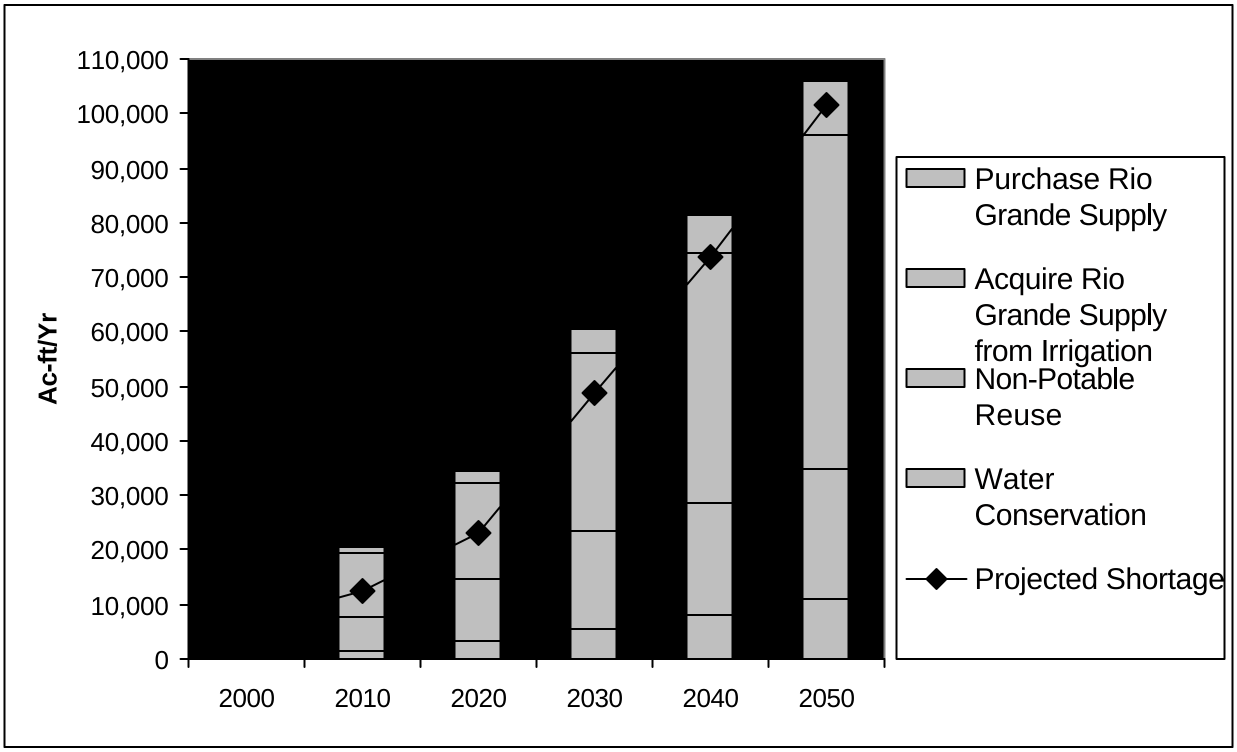
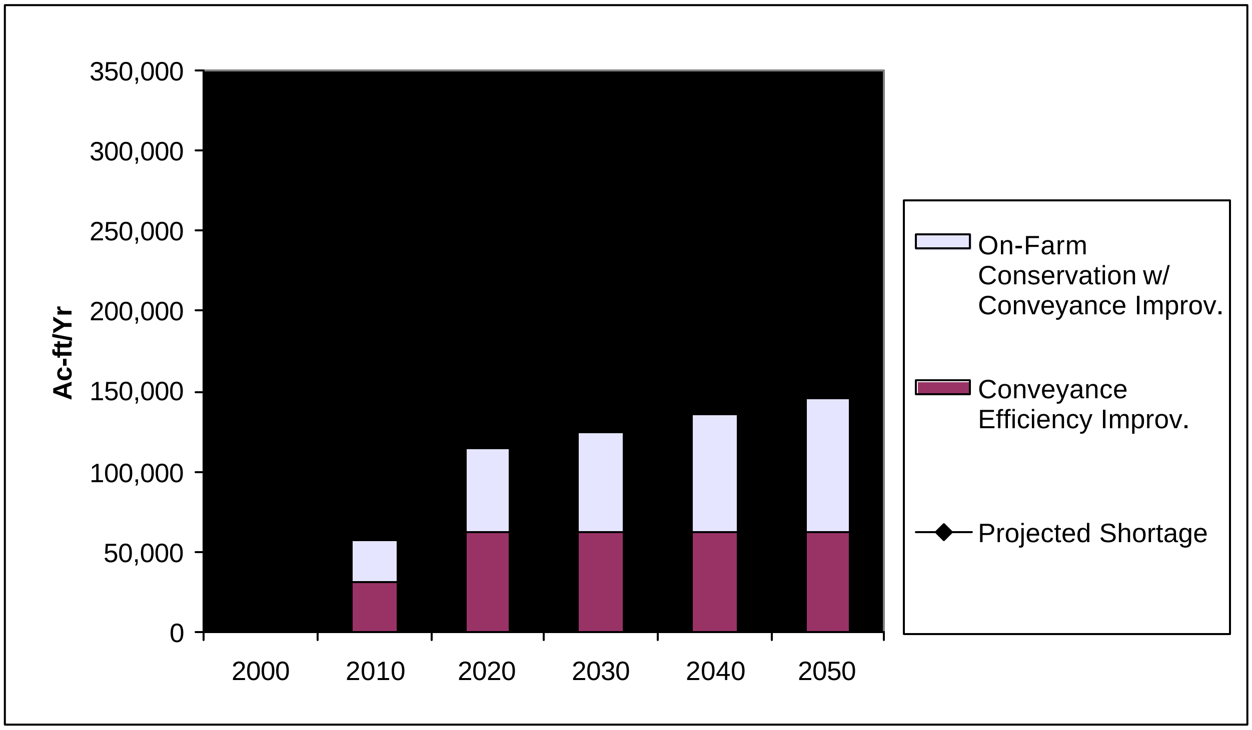


Figure 5.9 depicts projected irrigation shortages in Hidalgo County and the recommended strategies for meeting a portion of those needs. As indicated, agricultural water conservation measures are recommended that will reduce projected shortages by 124,714 acre-feet per year in 2030 and by 145,973 acre-feet per year (47 percent) in 2050. Additionally, the re-evaluation of irrigation supply availability, in light of reduced DMI needs for additional Rio Grande supplies, will reduce the projected irrigation deficit by 10,972 acre-feet per year (4.6 percent) in 2030 and by 17,830 acre-feet per year (5.7 percent in 2050). The remaining supply deficit represents a need for which there are no feasible water management strategies. However, this unmet need could be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that would further increase irrigation water supply availability.

Figure 5.9: Recommended Strategies for Partially Meeting Hidalgo Co. Irrigation Needs



5.5.3 Jim Hogg County

There are no projected water shortages in Jim Hogg County over the 50-year planning period.

5.5.4 Maverick County

There are projected water shortages in Maverick County for municipal WUGs and for the county-level irrigation WUG. The water demand projections adopted in this plan for the City of Eagle Pass indicates only minor shortages developing by 2050. The projections also indicate current shortages of 523 acre-feet per year for the Rio Grande Basin portion of the county-other WUG, increasing to 1,073 acre-feet per year and 1,822 acre-feet per year by 2030 and 2050, respectively. However, as discussed in both Chapter 2 and Chapter 4, information recently provided by the City of Eagle Pass indicates that they will likely become a regional water supplier and will assume responsibility for supplying the Rio Grande Basin portion of the county-other WUG. Also, a preliminary analysis of projected demands provided by Eagle Pass for their future regional service area indicates that the system will experience shortages of 1,493 acre-feet per year by 2010, increasing to 4,122 acre-feet per year in 2030 and 7,325 acre-feet per year in 2050. Recommendations are therefore included in this plan for meeting the water needs indicated by the "alternative" water supply/demand scenario for the City of Eagle Pass as a future regional water supplier.

It should be noted that at the July 28, 2000 RWPG meeting, the Rio Grande RWPG adopted the "alternative" supply/demand scenario for the Eagle Pass "regional system." The Rio Grande RWPG is not proposing, at this time, to amend the "official" demand projections; the revised demand projections will be evaluated in the next planning cycle or may be reflected in a future amendment of the regional water plan.

The recommended strategies for meeting municipal water needs in Maverick County as indicated by the official demand projections are displayed graphically in Figure 5.10. The City of Eagle Pass has indicated that its preferred strategy for meeting their remaining water needs, after considering conservation and reuse, will be to acquire additional Rio Grande water supplies. In addition, the city is actively evaluating groundwater supply options that could provide as much as 11,200 acre-feet per year. The City is also considering options for reuse of up to 1,680 acre-feet per year for non-potable purposes.

Figure 5.10: Recommended Strategies for Meeting Maverick Co. Municipal Water Needs

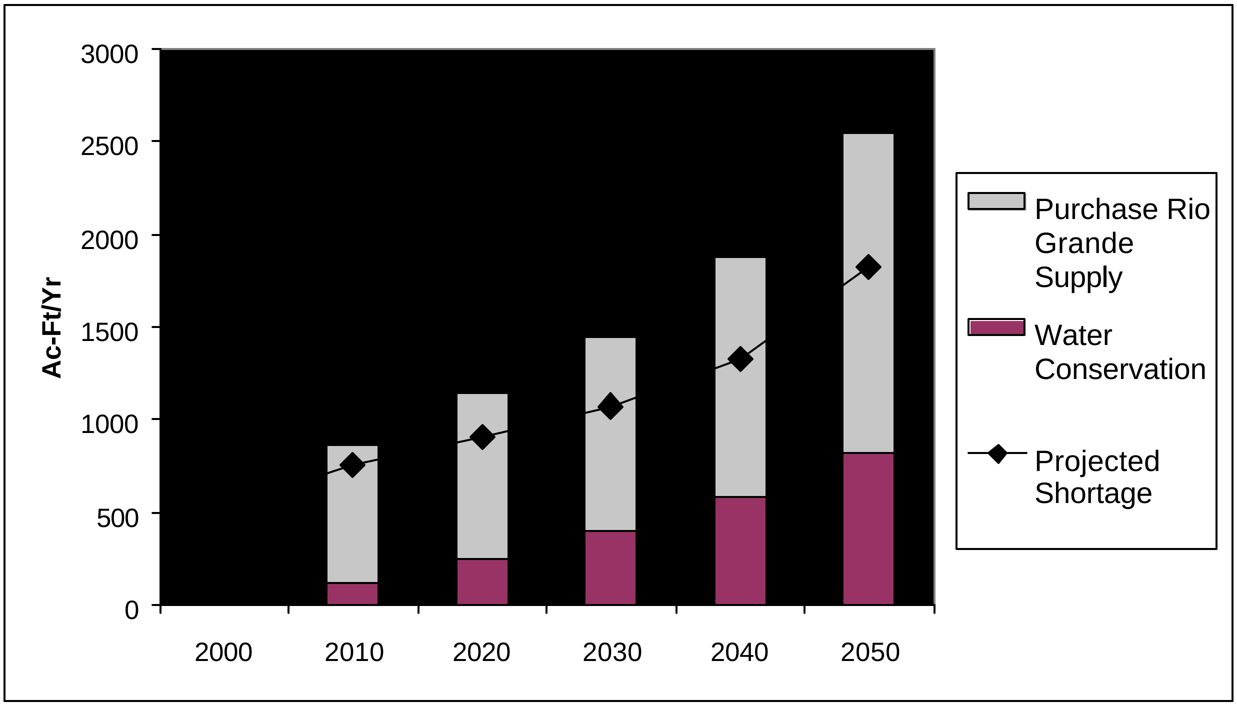
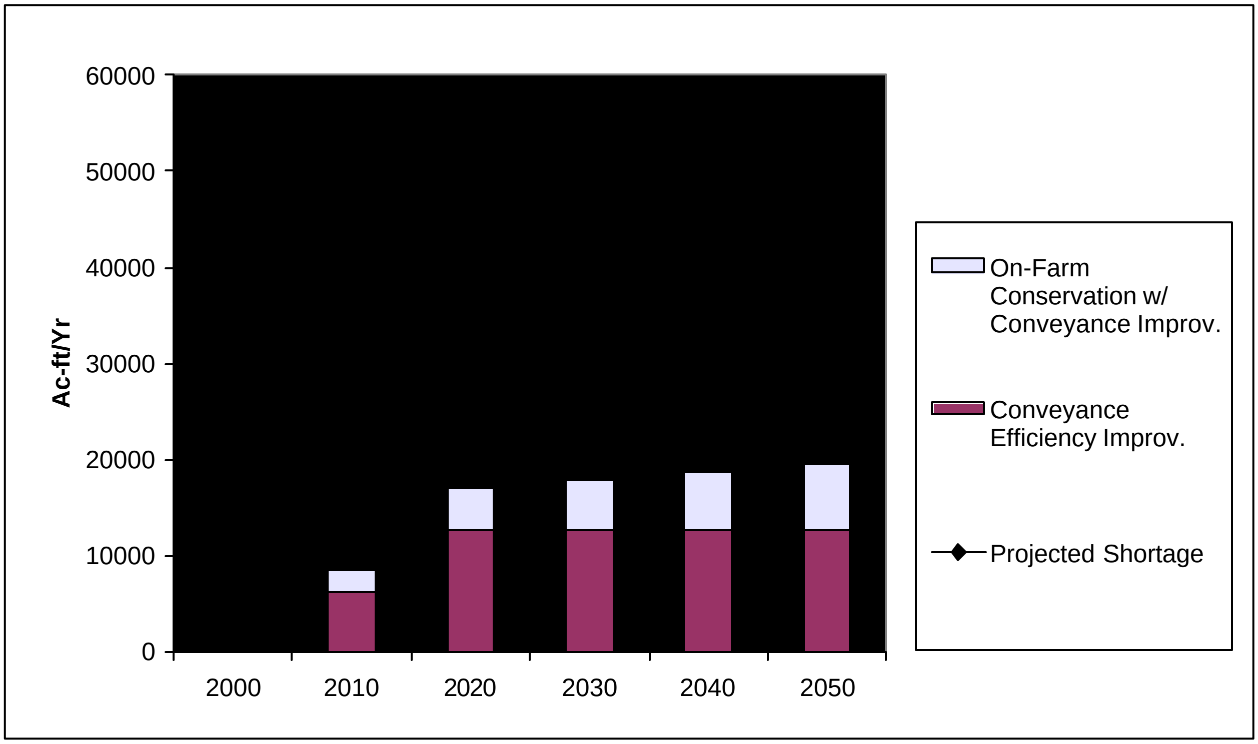


Figure 5.11 depicts projected irrigation shortages in Maverick County and the recommended strategies for meeting a portion of those needs. As indicated, agricultural water conservation measures are recommended that will reduce projected shortages by 17,877 acre-feet per year (42 percent) in 2030 and by 19,634 acre-feet per year (35 percent) in 2050. Additionally, the re-evaluation of irrigation supply availability, in light of reduced DMI needs for additional Rio Grande supplies, will reduce the projected irrigation deficit by 2,042 acre-feet per year (4.7 percent) in 2030 and by 3,319 acre-feet per year (5.8 percent in 2050).

The remaining supply deficit represents a need for which there are no feasible water management strategies. However, this unmet need could be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that would further increase irrigation water supply availability.

Figure 5.11: Recommended Strategies for Partially Meeting Maverick Co. Irrigation Needs



5.5.5 Starr County

As described in Chapter 4, there are projected water shortages in Starr County for the municipal WUGs and for the county-level irrigation WUG. At present, three of the four municipal WUGs in Starr County show supply deficits totaling 2144 acre-feet per year. By 2030, all of the municipal WUGs in the county have projected shortages totaling 11,377 acre-feet per year, increasing to 16,716 acre-feet per year in 2050. The county-level irrigation WUG for Starr County shows a current shortage of 14,434 acre-feet per year under drought of record conditions. The irrigation deficit is projected to decrease slightly to 11,996 acre-feet per year in 2030 due to reductions in irrigated acreage and then increase to 16,732 acre-feet per year in 2050 due to reduced irrigation supply availability. There are no projected shortages in Starr County for the manufacturing, steam electric, mining, or livestock WUGs.

The recommended strategies for meeting municipal water needs in Starr County are displayed graphically in Figure 5.12.

Figure 5.12: Recommended Strategies for Meeting Starr Co. Municipal Water Needs

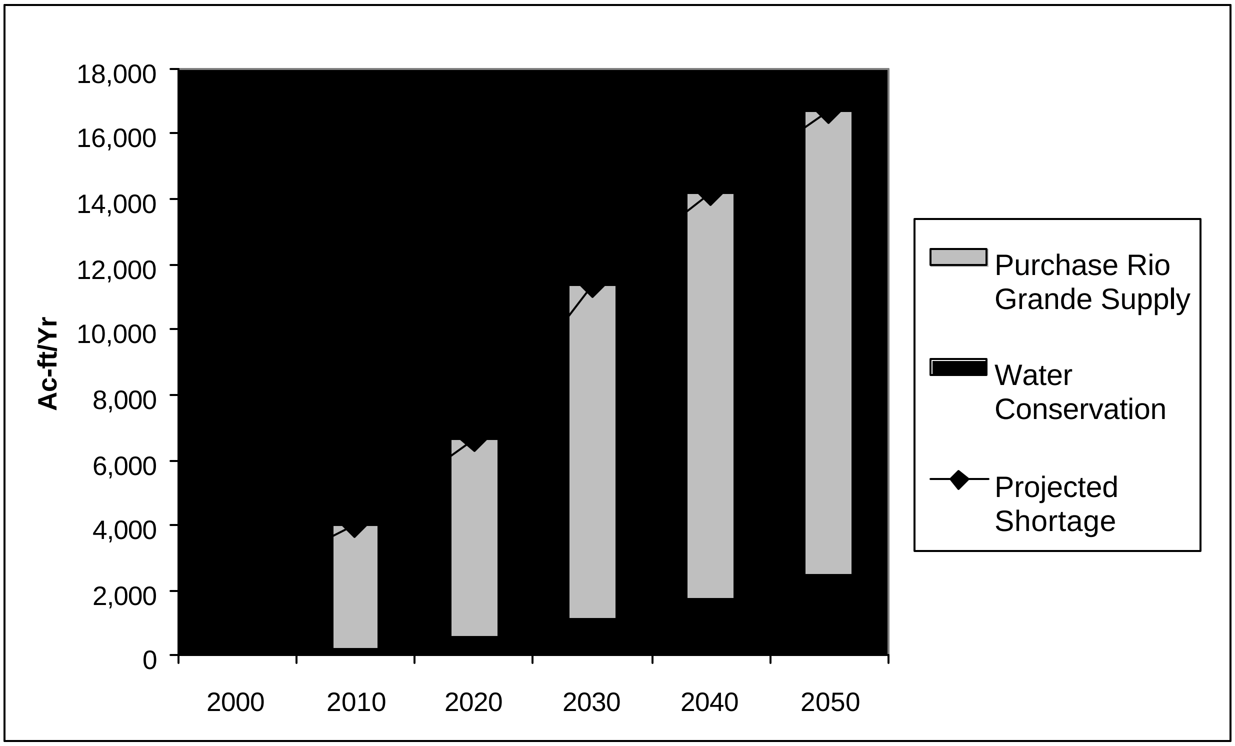
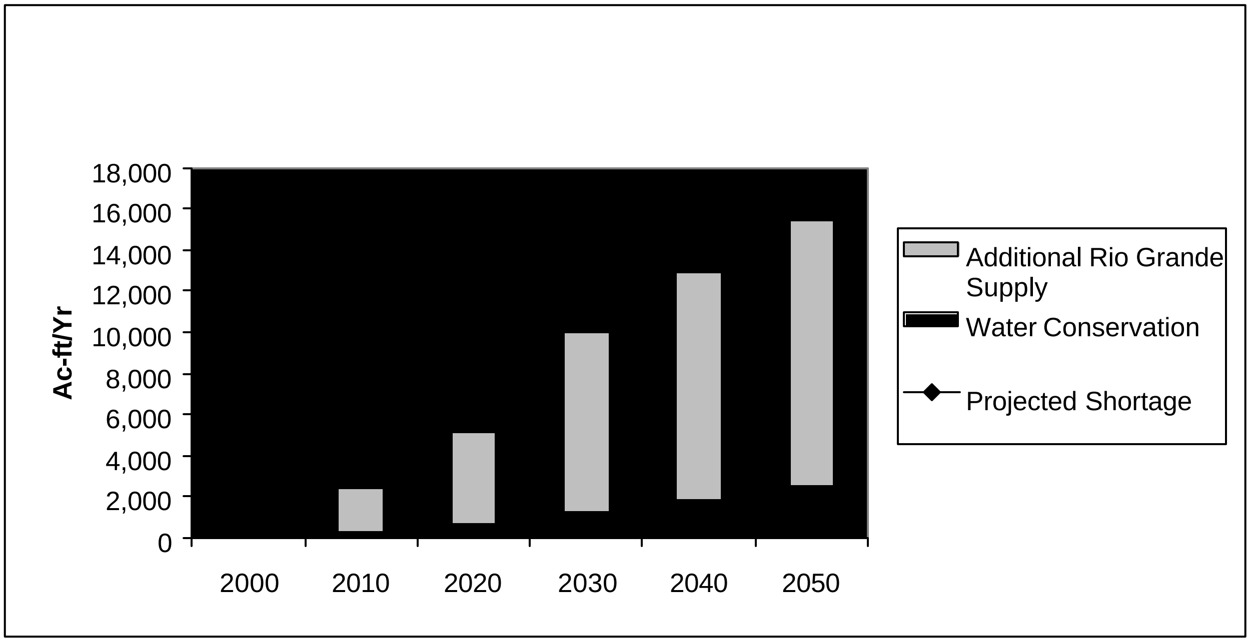


Figure 5.13 depicts projected irrigation shortages in Starr County and the recommended strategies for meeting a portion of those needs. As indicated, 910 acre-feet per year (8 percent) is recommended to come from agricultural water conservation measures in 2030 and 1,213 acre-feet per year (8 percent) in 2050. Additionally, the re-evaluation of irrigation supply availability, in light of reduced DMI needs for additional Rio Grande supplies, will reduce the projected irrigation deficit by 701 acre-feet per year (5.8 percent) in 2030 and by 1,140 acre-feet per year (6.8 percent in 2050).

The remaining supply deficit represents a need for which there are no feasible water management strategies. However, this unmet need could be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that would further increase irrigation water supply availability.

Figure 5.13: Recommended Strategies for Partially Meeting Starr Co. Irrigation Needs



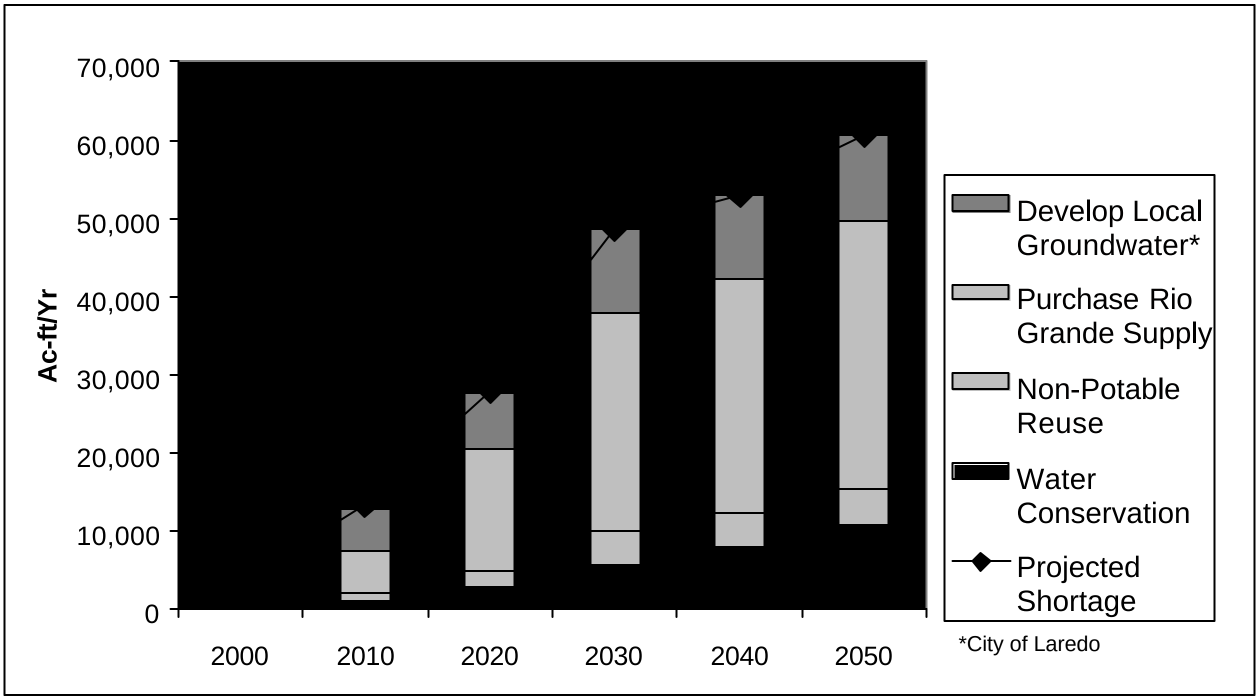
5.5.6 Webb County

There are projected water shortages in Webb County for the municipal WUGs and for the county-level manufacturing, steam electric, and irrigation WUGs. At present, the Rio Grande Basin portion of the county-other municipal WUG shows a shortage of 3,448 acre-feet per year. By 2030, the City of Laredo and the Rio Grande Basin portion of the county-other WUG are projected to have shortages totaling 48,765 acre-feet year. By 2050, the combined deficit for these WUGs is projected to increase to 60,654 acre-feet per year. The Rio Grande Basin portion of the county-level manufacturing WUG in Webb County is projected to experience a supply shortage of 17 acre-feet per year in 2050. The county-level steam electric WUG is projected to have a shortage of 1,705 acre-feet per year in 2010, increasing to 3,605 acre-feet per year in 2030 and continuing through 2050. There are no projected shortages for the county-level irrigation, mining, and livestock WUGs Webb County.

The recommended strategies for meeting municipal water needs in Webb County are displayed graphically in Figure 5.14.

The City of Laredo has been actively investigating groundwater supply options. At this time, the City has selected groundwater development as a recommended strategy to meet its DMI water demands. The City has estimated available supply from groundwater to be approximately 11,000 acre-feet per year.

Figure 5.14: Recommended Strategies for Meeting Webb Co. Municipal Water Needs



It is recommended that the relatively small manufacturing water needs that are projected to develop in Webb County by 2030 should be met by the City of Laredo. A combination of reuse of reclaimed water, groundwater, and acquisition of additional Rio Grande water are the recommended strategies for meeting the projected water supply needs (3,605 acre-feet per year in 2030 and thereafter) for the steam electric WUG in Webb County.

5.5.7 Willacy County

There are projected water shortages at present for two of the five municipal WUGs in Willacy County and for the county-level irrigation WUG. Municipal shortages totaling 118 acre-feet per year and 105 acre-feet per year are projected in 2030 and 2050, respectively. Under drought-of-record conditions, the county-level irrigation WUG for Willacy County has current deficits of 24,245 acre-feet per year, which are projected to increase to 25,598 acre-feet per year in 2030 and 33,360 acre-feet per year in 2050. There are no projected shortages for the manufacturing, steam electric, mining, or livestock WUGs in Willacy County.

The recommended strategies for meeting municipal water needs in Willacy County are displayed graphically in Figure 5.15. It should be noted however that recent studies sponsored by TWDB indicate that there may be significant groundwater supplies in portions of Willacy County that could be developed, with advanced treatment, to provide an alternative source of municipal water supply. It is recommended that the feasibility of developing a regional groundwater supply system to supply municipal water needs in Willacy County be fully explored. Additionally, if a significant supply of brackish groundwater is discovered, desalination of the brackish groundwater should be considered as a recommended water supply strategy. Because this option still requires more study, however, it is not included in Figure 5.15 with the other recommended strategies for Willacy County. Conceivably, such a system could be financed largely through the sale of DMI water rights to other DMI water users in the region.

Figure 5.15: Recommended Strategies for Meeting Willacy Co. Municipal Water Needs

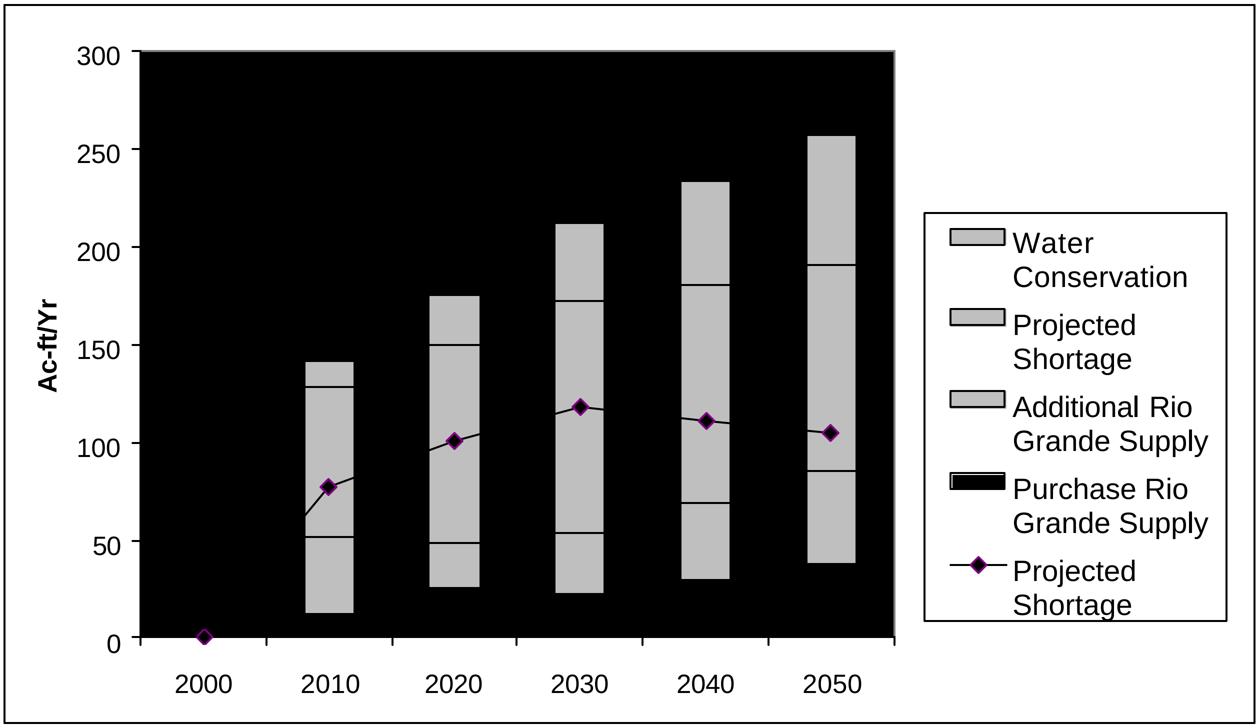
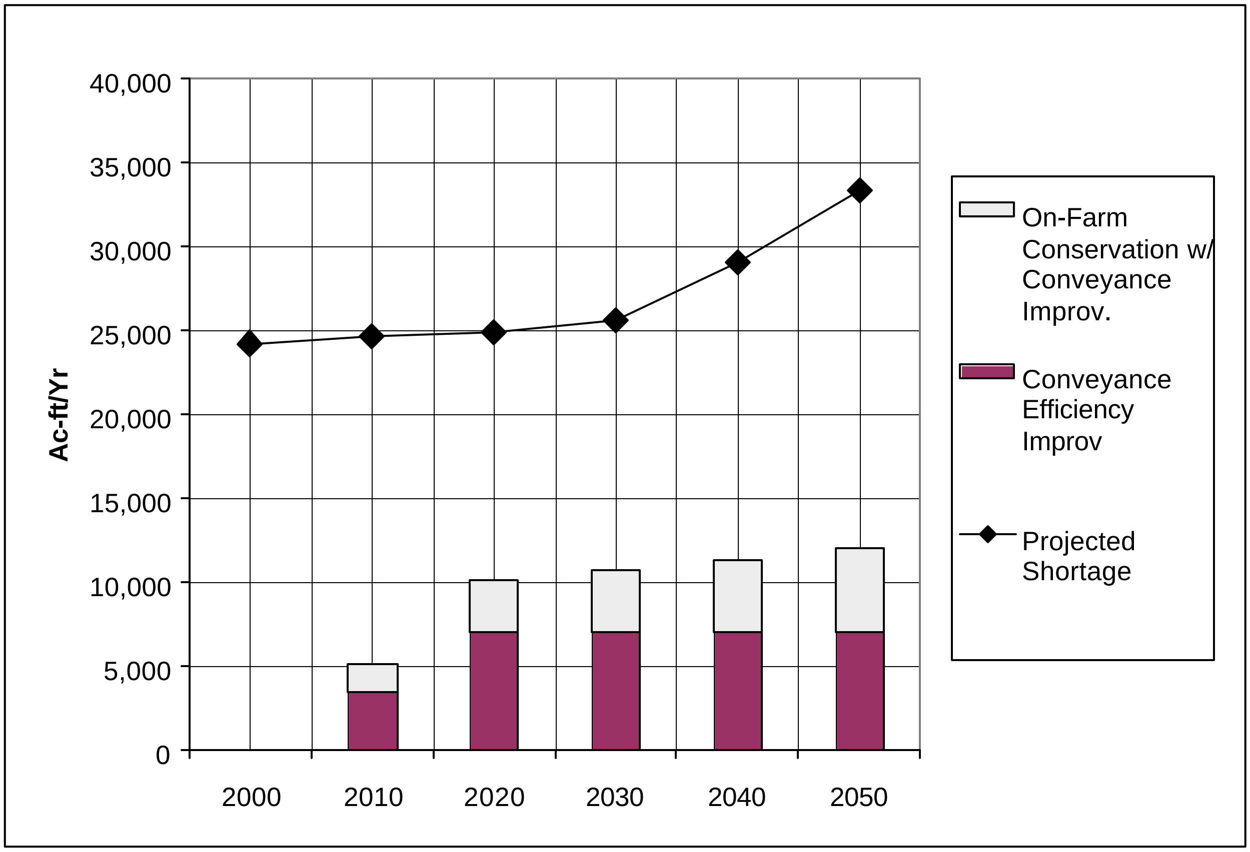


Figure 5.16 depicts projected irrigation shortages in Willacy County and the recommended strategies for meeting a portion of those needs. As indicated, 10,744 acre-feet per year (42 percent) is recommended to come from agricultural water conservation measures in 2030 and 12,002 acre-feet per year (36 percent) in 2050. Additionally, the re-evaluation of irrigation supply availability in light of reduced DMI needs for additional Rio Grande supplies, will reduce the projected irrigation deficit by 1,157 acre-feet per year (4.5 percent) in 2030 and by 1,881 acre-feet per year (5.6 percent in 2050). The remaining supply deficit represents a need for which there are no feasible water management strategies. However, this unmet need could be further reduced if consensus is reached on modifications to TNRCC rules regarding the operating and DMI reserves that would further increase irrigation water supply availability.

Figure 5.16: Recommended Strategies for Partially Meeting Willacy Co. Irrigation Needs

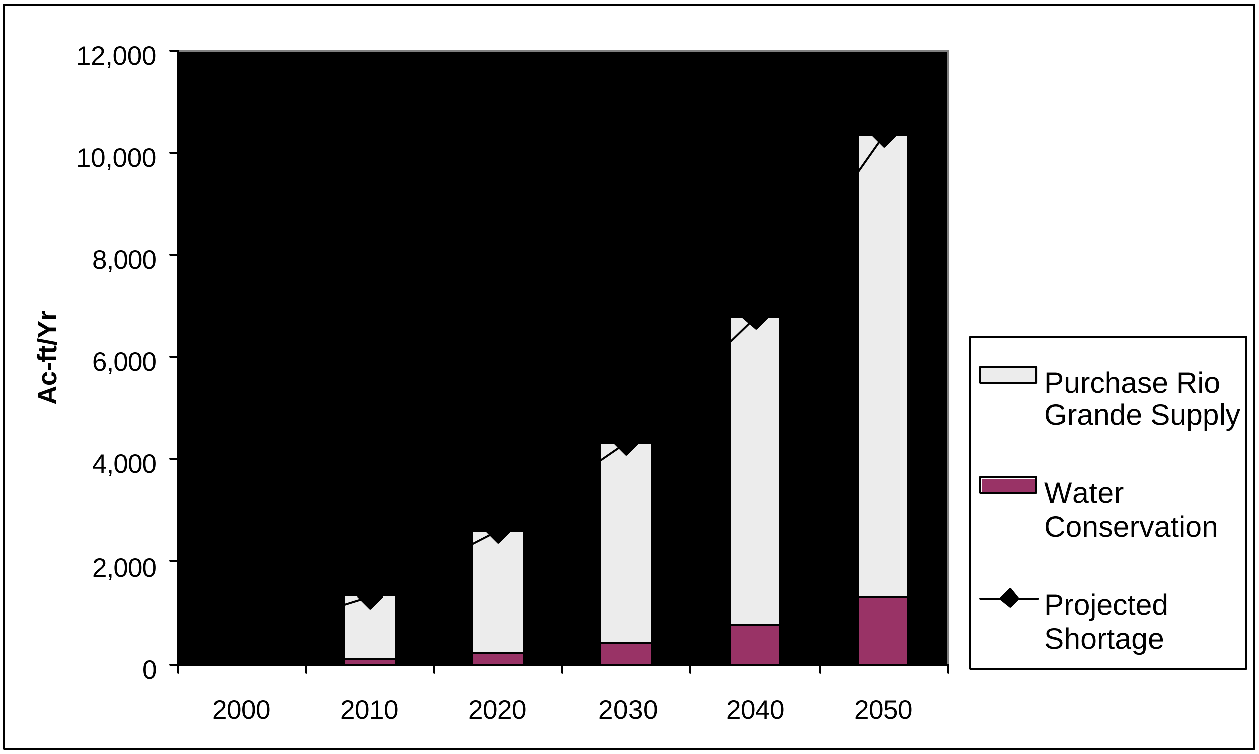


5.5.8 Zapata County

The City of Zapata shows a current water supply shortage of 523 acre-feet per year. By 2030, both the City of Zapata and the county-other municipal WUG show projected shortages totaling 4,333 acre-feet per year, increasing to 10,356 acre-feet per year in 2050. There is a relatively small (79 acre-feet per year) shortage for the county-level irrigation WUG in 2050. No shortages are projected for the manufacturing, stream electric, mining, or livestock WUGs.

The recommended strategies for meeting municipal water needs in Zapata County are displayed graphically in Figure 5.17.

Figure 5.17: Recommended Strategies for Meeting Zapata Co. Municipal Water Needs



There are no recommended strategies for meeting the projected irrigation shortage of 79 acre-feet per year in 2050.

5.6 STRATEGIES FOR MEETING DOMESTIC, MUNICIPAL, AND INDUSTRIAL WATER NEEDS

Opportunities for the development of additional water supplies for municipal use are limited in the Rio Grande Region, both because of the hydrologic characteristics of the region and by economics. As previously noted, there are few opportunities to increase the water supply yield of the Rio Grande. However, a number of strategies for augmenting municipal water supplies have been examined as part of this planning effort. These include advanced municipal water conservation and reuse of reclaimed water; strategies for optimizing surface water supply from the Rio Grande; groundwater development; and acquisition of additional Rio Grande supplies for domestic-municipal-industrial (DMI) uses. The evaluations of these strategies are presented in the sections that follow. More detailed back-up information is provided in Appendix 5.1 and in technical appendices to this plan (Volume II).

5.6.1 Advanced Water Conservation

The approved water demand projections for municipal water users in the Rio Grande Region includes significant reductions in future per capita water demand. Described as the “expected case” by the TWDB, the water conservation measures imbedded in the approved municipal water demand projections for the Rio Grande Region include:

- Compliance with current state and federal plumbing fixture efficiency standards for new construction and fixture replacement;
- Continued implementation of water conservation educational programs;
- Continued implementation of state requirements to develop water conservation programs; and,
- Current and expected future levels of effort in the areas of water distribution system leak detection and repair, commercial water conservation, and trends in home appliance water use efficiency.

5.6.1.1 Strategy Description

An “advanced” water conservation scenario has also been evaluated for municipal water users in the Rio Grande Region. This scenario, which was developed by the TWDB for the 1997 State Water Plan, includes implementation of all of the measures included in the expected case plus implementation of additional measures by local entities including:

- Accelerated replacement of older, less efficient plumbing fixtures through consumer incentive programs (e.g., rebates for toilet replacement, free low-flow shower heads);
- Implementation of landscape irrigation ordinances to require use of low-water use landscaping and efficient irrigation technology;
- Intensified programs to promote water conservation in institutional and commercial establishments;
- Intensified programs to control distribution system water losses; and,
- Implementation of conservation-oriented water rate structures (e.g., increasing block rates, season rates, excess use rates).

In addition, the advanced water conservation scenario would also involve additional action by the State of Texas, including mandatory implementation of water conservation programs by all municipal water users; a statewide water conservation education program with funding similar to that provided for the “Don’t

Mess with Texas" highway litter educational program; and requirements for labeling of clothes washers and dishwaters with consumer-oriented water use and conservation information.

5.6.1.2 Water Supply Yield

The goal and effect of implementing additional or advanced municipal water conservation measures is to reduce projected municipal water demands and thereby reduce future needs for additional supply. In a real sense, water demand management through properly designed and funded water conservation programs can be viewed as providing an additional source of water supply equivalent to new supply development and other supply acquisition strategies. An acre-foot less demand is an acre-foot less water supply required.

Estimates of the amount future municipal water demands that could be met by additional or advanced water conservation measures were developed using methods developed by the TWDB. However, the Rio Grande RWPG elected to take a simpler approach whereby the projected water demands of all municipal water with projected water shortages would be reduced by two (2.0) percent per decade over the 50-year planning period. The result is a yield from advanced water conservation measures of 10 percent of the projected 2050 water demand of each municipal WUG with a projected shortage. For the region as a whole, the estimated water savings by decade are shown in Table 5.4.

Table 5.4: Regional Estimates of Water Supply from Implementation of Advanced Municipal Water Conservation Measures (ac-ft/yr)

2000	2010	2020	2030	2040	2050
0	3,297	7,786	15,107	20,709	30,207

As a percentage of projected municipal water supply needs, the municipal water conservation scenario adopted by the Rio Grande RWPG would provide nearly 12 percent of the projected need in 2030 and approximately 14 percent of the projected need in 2050.

5.6.1.3 Cost

Water conservation is not free. To achieve the estimated water savings associated with the advanced municipal water conservation scenario, a significant commitment of funding and other resources to implement the measures will be required. Cost elements of a program to achieve the estimated savings include funding for rebates and other incentives, funding for educational and public awareness activities, and staff to manage and implement the various programs (e.g., plumbing fixture rebates, residential and commercial water audits, enforcement of landscape irrigation standards, leak detection and repair, etc.). It is important to note that the investment in municipal water conservation requires substantial front-end funding at the outset and for the duration of the planning period. Because the effects of conservation are incremental and build over time, the initial costs on a unit basis are relatively high at the outset and then decline significantly over time. Cost estimates are summarized below in Table 5.5.

Table 5.5: Cost Estimates for Advanced Municipal Water Conservation Programs

	2000	2010	2020	2030	2040	2050
Total Annual Costs ($1,000s)	$0	$5,008	$3,527	$3,758	$3,023	$2,775
Unit Costs ($/ac-ft/yr)	$0	$1,112	$334	$195	$145	$123

It is worth noting that in addition to reducing future water demands and the need to acquire additional water supplies, municipal water conservation programs also offer other potential benefits. For example, exterior water conservation programs (e.g., low-water use landscaping) can be targeted at reducing seasonal peak demands allowing for more optimal utilization of existing water treatment capacity or a delay in capacity expansion. Interior water conservation programs (e.g., rebates for plumbing fixture replacement) reduce demands for potable water and reduce wastewater flow volumes. Also, water conservation can reduce energy costs for pumping and heating water.

5.6.1.4 Environmental Impact

There are no significant direct or indirect environmental impacts associated with the implementation of municipal water conservation programs.

5.6.1.5 Implementation Issues

As indicated, region-wide implementation of advanced municipal water conservation measures will require a commitment of funding and other resources by nearly all public water suppliers in the Rio Grande Region. In addition to funding, many public water suppliers in the region, particularly small systems, lack the staff resources to devote to the development and implementation of water conservation programs. Perhaps the most fundamental problem with implementation of this strategy is the number of small water systems with a large number of small diameter lines that prevent the opportunity to cost effectively save water. This could be addressed through the development of regional approaches to implementation of conservation measures including regionalization of the water transmission and distribution network. For example, larger municipal water suppliers might allow smaller neighboring suppliers to participate in the implementation of certain programs (e.g., rebates for plumbing fixture replacement). Alternatively, if a regional water agency were established, it might assume responsibility for re-development of the water network infrastructure.

5.6.1.6 Recommendations

The Rio Grande RWPG recommends region-wide implementation of municipal water conservation programs that incorporate the elements of the advanced water conservation scenario. As described above, it is recommended that all municipal water users with projected shortages implement water conservation programs that will reduce projected water demands by one to two percent per decade above and beyond the conservation already built in to the demand projections, for a maximum of 10 percent total reduction by 2050.

5.6.2 Non-Potable Water Reuse

As a water management strategy, direct reuse of reclaimed water (i.e., appropriately treated municipal wastewater effluent) provides a water supply benefit when reclaimed water is used as a substitute or as supplemental water source. Direct reuse is defined as the application of wastewater effluent directly from the waste treatment plant to the point of use without co-mingling with state waters. Common examples of direct non-potable reuse for municipal purposes include irrigation of parks, golf courses, and other green space. In addition, there are potential opportunities for non-potable reuse of reclaimed water for existing and projected manufacturing and stream electric demands.

5.6.2.1 Strategy Description

At present, approximately 13,000 acre-feet per year of water supply is provided from non-potable reuse of reclaimed water within the Rio Grande. Current uses are for steam electric power generation (73 percent), manufacturing (17 percent), and irrigation of landscaped areas (10 percent). As a potential strategy for meeting future DMI water needs within the region, reuse of reclaimed water would be expanded beyond current levels for these and other suitable applications (e.g., uses that do not require potable quality water). In general terms, implementation of this strategy requires consideration of several factors including:

- The location of wastewater treatment facilities relative to the locations of potential users of reclaimed water;
- The level of treatment and quality of the reclaimed water;
- The water quality requirements of particular users;
- Regulatory considerations; and,
- Public acceptance.

These and other factors determine whether reuse of reclaimed water is economically feasible for specific uses. For example, the distance one has to convey reclaimed water from the source (i.e., a wastewater treatment plant) to a user (e.g., a golf course or power plant) a significant cost factor and determinant of feasibility. Similarly, the water quality requirements of potential users may mean that additional treatment would be necessary. Also, state regulatory requirements for non-potable reuse of reclaimed water place constraints on both the types of uses considered acceptable and the manner in which reclaimed water is managed and used. Public acceptance of water reuse is also an important factor. Perceptions, or misperceptions, about the public health or environmental risks of non-potable reuse can make or break a water reclamation project.

For this planning effort, two previous studies of the potential for and feasibility of non-potable reuse in the Rio Grande Region were reviewed. A 1993 study examined the potential for non-potable reuse in the Brownsville area. Specifically, potential users of reclaimed water were identified within a three-mile radius of the Brownsville Public Utilities Board's Robindale Wastewater Treatment Plant and the costs of constructing a six-inch transmission line to deliver reclaimed water to those users was evaluated and compared to current costs for potable water supply. Another study was performed for the McAllen-Edinburg area in 1977. In addition to examining the feasibility of indirect reuse of reclaimed water for potable uses, the study also examined non-potable reuse. Most of the non-agricultural water users in this area were institutional or residential and it was determined that their non-potable uses were not of sufficient volume to justify the costs associated with development of a separate reclaimed water distribution system. Consequently, this study focused more on the potential to supply reclaimed water to irrigate agricultural land (see discussion in Section 5.9.3).

5.6.2.2 Water Supply Yield

Theoretically, it is technically feasible to beneficially reuse all of the reclaimed water produced from municipal wastewater treatment plants for non-potable municipal and industrial uses. Achieving very high levels of water reuse requires the development of costly "dual water systems" capable of delivering water on demand to both large and small users over a large area. While extensive dual water systems have been developed in a handful of communities in California and Florida, generally the costs of such systems are prohibitive, particularly in already developed communities. In most settings, cost considerations limit reclaimed water distribution systems to delivery of relatively large volumes of reclaimed water to a relatively small number of large non-potable water users. As such, the realistically achievable reuse potential within a typical municipal water utility service area is generally less than 10 percent of total water demand.

For this planning effort, a reconnaissance-level evaluation of the potential for direct non-potable reuse of reclaimed water was performed. This involved making certain planning assumptions about the potential for reuse within each area served by central wastewater collection and treatment systems. Specifically, it was assumed that opportunities for non-potable reuse would generally only exist in the larger urban areas where the total wastewater treatment capacity was greater than or equal to five (5.0) million gallons per day (mgd). Experience suggests that reuse potential is limited in smaller communities due to the lack of relatively large non-potable water users in proximity to treatment facilities. In rural areas that lack central wastewater collection and treatment systems, reuse potential is virtually non-existent except at a small-scale through individual on-site systems or neighborhood scale cluster systems.

For this analysis, it was assumed that aggressive reuse programs in the larger urban areas could supply five (5.0) percent of each entity's projected 2010 water demand, increasing to 15 percent in 2020 and 25 percent by 2030 and beyond. It was also assumed that a portion of future water needs associated with steam electric power generation would be supplied by reclaimed water. Based on these assumptions, the estimated amount of supply from non-potable reuse of reclaimed water is shown below in Table 5.6. It should be emphasized, however, that more detailed investigations are required at the individual Water User Group level to accurately assess the achievable reuse potential within the region.

Table 5.6: Estimated Potential for Expanded Reuse of Reclaimed Water in the Rio Grande Region (ac-ft/yr)

Use Category	2000	2010	2020	2030	2040	2050
Municipal	0	10,153	19,921	32,828	37,738	43,290
Steam Electric	0	953	1,053	6,403	6,403	6,403
Total	**0**	**11,106**	**20,974**	**39,231**	**44,141**	**49,693**

5.6.2.3 Cost

It was beyond the scope of the regional planning process to evaluate the water reuse potential and develop cost estimates for each of the municipal entities included in the estimates of reuse potential. However, cost estimates developed for previous studies of non-potable reuse in the Rio Grande Region are considered representative. These costs were updated to account for inflation. Based on the Brownsville reuse study, which assumed delivery of reclaimed water without additional treatment required, the estimated cost of non-potable reuse is $360 per acre-feet per year. Applied to the estimated yields from non-potable reuse for municipal and steam electric user groups, total annual costs for would be approximately $21.6 million in 2030, increasing to $25.7 million in 2050.

5.6.2.4 Environmental Impact

There are potential environmental impacts associated with non-potable reuse of reclaimed water. One concern is the potential for reclaimed water to become a non-point source of water pollution. This could occur if the reclaimed water contains contaminants (e.g., nutrients, trace metals, etc.) and were allowed to runoff of application sites to surface or groundwater bodies. Current State regulations for non-potable reuse address these concerns to a degree. Also, extensive use of reclaimed water would decrease wastewater return flows, which could impact instream flows and water quality in stream reaches that have historically received wastewater return flows.

5.6.2.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. It should be noted that the widespread implementation of reuse programs would require detailed utility and site-specific assessments to identify feasible reuse applications. Generally, direct non-potable reuse is economically feasible where there are central wastewater collection and treatment systems and where there are large demands for non-potable water within relatively close proximity to the supply source (i.e., a wastewater treatment plant). However, some potential does exist in rural areas through the direct reuse of household gray water and through non-potable reuse in proximity to small "cluster" wastewater systems and other types of alternative wastewater management systems. Consequently, there may be reuse potential for some Water User Groups in the Rio Grande Region that were excluded from the analysis summarized above. Similarly, some municipal water users included in the analysis may exceed goals for reuse while others may fall short. In any case, it is recommended that all municipal water suppliers with central wastewater collection and treatment systems undertake an assessment to identify and develop cost-effective reuse opportunities. This should include evaluation of opportunities to use reclaimed water as a substitute supply for municipal, manufacturing, steam electric, and agricultural uses.

The largest potential impact on cultural resources associated with this option comes from pipeline construction and operation. Therefore, pipelines should follow existing and shared right-of-ways whenever possible to minimize the area of disturbance.

5.6.2.6 Recommendations

For meeting projected DMI needs, the Rio Grande RWPG recommended the following as a water management strategy:

Direct non-potable reuse of reclaimed water; non-potable water reuse will be considered as a water management strategy only for those cities with a potential to have a total of at least 5 mgd wastewater treatment plant capacity. This criteria was applied to cities with projected population exceeding 50,000 by year 2030, assuming 100 gpd of wastewater generated per person. For the cities that met the above criteria, the following reduction in water demand per decade was assumed: 5 percent in 2010, 15 percent in 2020, and 25 percent in 2030, 2040 and 2050 (This strategy was recommended by the Rio Grande RWPG at the planning group meeting on July 28, 2000). A few cities provided revised estimates of the yield from reuse.

It is further recommended that the non-potable use of reclaimed water be adopted as a strategy for meeting a portion of projected municipal water needs, as well as a portion of the projected steam electric power generation needs. It is also recommended that funding be provided by TWDB and from other sources for the purpose of conducting a more thorough assessment of non-potable reuse opportunities within the municipal, manufacturing, and steam electric water use categories. This assessment should be completed on a schedule that will allow the results to be incorporated into a future update of this regional water plan.

5.6.3 Potable Reuse

5.6.3.1 Strategy Description

Potable reuse of reclaimed water refers to the intentional reuse of highly treated wastewater effluent as a supplemental source of water supply for potable uses. Conceptually, potable reuse can involve the direct "flange-to-flange" introduction of reclaimed water into a potable water distribution system or the indirect introduction of reclaimed water through commingling with raw water supplies. While it is technically feasible to produce potable quality water from municipal wastewater effluent, direct potable reuse has not gained either regulatory or public acceptance. By contrast, indirect potable reuse is currently practiced elsewhere in Texas where surface water supplies are deliberately augmented with wastewater effluent or reclaimed water.

For this planning effort, a 1977 study that investigated the feasibility of indirect potable reuse in the McAllen-Edinburg area was reviewed. Based on the results of the pilot study, a potable reuse option was evaluated that would involve modification of existing wastewater treatment plants for biological nutrient removal, microfiltration, reverse osmosis, and ultraviolet disinfection. The reclaimed water would then be blended with raw water from the Rio Grande in a raw water storage reservoir from which the blended supply would be treated by existing water treatment plant processes, disinfected with ozone, and then sent to the potable water distribution system after adding a chlorine residual. To ore accurately assess the feasibility of potable reuse for the City of McAllen, a pilot study was performed as a separate project to assess the use of an integrated bioreactor and reverse osmosis treatment train to reclaim municipal wastewater for potable reuse. The results of the pilot study indicated that reverse osmosis filtration is capable of producing reclaimed water that meets all state and federal drinking water and reuse standards.

5.6.3.2 Water Supply Yield

Conceptually, the amount of water supply that could be provided through a strategy of indirect potable reuse of reclaimed water would be equal to the total amount of municipal wastewater discharges.

However, economic and regulatory constraints, as well as public perceptions of the potential health risks associated with potable reuse, would likely represent major impediments to widespread implementation of potable reuse. The option investigated the study cited above would produce 6.8 million gallons per day, or 7,617 acre-feet per year of reclaimed water to supplement the City of McAllen's water supply.

5.6.3.3 Cost

The costs estimates developed for the full-scale potable use system evaluated for the City of McAllen were reviewed and updated for this planning effort. In 1999 dollars, capital costs of the project would be approximately $17.6 million. The total annual cost, which includes debt service and operations and maintenance costs, are estimated to be $4.3 million per year. On an annualized basis, the unit cost of the additional water supply would be $564 per acre-foot per year. However, it should be noted that these estimates do not include the costs associated with conventional treatment of the blended raw/reclaimed water supply. Assuming no additional capital costs would be incurred, the variable costs of conventional water treatment (e.g., energy and chemicals) would add approximately $82 per acre-foot per year (based on $0.25/1,000 gallons) to the cost of the strategy.

5.6.3.4 Environmental Impact

The principal environmental issue pertaining to indirect potable reuse of reclaimed water is the potential public health risks in terms of transmission of pathogens and harmful contaminants to the drinking water supply. The pilot study conducted for the City of McAllen, as well as numerous other studies, have demonstrated that advanced treatment processes can reliably produce potable-quality water from municipal wastewater effluent. In addition, the blending of the reclaimed water with raw water, coupled with the detention time in storage before subsequent re-treatment and reuse, provides another level of assurance. Another important issue associated with the non-potable reuse strategy described above is the disposal of the brine concentrate from the desalination treatment processes. In the study cited, it was assumed that concentrate could be discharged to the Arroyo Colorado at existing permitted outfall locations using existing facilities. The concentrate could have localized impacts on water quality in the Arroyo Colorado. Lastly, extensive use of reclaimed water would decrease wastewater return flows, which could impact in-stream flows and water quality in stream reaches that have historically received wastewater return flows.

5.6.3.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. The key issue associated with the implementation of non-potable reuse of reclaimed water is public acceptance of the strategy. While opinion surveys indicate that the public is generally supportive of strategies that involve the use of reclaimed water for non-potable purposes, public acceptance of indirect potable reuse is questionable no matter what degree of public health safeguards are provided. Also, while indirect non-potable use has been implemented elsewhere in Texas, the practice involves blending relatively small quantities of reclaimed water with very large volumes of raw water in a large surface water reservoir. While the potable reuse option evaluated for McAllen would meet current state and federal drinking water standards, permitting of such a project could be in doubt, particularly if there is significant public opposition to such a project.

The largest potential impact on cultural resources associated with this option comes from pipeline construction and operation. Therefore, pipelines should follow existing and shared right-of-ways whenever possible to minimize the area of disturbance.

5.6.3.6 Recommendation

Direct or indirect use of reclaimed water for potable purposes is not recommended as a strategy for inclusion in this regional water plan. However, as previously indicated, non-potable use of reclaimed water is a strategy recommended for further study and implementation.

5.6.4 Acquisition of Additional Rio Grande Water (Conversion of Water Use)

5.6.4.1 Strategy Description

The Rio Grande is and will continue to be the principal water source for the Rio Grande Region. It is also widely held that the primary source of "new" water supply to meet increasing urban demands will be the conversion of irrigation rights to urban use. This strategy represents a continuation of a trend that began when water rights for the Lower Rio Grande Valley were adjudicated by the courts. To illustrate, in 1971, there were approximately 155,000 acre-feet of Rio Grande water rights held for DMI use. This 155,000 acre-feet of Rio Grande water rights for DMI use was the amount awarded in the Valley Water Suit Judgment. Additional amount of water was adjudicated in the middle Rio Grande in the Middle Rio Grande Adjudication case. Currently, there are approximately 240,000 acre-feet of DMI rights in the area below Falcon Reservoir and an additional 58,000 acre-feet of DMI water rights in the middle Rio Grande. This increase in the quantity of water rights held for DMI use is the result of the gradual, incremental conversion of irrigation and mining water rights to DMI use through voluntary, market-based transfers between willing buyers and willing sellers. This trend is expected to continue for the foreseeable future.

Because of the unique nature of the water rights system for the middle and lower Rio Grande, the Rio Grande Region enjoys one of the most active and robust water markets in the world. Because a water right is considered private property in Texas, it can be bought and sold or otherwise transferred subject to state administrative review and approval. In the middle and lower Rio Grande, such transfers have been common since the adjudication of water rights and, because of the nature of the water rights system for the Rio Grande, state administrative review is relatively simple and inexpensive.

Another common means of converting irrigation used rights to municipal urban use rights is the conversion of irrigation rights in conjunction with the "exclusion" of nonirrigable land or land that is urban in nature from a district boundaries. There are several state statues pertaining to the exclusion of urban land from a district boundaries. After the land is excluded from the district boundaries, there are other statutes which would allow the district to include other irrigable land that it can serve, but is not in the district boundaries into the district boundaries (exchange of land) and transfer the water service rights to such included land or the district may, through an arrangement with a municipal supplier (a city, municipal utility district, or water supply corporation), convert all or a portion of the water previously used to irrigate the excluded land to municipal use or the district may retain all or a portion of such water for irrigation use depending upon what is in the best interest of the district. One exclusion statute, § 49.314 of the Texas Water Code, provides that if land is excluded pursuant to this statute, a municipal supplier can petition an irrigation district to convert and reallocate the irrigation rights associated with land "excluded" to a nonirrigation use on terms agreeable to the parties. This is the process by which irrigation rights may be converted to municipal use, however, the specific terms of the water supply transfer is left to the parties agreement. In the past, some irrigation districts have converted some or all irrigation water rights associated with excluded lands to DMI and then supply the water to a city or a water supply corporation on a contractual or other basis. Usually, this involves the district diverting and delivering the water supply for the City or water supply corporation for a specified charge based on the quantity of water delivered or if delivered by another district, a specified charge for the water supply provided.

There are also examples of other types of contractual water sales. For example, the Brownsville Irrigation District has a contract with the Brownsville Public Utilities Board to provide 5,000 acre-feet of water per year at a cost of $45/acre-foot for a period of five years.

It is not possible to predict specifically when, where, and how future transfers of water from irrigation to DMI use will occur. As has been the case for the past 30 years, one can anticipate that there will be dozens transactions over the coming 50-years and that the terms of water rights sales and water sale contracts will vary from one transaction to another. Nonetheless, for planning purposes, the Rio Grande RWPG recommends that the balance of future municipal water needs, after considering conservation, reuse, and alternative sources as appropriate, be met through the acquisition of additional Rio Grande water supplies through two general approaches: acquisition of water made available as a result of the urbanization of irrigated lands and acquisition of water made available through investments in agricultural water conservation.

5.6.4.2 Water Supply Yield

A significant quantity of water can be expected to become available for DMI use as a consequence of further urbanization of irrigated lands in Cameron and Hidalgo counties. The approved water demand projections for the Rio Grande Region indicate a decrease in future irrigation demand of approximately 335,000 acre-feet per year solely as a consequence of reduced acreage levels due to urbanization. If fully converted to DMI use, this would represent a potential additional DMI supply of nearly 170,000 acre-feet per year. However, a portion of this irrigation water may need to be retained to reduce existing irrigation deficits depending upon site-specific factors. Also, as described later in this chapter, there are significant opportunities for reducing irrigation water demands through measures to improve water conveyance and distribution efficiency and measure to improve on-farm water use efficiency. To the extent that DMI users might help finance agricultural water conservation measures, additional irrigation rights might also become available for conversion to DMI use.

After considering the contributions to be made by advanced municipal water conservation programs, reuse, and other supply alternatives, the amount of additional Rio Grande supply that will be needed to meet the remaining municipal water needs is shown in Table 5.7. Assuming a two-to-one irrigation to DMI conversion factor, amounts both before and after conversion are shown. The "after conversion" amounts represent the remaining municipal water need after considering other recommended strategies.

Table 5.7: Additional Rio Grande Water Supply Required to Meet Municipal Water Needs in the Rio Grande Region (ac-ft/yr)

	2000	2010	2020	2030	2040	2050
Before Conversion	0	47,016	89,980	162,730	209,458	268,246
After Conversion	0	23,508	44,990	81,365	104,729	134,123

5.6.4.3 Cost

As indicated, it is not possible to predict when or who or how individual transactions will be structured by DMI users needing to acquire additional Rio Grande water supplies. It is also not possible to predict the cost of either future water rights purchases or the price of water provided to DMI users under contract. The specific terms of such transactions will be determined by the parties – willing buyers and willing sellers, which will also dictate the specific components required to implement this stragtegy. However, for this planning process it is necessary to provide cost estimates for acquisition of additional Rio Grande water supplies for DMI use. Using the purchase price for recent water transaction, anticipating a conversion from irrigation Class A rights to municipal rights and using certain assumptions regarding the treatment and distribution requirements, the estimated cost to provide treated water approximates $400 to $430 per acre feet. In the situation of annual contracts between DMI users and irrigation suppliers, the cost, based on current average transactions will approximate $300 to $330 per acre feet. Specific details of these and other potential pricing options are shown in Appendix 5.1.

5.6.4.4 Environmental Impact

There are little or no additional environmental impacts associated with the conversion of Rio Grande irrigation water rights to DMI use. Since the acquisition of additional Rio Grande water, either through purchase or through contract, involves changes in the type, location, or owner of water rights, TNRCC in general handles it as a routine administrative process and does not require a detailed evaluation for proposed amendments to Rio Grande water rights.

5.6.4.5 Implementation Issues

As indicated, acquisition of additional Rio Grande water supplies for DMI use can be accomplished either through outright purchase of water rights or through contractual arrangements between a water right holder and a DMI user. The process for amending Rio Grande water rights to change the ownership, type of use, or place of use requires approval by TNRCC. However, because water rights amendments generally do not affect instream flows or other water rights holders, approval of amendments is accomplished administratively by the TNRCC's executive director. A second issue is the lack of a standard methodology and contractual obligation for implementing the exclusion process. Although the process is defined by statute, the timeframes and terms under which the exclusion occurs varies considerably.

5.6.4.6 Recommendation

It is recommended that any remaining DMI water supply needs, after considering the effects of other recommended strategies for meeting DMI needs, be met through the acquisition of additional Rio Grande water supplies, either by purchase of water rights or through water supply contracts.

5.6.5 Development of Surface Water Supplies

While opportunities to develop additional surface water supplies are limited, several strategies were evaluated for increasing or otherwise optimizing the supply of water available from the Rio Grande. These include the proposed Brownsville weir and reservoir, reallocation of storage in the Amistad-Falcon Reservoir System, additional Rio Grande water supply reservoirs, additional conveyance of Rio Grande water supply via pipeline and/or via gravity canal, off-channel storage of excess flows, and capture and use of local runoff.

5.6.5.1 Brownsville Weir and Reservoir

5.6.5.1.1 Strategy Description

The Brownsville Weir and Reservoir Project is being proposed by the Brownsville Public Utilities Board (BPUB) as a surface water development project on the Lower Rio Grande in Cameron County. The proposed project is intended to provide additional dependable water supplies for municipal and industrial use by capturing and diverting "excess" flows of United States waters in the Rio Grande that would otherwise flow past Brownsville and discharge to the Gulf of Mexico. The proposed project consists of a weir structure across the channel of the Rio Grande approximately eight miles downstream of the Gateway Bridge at Brownsville. Under normal operating conditions the reservoir created by the proposed weir will have a maximum surface area of 600 acres and store approximately 6,000 acre-feet of water. The reservoir would extend 42 river miles upstream of the proposed weir.

5.6.5.1.2 Water Supply Yield

In addition to other water rights, BPUB currently has authorization to divert up to 40,000 acre-feet per year of "excess flows" from the Rio Grande under TNRCC Permit No. 1838. Excess flows are defined as all U.S. waters passing Brownsville stream flow gauging station above a base flow rate of 25 cfs. Excess U.S. River flows will be impounded in Brownsville Reservoir under BPUB's new TNRCC water rights Permit No. 5259. According to hydrologic studies preformed for the project sponsors, the proposed project would allow the diversion of the full 40,000 acre-feet per year authorized under the existing permit approximately 70 percent of the time. However, the firm yield of the project (based on hydrologic analysis for the period from 1960 to 1997) is estimated to be 20,640 acre-feet per year.

5.6.5.1.3 Cost

The most current cost estimate to construct the Brownsville Weir and Reservoir is just less than $36.2 million. TWDB guidelines require an annualized cost to construct the project to deliver water to meet end user based on firm yield requirements. Assuming the firm yield from the diversion is used as the basis for providing treated water for DMI use, the following determination of unit cost was developed. Using TWDB cost estimation guidelines, the inflation adjusted annualized cost to construct, operate, and maintain the project, and provide required treatment, is approximately $13.6 million dollars per year. Consequently, the unit cost of firm water supply from the project is approximately $438 per acre-foot (see Appendix 5.1). Of this amount, approximately $138 per acre foot is used to develop the water and the balance is used to treat and transfer the water.

5.6.5.1.4 Environmental Impacts

Several environmental issues have been raised concerning the proposed Brownsville Weir and Reservoir. These include impacts on water quality (i.e., increased salinity) within and downstream of the reservoir; impacts to aquatic and riparian habitat as a result of changes in downstream flow and salinity patterns; potential impacts to habitat from reservoir construction and inundation; potential adverse impacts to the Audubon Society's Sabal Palm Sanctuary; and increased risk of flooding. Although the project sponsors have indicated their intent to operate the proposed project in such a manner as to completely avoid or largely mitigate these concerns, resource advocates remain concerned about these issues.

A water right permit for the Brownsville Weir and Reservoir (BWR) Project was issued by the TNRCC on September 29, 2000. This permit authorizes on behalf of the State of Texas the construction of the Brownsville Weir on the Rio Grande and the impoundment of 6,000 acre-feet of Rio Grande water in the Brownsville Reservoir. Special conditions included in this permit require the BPUB to: (1) pass a minimum flow of 25-cfs whenever water is being impounded in the reservoir; (2) pass sufficient water through the reservoir to satisfy the demands of downstream water rights holders as directed by the Rio Grande Watermaster; (3) monitor salinity in the Rio Grande downstream of the weir near the riverine/estuarine interface (23.6 river miles upstream from the mouth of the river) and only impound water in the reservoir when the measured salinity is less than an established near-fresh (low salinity) condition; and (4) consult with the TNRCC, Texas Parks and Wildlife Department (TPWD), U.S. Fish and Wildlife Service (USFWS), and other appropriate agencies to develop and implement an acceptable mitigation plan for the overall BWR Project. The requirements in the TNRCC permit for the 25-cfs minimum streamflow and for the maximum salinity level at the riverine/estuarine interface are directed toward assuring that the BWR Project will not cause significant changes in estuarine habitat conditions so as to adversely impact existing aquatic resources, such as shrimp and finfish. In order to identify potential impacts of the Project on estuarine aquatic resources, the BPUB will fund a six-year monitoring study that is to be undertaken by the TPWD after the Project has been constructed and in operation.

The required mitigation plan for the Project will be developed and finalized through the Section 404/10 Federal permitting process that is now underway under the authority of the Galveston District of the Corps of Engineers (Corps). Although the mitigation plan will include a variety of measures dealing with the Project's environmental impacts, it will focus on protecting and/or re-establishing riparian habitat along the reservoir reach of the Rio Grande for two endangered species of cats, the ocelot and the jaguarundi. Other issues to be addressed as part of the mitigation plan will include runoff and pollution control strategies during construction activities, bank erosion control measures, temporarily and permanently impacted vegetation, wetland habitat impacts, passage facilities for supporting the upstream and downstream migration of aquatic species through the weir structure, and identification of potential impacts of the Project to federal, state and private environmental preserves and cultural/historical resources in the region. The BPUB currently is engaged in Section 7 Consultation of the ESA with the USFWS, Corps and other agencies regarding the Project's potential impacts on endangered species and the development of appropriate mitigation measures. Also, the Corps is evaluating public comments regarding the BWR Project and comments received from the various federal and state resource agencies to determine whether or not a full environmental impact statement needs to be prepared for the Project.

In summary, all of the environmental issues that have been raised regarding the BWR Project will have to be satisfactorily addressed through the Section 404/10 Federal permitting process and through the IBWC project approval process in order for the necessary authorizations for the Project to be issued by the various agencies. Otherwise, the Project cannot be constructed and operated. This also will include authorization for the Project from Mexico. The IBWC will be the lead agency for all discussions and dealings with Mexico, and these discussions and dealings will not be undertaken until after the Section 404/10 permit has been issued by the Corps.

5.6.5.1.5 Implementation Issues

In addition to environmental issues, there is significant concern about the effect that construction and operation of the project could have on the Rio Grande water rights system and, in particular, the effect on "no-charge pumping." According to the 1994 Hydrology Report and as amended in 1999 "… the existence of the Brownsville Weir and Reservoir should not impact no-charge pumping conditions since these proposed facilities will be located near the lower end of the Rio Grande below where any excess flows might enter the river …". The report also states that when the Watermaster designates excess flow conditions below Anzalduas Dam water right holders are notified in consecutive river order going downstream. These diverters are then allocated water until the available no-charge pumping supply is exhausted. Diverters downstream of this point do not receive any of the available excess flows. Since the proposed project is downstream of most of these diverters, the project should not affect no-charge pumping. In addition, BPUB has agreed to pass any available no-charge water through the proposed weir if it is requested by existing downstream water rights holders. Nonetheless, some irrigation districts continue to express concerns that the project would reduce the amount of "free water" available during no-charge periods it could affect accounting of water under the 1944 Treaty.

A comprehensive cultural resources evaluation will be undertaken as part of the Section 404/10 permitting process for the BWR Project. Field surveys will be conducted for the purpose of identifying existing archeological and/or historical resources of significance that potentially may be impacted by the Project. Working with the Texas Historical Commission, procedures for avoiding or minimizing these impacts will be developed and incorporated into the mitigation plan for the Project.

The issue of flooding impacts associated with the BWR Project also is being addressed by the BPUB. Under the current regulations of the IBWC, the proposed BWR Project cannot cause any increase in flood levels along the Rio Grande for the design flood condition. This condition corresponds to a flood flow of 20,000 cfs in the river at Brownsville. Currently, the BPUB is evaluating the flooding impacts of the Project using a state-of-the-art hydraulic computer model of the reach of the river from the weir upstream to the Gateway Bridge. The IBWC has reviewed preliminary modeling results and has suggested revisions, which now are being incorporated into the analysis. The objective of these studies is to develop a design for the weir structure that will be satisfactory to the IBWC and that will not cause any increase in design flood levels along the river. This work also is important because of an existing agreement between the IBWC and the USFWS that authorizes maintenance of only certain portions of the floodway between the levees along the Rio Grande in the vicinity of Brownsville so as to preserve minimum habitat areas for the endangered species of cats.

Concerns have also been expressed that a new structure at Brownsville could be designated as the new final water accounting point under the treaty dividing Rio Grande waters between the U.S. and Mexico. At present, the final accounting point is designated as the Anzalduas Dam located approximately 120 river miles upstream of the proposed Brownsville Weir. The concern is that a change in the physical point in accounting could in some manner alter the availability of water for Texas diverters. The project sponsors have stated that under their proposal “no identifiable harm” will occur if the IBWC chooses to move the accounting point from Anzalduas Dam to the proposed Brownsville Weir. IBWC staff has indicated that the only treaty implication associated with the proposed project is that Mexico could request, under terms of the treaty, to participate in the project and use it to capture excess river flows owned by Mexico. Conceivably, Mexican participation in the project could reduce the yield associated with capturing excess U.S. flows by decreasing the amount of U.S. storage capacity in the proposed reservoir and affect water supply to other water right holders because the changes in water accounting or river operations by the IBWC.

5.6.5.1.6 Recommendation

Based on the criteria established for the final recommendations for meeting the DMI shortages, Brownsville Weir and Reservoir was recommended by the Rio Grande RWPG as a water management strategy toward meeting Brownsville’s future needs.

5.6.5.2 Reallocation of Storage in the Amistad-Falcon Reservoir System

Approximately one-third of the controlled storage capacity in Amistad International Reservoir is below the top of the spillway gates and is the designated flood control pool. About 16 percent of the controlled storage capacity in Falcon International Reservoir is for flood control. The flood pool of each reservoir remains empty except during and following a flood event. As part of the *Phase II Integrated Water Resources Plan for the Lower Rio Grande Valley*, permanent and seasonal reallocation of a portion of the flood control storage capacity was investigated as a strategy for increasing the water supply yield of the reservoir system.

5.6.5.2.1 Strategy Description

Permanent or seasonal reallocation of the flood control storage capacity of the Amistad-Falcon Reservoir System could be implemented simply by raising the designated elevation of the top of the conservation pool. Increasing the conservation storage capacity of the reservoirs would allow additional inflows to be held in the reservoirs thereby increasing the firm yield of the system. Current reservoir operating procedures of the IBWC allow for storage of water in the flood control pool during the period from November through April when the threat of flooding, particularly related to tropical storm systems, is minimal. However, there are no set rules for this seasonal storage reallocation. Historically, the amount of water held in the flood control pool for water supply storage has ranged from zero to approximately 100,000 acre-feet in each reservoir.

A total of six alternative reservoir storage reallocation plans were evaluated for the *Phase II Integrated Water Resources Plan*. These included baseline scenarios for the current operating procedures with occasional seasonal storage in the flood pool, current-operating procedures without seasonal reallocation, and several scenarios for permanent reallocation of storage.

5.6.5.2.2 Water Supply Yield

The effects of alternative reservoir storage reallocation plans were estimated by simulating reservoir operations using the Reservoir Operations Model for the Amistad-Falcon reservoir System. Impacts were measured in terms of reducing diversion shortages, which represent failures to fully meet the water demands specified in the model. The results indicated that only relatively minor reductions in diversion shortages would occur with implementation of the alternative reallocation plans, except for the "extreme" scenario of reallocating most of the flood control storage in the two reservoirs to water supply. Furthermore, some shortages still occur even under the extreme reallocation scenario.

5.6.5.2.3 Cost

Previous studies did not assess whether implementation of flood storage reallocation would require modifications to the dams or control works of Amistad and Falcon reservoirs. It is implied in the study that modifications would not be required. There also would be no increase in reservoir system operations and maintenance costs.

5.6.5.2.4 Environmental Impacts

The previous study did not address potential environmental impacts associated with reallocation of flood storage in the Amistad-Falcon Reservoir System. However, it is not likely that there would be any significant environmental impacts.

5.6.5.2.5 Implementation Issues

Implementation of changes to IBWC reservoir operations policies and procedures to allow water supply storage in the flood control pools of the reservoirs would require the concurrence of Mexico. Also, any significant change in current procedures could generate public opposition if it is perceived that the change could increase the risks of flooding.

5.6.5.2.6 Recommendation

Based on previous studies, it does not appear that modification of current IBWC operating procedures for the Amistad-Falcon reservoir System will provide a significant water supply benefit. The strategy is therefore not recommended for inclusion in this plan.

5.6.5.3 Additional Water Supply Reservoirs on the Rio Grande

5.6.5.3.1 Strategy Description

Article 5 of the 1944 Water Treaty between the United States and Mexico allows, but does not require, construction of a third dam along the Rio Grande River between Eagle Pass and Laredo. However, previous studies indicate that Falcon and Amistad reservoirs alone are sufficient to capture flood flows and provide for the maximum beneficial use of the waters of the Rio Grande River. Since 1986, the issue of developing a third reservoir on the Rio Grande has been revisited. In 1986, the United States section of the IBWC completed a preliminary feasibility study of three dam sites between Eagle Pass and Laredo for the generation of hydroelectric power and recreational benefit. Results of the study indicated that the dam would not provide additional conservation or flood control storage but that it might be feasible based on benefits derived from the generation and sale of hydroelectric power.

Several additional studies investigating the feasibility of similar projects in different locations have been completed since the original IBWC study. Most recently, in 1997 Webb County investigated the feasibility of a "low-water" dam just upstream Laredo. Interest in this latest project was fueled by potential federal assistance for the project as part of the American Heritage River's Initiative. President Clinton announced this initiative in early 1997 to provide protection and restoration to qualifying rivers.

5.6.5.3.2 Water Supply Yield

As indicated, Falcon and Amistad reservoirs currently provide adequate water storage to capture flood flows in the Rio Grande. It has been determined from previous studies that he construction of a third dam would provide a significant increase in system firm yield relative the costs of developing the additional storage capacity.

5.6.5.3.3 Cost

Detailed cost estimates for the low-water dam and reservoir project proposed by Webb County have not been developed at this time. Webb County has indicated that it intends to proceed with more detailed engineering feasibility and environmental impact studies in the near future.

5.6.5.3.4 Environmental Impacts

The major environmental consequences of constructing a third reservoir include the potential loss of important riverine and riparian habitat, impacts to any endanger species that might occur in the project area, and impacts to downstream wetlands due to changes in the flood plains. The project may also impact water quality of Rio Grande in Zapata County and in the lower Rio Grande Valley.

5.6.5.3.5 Implementation Issues

Proponents of the development of a third reservoir near Laredo cite potential water quality benefits as a result of project. The reservoir would also provide a pool from which to divert water to a proposed new regional water treatment plant to be built by Webb County. The reservoir could also provide recreational and aesthetic benefits to the community. Opponents of the project contend that the reservoir will reduce downstream flows and will reduce water quality in Zapata County and the lower Rio Grande Valley. As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. Potential impact on cultural resources may result from reservoir construction. Additionally, coordination with Mexico will be necessary.

5.6.5.3.6 Recommendation

The Rio Grande RWPG has expressed support for further feasibility and environmental impact studies of the proposed Webb County low-water dam (see Chapter 6).

5.6.5.4 Conveyance of Rio Grande Water Supply - Pipeline from Falcon Reservoir to the LRGV

5.6.5.4.1 Strategy Description

Currently, both municipal and irrigation water supplies for Cameron, Hidalgo, and Willacy counties are released from Falcon Dam and conveyed down the Rio Grande where it is diverted for use. In most cases irrigation districts divert both irrigation and municipal water supplies through canal systems to delivery locations. For municipal water users, major disadvantages of the current water delivery system include relatively poor water quality water, reliability and the large transmission losses in the process. With regard to the latter, many municipal water users in the Lower Rio Grande Valley are assessed a 25 percent loss factor, or more, on delivery of their water supplies by an irrigation district. This loss factor effectively reduces the amount of water that is available for actual municipal water use. Also, during the current on-going drought, there has been concern that municipal water deliveries could be interrupted if irrigation supplies are exhausted. For many municipal water users in the region, delivery of water supplies requires that there be adequate irrigation “push” water.

As an alternative to the current system for the delivery of municipal water supplies, the feasibility of a water transmission pipeline from Falcon Reservoir to the lower Rio Grande Valley was evaluated in 1999 as part of the *Integrated Water Resource Plan – Phase II*.[1] The pipeline would be designed to convey water an amount of water equivalent to the projected increases in municipal water demands from Falcon Reservoir to four delivery points in the Lower Rio Grande Valley. Use of a pipeline for transport would increase the efficiency of water delivery by eliminating channel losses. An update of that study, published in March 2000, confined the proposed activity to municipal supplies in Hidalgo and Starr

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[1] Route A, as discussed in the *Integrated Water Resources Plan*, is along a utility easement that extends from the hydropower facility at Falcon Dam toward Moore field.

counties.[2] Current municipal water demands would continue to be conveyed by the Rio Grande and through canals to existing water treatment and distribution facilities. Since the pipeline would convey more water as demand increases, the initial phase of the project would be sized to convey only half of the projected increase in municipal demands over a 50-year period. Initially, water treatment capacity would be provided for only about 20 percent of the ultimate water delivery capacity. These facilities would be expanded as needed to meet increasing demand.

5.6.5.4.2 Water Supply Yield

According to the analyses presented in the *Falcon Reservoir Water Treatment lant and Pipeline System for Hidalgo and Starr Counties, Texas and Northern Mexico,* domestic water transportation losses through the existing irrigation canal system below Falcon Reservoir are between 29 to 52 percent. While the proposed water transmission pipeline, would not affect the firm yield available from the Falcon Reservoir, it would eliminate much of the transportation losses associated with the portion of future municipal diversions that would be conveyed by the pipeline. The effect of reduced transportation losses would be felt proportionately with the increase in the amount of water conveyed in the pipeline. It is estimated that the transportation losses that would be prevented with the full development of the pipeline system would be 19,000 acre-feet per year (see Appendix 5.1).

5.6.5.4.3 Cost

The previous evaluation of the feasibility of the water transmission pipeline was preliminary with several alternatives considered. These alternatives include three identified pipeline routes, delivery of treated or raw water, system size, and four delivery points. The cost information presented in this section focuses on the costs for the system to deliver 100 millions of gallons of treated water per day from Falcon Reservoir to Hidalgo and Starr Counties. The annualized cost to construct the entire project is estimated to be approximately $24 million dollars (see Appendix 5.1). When compared to the maximum net water savings at full utilization of the project, the annualized unit cost per acre-foot of recovered municipal water supply is $1,025. The cost to deliver the total amount of treated water approximates $275 per acre foot.

5.6.5.4.4 Environmental Impacts

Construction of a pipeline from Falcon Reservoir to the Lower Rio Grande Valley would have environmental impacts as a result of both the construction and operation of the project. Construction impacts would be predominately contained in the pipeline right-of-way (ROW) and could include disturbance to cultural resources, threatened and endangered species, wetlands, stream crossings, and prime farmland soils. Wildlife and migratory birds that depend on drinking water provided by the open canals will have a negative impact due to loss of canal areas.

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[2] Falcon Reservoir Water Treatment Plant and Pipeline System for Hidalgo and Starr Counties, Texas and Northern Mexico, March 2000.

5.6.5.4.5 Implementation Issues

In addition to reducing water transmission losses, the proposed pipeline project would have other potential benefits. For example, the pipeline would likely deliver higher quality water than the existing river and canal system and the pipeline project would facilitate the development of regional water treatment plants and perhaps induce further regionalization of water and wastewater utility services in the Lower Rio Grande Valley. A treated water transmission line routed through the northern portion of the Lower Rio Grande Valley could also provide important benefits in terms of providing water utility services in currently undeveloped area. However, a project of this nature would likely face significant institutional hurdles, for example, obtaining a high degree of regional participation by a large number of independent municipal water suppliers. Such participation would be required in order to finance a project of this magnitude. In addition, a project of this type could significantly alter existing relationships between municipal water users and the irrigation districts that deliver water and in many cases provide increasing amounts of water for municipal use.

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. Potential impacts on cultural resources may result from pipeline construction and operation. Therefore, pipelines should follow existing and shared ROWs whenever possible to minimize the area of disturbance. Lane easements for pipeline construction might be required. The existing Certificates of Adjudication (approximately 900) might need to be amended if there is a change in the diversion point.

5.6.5.4.6 Recommendation

A pipeline to deliver treated water to municipal users in Hidalgo and Starr counties does not appear to be economically feasible when viewed solely in terms of its estimated water supply benefits. Other strategies, such as acquisition of additional Rio Grande water supplies, are significantly less costly and have fewer potential environmental and implementation issues. However, it is recognized that a project of this nature could have significant benefits in addition to providing a net increase in DMI water supply. As such, it is recommended that this strategy be kept under consideration and be re-visited in future plan updates or amendments.

5.6.5.5 Conveyance of Rio Grande Water Supply - Gravity Canal

5.6.5.5.1 Strategy Description

In the late 1940s and early 1950s the Lower Rio Grande Authority spearheaded an unsuccessful attempt to build a project that would divert water from Anzalduas Diversion Dam through a gravity canal that would supply downstream irrigation districts and other water users in Hidalgo and Cameron counties. The project was proposed largely in response to a similar diversion canal that was constructed in Mexico and in an attempt to increase the efficiency of water delivery to downstream irrigators. Projected benefits from the proposed project included the elimination of the need for existing river pumping stations, reduced sedimentation in the existing irrigation canal systems, and an increase in the reliability and rate of water deliveries to irrigators.

The gravity canal project was proposed to flow in a southeasterly direction, roughly parallel the Rio Grande. The first seven miles of the canal were to be unlined, with a bottom width of 160 feet. This section would act as a settling basin for sediments, with silt removal by means of a floating dredge. The remainder of the canal was to be concrete-lined in order to minimize water losses. The canal was to be sized large enough to convey the entire United States portion of releases from Falcon Reservoir. Feasibility studies completed in 1952 concluded that, at that time, the gravity canal project was feasible.

5.6.5.5.2 Water Supply Yield

The development of the project could increase the effective supply of water available for irrigation by reducing river channel and irrigation canal losses. Estimates of such savings were not previously developed. However, to the extent that minimum releases would likely be required from Anzalduas Diversion Dam to maintain downstream aquatic and riparian habitat, all or a portion of the water conservation benefits would be negated.

5.6.5.5.3 Cost

In 1952 the Gravity Canal Project was projected to cost approximately $18.32 million, with annual operation and maintenance costs of approximately $154,000. When these cost estimates are adjusted to current (1999) conditions, the Gravity Canal Project would cost over $193 million, with annual operation and maintenance costs of over $1.6 million. However, it should be noted that the original cost estimates likely do not account for such factors as permitting and mitigation of environmental impacts.

5.6.5.5.4 Environmental Impacts

When this project was originally proposed and evaluated, current state and federal environmental regulations were not in effect. During that era, feasibility was defined almost exclusively in terms of economic feasibility. By today's environmental standards, the proposed project would likely be closely scrutinized due to its potential adverse effects on the Rio Grande River downstream of Anzalduas Diversion Dam. Operation of such a canal as originally proposed would have the effect of significantly dewatering the Rio Grande downstream of Anzalduas Diversion Dam. It would be likely that minimum releases would be required to preserve downstream aquatic and riparian habitat, which, as noted above, could negate much of the water supply benefit of such a project. Wildlife that are dependent on water from the existing canal system may be impacted. There would also likely be extensive environmental and socioeconomic impacts along the canal route and the canal itself could create a barrier to migration of indigenous threatened and endangered animals.

5.6.5.5.5 Implementation Issues

The development of a gravity canal to deliver water to irrigation and DMI users in Cameron and Hidalgo counties would face significant institutional impediments. The major issue would be the likely difficulty of gaining the very high degree of cooperation among the large number of DMI and irrigation users that would benefit from such a project. Such cooperation would be essential in securing financing. It could be expected that some water suppliers would be resistance to abandoning existing water diversion and delivery infrastructure.

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. Potential impact on cultural resources may result from the canal development project.

5.6.5.5.6 Recommendation

Development of a gravity canal to deliver water to irrigation and DMI users in Cameron and Hidalgo counties does not appear to be economically feasible as a water supply strategy and would likely face significant environmental and institutional hurdles.

5.6.5.6 Off-Channel Storage of Excess Flows (e.g., surface storage, aquifer storage and recovery)

Occasionally during high runoff conditions, flood spills, or releases from reservoir storage, flows in the Rio Grande exceed the amount needed to satisfy downstream water demands. When these conditions occur, the Rio Grande Watermaster may allow diverters to withdraw this water without charge to their water rights accounts. This is known as "no-charge" pumping. Some diverters have the ability to divert excess flows under no-charge pumping and store the water for subsequent use within resacas, existing off-channel reservoirs, and within their water conveyance and delivery systems. Still, in many cases, portions of the excess flow passes unused into the Gulf of Mexico.

The scope of work for the Rio Grande Regional Water Plan requires an assessment of the potential for additional off-channel storage of excess Rio Grande flows. TC&B has found no evidence of prior study of the concept, except at a cursory level, and is therefore unable to fully assess the potential yield, costs, and impacts of additional off-channel storage. However, based on water rights held by the Brownsville Public Utilities Board (BPUB) and BPUB's plans to construct the weir and reservoir, as well as existing procedures for no-charge pumping, additional off-channel storage of excess Rio Grande flows does not appear to be feasible.

In 1956, BPUB was granted water right permit 1838A (amended in 1994), which allows the diversion of up to 40,000 acre-feet per year of excess Rio Grande flows (i.e., whenever flows are greater than 25 cfs at the Brownsville gauge) and allows for the construction off-channel storage with a capacity up to 26,500 acre-feet. Because of this water right and current policy regarding no-charge pumping, BPUB is the only entity that could legally develop off-channel storage for the purpose of providing additional firm water supply. Except for the non-firm water available under no-charge pumping, there is no unappropriated excess flow remaining in the lower Rio Grande.

In 1999, BPUB filed an application with the TNRCC for a permit to proceed with construction of the Brownsville weir and reservoir project, described in a previous section (5.6.5.1). This project would be constructed to fully develop and utilize excess flows under water right permit 1838A. The development of this project, if authorized and funded, will preclude development of additional off-channel storage by BPUB.

5.6.5.7 Capture and Use of Local Runoff in the LRGV

5.6.5.7.1 Strategy Description

Below Falcon Dam, the terrain along the Lower Rio Grande is characterized as coastal plain, with some rolling hills and numerous isolated low areas and depressions. Much of the area toward the Gulf once formed a broad, fan-shaped delta at the river's mouth that was dissected by multiple meandering channels. These channels carried river flows with heavy sediment loads through the delta to the Gulf. Today, these abandoned deltaic channels form finger lakes, which are called "resacas".

One of the possibilities for developing additional supplies of surface water in the Lower Rio Grande Basin would be to collect stormwater in the isolated low areas, depressions and resacas that are scattered throughout the area, primarily in Cameron and Hidalgo counties. Such water could be made available for local use, provided that the stormwater captured is not already appropriated to existing water rights. For stormwater to be considered unappropriated, it would have to drain into isolated low areas or water bodies which are not the source of supply for any existing water rights. Hence, any stormwater that eventually could flow into the Rio Grande would be considered to be appropriated and unavailable for development. Similarly, any stormwater flowing in the tributaries or the mainstem of the Arroyo Colorado also would likely be considered to be appropriated because of existing water rights located on this watercourse.

Cameron and Hidalgo counties cover an area of approximately 2,860 square miles. The Arroyo Colorado extends eastward for about 90 miles from near the city of Mission through southern Hidalgo County to the city of Harlingen in Cameron County, eventually discharging into the Laguna Madre near the Cameron-Willacy county line (see Figure 3.12). The watershed of the Arroyo Colorado drains approximately 700 square miles. Excluding the watershed of the Arroyo Colorado because of potential conflicts with existing water rights, the remaining drainage area of Cameron and Hidalgo counties that potentially could be considered for collection of stormwater encompasses about 2,160 square miles. A general inspection of available topographic maps, county road maps, and aerial photographs indicates that no more than about 25 percent of this area would likely contribute stormwater flows into water bodies that are not subject to diversions by existing water rights such that the stormwater flows could be considered to be unappropriated. Hence, there appears to be no more than a total of about 700 square miles of drainage area within Cameron and Hidalgo counties from which stormwater flows could be collected and made available for water supply.

Annual rainfall in Cameron and Hidalgo counties averages about 25 inches according to data presented in the "Climatic Atlas of Texas" (Texas Department of Water Resources, LP 192, 1983). Assuming that approximately five percent of this annual rainfall actually occurs as runoff, which is reasonable for the coastal areas of lower Texas, the total volume of stormwater that could be potentially collected and made available for water supply in Cameron and Hidalgo counties would average approximately 50,000 acre-feet per year. Of course, depending on rainfall, this could range from only about 20,000 acre-feet during dry years (10 inches of rainfall) up to possibly 90,000 acre-feet in a very wet year (45 inches of rainfall).

Although as noted above, a significant quantity of stormwater potentially could be available for use on an annual basis, one of the major disadvantages with trying to develop stormwater as a source of supply is that it would not be dependable at a particular location because of the variable nature of rainfall, both spatially and temporally. Without a substantial amount of storage capacity in a low area, depression or resaca to hold the stormwater over extended periods of several months, the only supply of stormwater that might be available at any given location would be that which occurs as runoff during a single rainfall event. This, of course, would be of little value as a dependable water supply, but it could be useful as a short-term supplemental supply. The use of such stormwater on a short-term basis would reduce the need for releases from Falcon Reservoir and thereby extend the more permanent supply of water stored in the reservoir for later use.

Another issue regarding the stormwater supply option relates to the geographical area within which the stormwater could be effectively used as a water supply. Because of the relatively small amount of water that likely could be accumulated in a given low area, depression or resaca during a rainfall event, the subsequent use of the water probably would have to be limited to the immediate vicinity of the low area, depression or resaca. It is unlikely that it would be cost effective to design and install an extensive system of canals and/or pipes to transport and distribute the limited quantities of stormwater over a wide area. What would also complicate the distribution and use of such water would relate to who actually would own the water. Some type of agreement or institutional arrangement would have to be implemented whereby the ownership of the stormwater and the users of the water would be defined, together with their duties and responsibilities. These arrangements could vary widely depending on local circumstances regarding where a particular low area, depression or resaca is located and who owns it, which water users are to be supplied the associated stormwater, and who is to pay for development of the water supply project.

5.6.5.7.2 Water Supply Yield

As discussed above, the water supply yield from developing the stormwater option in Cameron and Hidalgo counties could potentially average about 50,000 acre-feet per year. Because of the variable nature of rainfall both spatially and temporally, the available water supply would not be dependable on a localized basis and could range between 20,000 acre-feet per year up to 90,000 acre-feet per year for the two-county region depending on annual rainfall conditions. These water supply yield amounts would be refined based on the results from the recommended pilot studies.

5.6.5.7.3 Cost

The costs of developing local stormwater runoff for use as a water supply source would be highly dependent upon site-specific factors including the amount of yield available at a given site and the sites proximity to potential users. It was beyond the scope of this planning effort to investigate the costs of this strategy for a specific site. It is recommended, however, that a study be conducted to develop water supply yield, cost, and environmental impact information for five localized areas.

5.6.5.7.4 Environmental Impact

The potential environmental impacts associated with this water supply strategy would be primarily localized in nature and related mostly to any disturbances of the existing environment resulting from modification of low areas, depressions or resacas to enhance their storage capabilities or from installation of water transport and distribution facilities. Such impacts would need to be minimized to the extent possible and mitigated where necessary.

5.6.5.7.5 Implementation Issues

The implementation issues that potentially could be factors affecting development of the stormwater supply strategy include the following:

- Identification of low areas, depressions or resacas with stormwater inflows not subject to appropriation by existing water rights;
- Definition of the reliability and dependability of water supplies developed using localized stormwater because of the spatial and temporal variability of rainfall;
- Availability of adequate storage capacities to provide short-term stormwater supplies that can effectively supplement permanent Falcon Reservoir water;
- Availability of local water users within the immediate vicinity of low areas, depressions or resacas where stormwater could be stored;
- Cost of water transport and distribution facilities to serve local water users;
- Ownership of stormwater and relationship to water users and cost of water distribution facilities; and,
- Financing of project costs.

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with either Section 7 or Section 10 Consultation under the Endangered Species Act if any threatened and endangered species is impacted.

5.6.5.7.6 Recommendation

A detailed analysis of the prospect of developing an additional water supply for the region through the storage and use of localized stormwater is beyond the scope of this planning effort. However, it is apparent from the above general evaluation that there is some potential for using stormwater that accumulates in low areas, depressions or resacas in the immediate vicinity of such storage facilities, provided that the stormwater is not already appropriated for use by existing water rights.

To identify specific areas where such water supplies might be developed will require extensive studies involving field surveying, photographic interpretations, detailed mapping, stormwater storage assessments, hydrologic and runoff analyses, localized water user investigations, water transport and distribution facilities planning and conceptual design, and implementation costing and financing. While such studies cannot be undertaken within the scope of this planning effort, it is recommended that pilot studies for specific areas with high potential for producing additional supplies of stormwater be considered as part of future planning activities. Such studies would necessarily involve all of the technical tasks identified above for several selected high-potential areas within Cameron and/or Hidalgo counties. The results from these pilot studies then could be extrapolated to other areas of the two counties to develop a better estimate of the overall supply of stormwater that possibly could be developed through a more comprehensive regional or subregional program.

It is estimated that the cost for undertaking the stormwater supply pilot studies for five localized areas within Cameron and/or Hidalgo counties and extrapolation of these results would be approximately $155,000.

5.6.5.8 Importation of Surface Water

Surface water importation (i.e., interbasin transfers) was evaluated at a reconnaissance-level, as a potentially feasible strategy for meeting DMI needs in the Rio Grande Region. A summary of the results of this analysis is provided below and in Appendix 5.1. Additional details are presented in a technical memorandum entitled, *Interbasin Transfer Water Supply Options (January 2001)*, which is found in the technical appendix to this plan (Volume II).

5.6.5.8.1 Strategy Description

Three surface water importation options were evaluated, two involving delivery of additional water supply to the City of Laredo and one involving the delivery of additional water supply to DMI users in the Lower Rio Grande Valley. These options are:

Lavaca Basin Supply to Laredo: This option would involve the supply of 20 mgd (22,403 acre-feet per year) of raw water from the Lavaca River Basin to the City of Laredo. The diversion would be located near the town of Edna, Texas and a 36-inch diameter transmission pipeline approximately 220 miles long would generally follow the right-of-way of U.S. Highway 59. For the purposes of this analysis, it was assumed that the water supply would be available through a long-term water purchase contract with the Lavaca-Navidad River Authority.

Nueces Basin Supply to Laredo: This option would involve the supply of 20 mgd of raw water from the Nueces River to the City of Laredo. The diversion would be located downstream of the Choke Canyon reservoir in the vicinity of the town of George West, Texas. A 36-inch diameter transmission pipeline approximately 110 miles in length would follow the right-of-way of the U.S. Highway 59. It is assumed that the water supply would be available through a long-term water purchase contract with the City of Corpus Christi.

Nueces Basin Supply to the Lower Rio Grande Valley: This option would involve the supply of 17 mgd (19,042 acre-feet per year) of raw water from the Corpus Christi regional water system to the Lower Rio Grande Valley by extending the existing 42-inch “Sarita Pipeline” from Kingsville to Harlingen. The pipeline extension would be 33-inches in diameter, approximately 98 miles long, and would follow the

U.S. Highway 77 right-of-way. As with the other options, it was assumed that the water supply would be available through a long-term water supply contract.

5.6.5.8.2 Water Supply Yield

As indicated, the two surface water importation options evaluated for Laredo would supply 22,403 acre-feet of additional water supply for DMI use. The water importation option examined for the Lower Rio Grande Valley would supply 19,042 acre-feet of additional DMI water supply.

5.6.5.8.3 Cost

Cost estimates for the three surface water importation options are presented in Table 5.8.

Table 5.8: Summary of Costs Associated with Surface Water Importation Options

	Lavaca Basin to Laredo	Nueces Basin to Laredo	Nueces Basin to LRGV
Supply	22,403	22,403	19,042
Unit Cost ($/ac-ft/yr)	$1,610	$1,030	$600

5.6.5.8.4 Environmental Impact

Large-scale interbasin transfers of surface water have potentially far-reaching environmental impacts. Of particular concern are the potential adverse effects of trans-basin diversions on instream flows and bay and estuary inflows. In addition, significant disturbance of land and environmental resources could occur from construction and operation of water transmission pipelines. Of particular concern would be the impacts on wetlands and riparian and aquatic habitat associated with pipeline stream crossings and native brush clearing. However, many of these potential impacts could be at least partially avoided by following existing highway right-of-ways.

5.6.5.8.5 Implementation Issues

There are a number of key issues associated with large-scale interbasin transfers of surface water. As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted.

Other key issues include current state laws, which restrict new interbasin transfers by establishing a junior priority date to new or amended water rights involved in an interbasin transfer. Additionally, current state law includes provisions (Texas Water Code, Section 11.085) requiring the TNRCC to weigh the benefits of a proposed new interbasin transfer to the receiving basin against the detriments to the basin supplying the water. The criteria established in statute to be used by the TNRCC in the evaluation of proposed interbasin transfers are:

- The need for the water in the basin-of-origin and in the receiving basin;
- Factors identified in the applicable regional water plan(s);
- The amount and purposes of use in the receiving basin;
- Any feasible and practicable alternative supplies in the receiving basin;
- Water conservation and drought contingency measures proposed in the receiving basin;
- The projected economic impact that is expected to occur in each basin;
- The projected impacts on existing water rights, instream uses, water quality, aquatic and riparian habitat, and bays and estuaries; and,
- Proposed mitigation and compensation to the basin-of-origin.

In addition to statutory and regulatory impediments to new interbasin transfers, public and political opposition in the basin-of-origin has become the norm throughout Texas.

Potential impacts on cultural resources may result from pipeline construction and operation. Therefore, pipelines should follow existing and shared ROWs whenever possible to minimize the area of disturbance.

5.6.6 Development of Groundwater Supplies

Groundwater currently provides about 80,000 acre-feet per year of water supply to users within the Rio Grande Region. Of this amount, only about 20,000 ac-ft/yr is currently used for municipal, manufacturing, and steam electric purposes. The balance of current groundwater use within the Rio Grande Region is for irrigation, mining, and livestock use (see Table 3.12). The limited development of groundwater within the region for DMI uses is due in large measure to the limited availability of suitable quality water groundwater in most areas of the region. Notably, relatively large quantities of groundwater exist throughout much of the Lower Rio Grande Valley, but the quality is such that advanced treatment is required for most DMI uses. Also limiting groundwater development for DMI use has been the relative ease by which DMI water users have been able to acquire additional Rio Grande water supplies.

Despite the limited availability of suitable quality groundwater within the Rio Grande Region, additional groundwater development will be an important strategy for meeting future urban needs. At present, the cities of Brownsville, Laredo, and Eagle Pass are actively evaluating groundwater supply options. Additionally, several areas in "county other" WUG are viewed as potential candidates for groundwater development (see Section 5.3.1).

A number of studies have been conducted recently to evaluate the availability and cost of groundwater supply development for DMI use in the Rio Grande Region. This section summarizes the key results of these studies for the named major and minor aquifers within the region.

5.6.6.1 Gulf Coast Aquifer

5.6.6.1.1 Strategy Description

The use of brackish groundwater as a potable water source has been previously evaluated in the Brownsville area. The study, completed in November 1996, included a groundwater assessment, evaluation of treatment alternatives, reverse osmosis pilot study, and cost projections. The groundwater assessment in the Brownsville area indicated that it would be possible to develop a well field to produce 10.5 mgd of water supply.

The Brownsville, Texas study considered two methods for groundwater treatment – Reverse Osmosis (RO) and Electrodialysis (EDR). The analysis indicated that RO would be the least expensive option, so an RO pilot plant was constructed. This pilot scale system was used to determine the basic design parameters of a full scale RO system. A full scale RO system to treat 8-10 mgd of brackish groundwater would require pretreatment, which would include a desander to remove suspended material followed by a cartridge filtration system. Acid and a silica scale inhibitor would also be added to prevent scale formation. Based on the pilot testing, a full-scale system would be expected to have a membrane life of approximately five years. Chemical cleaning of the membrane would be required approximately four times per year. The results of the Brownsville pilot study imply that a full-scale RO system to treat brackish groundwater could successfully meet all state and federal primary and secondary drinking water standards

Concentrate from the RO system must be disposed of in an environmentally acceptable manner. Three options were proposed for a full-scale system including disposal to a brackish surface body, disposal to a sewer system, and deep well injection. Of these, disposal to a brackish surface by via a drainage ditch that ultimately discharges into the Brownsville Ship Channel and then to the Gulf of Mexico was the least cost.

5.6.6.1.2 Water Supply Yield

The total amount of water supply that could be made available from the Gulf Coast aquifer with advanced water treatment technology has not been determined. However, it is known that large quantities of poor quality groundwater occur throughout the Lower Rio Grande Valley. As indicated, the Brownsville study determined that it would be feasible to develop a groundwater well field capable of producing 8-10 mgd of groundwater supply (8,961 to 11,201 acre-feet per year).

5.6.6.1.3 Cost

The estimated capital costs to develop an 8.5 mgd groundwater supply project with advanced desalinization treatment technology is approximately $21 million. Estimated annual costs, including debt service and operations and maintenance, is approximately $3.1 million resulting in an annualized unit cost of water of approximately $320 per acre-foot. These cost estimates compare favorably with the reported costs of $328 per acre-foot for a recently completed groundwater supply project for Rancho Viejo in Cameron County.

5.6.6.1.4 Environmental Impact

The primary environmental issue associated with the development of brackish groundwater supplies is the disposal of the concentrated brine produced from the membrane filtration process. Disposal options include discharge to a surface water body, preferably one of similar or greater salinity, discharge to a sewer system, and deep well injection into a suitable underground formation. For most potential applications in the Lower Rio Grande Valley, the preferred method of concentrate disposal would likely be through discharge to the Arroyo Colorado. However, this method would increase the salinity of this already impaired water body. Another environmental concern relates to the energy requirements of the desalinization process. Also, there would be disturbance and potential environmental impacts in the immediate vicinity of the well fields during drilling and other construction activities.

5.6.6.1.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with either Section 7 or Section 10 Consultation under the Endangered Species Act if any threatened and endangered species is impacted. Potential impacts on cultural resources may result from pipeline construction and operation. Therefore, pipelines should follow existing and shared ROWs whenever possible to minimize the area of disturbance. The small area disturbed due to well construction and operation is not expected to have a large impact on cultural resources. There are no other significant implementation issues associated with this strategy. However, additional technical information is required on the availability, quality, and cost of developing groundwater as a supply source for DMI uses. Also, consideration should be given to converting some DMI users entirely from surface to groundwater.

5.6.6.1.6 Recommendation

The Brownsville PUB intends to use available groundwater supply only as a supplemental source of water when it's surface water supplies are limited, since it is estimated that the groundwater supply would be available for 20 to 25 years only. As such, this strategy was not recommended in this plan.

Additional study is required and also recommended to more fully assess both the availability and cost of groundwater supplies from the Gulf Coast aquifer in Cameron, Hidalgo, Jim Hogg, Webb, and Willacy counties. Studies currently in progress by the TWDB should provide more and significantly better information on the distribution, quantity, and quality of water from the Gulf Coast aquifer in those counties. Also, the development of a groundwater model for this portion of the Gulf Coast aquifer will aid in determining how much groundwater could be withdrawn from the aquifer for municipal use on a sustainable basis. Once these data and analytical tools are available, it is recommended that a comprehensive assessment be conducted to identify areas most promising for groundwater development. In particular, opportunities for developing brackish groundwater as a substitute for current municipal supplies from the Rio Grande should be thoroughly explored. In concept, a substantial portion of the cost of developing brackish groundwater supplies for particular DMI users could be offset by selling existing Rio Grande water rights to other DMI users. This assessment should be funded and completed prior to the first update of the Rio Grande Regional Water Plan.

5.6.6.2 Groundwater Supply Alternatives for the City of Laredo

The City of Laredo has been actively evaluating various groundwater supply alternatives. The results of these evaluations are presented in a report entitled, *Groundwater Source Study Alternatives Evaluation: Final Report (November 1999)*, and are summarized below. A more detailed summary of this information is presented in a technical memorandum entitled, *Groundwater Supply Alternatives for the City of Laredo (January 2001)*, which can be found in the technical appendix to this plan (Volume II).

5.6.6.2.1 Strategy Description

A total of 13 groundwater supply alternatives were initially identified and subjected to a preliminary screening analysis. From this analysis, five alternatives were considered potential feasible and were evaluated in greater detail. The five alternatives are:

- Carrizo aquifer in northwest Webb County with conveyance to Laredo via pipeline (Alternative 1);
- Carrizo aquifer in northwest Webb County with bed and banks conveyance to Laredo via the Rio Grande (Alternative 2);
- Laredo/Carrizo aquifers within 10 miles of Laredo (Alternative 3);
- Edwards/Trinity aquifers in Kinney County with bed and banks conveyance via the Rio Grande (Alternative 4); and,
- Carrizo aquifer in Dimmit County (Alternative 5).

A key engineering assumptions used in the analysis was that each option would be capable of producing 5.0 mgd of sustainable groundwater supply over the 30-year operating life of the projects. Additionally, for the two alternatives that involve bed and banks conveyance of supply via the Rio Grande, required water treatment would be provided at the City's existing water treatment plants.

5.6.6.2.2 Water Supply Yield

Each of the alternatives evaluated would provide 5,600 acre-feet per year of municipal water supply over a 30-year period. However, the long-term sustainability of each alternative is not certain and will require additional evaluation prior to implementation. Also, the potential to increase groundwater withdrawals beyond 5.0 mgd is moderate to poor for all of the alternatives. For low-yield aquifers such as the Laredo Formation and the Carrizo aquifer in southwest and south-central Webb County, increased production is limited by the length of the aquifer outcrop area as well as the prevalence of existing users of groundwater. For the higher yielding formations, such as the Edwards aquifer and the Carrizo in northwest Webb and Dimmit counties, the potential for increased groundwater production is limited by current competition and future increases in demand by other users.

5.6.6.2.3 Cost

Cost estimates for each of the alternatives were prepared which included capital and operations and maintenance costs for well fields, conveyance facilities, and water treatment.

The cost to develop groundwater varies significantly depending upon the groundwater source, well completion, and many other variables. The cost estimates ranged from $580 to $1,000 per acre-foot of water developed.

5.6.6.2.4 Environmental Impact

The potential environmental impacts associated with the groundwater development options evaluated for Laredo include impacts to other existing water users, wetlands, and stream flow due to a lowering of water levels. In addition, construction and operation of well fields and transmission pipelines could adversely impact sensitive environmental resources (e.g., native brush clearing) and should be evaluated in detail prior to project implementation.

5.6.6.2.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with either Section 7 or Section 10 Consultation under the Endangered Species Act if any threatened and endangered species is impacted. Each of the groundwater supply alternatives considered for Laredo will require regulatory approvals by the TNRCC Public Drinking Water Program. In addition, regulatory controls on groundwater withdrawal are in place for those alternatives that fall within the jurisdiction of the Winter Garden Water Management District. It is uncertain, however, whether the district's regulations would be effective in limiting withdrawals in excess of the recharge rate over the 30-year lifespan of the projects. The only fail-safe method for managing withdrawals is to control a sufficiently large land area that includes the contributing portion of the aquifer recharge zone. This can be accomplished through direct ownership, lease agreements, or other contractual arrangements.

Potential impacts on cultural resources may result from those conveyance options requiring pipeline construction and use. Therefore, pipelines should follow existing and shared ROWs whenever possible to minimize the area of disturbance. Conveyance via bed-and-banks will minimize the need for pipelines, consequently reducing the risk to cultural resources.

5.6.6.2.6 Recommendation

The City of Laredo has been evaluating groundwater development options for some time, and, at this time, has selected a groundwater development as a recommended strategy to meet its DMI water demands.

5.6.7 Desalinization of Seawater

Desalinization of seawater was evaluated as a potential strategy for meeting DMI water demands within the Rio Grande Region. The evaluation was based on a study entitled "Seawater Desalination Feasibility Study in the Laguna Madre Area" that was completed in December 1997. This study provided background information, and described a reverse osmosis pilot study performed to assess the feasibility of using seawater as a water source. The study also determined key design parameters and estimated costs that would be associated with a full-scale seawater desalination facility. Additionally, the feasibility of seawater desalinization was also evaluated in a report prepared for the TWDB entitled, *Desalination for Texas Water Supply*. This study included water supply yield and cost estimates for a full-scale desalinization facility located in the vicinity of Port Isabel.

5.6.7.1 Strategy Description

As a potential water supply strategy for the Rio Grande Region, seawater desalinization would involve the development of a full-scale facility in the vicinity of South Padre Island/Port Isabel. The option considered in the siting study performed for the TWDB would involve the development of a 25 mgd treatment facility; with treated water storage and transmission facilities to transport the product water approximately 20 miles to Brownsville. Municipal and industrial uses in Brownsville were assumed to be the intended use of the water supply as Brownsville is the largest demand center in proximity to the Gulf of Mexico.

5.6.7.2 Water Supply Yield

The water supply yield of a seawater desalinization facility is variable. The facility considered in the Laguna Madre study would provide 1.0 mgd of water supply or 1,120 acre-feet per year assuming 100 percent utilization.

5.6.7.3 Cost

Cost estimates were developed 1 mgd desalinization facility near Port Isabel. Estimated total project costs are $6 million, with total annual costs of nearly $1.5 million. Based on an estimated firm yield of 1,120 acre-feet per year, the cost estimate per acre-foot is $1,300.

5.6.7.4 Environmental Impacts

Major environmental issues associated with a large-scale seawater desalinization facility include disposal of the brine concentrate produced from the membrane filtration process, energy consumption associated with operation of the facility, and land and environmental resource impacts associated with the construction and operation of the facility and the construction of a treated water transmission pipeline. The impacts of brine concentrate disposal would be minimal with dispersion into seawater at an offshore location. Land and environmental resource impacts could be avoided or minimized through careful siting of facilities.

5.6.7.5 Implementation Issues

A major implementation issue for a large-scale desalinization facility is whether there are users that are willing to finance and implement such a project. It should be noted that the development of the example facility at Port Isabel was predicated on the assumption that the City of Brownsville would be the user of the water supply. Brownsville already holds rights and contracts to Rio Grande water supplies sufficient to meet current demands. The City of Brownsville Public Utilities Board has also indicated that it intends to develop the Brownsville Weir and Reservoir, local groundwater supplies, and non-potable reuse of reclaimed water to meets its future water supply needs. Brownsville's local water supply plan does not include seawater desalinization. Nonetheless, a seawater desalinization project could become a feasible water supply strategy for Brownsville if it were to sell all or a large portion of its existing Rio Grande water rights to other DMI users. This could have the benefit of providing a revenue source to offset a portion of the costs of a desalinization project while also making DMI water rights available to meet the future needs of other DMI water users in the region.

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. Regulatory permitting of a large-scale desalinization facility in the vicinity of Port Isabel would require extensive coordination with numerous federal, state, and local agencies. Land acquisition for the desalinization facility and acquisition of right-of-way for construction of the concentrate disposal pipeline and treated water pipeline would also be major implementation issues. The treatment facility should be located to minimize cultural resource impacts. Also, pipelines should follow existing and shared ROWs whenever possible to minimize the area of cultural disturbance.

5.6.7.6 Recommendation

Due to its relatively high cost desalinization is not a recommended water management strategy for the Rio Grande Region at this time. Also, the large DMI demand centers in relative proximity to the Gulf of Mexico (e.g., Brownsville and Harlingen) have expressed no interest in pursuing seawater desalinization as a future water supply strategy. Nonetheless, it is recommended that the feasibility of seawater desalinization be re-visited periodically in light of technological advancements and other factors that might affect the economic feasibility of the strategy (e.g., increasing costs of other strategies, water quality concerns, etc.).

5.6.8 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) options were evaluated as a potentially feasible water management strategy for meeting future DMI needs in the Rio Grande Region. Aquifer Storage Recovery is a water management technique in which large volumes of treated water is stored underground in aquifers using wells to inject the water into the aquifer and the same wells to recover the water from storage. The technique is particularly useful to utilities that experience conditions of excess water supplies during certain times and water shortfalls during others. This can either be seasonal or longer term such as over several years.

Water is typically produced for ASR storage during times of the year when excess treated water supplies are available. The stored water is later recovered by pumping the wells to meet demands when supply is limited, or treatment capacity is exceeded. Experience with ASR systems for other utilities has shown that

ASR systems can be implemented for substantially less cost than more conventional alternatives to meeting peak water demands. Other applications that could be applied in the Rio Grande region include:

- Storage of water or banking the water during years when water rights or short term water transfers (annual purchases) exceed demand and subsequent recovery during years when water rights may be less than demand;
- Storage of water during "no-charge" periods for subsequent recovery to meet demand; and,
- Storage of water available from water supply projects like interbasin transfers or desalination projects during off-peak period for recovery during peak demand periods.

Previously, two separate studies of the feasibility of ASR systems in the region have been conducted, one for the Brownsville Public Utilities Board and another for the City of Laredo. Following is a summary of the findings of those two studies. A more detailed discussion of this strategy is presented in the technical memorandum entitled, *Aquifer Storage and Recovery System (ASR) Options for the Rio Grande Regional Water Planning Group* (January 2001) and is found in the technical appendix to this plan (Volume II).

5.6.8.1 ASR in Brownsville, Texas

5.6.8.1.1 Strategy Description

The results of the ASR system investigation for the Brownsville Public Utilities Board (PUB), which was completed in January 1996, suggest that an ASR system may be a feasible water supply strategy for the City of Brownsville PUB. It may be possible for an ASR facility to work with the PUB's expanded water treatment facilities, existing water rights, and Water Use Permit 1838, to meet a portion of projected water demands.

At the time of the 1996 investigation, the Brownsville PUB had recently obtained Water Use Permit 1838. This permit allows the PUB to pump additional raw water during times when the Rio Grande flows equal or exceed 25 cubic feet per second (cfs). The permit allows the use of up to 40,000 acre-feet of excess Rio Grande water annually that would normally flow into the Gulf of Mexico. The amount of water available each year will depend on actual river flows. Based on historical conditions, it is expected that about 17,000 acre-feet per year would be available for diversion.

Unfortunately, the raw water available under Permit 1838 during high river flows may not correspond to periods of high water needs. In order to provide the most effective use of this water, large volume storage is required. In this way, water could be diverted under Permit 1838 and stored until needed. An ASR system would provide a method to store water obtained and treated under Permit 1838. Water for storage could be diverted during the low demand months (approximately November through May) utilizing excess water treatment plant capacity during that portion of the year.

The ASR system that appears to be best suited for the PUB will be a system of wells and piping that operates at average injection and recovery rates of 10 mgd and 12 mgd, respectively. The system will be capable of handling maximum rates higher than this in order to take advantage of the Permit 1838 water, which may only be available in large quantities for short periods of time. The maximum rates for injection and recovery of the conceptual ASR system are approximately 15 mgd and 19 mgd, respectively.

5.6.8.1.2 Water Supply Yield

At a design of 10 mgd, an ASR system in Brownsville could provide a water supply yield of approximately 11,200 acre-feet per year, depending upon the availability of water under Permit 1838. Recovery of this stored water during the peak demand season would serve two purposes. First, the recovered water would reduce the use of Brownsville PUB's firm water rights. Secondly, the recovered water would supplement water treatment plant flows during peak demand months and allow the water system to meet maximum day demands in excess of the capacity of the upgraded water treatment plants.

It should be noted that the water supply available under Permit 1838 is the same water supply that would provide the yield of the locally preferred Brownsville Weir and Reservoir. It is possible that an ASR strategy could be developed in conjunction with the reservoir with a larger combined yield than that provided by the reservoir alone. However, on-channel reservoir and ASR project has not been evaluated and it is not certain whether the individual yields would be additive or whether the combined yield would be more or less than the sum of the individual yields.

5.6.8.1.3 Cost

Preliminary costs were developed for a 10-mgd ASR facility as described conceptually above. It is estimated that an ASR system with a firm recovery capacity of 10 mgd would consist of 12 to 16 wells at four or five locations within the PUB system. Based on the limited information currently available, the capital and engineering costs associated with this system would be approximately $8.5 million. Total annual costs, which include debt service and operations and maintenance, are estimated to be $1.23 million per year, which results in an annualized unit cost of $150 per acre-foot. It should be noted that these cost estimates are based on the assumption that existing surface water diversion, treatment, and distribution facilities would be utilized to provide water to the ASR well locations.

5.6.8.1.4 Environmental Impacts

Potential environmental impacts associated with development and operation of an ASR system would likely be minimal. There would be some disturbance during the drilling of ASR wells but once completed, there would minimal permanent impacts. Other potential impacts include increases in the potentiometric water surface of the groundwater near ASR well fields and improved groundwater quality over the long term.

5.6.8.1.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. In addition to the above, there are several other implementation issues associated with ASR projects. Foremost is the issue of protection of the stored water supply from other users. Under the common law doctrine of rule-of-capture, which underpins Texas groundwater law, landowners have the right to develop and withdraw groundwater from beneath their lands. This creates the potential for nearby landowners to withdraw water supplies placed into a formation through artificial means, such as with an ASR system. Controlling access to water supplies developed through ASR could be achieved through municipal ordinances which prohibit drilling of private wells within a city's corporate boundaries or through contracts with neighboring landowners. ASR projects also require regulatory approval by the TNRCC Public Drinking Water Program and issuance of a Class V injection well permit. Potential impacts on cultural resources due to well construction and operation are expected to be minimal. Some impact may result, however, from pipeline construction and use. Therefore, pipelines should follow existing and shared ROWs whenever possible to minimize the area of disturbance.

5.6.8.1.6 Recommendation

The City of Brownsville Public Utilities Board (PUB) has indicated that ASR is not a preferred water management strategy in their local water supply plan. The PUB intends to develop the water supply available under Permit 1838 through the construction of the Brownsville Weir and Reservoir.

5.6.8.2 ASR in Laredo, Texas

5.6.8.2.1 Strategy Description

The results of the ASR system investigation for the City of Laredo, submitted in October of 1996, suggest that an ASR system may be a feasible alternative for the City of Laredo to meet future water demands and provide a backup supply of water for emergency or drought demands. Several potential benefits an ASR system could provide the City were identified. These include system operation benefits in helping to meet peak demands, possibly postponing or eliminating a future WTP in the northern portion of the City, and providing treated water storage and pumping in areas of growth within the City distribution system. Additionally, an ASR system could provide large volume storage of treated water for use during periods when the quality of water in the Rio Grande is poor or during periods of low river supply or drought.

Limited available data suggest that there are three potential aquifers beneath Laredo with similar characteristics: brackish water quality and moderate yield. It was therefore determined that the most cost effective option would be to develop ASR wells in the shallowest aquifer, the Laredo Formation. A full-scale ASR system with an average design capacity of 10 mgd would require 28 injection/recovery wells drilled to an average depth of 600 feet.

5.6.8.2.2 Water Supply Yield

The ASR system investigated for Laredo would have an average design capacity of 10 mgd but would only yield approximately 5,600 acre-feet of water per year or one-half that of a comparable system for Brownsville. This is indicative of aquifer properties in Laredo that are less suitable for ASR than the aquifers in the Brownsville area. Also, it should be noted that Laredo's ability to divert surface water from the Rio Grande for an ASR project is constrained by its water rights. Unlike Brownsville, there are no "excess flows" in the Rio Grande that could be developed with an ASR project. Rather, Laredo can only divert Rio Grande water up to its annual authorized water rights amounts. As such, development of an ASR system, while potentially providing other benefits, would not generate significant amounts of additional water supply.

5.6.8.2.3 Cost

Preliminary costs were developed for a 10-mgd ASR facility as described conceptually above. It is estimated that an ASR system for Laredo would consist of 28 wells at various locations within the Laredo water system service area. The capital and engineering costs associated with this system would be approximately $5.1 million. Total annual costs, which include debt service and operations and maintenance, are estimated to be nearly $1.5 million per year, which results in an annualized unit cost of $261 per acre-foot. It should be noted that these cost estimates are based on the assumption that existing surface water diversion, treatment, and distribution facilities would be utilized to provide water to the ASR well locations.

5.6.8.2.4 Environmental Impacts

Potential environmental impacts associated with development and operation of an ASR system would likely be minimal. There would be some disturbance during the drilling of ASR wells but once completed, there would minimal permanent impacts. Other potential impacts include increases in the potentiometric water surface of the groundwater near ASR well fields and improved groundwater quality over the long term.

5.6.8.2.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted. In addition to the above, there are several implementation issues associated with ASR projects. Foremost is the issue of protection of the stored water supply from other users. Under the common law doctrine of rule-of-capture, which underpins Texas groundwater law, landowners have the right to develop and withdraw groundwater from beneath their lands. This creates the potential for nearby landowners to withdraw water supplies placed into a formation through artificial means, such as with an ASR system. Controlling access to water supplies developed through ASR could be achieved through municipal ordinances which prohibit drilling of private wells within a city's corporate boundaries or through contracts with neighboring landowners. ASR projects also require regulatory approval by the TNRCC Public Drinking Water Program and issuance of a Class V injection well permit. Potential impacts on cultural resources due to well construction and operation are expected to be minimal. Some impact may result, however, from pipeline construction and use. Therefore, pipelines should follow existing and shared ROWs whenever possible to minimize the area of disturbance.

5.6.8.2.6 Recommendation

Given that an ASR system for Laredo would likely provide little net additional water supply, ASR is not recommended as a strategy for meeting Laredo's future water supply needs.

5.7 STRATEGIES FOR REDUCING IRRIGATION SHORTAGES

As discussed previously in this chapter and in Chapter 4, irrigated agriculture will experience substantial water supply shortages under drought-of-record conditions and, even with significant projected reductions in irrigation demand, irrigation shortages are projected to increase throughout the 50-year planning period. Under the demand scenario adopted for this plan, irrigation shortages under drought-of-record conditions are approximately 580,000 acre-feet per year at present and will increase to approximately 600,000 acre-feet per year in 2050. However, it should be noted that actual irrigation shortages may be more in the range of 200,000 to 400,000 acre-feet per year. This is because average irrigation demand over the past decade has been significantly lower (approximately 1.1 million acre-feet per year) than the projected demand adopted for planning purposes (1.5 million acre-feet per year in 2000).

Because of the economics of farming, the amount that irrigators can afford to pay for water is limited. Consequently, development of new water supply sources for irrigated agriculture – whether surface or groundwater – is not seen as a viable strategy. There nevertheless are strategies that could significantly reduce irrigation demand or increase the available supply of water for irrigation. These strategies are: water conservation; modification of state rules for the operation of the Amistad-Falcon Reservoir System; reuse of reclaimed water; brush management; and weather modification. In addition, while not a water management per se, transfers of irrigation supplies among agricultural users is a strategy for minimizing the economic impacts of water shortages. Each of these strategies has been considered for possible inclusion as recommended water management strategies in this regional water plan. The results of those evaluations are presented below.

5.7.1 Agricultural Water Conservation

Water conservation in the agricultural sector represents a strategy both for reducing the magnitude of projected irrigation shortages as well as a potential strategy for "freeing up" additional Rio Grande water supplies for future domestic-municipal-industrial (DMI) needs. Consequently, a major element of the water planning process for the Rio Grande Region has been to refine regional estimates of the achievable water conservation potential in irrigated agriculture. For this planning effort, water savings estimates were developed for the five counties within the region with significant irrigation demands: Cameron, Hidalgo, Maverick, Starr, and Willacy. The current studies have confirmed the findings of previous investigations - there are significant opportunities to reduce irrigation water demands through the implementation of measures to reduce water losses in irrigation district conveyance and distribution facilities and through the implementation of measures to improve on-farm water use efficiency. The results of studies conducted by the Texas Agricultural Experiment Station (TAES) are documented in reports entitled, *Potential Water Savings in Irrigated Agriculture for the Rio Grande Planning Region* (December 2000) and *Estimated Costs of Implementation for Irrigated Agriculture in Rio Grande Planning Region* (August 2000). The complete report can be found in Volume II of this plan.

5.7.1.1 Conveyance and Distribution Efficiency Improvements

5.7.1.1.1 Strategy Description

The Texas Agricultural Experiment Station (TAES) evaluated and developed water savings and cost estimates for a comprehensive program to rehabilitate and improve the management of irrigation conveyance and distribution facilities in the four of the five subject counties. Starr County was not included in this analysis as there are not extensive irrigation water conveyance and distribution facilities in that county. The program would consist of six principal components:

- Installation of no-leak gates;
- Installation of additional water measurement weirs;
- Conversion of smaller concrete canals that are in poor condition to pipeline;
- Relining of concrete-lined canals that are in poor condition;
- Lining of smaller earthen canals constructed of more porous soils; and,
- Implementation of verification program to monitor and measure the effectiveness of the efficiency improvements.

5.7.1.1.2 Water Supply Yield

Based on studies conducted for this planning effort, TAES estimates that irrigation district conveyance and distribution losses could be reduced by nearly 160,000 acre-feet per year during drought conditions and by nearly 211,000 acre-feet per year under average conditions. The lower water savings estimates for drought conditions are based lower overall water demands due to water availability constraints. These estimates are based on improving the average conveyance/distribution efficiency from present levels, which average 70.8 percent, to an average of 90 percent. Table 5.9 summarizes the estimated water savings from conveyance and distribution efficiency improvements for the five counties evaluated.

Table 5.9: Potential Water Savings From Irrigation District Water Conveyance and Distribution Improvements

County	**Average Conveyance Efficiency (%)**	**Water Supply Scenario (ac-ft/yr)**		**Water Savings Potential (ac-ft/yr)**	
		Normal	**Drought**	**Normal**	**Drought**
Cameron	69.8	307,109	251,678	62,036	50,839
Hidalgo	72.4	623,416	469,823	109,721	82,689
Maverick	67.0	118,390	73,091	27,229	16,810
Willacy	65.0	47,831	37,174	11,958	9,293
Region M	**70.8**	**1,096,746**	**831,766**	**210,944**	**159,631**

The amount of water savings that can be realistically achieved through water conveyance and distribution system improvements is likely to be less than the estimates shown. Not all conveyance improvements are economically attractive under current conditions and other factors will likely limit the degree to which efficiency improvements are implemented. For example, investments in conveyance and distribution improvements would best be targeted at areas where urbanization is not expected to encroach on irrigated lands and there irrigation water distribution facilities are like to be in service for the long-term. Also, the limited financial capacity of irrigation districts and limited sources of outside financial assistance will likely affect the rate and degree to which savings are realized.

In recognition of the practical limitations on the implementation of irrigation conveyance and distribution improvements, the Rio Grande RWPG has adopted a scenario whereby 75 percent of the estimated water savings under drought conditions would be achieved by 2020. Thereafter, efficiency levels would be maintained through the remainder of the planning period. Table 5.10 reflects the water savings estimates under this scenario.

Table 5.10: Potential Water Savings from 75 Percent Level of Investment In Irrigation Conveyance and Distribution Improvements (ac-ft/yr)

County	2000	2010	2020	2030	2040	2050
Cameron	0	19,065	38,129	38,129	38,129	38,129
Hidalgo	0	31,008	62,017	62,017	62,017	62,017
Maverick	0	6,304	12,608	12,608	12,608	12,608
Willacy	0	3,485	6,970	6,970	6,970	6,970
Region M	**0**	**59,862**	**119,724**	**119,724**	**119,724**	**119,724**

5.7.1.1.3 Cost

In addition to water savings estimates, TAES also prepared cost estimates for implementation of irrigation conveyance and distribution improvements according to the scenario presented above. Cost elements evaluated include capital outlays, contingencies, operation and maintenance costs, and costs for an on-going program to verify the impacts of improvements. Table 5.11 presents the results of the cost analysis by county for the 75 percent implementation scenario.

Table 5.11: Cost Estimates for 75 Percent Level of Investment in Irrigation Conveyance and Distribution Improvements

County	Water Savings (ac-ft/yr)	Total Project Cost ($1,000s)	Total Annual Cost ($1,000s)	Annual Unit Cost per Ac-ft
Cameron	38,129	$41,075	$7,473	$196
Hidalgo	62,017	$20,581	$3,753	$61
Maverick	12,608	$22,047	$4,017	$319
Willacy	6,970	$14,701	$2,677	$384
Region M	**119,724**	**$98,404**	**$17,920**	**$150**

It is important to note that there are other potential benefits associated with irrigation conveyance and distribution improvements that are not reflected in the water savings or cost-estimates. For example, to the extent that diversions are reduced energy costs for pumping will be reduced. Also, replacement of open canals and laterals with pipeline will significantly reduce maintenance costs and may allow irrigation districts to dispose of excess right-of-way. Conveyance and distribution improvements will also reduce water losses associated with the delivery of DMI water supplies and will improve the quality and reliability of service provided to agricultural producers.

5.7.1.1.4 Environmental Impacts

Generally, the direct environmental impacts associated with implementation of irrigation conveyance and distribution improvements would be minimal. However, construction activities could impact ecological and cultural resources to the extent that such resources occur in areas targeted for improvements. Specifically, areas in proximity to the known habitat of threatened and endangered species should be identified prior to construction activities and appropriate measures should be taken to minimize any adverse impacts. Improvements to irrigation conveyance and distribution facilities could also result in impacts to wetlands and other habitat that occur in areas where canal seepage indirectly contributes water supply. These potential impacts should be investigated more thoroughly prior to undertaking improvements.

5.7.1.1.5 Implementation Issues

There are several impediments to the implementation of large-scale canal rehabilitation projects and other types of conveyance efficiency improvements. These include inadequate information at the irrigation district level about specific capital improvements, the potential impacts of urbanization on rehabilitation planning, and access to financing for capital improvements.

The information generated by the investigations undertaken for this planning effort fall short of what is required for large-scale investments to occur in conveyance and distribution efficiency improvements. Ideally, each irrigation district should undergo a systematic hydrologic and engineering evaluation of its water delivery facilities and management policies to identify cost-effective water efficiency improvements.

In developing a canal rehabilitation or capital improvement plan, most irrigation districts need to pay particular attention to identifying those portions of their distribution systems that should be targeted for improvements. For example, investments should generally be directed to areas where water distribution facilities are likely to stay in service for an extended period. Also, in areas that are experiencing rapid urbanization (e.g., western Hidalgo County), the evaluation of water efficiency improvements might best be done on a cooperative basis involving several districts. This would facilitate the identification and evaluation of strategies for the consolidation of district facilities. For example, significant water savings might occur if an isolated block of irrigated acreage were served by an adjoining irrigation district, thereby allowing retirement of under-utilized and inefficient water distribution facilities.

Despite the importance of further planning and engineering evaluations, irrigation districts may lack the financial and/or technical resources to undertake such planning on their own and may therefore require outside assistance. This could include technical assistance from state or federal agencies, such as the Texas Water Development Board (TWDB), the Texas Agricultural Extension Service (TAES), the USDA Natural Resources Conservation Service (NRCS), and the U.S. Bureau of Reclamation. Also, the costs of front-end project planning could be included in loans from the TWDB for agricultural water conservation projects. Another option is to “internalize” the costs of front-end planning as part of the overall costs of transactions involving the sale of “conserved” water to DMI users. For example, the buyer of conserved water might provide up-front funding for project planning and engineering with agreement that such costs would be credited to the purchase price for the water rights.

A lack of funding is often cited as the primary impediment to the implementation of irrigation conveyance and distribution improvements. A common view is that many irrigation districts lack the capacity to finance major capital improvements on their own. Districts often cite concerns about the ability of agricultural producers to absorb increases in either flat rate assessments or water delivery charges that might result from major capital improvement projects. Nonetheless, there are several options for self-financing of improvements by irrigation districts as well as for third party financing. These options are discussed below.

Options for self-financing of water efficiency improvements by irrigation districts include:

- Pay-as-you-go funding from operating revenues;
- Loans through commercial lending institutions; and,
- Loans from the Texas Water Development Board.

Pay-as-you-go funding of improvements from operating revenues would lend itself to a long-term system rehabilitation program whereby improvements are implemented in phases that are matched to revenue availability. For example, a district might budget a set amount annually from operating revenues for capital improvements. This approach has the advantage of avoiding the interest costs associated with debt financing. However, current water users would bear the full costs of such improvements through their flat rate assessments and/or water delivery charges. One way to minimize rate impacts on irrigators would be to dedicate a portion of any revenues derived from DMI water sales, or from DMI water deliveries, to fund capital improvements. If structured appropriately, this approach could provide an on-going source of revenue to fund improvements. Revenues from DMI water sales would be used for improvements that free-up additional water for conversion and sale to DMI use, which would generate additional revenues and so forth.

Under state law, irrigation districts have the authority to finance capital improvements through the issuance of general revenue bonds backed by tax revenues, through the issuance of revenue bonds, or through loans from commercial or public lending institutions, such as the TWDB. Irrigation districts also have the authority to impose special assessments for improvements made to a portion of their water conveyance and distribution system. Such assessments are made only on the users that benefit directly from the improvements. Voter approval of tax assessments and special assessments is required.

The feasibility and attractiveness of using debt financing of improvements depends in large measure on the overall financial health of each irrigation district. Some irrigation districts may not be considered credit worthy – due to a lack of credit history or poor fiscal performance – and would therefore find it difficult to attract investors to their revenue bonds or to obtain commercial loans without paying excessively high interest rates.

An advantage of debt financing of water irrigation efficiency improvements is that all of the funds required for a major capital improvement program could be obtained in advance, thus assuring a source of funds for completion of the program. However, as with pay-as-you-go funding, debt financing requires the commitment of a stable revenue stream to service the debt. Debt service could be from revenues derived from flat rate assessments and/or revenues from irrigation water sales. It would also be possible to establish a dedicated stream of revenues based on future DMI water sales. This would likely entail a long-term contractual relationship with one or more DMI users whereby the DMI user(s) would agree to purchase increasing amounts of conserved water as it becomes available on take-or-pay basis.

There are also a number of options for third party financing of irrigation water efficiency improvements. One approach would be for individual irrigation districts and DMI users to enter into partnership arrangements whereby the DMI user provides the funds required for improvements in exchange for access to some portion of the conserved water, either through outright purchase of water rights or through long-term water sale contract. Similarly, a voluntary consortium of DMI users could be formed to finance irrigation efficiency improvements in exchange for access to additional water supplies. Under this arrangement, each DMI user would obtain additional supplies proportionate to their share of the funding of improvements. Another potential approach would be to create a regional water authority for the purpose of financing irrigation efficiency improvements and to distribute DMI water supplies made available from such improvements. This concept is discussed in detail in Chapter 6. Finally, private sector entities could similarly finance efficiency improvements and acquire rights to conserved water for subsequent re-sale to DMI users.

5.7.1.2 On-Farm Water Conservation

5.7.1.2.1 Strategy Description

For the current planning effort, TAES also investigated the extent to which irrigation demands could be reduced through adoption of on-farm water conservation measures. Such measures include farm-level water measurement (a.k.a. metering) and volumetric water pricing, replacement of field ditches with poly or gated pipe, and adoption of improved water management practices and irrigation technologies. It should be noted that the investigation conducted by TAES provides documentation that a significant degree of on-farm water conservation measures have already been adopted.

On-farm water conservation offers a large potential to reduce volume of water used for irrigation in agriculture. Technologies currently available for on-farm water conservation include 1) drip, 2) low energy precision application, 3) irrigation scheduling using an evapotranspiration network, 4) plastic pipe, 5) metering, 6) unit pricing of water, 7) water efficient crops and 8) other options.

Water savings estimates were prepared for two scenarios: on-farm water savings without improvements to irrigation conveyance and distribution facilities and on-farm savings with such improvements. The amount of water that reaches the field turnout is partially dependent upon conveyance efficiency, which also influences the type of on-farm water conservation measures that can be applied. For example, insufficient "head" at the delivery point can make it difficult to irrigate a field efficiently no matter what irrigation methods or technologies are used. Similarly, certain irrigation technologies, such as drip and micro irrigation, require near continuous delivery of relatively small amounts of water. Most existing irrigation conveyance and distribution systems were designed to deliver large volumes of water over relatively short time periods.

5.7.1.2.2 Water Supply Yield

On-farm water savings estimates by county under drought conditions are presented in Tables 5.12 and 5.13 for the two scenarios described above. As with estimates of water savings from conveyance improvements, estimates of on-farm water savings were developed for both "normal" and "drought" conditions. However, for purposes of this plan, only the estimated savings under drought conditions are included here.

Table 5.12: Achievable On-Farm Water Savings With Conveyance Efficiency Improvements Under Drought Conditions (ac-ft/yr)

Measure	**Cameron**	**Hidalgo**	**Maverick**	**Starr**	**Willacy**	**Total**
Measurement	10,420	19,451	0	0	0	29,871
Gated Pipe	15,403	28,753	888	0	2,275	47,319
Improved Management/ Technology	27,181	56,741	7,894	1,516	4,015	97,347
Total	**53,004**	**104,945**	**8,782**	**1,516**	**6,290**	**174,537**

Table 5.13: Achievable On-Farm Water Savings Without Conveyance Efficiency Improvements Under Drought Conditions (ac-ft/yr)

Measure	**Cameron**	**Hidalgo**	**Maverick**	**Starr**	**Willacy**	**Total**
Measurement	8,081	15,647	0	0	0	23,728
Gated Pipe	11,946	23,130	661	0	1,643	37,380
Improved Management/ Technology	12,648	24,491	3,526	1,516	1,740	43,921
Total	**32,675**	**63,268**	**4,187**	**1,516**	**3,383**	**105,029**

For the purposes of this plan, the Rio Grande RWPG adopted an implementation scenario for on-farm water conservation measures based on implementation of the conveyance and distribution improvements previously described and in which investments in on-farm water conservation measures and the resultant water savings are to be "ramped up" or phased in over the 50-year planning period. This is in recognition that implementation of on-farm water conservation measures requires acceptance and adoption (i.e., expenditure) by individual agricultural producers. The rate of implementation of on-farm water conservation measures is 25 percent of the estimated achievable on-farm water savings by 2010, increasing to 50 percent by 2020. Thereafter, an additional 10 percent per decade of additional investment and savings would be achieved, resulting in 80 percent of the estimated achievable on-farm savings being "captured" by 2050. The projected impacts of this implementation scenario are shown in Table 5.14.

Table 5.14: Potential On-Farm Water Savings With Conveyance Improvements and Phased Implementation (ac-ft/yr)

Measure	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Measurement	0	7,468	14,936	17,923	20,910	23,897
Gated Pipe	0	11,830	23,660	28,391	33,123	37,855
Improved Management/ Technology	0	24,337	48,674	58,408	68,143	77,878
Total	**0**	**43,635**	**87,270**	**104,722**	**122,176**	**139,630**

5.7.1.2.3 Cost

The costs associated with the implementation of on-farm water conservation measures has also been evaluated for the implementation scenario described above. Cost elements include capital costs and contingencies, operation and maintenance, education and technical assistance, and on-going verification of the impacts of on-farm water conservation measures. These estimates are summarized in Tables 5.15 through 5.19.

Table 5.15: Cost Estimates for 25 Percent Level of Investment in On-Farm Water Conservation Measures – 2010 (Cumulative)

County	**Water Savings (ac-ft/yr)**	**Capital Costs ($1,000)**	**Annual O&M & Verification Costs ($1,000)**	**Total Annual Costs ($1,000)**	**Annual Unit Cost ($/ac-ft)**
Cameron	13,251	$11,138	***$1,888***	$3,365	$254
Hidalgo	26,236	***$15,658***	$2,605	$4,695	$179
Maverick	2,196	$1,972	$315	$582	$265
Starr	379	$1,200	$192	$355	$937
Willacy	1,573	$2,867	$450	$840	$534
Region M	**43,635**	**$32,835**	**$5,450**	**$9,838**	**$225**

Table 5.16: Cost Estimates for 50 Percent Level of Investment in On-Farm Water Conservation Measures – 2020 (Cumulative)

County	**Water Savings (ac-ft/yr)**	**Capital Costs ($1,000)**	**Annual O&M & Verification Costs ($1,000)**	**Total Annual Costs ($1,000)**	**Annual Unit Cost ($/ac-ft)**
Cameron	26,502	$22,274	$3,776	$6,730	$254
Hidalgo	52,473	$31,310	$5,210	$9,390	$179
Maverick	4,391	$3,944	$630	$1,164	$265
Starr	758	$2,400	$384	$710	$937
Willacy	3,145	$5,734	$900	$1,680	$534
Region M	**87,269**	**$65,670**	**$10,900**	**$19,676**	**$225**

Table 5.17: Cost Estimates for 60 Percent Level of Investment in On-Farm Water Conservation Measures – 2030 (Cumulative)

County	**Water Savings (ac-ft/yr)**	**Capital Costs ($1,000)**	**Annual O&M & Verification Costs ($1,000)**	**Total Annual Costs ($1,000)**	**Annual Unit Cost ($/ac-ft)**
Cameron	31,802	$26,730	$4,531	$8,076	$254
Hidalgo	62,967	$37,574	$6,252	$11,268	$179
Maverick	5,269	$4,733	$756	$1,397	$265
Starr	910	$2,880	$461	$852	$937
Willacy	3,774	$6,882	$1,080	$2,016	$534
Region M	**104,722**	**$78,799**	**$13,080**	**$23,609**	**$225**

Table 5.18: Cost Estimates for 70 Percent Level of Investment in On-Farm Water Conservation Measures – 2040 (Cumulative)

County	Water Savings (ac-ft/yr)	Capital Costs ($1,000)	Annual O&M & Verification Costs ($1,000)	Total Annual Costs ($1,000)	Annual Unit Cost ($/ac-ft)
Cameron	37,103	$31,186	$5,286	$9,422	$254
Hidalgo	73,462	$43,836	$7,294	$13,146	$179
Maverick	6,147	$5,522	$882	$1,630	$265
Starr	1,061	$3,360	$538	$994	$937
Willacy	4,403	$8,028	$1,260	$2,352	$534
Region M	**122,176**	**$91,932**	**$15,260**	**$27,544**	**$225**

Table 5.19: Cost Estimates for 80 Percent Level of Investment in On-Farm Water Conservation Measures – 2050 (Cumulative)

County	Water Savings (ac-ft/yr)	Capital Costs ($1,000)	Annual O&M & Verification Costs ($1,000)	Total Annual Costs ($1,000)	Annual Unit Cost ($/ac-ft)
Cameron	42,403	$35,642	$6,041	$10,768	$254
Hidalgo	83,956	$50,098	$8,336	$15,024	$179
Maverick	7,026	$6,935	$1,008	$1,836	$261
Starr	1,213	$3,840	$616	$1,136	$937
Willacy	5,032	$9,174	$1,440	$2,688	$534
Region M	**139,630**	**$105,689**	**$17,441**	**$31,452**	**$225**

5.7.1.2.4 Environmental Impact

There are no known direct or indirect environmental impacts associated with the on-farm water conservation measures evaluated for implementation in the Rio Grande Region. Rather, in addition to reducing water demands and the magnitude of projected irrigation shortages, on-farm water conservation measures have generally been found to also provide water quality benefits inasmuch as tail water runoff is minimized.

5.7.1.2.5 Implementation Issues

In looking to the future and adoption of on-farm water conservation strategies, there are several factors that impact the rate of adoption. A major factor relates to water rights being held by the irrigation district. In the absence of an incentive structure for the producer, the investment in distribution technologies cannot be justified. The value of water savings needs to be shared with the agriculture producer.

Irrigation scheduling is being practiced across the U.S. and other regions of Texas. This technology requires an evaporation-transpiration network as well as specific crop water coefficients. Typically neither the network or crop coefficients are available for South Texas. This can be addressed by research and education but takes time and investment.

Metering and per unit pricing typically are resisted in regions where they are not used. Metering requires an initial investment by either the producer or the irrigation district, suggests bureaucracy and imposes a cost for excessive water use. Plastic pipe is somewhat impacted by the initial investment and potential impact on labor requirements for irrigation.

Often, water efficient crops or breeding programs to reduce crop water requirements are proposed to save on-farm water use. Unfortunately, the lowest water-using crop is often the lowest value crop. Hence, economics and farm profitability become driving forces in farmer crop selections. Using plant breeding programs and biotechnology offer an opportunity to reduce plant water dependency. However, this requires sophisticated and expensive science as well as significant time.

Therefore, there are no quick fixes to reduce on-farm water use dramatically. Texas has a low interest loan program for agriculture which can be used to purchase water conserving distribution systems. However, the producer still must repay the loan. Without an incentive to benefit from reduced water use adoption, this is going to be very slow. The constraints to on-farm water conservation can be summarized as 1) water rights do not reward producers for conservation, 2) investment requirements an disconnect of benefits to the producers and 3) limitations of science on crop water requirements and time to develop new cultivars.

Implementation of on-farm water conservation measures will require individual agricultural producers to adopt new irrigation technologies and management practices. As noted previously, there has already been a significant degree of adoption of on-farm water conservation measures by producers in the Rio Grande Region. However, to achieve the recommended rates of implementation, it will be important to expand state and federal technical assistance programs, provide incentives (e.g., cost-sharing), and/or financial assistance (e.g., low-interest loans). Also previously noted, the degree to which on-farm water savings can be achieved is partially dependent upon improved efficiencies of irrigation conveyance and distribution facilities. To some extent, such improvements are required in advance of adoption of on-farm water conservation measures. It is therefore essential that the required technical assistance and financial resources be brought to bear on irrigation conveyance and distribution improvements as soon as possible.

5.7.2 Modification of State Rules for the Operation the Amistad-Falcon Reservoir System

The water rights system for the middle and lower Rio Grande is administered by the State of Texas through the Office of the Rio Grande Watermaster, which is an administrative unit of the Texas Natural Resource Conservation Commission (TNRCC). The Rio Grande Watermaster allocates available water supplies to holders of water rights, monitors actual diversions, and maintains a water use accounting system. According to the TNRCC's rules for the "Operation of the Rio Grande" (Title 30, Texas Administrative Code, Chapter 303), waters allocated to the United States are managed in three "pools" in the Amistad-Falcon Reservoir System: an operating reserve, a domestic-municipal-industrial (DMI) reserve, and the irrigation and mining water rights accounts. The origin of this three-pool water management and accounting system is the 1969 decision of the Thirteenth Court of Civil Appeals in the landmark case styled "State of Texas, et al. vs. Hidalgo County Water Control and Improvement District No. 18, et al.", which is commonly referred to as the Rio Grande Valley Water Case.

The purpose of the "operating reserve" is to provide for: 1) the loss of water by seepage, evaporation and conveyance; 2) emergency water requirements; and, 3) adjustments in the computations of water ownership between the United States and Mexico, as performed by the International Boundary and Water

Commission (IBWC). Current TNRCC rules state that whenever water is available in the Amistad-Falcon Reservoir System, the operating reserve should be maintained between 275,000 acre-feet and 380,000 acre-feet, depending on the amount of United States stored water in the reservoirs. However, during periods of water shortage, the operating reserve is allowed to decrease to 150,000 acre-feet. In unusually dry periods when reservoir inflows are insufficient to maintain the operating reserve at 150,000 acre-feet, TNRCC rules require the Rio Grande Watermaster to implement a "negative allocation". This involves shifting water from the irrigation and mining storage accounts to make up the deficit in the operating reserve. All irrigation and mining accounts with storage balances are reduced proportionately to achieve a total amount equivalent to the operating reserve deficit. When additional inflows to the reservoir system become available, these reductions in the irrigation and mining accounts are restored before any other water is allocated to the accounts.

The DMI reserve is intended to provide DMI water users with a high degree of assurance of uninterrupted water supplies under severe drought conditions. Historically, the DMI reserve has been set approximately equal to annual DMI water use. At present, the DMI reserve is set at 225,000 acre-feet. Originally, this reserve was established by the appellate court at 60,000 acre-feet in the Falcon Reservoir for the lower Rio Grande but has since been increased periodically as irrigation water rights have been converted to DMI use.

At the beginning of each calendar year, the individual accounts for DMI water rights are restored to their fully authorized annual diversion amounts. Unused DMI account balances from the previous calendar year are returned to reservoir storage and reallocated within the total of all DMI accounts. Each month, the Rio Grande Watermaster debits DMI water rights accounts for any reported use and then allocates available inflows into the reservoir system to maintain the DMI reserve at the full 225,000 acre-feet. By this approach, approximately a one-year supply of water for DMI needs is maintained as a drought reserve in the reservoir system at all times.

The third pool established under the TNRCC rules is comprised of the storage balances of the irrigation and mining water rights. Irrigation and mining water rights have a perpetual reservoir storage account that functions much like a checking account. Withdrawals from individual accounts are made monthly based on reported diversions and “new” water is added to the accounts only when reservoir inflows exceed diversions, evaporation, and other system losses; and the amounts required to maintain the operating and DMI reserves. Importantly, the accumulated irrigation and mining account balance for a particular water right is carried over from month-to-month and year-to-year up to a maximum of 1.41 times authorized annual diversion amount of the water right. This permits irrigation and mining water users to save a portion of their storage account balance (up to 41 percent of their authorized annual diversion amount) for use in the following year.

5.7.2.1 Strategy Description

Under the water rights system described above, irrigation and mining water uses are a “residual” claimant to available water supplies from the Amistad-Falcon Reservoir System. During extended periods of low inflows to the reservoir system, when there are little or no allocations made to irrigation and mining storage accounts, these users deplete their storage accounts and may suffer shortages. Consequently, irrigated agriculture bears the brunt of drought in terms of supply shortages and the associated economic costs of such shortages. As previously discussed, irrigation water users in the Rio Grande are projected to experience significant shortages under drought-of-record hydrologic conditions.

The operating reserve and the DMI reserve have the effect of setting aside a significant portion of the firm yield of the Amistad-Falcon Reservoir System, thereby reducing the amount of water that otherwise could be allocated for beneficial use. As noted in Chapter 3, simulations to determine the firm yield of the reservoir system indicate that the minimum amount of water stored by the United States in the reservoirs during the critical drought period is approximately 650,000 acre-feet. This occurs largely because of the requirement that the operating reserve and the DMI reserve be fully restored and maintained each month. In effect, the reservoir storage reserve requirements provide an additional supply of water beyond the firm yield of the system. Under a typical firm yield analysis for a reservoir or reservoir system, the minimum amount of water in storage during the critical period would be zero (0).

The reservoir system yield analyses described in Chapter 3 suggest that there may be ways to effectively increase the supply of water from the Amistad-Falcon Reservoir System by modifying current State policy with respect to the operating and DMI reserves. Specifically, reducing the amount of water held in storage to maintain the reserves would increase the amount of water available for allocation to irrigation and mining water rights accounts. As such, modification of the current TNRCC rules regarding the operating reserve and the DMI reserve was investigated as a potential feasible strategy for increasing the supply of water available from the Rio Grande for irrigation or, alternatively, as a strategy for reducing the magnitude of projected irrigation shortages.

5.7.2.2 Water Supply Yield

Simulations using the Reservoir Operations Model (ROM) for the Amistad-Falcon Reservoir System were performed to determine the water supply effects of a broad range of alternative storage levels for the operating and DMI reserves. The key question addressed by this analysis is whether the supply of water available for beneficial use can be increased through changes in TNRCC rules without affecting the reliability of DMI water supplies. To answer this question, simulations were performed to quantify the effects of both increases and decreases in the reserve levels. In simple terms, the simulations confirm that increases in the amount of water held in reserve results in decreases in the amount of water available for allocation to irrigation users while decreases in the reserve levels result in increases in the supply that could be allocated to irrigation users. For example, an increase in the DMI reserve from 225,000 acre-feet to 300,000 acre-feet would reduce the firm yield for irrigation and mining uses by approximately 25,000 acre-feet per year. Conversely, eliminating both the operating and DMI reserves altogether would increase the firm annual yield for irrigation and mining uses by nearly 150,000 acre-feet.

To assist with the review and interpretation of the results of the reservoir simulations, a special working group was established by the Rio Grande RWPG which included members of the RWPG and non-member "stakeholders" representing both DMI and irrigation water users. The Rio Grande Watermaster also participated as a member of the working group. In addition, the Rio Grande Watermaster Advisory Committee was also consulted. From this process, consensus emerged on several key findings and conclusions, which include the following:

- The historical policy of periodically increasing the level of the DMI reserve to an amount equal to DMI use or authorized DMI diversions does not have a sound hydrologic basis and should be discontinued.
- The operating reserve levels can be reduced from present levels without adversely impacting DMI water users.

- Reservoir inflows, which are a key element of the reservoir system's firm yield, provide a very high degree of reliability for the available water supply for DMI users, even during a repeat of the critical drought. The current level of the DMI reserve could therefore be reduced without adversely affecting the reliability of DMI supplies. However, a DMI reserve of at least 60,000 acre-feet should be maintained (i.e., the amount set by the appellate court in the Rio Grande Valley Water Case).
- With improved modeling capabilities and experience with the operations of the reservoir system, the TNRCC rules for the "Operation of the Rio Grande", particularly with regard to the reserves, should be re-evaluated periodically (e.g., every four years) and modified as appropriate.

At the time of this writing, no consensus has been reached among the stakeholders on specific proposals for modifying the TNRCC rules for the DMI reserves. However, the Rio Grande RWPG has adopted a recommendation with the following elements:

1. Establish maximum Operating Reserve as a fixed amount at 75,000 acre-feet.
2. Allow Operating Reserve to be reduced down to zero as necessary when reservoir inflows are not sufficient to offset system losses and municipal diversions in a given month.
3. Make Negative Allocations from Irrigation and Mining accounts when the remaining Operating reserve is less than zero, with the amount of the total Negative Allocation sufficient to restore the Operating reserve to 48,000 acre-feet.
4. After a Negative Allocation has been made in one month, continue normal reservoir storage accounting in subsequent months until the Operating Reserve is fully restored to 75,000 acre-feet.
5. Make Positive Allocations to Irrigation and Mining accounts each month when sufficient excess inflows to the reservoirs are available as determined by the Watermaster.
6. Continue to maintain the DMI reserve at 225,000 acre-feet.

5.7.2.3 Cost

Other than the administrative costs for the TNRCC to amend the rules for the "Operation of the Rio Grande", there are no direct costs associated with implementation of changes to current policies regarding the reservoir operating reserve and the DMI reserve.

5.7.2.4 Environmental Impact

There are no known direct or indirect environmental impacts associated with modifying the current TNRCC rules for the "Operation of the Rio Grande".

The effect of reducing the operating reserve from its current level of 150,000 acre-feet down to 75,000 acre-feet will result in an initial transfer of 75,000 acre-feet of water in storage from the operating reserve to the irrigation accounts. No immediate change in the total reservoir storage will occur; hence, there will be no sudden lowering of the reservoirs and used downstream. The use of this additional water could result in slightly lower reservoir levels and slightly higher flows in the Rio Grande downstream of the reservoirs. Neither of these potential hydrologic effects would be appreciable and should not result noticeable changes in existing environmental conditions. The 66,000 acre-feet of increased yield that is projected for the reservoir system for the United States represents approximately six percent of the current yield, and assuming that this additional yield will be used for irrigation purposes, the associated changes in projected reservoir and steamflows is not expected to be appreciable.

5.7.2.5 Implementation Issues

The primary impediment to the modification of the current TNRCC rules to reduce the levels of the operating and DMI reserves is public misperceptions about the hydrology of the lower and middle Rio Grande, and the perception that such a change would lessen the reliability of DMI water supplies to critical levels. There is consensus that an outreach effort is needed to educate DMI water rights holders, decision-makers, and the general public about the hydrology of the Rio Grande as it relates to the reliability of DMI supplies and the potential benefits of changes to the current TNRCC rules that would increase the supply of water available for irrigation.

5.7.3 Use of Reclaimed Water

Agricultural irrigation with reclaimed water (i.e., appropriately treated municipal wastewater effluent) offers potential as a supplemental source of supply for irrigation. Based on data compiled in 1996 for a *Survey of Water Reuse Programs in Texas,* 35 Texas cities provide reclaimed water for agricultural irrigation. In Florida and California, agricultural irrigation accounts for approximately 34 percent and 63 percent of the total volume of reclaimed water used, respectively. Use of reclaimed water for irrigated agriculture has been identified as a potentially feasible strategy for reducing irrigation shortages in the Rio Grande Region, particularly in the areas of the Lower Rio Grande Valley where urbanized areas are in close proximity to large tracts of irrigated lands. In addition to providing a supplemental source of water supply, reuse of reclaimed water provides a reliable and essentially un-interruptible supply even during drought. Reclaimed water can also provide nutrients that are of value to agricultural production.

For this planning effort, previous studies of the feasibility of agricultural reuse of reclaimed water in the Rio Grande Region were reviewed. The results were updated and are summarized below. A technical memorandum entitled, Rio Grande RWPG, Evaluation of Desalinization (January 2001), presents the evaluation in its entirety and can be found in Volume II of this plan.

5.7.3.1 Strategy Description

This strategy involves the use of reclaimed water as a substitute or supplemental water supply for agricultural irrigation. In 1997, the cities of McAllen and Edinburg participated in a study to evaluate various water reuse opportunities and options. In addition to evaluating options for non-potable reuse for DMI uses, the study examined the feasibility of large-scale reuse of reclaimed water for agricultural irrigation. Specifically, the study proposed using effluent from the City of McAllen's No. 2 wastewater treatment plant as a source of supply for agricultural irrigation. The strategy evaluated would involve additional treatment of approximately one-third of the effluent from the plant using microfiltration and reserves osmosis to remove dissolved solids and sodium in the product water. The desalinized product water would then be mixed with the other two-thirds of the effluent from the plant, which is treated to secondary standards, to achieve an acceptable level of water quality. Although the level of treatment required for agricultural reuse depends on the specific requirements of the crops to be irrigated, it was assumed that the reclaimed water supply must be of equal or better quality than the raw water supply from the Rio Grande. The one-third desalinized to two-thirds secondary effluent blending ratio appears to satisfy this assumption.

5.7.3.2 Water Supply Yield

For this planning effort, a region-wide assessment of the potential supply available from agricultural reuse of reclaimed water was not conducted. However, it is conceivable that a significant amount of the treated wastewater effluent generated from DMI uses within the region could be made available for agricultural irrigation. In practical terms, the same limitations on reuse potential for DMI uses that were described previously in Section 5.3.2 would apply to agricultural reuse of reclaimed water. Specifically, the proximity of the reclaimed water supply to potential users is a primary factor affecting the economic feasibility of agricultural reuse. Also, the suitability of the quality of the reclaimed water for specific crop applications is a concern. For the Rio Grande Region, agricultural reuse as a water management strategy is primarily applicable to agricultural uses in Cameron and Hidalgo counties, although there may be some potential in other areas of the Rio Grande Region as well. Agricultural reuse of reclaimed water is considered most applicable to these counties because of the close proximity of large tracts of irrigated lands to urbanized area served by central wastewater collection and treatment facilities.

The option evaluated as part of the McAllen/Edinburg reuse study was based on a 6.0 million gallon per day project (2.0 MGD desalinized, 4.0 MGD secondary effluent). Assuming all of the reclaimed water produced is reused, this size project would provide 6,721 acre-feet per year of water supply.

5.7.3.3 Cost

As with non-potable reuse for DMI uses, the costs of agricultural reuse of reclaimed water are influenced by various factors, many of which are site specific (e.g., proximity of supply to users, water quality, etc.). For the purposes of this plan, however, the cost estimates prepared for the McAllen/Edinburg reuse feasibility study were updated and are considered representative of the costs of this strategy in other settings. Two scenarios were considered. The first scenario would provide a total of 6.0 MGD for agricultural reuse only and included treatment facilities, a pump station, and two miles of force main to deliver the water to areas of use. The updated annualized cost of reclaimed water for this scenario, treated and delivered, is $201 per acre-foot. The second scenario evaluated was for a combination of potable reuse and non-potable reuse. The costs for the non-potable reuse component for agricultural irrigation was estimated to be $191 per acre-foot per year.

5.7.3.4 Environmental Impact

The principal environmental issue pertaining to agricultural reuse of reclaimed water is the suitability of the quality of the water supply for irrigation of crops, particularly crops grown for direct human consumption. Another important issue associated with the agricultural reuse strategy described above is the disposal of the brine concentrate from the desalination treatment processes. In the study cited, it was assumed that concentrate could be discharged to the Arroyo Colorado at existing permitted outfall locations using existing facilities. The concentrate could have localized impacts on water quality in the

Arroyo Colorado. Extensive use of reclaimed water would decrease wastewater return flows, which could impact in-stream flows, water quality in stream reaches that have historically received wastewater return flows, and biological productivity. However, the overall pollutant loading to the stream could decrease significantly from present levels as nutrients, dissolved solids, and other constituents entrained in the reclaimed water supply would not be discharged to the stream.

5.7.3.5 Implementation Issues

As with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. Additionally, project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted.

Other key issues associated with the implementation of agricultural use of reclaimed water include public acceptance, acceptance by irrigators that would use the water, and regulatory approvals. Although practiced in other areas of the United States, irrigation of food crops with reclaimed water has not gained public or regulatory acceptance in Texas. It may therefore be necessary to limit the use of reclaimed water to irrigation of fiber and forage crops and other agricultural commodities that are not destined for direct human consumption. Alternatively, an additional safety factor could be gained by blending relatively small volumes of reclaimed water with the large volumes of raw water in irrigation canals. This could also have the advantage of reducing costs to convey reclaimed water from the source to the user.

5.7.4 Re-Evaluation of Irrigation Water Supply Availability

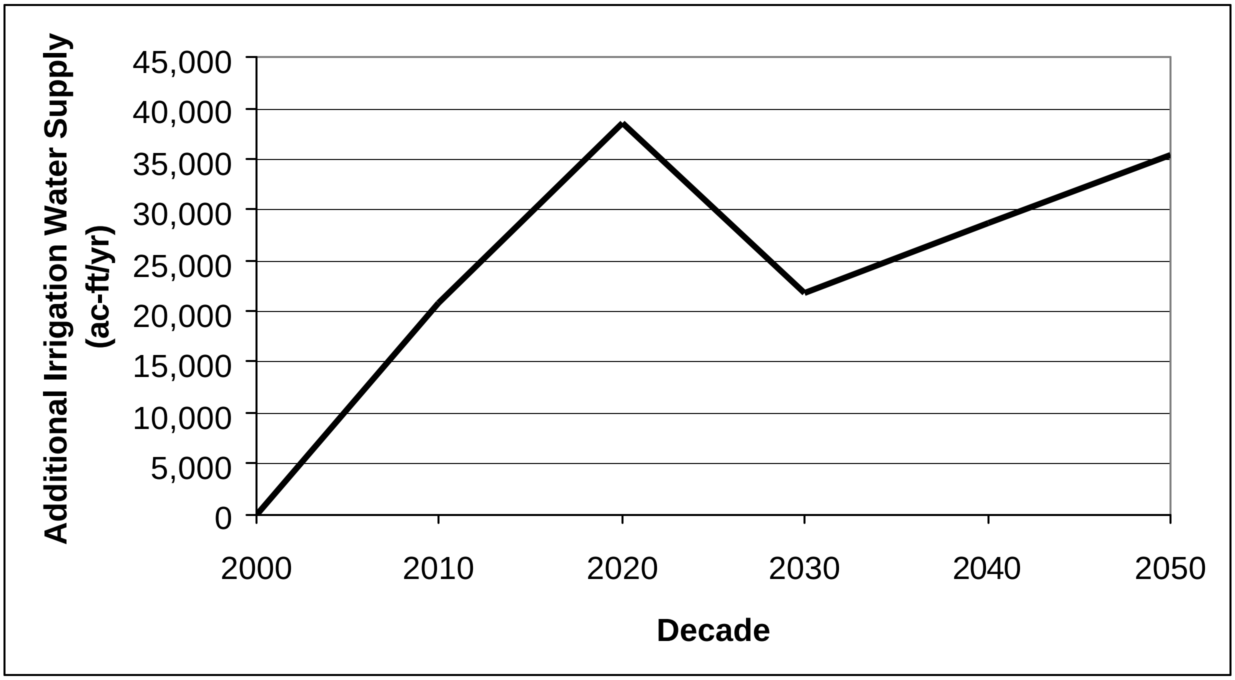
As previously noted, estimates of the quantity of water available for irrigation under drought-of-record conditions are based on the assumption that all current DMI users of water from the Rio Grande would have all of their projected future water needs met from the Rio Grande. Under this scenario, approximately 270,000 acre-feet of additional DMI water demand would be met from the Rio Grande in 2050. At a two-to-one conversion rate, this would require that approximately 540,000 acre-feet of irrigation rights be converted to DMI use by 2050. Combined with reduced reservoir yields due to losses to reservoir storage from sedimentation, this level of conversion of irrigation rights results in significant decreases in the projected availability of irrigation supplies through the planning period. However, based on the recommended strategies for meeting DMI presented in Section 5.3 above, the amount of additional Rio Grande supply required to meet DMI uses has been reduced to 134,100 acre-feet in 2050, or the equivalent of 268,200 acre-feet of irrigation rights prior to conversion to DMI use. In essence, reductions in projected DMI needs through conservation and diversification of water supplies is a management strategy for increasing the future availability of irrigation supplies in the region. Page 5-57 dealing with the DMI reserve: It should be noted that the amount held in reserve in the reservoirs, creates a constant reservoir loss charge since reservoir losses (evaporation, transportation, etc.) is charged based upon a proration of water owned by the U.S. and Mexico. Irrigation supply availability has therefore been re-evaluated to account for reduced DMI needs for Rio Grande supplies. The results of this re-evaluation are presented below (Table 5.20 and Figure 5.18). As the table shows, the volume increases vary dramatically from county to county and decade to decade. For example, in the year 2010, the smallest increase occurs in Webb County (77 ac-ft/yr) and the largest is in Hidalgo County (11,359 ac-ft/yr). However, when these water volumes are translated to percent increase values, the county irrigation water supply increases become very similar from decade to decade, with a regional average of 2.8 percent for 2010, and 5.8 percent average for 2050.

Table 5.20: Increases in County Irrigation Water Supply Availability From the Rio Grande Due to Re-Evaluation of Projected DMI Needs

County*	2000	2010	2020	2030	2040	2050
Cameron	0	6,085	11,481	6,745	8,875	10,961
Hidalgo	0	11,359	20,359	10,972	14,437	17,830
Maverick	0	1,767	3,395	2,042	2,687	3,319
Starr	0	611	1,165	701	923	1,140
Webb	0	77	145	86	114	140
Willacy	0	899	1,825	1,157	1,523	1,881
Zapata	0	31	58	35	46	57
Region M Total	**0**	**20,828**	**38,430**	**21,739**	**28,605**	**35,328**

**Jim Hogg Co. does not project a deficit within the 50-year planning period, therefore it was not included in the DMI re-evaluation.*

Figure 5.18: Region M Total Increases In Irrigation Water Supply Availability Due to Re-Evaluation of Projected DMI Needs*



*The water supply source used for the re-evaluation was the Amistad-Falcon Reservoir System for DMI water supplies.

5.7.5 Weather Modification

Sparked by recent droughts, there has been a resurgence of interest in Texas in the science and practice of weather modification or rainfall enhancement. Currently, there are 10 TNRCC permitted weather modification programs operating in Texas covering approximately 44 million acres. Many of these programs have received partial funding through the TNRCC. There are currently two weather modification programs that overlap the Rio Grande Region. The Texas Border Weather Modification Association covers an area below the Big Bend to beyond Eagle Pass and includes Kinney, Maverick, and Val Verde counties as members. The program is based in Del Rio and is expected to become financially self-sufficient in 2001. The second program is the Southwest Texas Rain Enhancement Association, which is based in Carrizo Springs and has a target area encompassing Dimmit, LaSalle, Webb, Zapata, and Zavalla counties. The program has recently become self-sufficient and will operate on a year-round basis.

Weather modification has been evaluated as a potentially feasible water management strategy for the Rio Grande Region. The results of that evaluation are summarized below. A technical memorandum entitled, *Weather Modification in the Rio Grande Region* (June 2000) is provided in the technical appendix to this plan (Volume II).

5.7.5.1 Strategy Description

In a typical, growing thundercloud, there are up to billions of cloud droplets that possess the potential to become raindrops. Seeding a cloud, typically with silver iodide, introduces more of the ice crystals that are required for the conversion of cloud droplets in rain. Aircraft equipped with flares that contain silver iodide are typically used to seed clouds. Cloud seeding appears to work best when two criteria are met. First, the target clouds must have strong enough updrafts to carry moisture to elevations where temperatures are suitable for the artificial nucleation of rain droplets. Second, updrafts within the cloud cannot be strong enough to transport the water to elevations where complete natural freezing occurs. As a rule, updraft velocities should be similar to the terminal fall velocity of the raindrops at that level, approximately 10 meters per second. Cloud seeding can be counterproductive, however, if it is done too late in the cloud's life cycle.

Cloud seeding is most effective in times of normal or wetter-than-normal weather. During a drought, the number of treatable convective clouds is greatly reduced. Although there is some evidence of the efficacy of cloud seeding during dryer-than-normal periods, cloud seeding is best viewed as long-term water management strategy.

5.7.5.2 Water Supply Yield

In each of the existing programs that have been active for more than five years, the average annual rainfall in the target area increased by a significant amount. This increase was anywhere from 20 percent in some cases up to 45 percent in others. The potential amount of additional acre-feet of rainfall per year obtained from the implementation of a cloud seeding program in the RGRWPG has been calculated. The calculation was somewhat conservative according to the literature; a 20 percent increase was assumed.

Unfortunately, though, a large increase in rainfall does not necessarily mean a large increase in dependable water supply that becomes available in surface or subsurface storage. According to the 1999 Annual Report published by the Colorado River Municipal Water District (CRMWD), the average rainfall in the target area of their cloud seeding program was 29 percent higher than the average rainfall for the 24-year period that the program has been in operation. This is equivalent to an increase in annual average rainfall of 11.61 inches. When applied to the 2.24 million acres this program covers, the additional rainfall in the area would produce 2.17 million acre-feet of water. Because the main purpose of this program is to increase the volume of water in Lakes Thomas and Spence, it is important to note the volume of water that was added to these lakes. In Lake Thomas, 42,414 acre-feet of water were added and 15,125 acre-feet of runoff were added to Lake Spence, giving a total of 57,539 acre-feet. In other words, the amount of rain that went to added storage in the lakes was 0.0265 percent of the rain that was observed in the area.

There are several factors that would either help or hurt the amount of increased rainfall that becomes available in reservoir storage. For example, the amount of rainfall the area has experienced prior to additional rainfall is important. When the ground is dry, a large portion of the rain is absorbed in the earth and does not become run off. On the other hand, the more urbanization in the area, i.e. parking lots and sidewalks, the less water can be absorbed in the ground.

As a water management strategy, the purpose of a rain enhancement program in the Rio Grande Region would be to increase storage in the Amistad and Falcon Reservoirs. Using the ratio of rainfall to water added to storage obtained from the CRMWD program, a cloud seeding program in the Rio Grande Region could be expected to increase reservoir storage by only 695 acre-feet per year. However, it should be noted that the true benefit of weather modification may lie in improving soil moisture conditions in the target area, both for dry land farming and ranching and for irrigated farming. To the extent that increased rainfall occurs during irrigation periods, irrigation water supplies would be conserved as a result of decreased demand.

It should also be noted that an effective cloud seeding program for the Rio Grande Region would require participation by Mexico as the largest portion of the Rio Grande watershed that contributes flows to the Amistad-Falcon Reservoir System is within the Rio Conchos Basin in Mexico.

5.7.5.3 Cost

The average cost associated with weather modification programs funded by the TNRCC and other agencies is $0.08 per acre of program coverage. The CRMWD has budgeted $0.0614 per acre for 2001. The Texas Border Weather Modification Association, once they become self-sufficient, will spend $0.035 to $0.04 per acre or approximately $175,000 per year to operate their program. The Southwest Texas Rainfall Enhancement Association has estimated their program cost to be $0.092 per acre. Based on a cost of $0.08 per acre of coverage, a cloud seeding program covering all of the counties of the Rio Grande Region would cost approximately $576,500 per year. The cost per acre-foot of increased rainfall would be only $0.22. However, the cost per acre-foot of additional water in reservoir storage would be $821.

5.7.5.4 Environmental Impact

An issue commonly raised about cloud seeding is the potential environmental impact of the silver iodide used in the seeding programs. All of the data from existing programs shows that the concentration of silver iodide in precipitation obtained from a seeded cloud is much lower than the limit established by the United States Public Health Service. No significant environmental impacts have been observed around cloud seeding programs, including those that have been active for more than 30 years.

5.7.5.5 Implementation Issues

There are a number of potential problems associated with weather modification programs. Some are technical problems that must be avoided through effective operating practices, some are public opinions that must be dealt with through education, and some are a combination of both. For example, a common perception is that cloud seeding reduces the amount of rain that would ordinarily fall on lands downwind of the target area. A group of ranchers even filed suit against Southwest Weather Research, Inc. in 1959, and the case went to the Texas Supreme Court. The Court, however, ruled that the cloud seeding could continue because all Texans are entitled to the water above them, even if it is in the clouds. In addition, several current sources claim that there is no evidence that seeding contributes to less rainfall anywhere else.

Another potential problem linked with cloud seeding involves hail. In addition to rainfall enhancement, cloud seeding has also been used for hail suppression, which is a stated objective of the program operated by the Southwest Texas Rainfall Enhancement Association. Research in other parts of the country has shown that rainfall-enhancement programs very likely lessen the amount and size of hailstones by reducing the amount of cloud moisture available to growing hailstones. Seeding clouds to suppress hail, though, seems to increase the efficiency with which the clouds convert the cloud droplets into rain. Available evidence shows that seeding for hail suppression actually decreases rainfall from seeded storms.

Arguments for and against the use of cloud seeding to minimize hail losses came to the High Plains area in the 1970s. Operators of a local program asserted that seeded areas suffered much less hail damage than was typical, but the unseeded areas suffered three times more hail damage than was typical. The Ranchers and Farmers Association for Natural Weather was formed and protests were made to the TWDB and to the Texas Legislature. The argument was that cloud seeding programs to control hail should not be allowed unless a majority of the property owners affected approved of them. As a result, these programs were discontinued in the state.

There are also significant institutional issues associated with weather modification as a water supply augmentation strategy for the Rio Grande Region. First, because of the manner in which water rights in middle and lower Rio Grande are administered, increasing storage in the Amistad-Falcon Reservoir System would not benefit DMI users. DMI water rights holders are authorized to use up to a specified quantity of water during each calendar year. Increasing the amount of water in reservoir storage would therefore not increase the amount of water available to DMI users. Rather, any increase in inflows to the reservoir system would only affect the irrigation and mining pool. Also, even long-term increases in inflows to the reservoir system would not result in an increase in the firm yield of the reservoir system. The methodology for calculating firm yield is based on a backward look at historical conditions. The only time one would re-compute the firm yield of a reservoir would be if a drought worse than the historical drought-of-record were to occur, in which case firm yield would be reduced.

5.7.5.6 Recommendation

The Rio Grande RWPG recommends that the weather modification program be continued in the future in this region for augmenting water supplies.

5.7.6 Brush Control

Like weather modification, the control or management of certain invasive brush species has gained increasing attention as a potentially feasible water management strategy. For the current planning effort, brush control was considered as a strategy for enhancing irrigation water supplies in the Rio Grande Region. A report entitled, *Reconnaissance-Level Evaluation of the Feasibility of Brush Control to Enhance Water Supplies* (June 2000) is provided in Volume II of this plan and is summarized below.

5.7.6.1 Strategy Description

Research on brush control and its effects on water balance began in the 1920s, but the idea of brush control as a strategy for alleviating water scarcity in drought-prone areas of the western United States started to take hold in the 1970s. The control of brush species can yield more water, but the effects are dependent upon rainfall variations and many other landscape variables. Past research has predicted that the removal of woody plant species from rangeland can yield an additional three-tenths of an inch of surface flow water for each inch of rainfall above 15 inches. This is possible where deep-rooted brush species are replaced with shallow-rooted, deciduous, low-biomass herbaceous species. Other benefits of brush control are also cited, such as improved range conditions for ranching and improved groundwater conditions.

For the Rio Grande region, a program to control brush would be targeted at the 2.3 million acres of land within the region that drain to the Amistad-Falcon reservoir System. Land cover classifications deemed suitable candidates for brush control in this target area are “Mesquite or Acacia Shrubland” and “Mesquite-Juniper Shrubland”. An analysis of land cover data indicates that approximately 936,000 acres of land in the target area was covered with these two types of brush. Considering soil types that are most conducive to producing favorable results from brush control, the amount of land considered suitable for treatment within the region is reduced to approximately 485,000 acres. The preferred method of control would be to kill and remove the entire brush plant as this lessens brush re-growth and the need for brush control maintenance.

5.7.6.2 Water Supply Yield

Using the results of research conducted elsewhere in Texas, estimates were developed for the amount of water supply enhancement from brush control in the Rio Grande Region. One study in the North Concho watershed estimated a yield enhancement of 0.02 acre-feet/acre/year with 95 percent brush control in the target area. Applied to the eligible acres within the Rio Grande Region, 96,830 additional acre-feet of water would be generated over a ten-year period (9,683 ac-ft/yr). Alternatively, another study conducted on the North Concho watershed estimated off-site water yield from brush control to average 0.076 acre-feet/acre/year for all types of range conditions. Applied to the entire 936,000 acres of land within the region that contributes flows to the Amistad-Falcon Reservoir System, the total yield over a ten-year period would be 711,360 acre-feet (71,136 ac-ft/yr).

It should be noted that the actual water supply yield from brush control during extreme drought conditions may be much less than indicated above. As mentioned, the efficacy of brush control as a water management strategy is in doubt in areas that receive less than 15 inches of rainfall per year. Average rainfall in much of the target area within the Rio Grande Region is below 15 inches per year and is significantly lower during the frequent periods of drought that affect the region.

5.7.6.3 Cost

For the two alternatives described above, a cost of $30.51 per acre of land treated was used to develop cost estimates for a brush control program. In the first example, the total up front costs of a brush control program implemented over a ten-year period would be $14.77 million. Assuming a ten-year project life and a six percent discount rate, the cost of the additional water is $207 per acre-foot. However, extending the program to 30 years may also require extensive, repeated treatment or removal in addition to routine maintenance. Absent data or experience, it is considered prudent to assume that the costs would triple in extending removal and maintenance activities from 10 to 30 years. This would result in a cost of $332 per year per acre-foot of additional yield. For the second example, the estimated cost for a ten-year brush control program is $28.56 million. This equates to approximately $55 per acre-foot of additional yield. Extending the program to 30 years results in a total estimated cost of $85.68 million and a cost of approximately $87 per year acre-foot of additional yield.

5.7.6.4 Environmental Impact

Extensive brush control poses potentially significant environmental impacts. Most notable would be the potential impacts on terrestrial habitat of rare, threatened, or endangered species, both as a result of brush removal operations and from long-term changes in habitat. In areas of the Edwards Plateau where brush control research is underway, selective brush removal is required to avoid or minimize impacts to the habitat of certain listed endangered species. If such concerns and measures were applied to a brush control program for the Rio Grande it would likely reduce the effectiveness of the program by further limiting the amount of land that could be treated and by limiting the percentage of brush that could be removed from treated lands. Brush control may also negatively impact the LRGV economy since brush clearing would be detrimental to bird watching activity in this region.

5.7.6.5 Implementation Issues

Funding is the most significant impediment to widespread implementation of brush control programs. While some state that cost sharing is available, the lack of other third-party sources of funding would cause much of these costs to be borne by private landowners that may not benefit directly from the water supply enhancements. Also, as with weather modification, the realities of the Rio Grande water rights system is that supply enhancement from brush control would only benefit irrigation and mining water rights holders.

5.7.7 Retaining Irrigational Rights Associated with "Excluded" Properties

As was discussed in DMI strategies under 5.6.4, one of the common means for municipalities to acquire additional water supplies occurs through the exclusion process under §49.309 of the Texas Water Code. Through this process, property proposed for development is accepted by a municipality who in turn request the irrigation district to re-allocate the irrigation rights associated with the property to a non-irrigation use. A modification to this strategy would allow a portion of the water rights to remain as irrigation rights that could be used on other properties.

5.7.7.1 Strategy Description

As development proceeds in the future, water use characteristics should reflect the projected savings anticipated from expected conservation techniques as well as the propose advanced conservation techniques. In addition, land use planning could establish certain tracts of land requiring less water when converted for urban use. Commercial properties, for example, might be considered to use far less water than residential properties (except during extreme events).

The combination of municipal conservation and land use planning potentially results in a residual water availability between the current irrigative land use and the further land use. This excess water could remain as irrigation water and be transferred to another tract of land. The process could be established to allow for a varying percentage of water remaining with the irrigation district, potentially for an offsetting fee or associated retained investment by the district that would otherwise have been charged to the municipality.

5.7.7.2 Water Supply Yield

The total yield of this strategy has not been determined. It is estimated that as much as 270,000 acre-feet of irrigation water will be lost as urbanization of the Rio Grande basin continues. A substantial portion of this water is attributed to the exclusion process, and a portion may be attributed to §49.309 Water Code exclusions. In the latter event, a formal program could be established that is agreed upon by both municipalities and irrigators, that allows a percentage of water to remain as irrigation water based on land use type, thereby encouraging a continuation of the exclusion process and encouraging continued development at the same time.

5.7.7.3 Cost

No cost has been identified for this strategy, because it represents a retained investment by the district.

5.7.7.4 Environmental Impact

Environmental impacts would be as described in Section 5.6.4.4

5.7.7.5 Implementation Issues

Implementation issues would include consensus by both municipal and irrigation interests on how a §49.309 Water Code exclusion program can be equitably established.

5.7.8 Additional Recommended Strategies for Reducing Irrigation Shortages

In support for the implementation of the recommended agricultural water conservation strategies, the Rio Grande RWPG also recommends the following:

- Expanded technical assistance should be made available from local, state, and federal sources to assist irrigation districts with more detailed, systematic evaluations of district facilities and management policies to identify cost-effective water efficiency improvements. In lieu of direct technical assistance, funding should be made available for irrigation districts to procure the required professional services. Also, those districts with the greatest potential water savings should be identified and given priority for technical assistance.

- All irrigation districts within the region should evaluate and implement comprehensive programs to improve the efficiency of water conveyance and distribution facilities. Irrigation districts, with technical assistance from state and federal agencies, should also encourage and/or assist irrigators with the implementation of on-farm water efficiency measures. On-farm water conservation programs should include measurement of on-farm water deliveries and adoption of conservation-oriented water pricing policies as appropriate and where feasible.

- Municipal water users requiring additional Rio Grande water supplies should develop partnerships with irrigation districts for the purpose of investment in water efficiency improvements in exchange for access to a portion of the conserved water supply. Particular emphasis should be placed on establishing partnerships between municipal water users and those districts with the greatest potential water savings. To ensure optimal implementation of irrigation efficiency projects and equal access to the benefits of such projects, multiple municipal water users should be encouraged to participate jointly in the development of such projects through voluntary association or through the creation of a regional governmental entity with the powers to plan, finance, and implement water conservation and water supply projects.

- The State of Texas and the federal government should assist with the financing of irrigation water efficiency improvements through the provision of low-interest loans and/or grants. As with technical assistance programs, those districts with the greatest potential water savings should be identified and given priority for financial assistance. In addition, the State should implement plans, which encourage voluntary participation in farmland preservation.

It is also recommended that efforts continue to reach consensus on changes to the current TNRCC rules regarding the operating and DMI reserves for the Amistad-Falcon Reservoir System. Hydrologic analyses indicate that the amounts of water held in the reserves can be reduced significantly without adversely affecting the reliability of DMI supplies. Reducing the levels of the reserves and other modifications to current rules could significantly increase the supply of water available from the reservoir system for irrigation. Additionally, retaining irrigation water rights associated with “excluded” properties, if implemented, may help further reduce irrigation shortages.

5.8 OTHER WATER MANAGEMENT STRATEGIES

In addition to the strategies that were evaluated for meeting DMI needs and for reducing irrigation shortages, three strategies for improving the overall management that could optimize and increase the dependable water supply of the Rio Grande were also considered. These are: (1) improved management of the Rio Grande with an enhanced real-time monitoring system; (2) control of exotic vegetation in the lower reaches of the Rio Grande; and, (3) re-channelization of portions of the Rio Grande above the Amistad International Reservoir. While specific water supply benefits associated with these strategies have not been quantified, these strategies are believed to be of general benefit to all users of water from the Rio Grande. A discussion of each strategy is presented below.

5.8.1 Improved Real-Time Monitoring of the Rio Grande

The availability of real-time data from streamflow and meteorological monitoring stations is an important aspect of properly managing a complex river system such as the Rio Grande. Accurate current information regarding stream flows and rainfall is essential for operating the reservoir and floodway system of the Rio Grande during flooding periods, as well as for effectively and efficiently delivering water to municipalities and irrigation districts under normal flow conditions. From a water supply perspective, the installation and operation of a dedicated Supervisory Control and Data Acquisition System (SCADA) would provide real-time data for purposes of monitoring and managing river flows, including reservoir releases and diversions, thereby resulting in increased opportunities for more efficient water use and water conservation. This effort should be closely coordinated with Mexico to ensure that there is a comprehensive monitoring programs for the entire portion of the Rio Grande Basin that contributes flows to the middle and lower Rio Grande.

5.8.1.1 Description of the Existing Monitoring System

The monitoring of stream flows and meteorological conditions along the Rio Grande is currently performed by a number of federal, state and local governmental agencies. Downstream of Fort Quitman (Huspeth County, Texas; Region E), the daily measurement of stream flows at numerous points along the river and at the mouths of major tributaries is particularly important because of the provisions of the 1944 Treaty that require the division of the waters of the Rio Grande along this reach between the United States and Mexico. The administration of this Treaty on behalf of the United States is the responsibility of the United States Section of the International Boundary and Water Commission (IBWC), and, consequently, the operation and maintenance of much of the existing streamflow monitoring system for the Rio Grande, including the compilation and reporting of related data from other agencies, is a primary function of the IBWC. The IBWC publishes an annual Water Bulletin that includes listings of measured daily and monthly flows for all of the gages used in administration of the 1944 Treaty[3], as well as other related data and information.

In addition to the IBWC, other agencies involved in regular monitoring of streamflow and meteorological conditions along the Rio Grande include the U. S. Geological Survey (USGS), the U. S. Bureau of Reclamation, the National Weather Service (NWS) of the National Oceanic and Atmospheric

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[3] International Boundary and Water Commission, United States and Mexico; "Flow of the Rio Grande and Related Data, From Elephant Butte Dam, New Mexico to the Gulf of Mexico"; United States Section; El Paso, Texas; 1997 (most recent).

Administration (NOAA), the Rio Grande Watermaster of the Texas Natural Resource Conservation Commission (TNRCC), and some local entities such as the Maverick County Water Control and Improvement District No. 1. Across the border in Mexico, the Mexican Section of the IBWC also maintains streamflow gages on the Rio Grande and its major tributaries pursuant to the requirements of the 1944 Treaty, and during the last several years, Mexico's National Commission of Water (Comisión Nacional de Agua, CNA) installed an extensive network of 44 automated hydro-meteorological stations along the Rio Grande.

A listing of all of the flow gages that are operated by the IBWC, or by some other governmental entity in cooperation with the IBWC, at 55 locations along the Rio Grande from the mouth of the Rio Conchos (northwest of Ojinaga, Chihuahua, Mexico, and Presido, Texas) downstream is presented in the Table 1 of the associated technical memo within the technical appendix to this plan (Volume II). For each gage, its IBWC identification number and name are indicated. Those gages currently with telemetry capabilities and their respective modes of data transmission also are identified. The mode of data transmission is important because, according to IBWC personnel, telemetry via radio and telephone transmissions is more immediate (instantaneous), but typically limited in coverage to only a local area (such as an IBWC regional office). Satellite telemetry provides a more delayed response (up to four hours or so), but the data is accessible from practically anywhere (such as IBWC's El Paso headquarters office), thereby providing a better means for posting data on the Internet. The locations of the flow gages that are operated by the IBWC, or by some other governmental entity in cooperation with the IBWC, along the middle and lower Rio Grande are shown on the map presented in Figure 1 of the associated technical memo within the technical appendix to this plan (Volume II). The descriptive and location information for these gages has been compiled from IBWC's annual Water Bulletins and from discussions with IBWC personnel.

There are currently 44 automated hydro-meteorological stations operated by Mexico's CNA (listed in Table 2 of the associated technical memo within the technical appendix to this plan (Volume II). All of these stations are telemetered and, as indicated, practically all monitor stream stage. However, discharge ratings for these gages are apparently not available. The climatic parameters monitored at the stations always include precipitation and usually air temperature. Other parameters include relative humidity, wind velocity and direction, barometric pressure, solar radiation, salinity of water, pH of water, dissolved oxygen of water, and turbidity of water. The locations of these stations along the middle and lower Rio Grande are shown on the map presented in Figure 2 of the associated technical memo. Also shown in this figure are the locations of precipitation gages maintained by the U. S. National Weather Service (NWS).

5.8.1.2 Effective Use of the Existing Monitoring System

While the geographical coverage of the existing system of stream flow and meteorological monitoring stations along the middle and lower Rio Grande is fairly extensive, there are a number of deficiencies with the system that should be addressed in order to improve its utility with respect to flood operations and normal water supply deliveries such as improving the accessibility of the monitoring data, upgrading equipment at existing monitoring stations, and expanding the network of monitoring stations along the Rio Grande and its tributaries. Accessibility can be improved by implementing a program that would provide direct access of the monitoring stations' data from both Mexico and the United States, via telemetry, to all interested individuals and entities. Currently, some of the IBWC and NWS data are posted on the Internet and are available to users in both countries. Historical mean daily flows are available for most IBWC gages from IBWC's web site, and near instantaneous (delayed by several hours) flow data are available for some gages. Current river stage data and climatic parameters (also delayed by several hours) are available on the Internet from the NWS Hydrometeorological Automated Data System (HADS) for many of the IBWC gages, NWS stations, and most of Mexico's hydro-meteorological stations. However, it would be useful to tailor the existing databases on the Internet to the specific needs of river operators (IBWC and TNRCC Watermaster) and water users (cities, irrigation districts, etc.). This would likely involve creating a special web site for specific flow and climatic information related to the middle and lower Rio Grande

5.8.1.3 Enhancement and Expansion of the Monitoring System

Enhancement and expansion of the existing system of monitoring stations is also essential to the development of a comprehensive useful network of stream flow and meteorological monitoring stations along the middle and lower Rio Grande for the purpose of improving river operations for water supply. The U.S. Section of the IBWC currently has budget requests to Congress for funding to upgrade the existing system of telemetered flow gages; however, this does not include the installation of any new gages. Most of the funding is targeted for acquiring new up-to-date telemetry and gaging equipment to allow more instantaneous readings at the local and regional levels, and to provide more capability for posting a broader range of data on the web sites of the IBWC and other agencies. The comparatively low cost of implementation of this strategy when compared to the potential benefits to be achieved through improved capability suggests this strategy be considered for funding.

Certainly, the currently requested program enhancements would make the existing system much more useful; however, additional funding for new stations at strategic locations along the Rio Grande and its tributaries would improve the monitoring network and create a more comprehensive management tool for the waters of the Rio Grande. The most important measure would be to install additional flow gages to "fill in the gaps" in the coverage provided by existing gages. Because of the dense stands of aquatic vegetation that currently exist along much of the lower Rio Grande, gage data sometimes is questionable and unreliable. Additional gages, with appropriate telemetry, would provide more complete coverage and allow better checks and balances to be made with respect to the flows in the river at any particular time. This information would be particularly useful to the IBWC relative to the international ownership of the waters flowing in the river and to the TNRCC Watermaster with respect to the instantaneous quantities of water available in the river for diversion by Texas water rights holders. With more comprehensive and reliable flow information, releases of water from the Falcon Reservoir and the Anzalduas Reservoir could be more effectively coordinated with downstream demands. Based on discussions with personnel from the IBWC and from the Watermaster's office, 16 additional flow gage locations, with appropriate telemetry, have been identified, that would dramatically enhance the monitoring efforts on the Rio Grande (site listings and station descriptions are located in the associated technical memo within the technical appendix to this plan (Volume II).

5.8.1.4 SCADA System Budget and Implementation Schedule

Implementation of the various measures described above to provide an effective SCADA network for improving river operations related to water supply will require funding for a variety of purposes, including the purchase and installation of monitoring and telemetry equipment, the development of data processing and analysis systems, the development of data compilation and display features, and system operation and maintenance. Table 5.21 presents a general listing of these estimated expenditures in terms of both capital costs and annual costs.

With regard to a schedule for implementation of the SCADA System network and associated facilities, it is expected that the development of capabilities for better utilizing data and information from the existing streamflow and meteorological monitoring system could be undertaken as a first phase. It is anticipated that this could be accomplished over a two-year period. During this time, detailed planning for a more aggressive program involving the purchase and installation of new monitoring and telemetry equipment and the various required support capabilities could be undertaken. Hence, implementation of this second phase could begin in about two years and continue over the next five years or so depending on funding availability. It is envisioned that the overall SCADA System project would be an ongoing effort, with improvements and enhancements continuing over the long term. It is recommended that the project be sponsored through local, state and/or federal entities, and be implemented through the Watermaster's office.

Table 5.21: Cost Summary for Implementation of a SCADA Network and Associated Facilities and Capabilities

ITEM NO.	DESCRIPTION	QUANTITY	INITIAL CAPITAL COSTS ($)	ANNUAL O & M COSTS ($)
1	Development of Special River Operations Web Site for Displaying Data From Existing Monitoring Systems	1	$100,000	$20,000
2	Installation of Additional Flow Monitoring Stations on Rio Grande, Including Initial Discharge Rating	5	$100,000	$50,000
3	Installation of Diversion Monitoring Stations for BID, Brownsville PUB, Matamoros and CCID No. 6	4	$60,000	$20,000
4	Installation of Additional Flow Monitoring Station for Anzalduas Canal	1	$20,000	$7,500
5	Installation of Telemetry Systems for Additional Flow and Diversion Monitoring Stations	10	$80,000	$20,000
6	Installation of Enhanced Telemetry System for Existing Rio Grande Flow Gage Below Anzalduas Dam	1	$8,000	$2,000
7	Installation of Telemetry Systems for Existing Flow Gages on Mexican Tributaries Below Falcon Dam	2	$16,000	$4,000
8	Installation of Telemetry Systems for Existing Flow Gages on Mexican Tributaries Above Falcon Dam	6	$48,000	$12,000
9	Development of Data Processing and Analysis System for Telemetered Information	1	$150,000	$25,000
10	Development of Data Compilation and Display System for Telemetered Information	1	$100,000	$25,000
11	Contingency, 25%	1	$170,500	$46,375
	TOTAL COSTS		**$852,500**	**$231,875**

5.8.2 Control of Exotic Plant Species

The invasion of exotic plant species, specifically water hyacinth and hydrilla, into the lower Rio Grande and the irrigation canal systems has worsened the effects of recent drought in the Rio Grande Region. These plant species have gained a competitive advantage over native plant species and have in many cases grown out of control, interfering with the conveyance and distribution of Rio Grande water supplies.

Water hyacinth, *Eichhornia crassipes*, is a floating plant species that is native to South America. Water hyacinth has invaded 29 water bodies in Texas to date. In the Rio Grande Region, water hyacinth is found near Brownsville and as far upstream as Progresso, Texas (located in the southeast corner of Hidalgo County). In favorable environmental conditions, the plant is extremely aggressive. Established populations of water hyacinth have been found to double in size every 6-18 days.
Hydrilla, *Hydrilla verticillata*, is an underwater plant species native to Africa, Asia, and Europe. Hydrilla has been found in at least 85 water bodies in Texas. In the Rio Grande Region, hydrilla can be found in irrigation canal systems and in the Rio Grande from Falcon Dam (located on the southwestern boundary of Starr County) downstream to an area just upstream of Brownsville, Texas.

5.8.2.1 Strategy Description

Efforts are underway to find a cost-effective and environmentally acceptable means of either controlling or removing hydrilla and hyacinth from the Rio Grande and the water distribution canals. Hydrilla and water hyacinth may be controlled in three general ways: physical removal, biological control, and chemical control through the use of herbicides. To date, physical removal with mechanical, bank-based machines has been the only allowed method. Physical removal has the advantage of removing plant biomass without using artificial physical substances. The disadvantages of physical removal include the slow rate of removal, high cost, and the re-growth and potential spread of the infestation.

Biological control refers to the introduction of animal species that feed upon the exotic plant species. Species that have been considered include sterile grass carp, water hyacinth weevils, and hydrilla flies. Biological controls share the advantages mentioned for mechanical removal. Disadvantages include the possible spread of the foreign species beyond the target area and only partial removal of exotic plants.

Chemical control refers to the use of herbicides to remove water hyacinth and hydrilla. This option has the advantages of being relatively inexpensive and very quick acting, however, have possible negative environmental impacts. In addition, the United States and Mexico do not currently have compatible standards for the selection and use of herbicides.

According to the USFWS, a grass carp pilot project is being implemented and monitored in the fall of 2000, along the Rio Grande River. Twenty-five triploid grass carp are planned to be monitored for six months to see if they will stay within the project area and consume the hydrilla and water hyacinth where the problem areas exist. The grass carp monitoring is expected to find if they escape from the Rio Grande, as well as to find whether they do not escape into the Arroyo Colorado and Laguna Madre where they can negatively impact the vegetation including sea grasses that shrimp and sea turtles depend on.

According to the USFWS, the water hyacinth weevils and hydrilla flies have been used with good success in the U.S. and Mexico. These two biological control species already exist in the valley. In some areas, the water hyacinth has had 100% control and in other areas it has stunted the plant growth. The hydrilla fly has had 50% reduction of hydrilla in two years. The biological control takes three to five years before showing good results; this is a long-term maintenance method. A combination of control methods is needed to maintain these two invasive species under control.

5.8.2.2 Water Supply Yield

Water hyacinth and hydrilla adversely impact the management of flows in the Rio Grande and in the irrigation canal systems. Water hyacinth increases evaporative water loss by as much as five times over that from open water. This increased evaporation is attributable to the increased surface area for transpiration to occur from the plant's leaves. Infestations of hydrilla increase the amount of water loss due to the damming effect of the plant. When water levels in the river channel are raised upstream of the infestation, absorption through channel banks is increased. In addition, absorption of solar radiation by the plants has the effect of increasing water temperature, which also induces a higher rate of evaporation.

As mentioned above, hydrilla often grows densely enough to act as a barrier to natural flow in Rio Grande and in distribution canals. This has the effect of increasing water levels upstream of the infested areas and impeding the flow downstream of through dense mass of vegetation. In some cases as much as 30 percent more water must be released from reservoir storage in order to ensure the needed flow of water passes though the hydrilla beds to the delivery location.

5.8.2.3 Cost

The removal or control of hydrilla and water hyacinth, while offering the potential to improve the management of Rio Grande water and reduce losses, will not provide additional reliable water supply that can be allocated to existing or future users. Rather, the benefit of a program to control or remove this vegetation will be to reduce overall losses from the Rio Grande system or to reduce losses experienced by individual water users. As such, cost cannot be expressed in the terms required by the SB 1 planning process. However, as a point of reference, it is worth noting that in 1998 over $100,000 was spent to mechanically remove hydrilla and hyacinth from an eight-mile stretch of the Rio Grande, just upstream of Brownsville.

5.8.2.4 Environmental Impacts

In addition to negative impacts on water supply, the presence of hydrilla and water hyacinth infestations has been found to have negative environmental impacts. These include a reduction in plant and animal diversity and changes to water quality in water bodies infested with these plants. Obstructions to river flow created by hydrilla may also have the potential to increase flooding. It has been suggested that these obstructions could increase upstream water surface elevations enough to cause flooding and could potentially compromise the integrity of some bridges along the river. Removal and/or control of hydrilla and hyacinth also pose environmental risk. As noted, mechanical removal poses the risk of spreading the vegetation. Use of herbicides poses risks to water quality and to aquatic and riparian habitat of native plant and animal communities. Biological controls also run the risk of creating unintended negative consequences. For example, sterile grass carp have been known to reproduce and reach populations that consume both the exotic and native plant communities.

5.8.2.5 Implementation Issues

Funding is a major consideration in the development of a program for the removal and/or control of hydrilla and water hyacinth. Funding for such a program must be both adequate to achieve the desired result and long-term to maintain this result, as eradication is not likely to be achieved through currently available measures. Also, because the benefits of removal/control are difficult to quantify and because the problem affects multiple water users on both sides of the border, developing a funding mechanism supported by some type of user fees would be problematic. The TPWD has a new Aquatic Vegetation Management Plan that can be used as a guideline. The project may need to comply with the ESA if any threatened and endangered species are impacted.

5.8.3 Re-Channelization/Restoration of the Rio Grande

5.8.3.1 Strategy Description

In 1970, the United States and Mexico signed a treaty that specifies the centerline of the Rio Grande main channel to be the boundary between the two countries. The 1970 Boundary Treaty also provides for the restoration and preservation of the river as the international boundary. This treaty was entered into largely in response to the sedimentation and general degradation of the character of portions of the Rio Grande channel. Specifically, portions of the channel along a 199-mile stretch of river from near Fort Quitman (located in Region E about 85 miles south of El Paso) to just upstream of the City of Presidio, Texas (located in Region E northwest of Big Bend National Park) had deteriorated due to sedimentation and the encroachment of vegetation, particularly salt cedar.

In 1979, the United States and Mexican federal governments approved an IBWC-recommended joint project for work to restore and preserve the Rio Grande's character along this 199-mile stretch. This project consisted of restoring the channel in stretches where the river, and therefore the international boundary, was difficult to locate due to silt and vegetation. In these reaches the channel was restored to a cross-section with an average depth of six feet, a bottom width of 16.4 feet, and a top width of 38 feet. In addition, a 56-foot wide area of land was cleared on either side of the river to act as a floodway and to prevent further degradation of the channel. Implementation of this project began in 1980.

5.8.3.2 Water Supply Yield

As noted, the primary purpose of the re-channelization project undertaken in the 1980s was for preservation of the international boundary between the United States and Mexico. Periodic removal of salt cedar and other vegetation, along with channel improvements, would likely increase flows in this stretch of the Rio Grande and allow the passage of more flows from upstream reaches of the river. This could serve to firm up existing water rights in this portion of the Rio Grande and could increase the number of events in which spills from upstream reservoirs (i.e., Elephant Butte) and other floodwaters reach Amistad Reservoir (Region J, northwest of Del Rio). It should be noted that to maintain such benefits it would be necessary to provide funding for an on-going channel maintenance program. Also, the potential effects of such river channel improvements on the firm yield of the Amistad-Falcon

Reservoir System have not been previously studied and such detailed hydrologic analyses are beyond the scope of the current study.

5.8.3.3 Cost

Costs for the previously completed re-channelization project were shared equally between the United States and Mexico. The final environmental impact statement for the project, completed in 1978, estimated total cost of the project to be $8.6 million, representing a present day value of $10 million. Because there have been no previous studies to determine the potential water supply benefits of an on-going channel/boundary maintenance program, it is not possible to develop an estimate of the costs of any additional water supply that might result from such a program. However, it is likely that any increase in firm yield would be small relative to the initial and on-going costs of maintaining the channel in this reach of the Rio Grande. Nonetheless, the potential water supply benefits should be evaluated and considered in an overall cost-benefit analysis of an on-going boundary maintenance program.

5.8.3.4 Environmental Impacts

The environmental effects of the boundary preservation project were studied extensively in the late 1970s. Numerous studies were conducted to determine the effect of the proposed project on the vegetation and wildlife in the area. These studies concluded that the proposed project would be of environmental benefit due to improved habitat both in and adjacent to the river. A new EIS would have to be done since the last one was completed in 1978 and new federally endangered species have been listed since then. Natural resource losses from the clearing of vegetation along the riverbank were to be mitigated by acquiring 295 acres of wetlands and constructing permanent ponds. In 1993, a study was conducted to try to measure the environmental effects of the boundary preservation project. The results of the study indicated some environmental improvement, but noted that the project had not been maintained as proposed. This lack of maintenance has resulted in less environmental benefit and improvement to the character of the channel than expected.

5.8.3.5 Implementation Issues

The primary issues affecting the implementation of a re-channelization project are funding and bi-national cooperation. Additionally, as with any project, necessary state and federal permits must be obtained before construction can begin, potentially including a Section 404, Clean Water Act Permit. The project may need to comply with the National Environmental Policy Act if federal funding is involved, and with the Endangered Species Act if any threatened and endangered species is impacted.

5.8.4 Recommendations

Opportunities to increase the available water supply from the Rio Grande are limited. Nonetheless, three management strategies are recommended for implementation or further study that could optimize and increase the dependable water supply from the Rio Grande. These are:

1. Improved real-time monitoring of the Rio Grande and major tributaries to minimize river conveyance losses and to maximize utilization of unregulated "excess" river flows (i.e., no-charge pumping). This effort should be closely coordinated with Mexico to ensure that there is a comprehensive monitoring program for the entire portion of the Rio Grande Basin that contributes flows to the middle and lower Rio Grande;
2. On-going control of hydrilla and water hyacinth vegetation infestations in the lower portions of the Rio Grande to minimize water losses associated with increased evapotranspiration, river channel bank losses, and increased releases from reservoir storage that are required to "push" flows through infested areas.
3. Re-channelization of portions of the Rio Grande upstream of Amistad International Reservoir.

The water supply benefits associated with improved real-time monitoring of the Rio Grande and control of exotic plant species cannot be quantified. It is nonetheless believed that these strategies will be of general benefit to water users throughout the region and should be implemented by appropriate state, federal, and/or regional agencies. The Rio Grande RWPG also supports the International Boundary and Water Commission's request for federal funding to thoroughly investigate the costs, benefits, and potential environmental impacts associated with re-channelization of portions of the Rio Grande above Amistad Reservoir. It is believed there is potential to increase the frequency and amount of flood flows that reach Amistad Reservoir through re-channelization and an on-going program to maintain channel improvements.

appendix 5.1

water management strategy data summaries

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CHAPTER 6.0: ADDITIONAL RECOMMENDATIONS REGARDING ECOLOGICALLY UNIQUE STREAMS, RESERVOIR SITES, AND POLICY ISSUES

In addition to making recommendations regarding strategies for meeting current and future water needs, TWDB rules for SB 1 regional planning allow the regional water planning groups (RWPG) to include recommendations in the regional water plan with regard to legislative designation of ecologically unique streams, sites for future reservoir development, and policy issues. The Rio Grande RWPG elected to consider recommendations in each of these areas, which are presented in this chapter.

6.1 LEGISLATIVE DESIGNATION OF ECOLOGICALLY UNIQUE STREAM SEGMENTS

TWDB rules for SB 1 regional water planning describe the process by which RWPGs may prepare and submit recommendations for legislative designation of ecologically unique river and stream segments. This process involves multiple steps with the Rio Grande RWPG, the Texas Parks and Wildlife Department (TPWD), the TWDB and, ultimately, the Texas Legislature each having a role. According to SB 1, the Rio Grande RWPG may recommend legislative designation of river or stream segments within the North East Texas Region as “ecologically unique.” TWDB rules (30 Texas Administrative Code 357.8) state:

> *Regional water planning groups may include in adopted regional water plans recommendations for all or parts of river and stream segments of unique ecological value located within the regional water planning area by preparing a recommendation package consisting of a physical description giving the location of the stream segment, maps, and photographs of the stream segment and a site characterization of the segment documented by supporting literature and data.*

According to state law (Texas Water Code Sections §6.101 and §10.053), state agencies and local units of government cannot develop a water supply project that would destroy the ecological value of a river or stream segment that has been designated by the Texas Legislature as ecologically unique. Also, the TWDB is prohibited from financing water supply projects that would be located on a stream segment that has been designated as ecologically unique.

TWDB rules provide that the RWPGs forward any recommendations regarding legislative designation of ecologically unique streams to the TPWD and include TPWD’s written evaluation of such recommendations in the adopted regional water plan. The RWPG’s recommendation is then to be considered by the TWDB for inclusion in the state water plan. Finally, the Texas Legislature will consider any recommendations presented in the state water plan regarding designation of stream segments as ecologically unique.

6.1.1 Criteria for Designation of Ecologically Unique Stream Segments

TWDB rules also specify the criteria that are to be applied in the evaluation of potential ecologically unique river or stream segments. These are:

- Biological Function: stream segments that display significant overall habitat value, including both quantity and quality, considering the degree of biodiversity, age and uniqueness observed, and including terrestrial, wetland, aquatic or estuarine habitats;
- Hydrologic Function: stream segments that are fringed by habitats that perform valuable hydrologic functions relating to water quality, flood attenuation, flow stabilization or groundwater recharge and discharge;
- Riparian Conservation Areas: stream segments that are fringed by significant areas in public ownership including state and federal refuges, wildlife management areas, preserves, parks, mitigation areas or other areas held by governmental organizations for conservation purposes, or segments that are fringed by other areas managed for conservation purposes under a governmentally-approved conservation plan;
- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: stream segments and spring resources that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality; and/or,
- Threatened or Endangered Species/Unique Communities: sites along streams where water development projects would have significant detrimental effects on state- or federally-listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities.

6.1.2 Candidate Stream Segments

To assist each of the 16 RWPGs, the TPWD developed a list of candidate stream segments in each region that appear to meet the criteria for designation as ecologically unique. For the Rio Grande Region, TPWD prepared a report entitled *Ecologically Significant River and Stream Segments of Region M, Regional Water Planning Area* (May 2000) that presents information on four (4) stream segments within the region that meet one or more of the criteria for designation as ecologically unique. (The Report is available on-line at http://www.tpwd.state.tx.us/texaswaters/sb1/rivers/unique/regions_text/region_m.htm.) The Rio Grande RWPG also received suggestions from the U.S. Fish & Wildlife Service, Zapata County, and the Texas Shrimp Association through two stakeholder "focus group" meetings. The focus group meetings were held in December 1999 and January 2000 and over 200 individuals representing local, state, and federal agencies, environmental groups, and other parties with a known interest in the subject received written invitations to attend and provide input. Nominations for stream segment designations, as well as support for TPWD-nominated segments, were received at both meetings. The information provided by the TPWD and through the focus group meetings is summarized in Table 6.1.

6.1.3 Recommendation

The Rio Grande RWPG reviewed the nominations submitted by TPWD and others with regard to legislative designation of river or stream segments as ecologically unique. The RWPG has decided not to offer any recommendations in this initial water plan for the Rio Grande Region. Rather, the Rio Grande RWPG requests that the Texas Legislature reconsider and amend current state law to clarify the implications of stream segment designation. Specifically, the Rio Grande RWPG has concerns regarding

Table 6.1: Potential Ecologically-Unique River and Stream Segments within the Rio Grande Region Group

River Segment Number	Basin	Waterway	Nominating Entity	Location	Sublocation (if applicable)	Remarks	Biological function	Hydrological function	Riparian Conservation Areas	High Water Quality, Exceptional Aquatic Life, High Aesthetic	Threatened or Endangered Species, Unique Communities	TNRCC Segment Identification
1	Lower Rio Grande	Las Moras Creek	TPWD	From confluence with Rio Grande in Maverick County upstream to Maverick/Kinney County line		Whole segment identified as signif-icant, but primary area of concern due to spring-fed springs is in Kin-ney County, out-side Region M boundaries. Selection criteria from *Ecologically Significant River & Stream Segments of the Rio Grande (Region M) Regional Water Planning Area* (TPWD)	Riparian habitat with trees and shrubs; habitat & associated water very valuable fish/wildlife habitat	Regulation and protection of baseflows, fisheries habitat, water supplies, and groundwater	None identified on this segment	Ecoregion stream, dissolved oxygen, benthic macroinvertebrates; aesthetic and economic value for fishing, birding, hicking, picnicking, and camping	Wood stork; least tern;,Proserpine shiner; ocelot; jaguarundi; several other state threatened species	
2	Lower Rio Grande	Rio Grande	TPWD Support from FWS – Lower Rio Grande National Wildlife Refuge, Zapata County and Texas Shrimp Association	From confluence with Gulf of Mexico in Cameron County upstream to Falcon Dam in Starr County		Selection criteria from *Ecologically Significant River & Stream Segments of the Rio Grande (Region M) Regional Water Planning Area* (TPWD)	Extensive freshwater and estuarine wetland habitat, resaca woodlands, lomas, emergenct saltmarsh, seagrass beds in South Bay	Flood control; regulation/protection of fisheries, water supplies, groundwater and baseflows in the river; freshwater inflow prevents saltwater intrusion	Lower Rio Grande Valley NWR; Bentsen Rio Grande SP; Santa Ana NWR; Sabal Palm Sanctuary; Boca Chica SP; S. Bay Coastal Preserve	Overall use; benthic macroinvertebrates; high economic value for fishing, boating, and birding; important for common snook population	Texas ayenia, piping plover, Blackfin goby, several other state threatened species; Black Mangrove Series; Texas Palmetto Series	2301 2302

River Segment Number	Basin	Waterway	Nominating Entity	Location	Sublocation (if applicable)	Remarks	Biological function	Hydrological function	Riparian Conservation Areas	High Water Quality, Exceptional Aquatic Life, High Aesthetic	Threatened or Endangered Species, Unique Communities	TNRCC Segment Identification
2A	Lower Rio Grande	Rio Grande	FWS – Lower Rio Grande National Wildlife Refuge	From confluence with Gulf of Mexico in Cameron County upstream to Falcon Dam in Starr County	From Roma area upstream to Falcon Dam	No documentation submitted					Wild muscovy duck, hookbill kite, breeding populations of brown jay and red-billed pigeon	
2B	Lower Rio Grande	Rio Grande	FWS – Lower Rio Grande National Wildlife Refuge	From confluence with Gulf of Mexico in Cameron County upstream to Falcon Dam in Starr County	From confluence with Gulf of Mexico upstream to just east of Brownsville	No documentation submitted					Unique marine organisms, incl. blue land crab and red land crab	
2C	Lower Rio Grande	Rio Grande	Project Coordinator, Zapata County	From confluence with Gulf of Mexico in Cameron County upstream to Falcon Dam in Starr County	From Rio Grande City area upstream to south of Falcon Dam	No documentation submitted						
2D	Lower Rio Grande	Rio Grande	Texas Shrimp Association	From confluence with Gulf of Mexico in Cameron County upstream to Falcon Dam in Starr County	From confluence with Gulf of Mexico upstream to Laredo area	No documentation submitted	Recruitment value/ productivity of estuary, importance to marine shrimp of Laguna Madre and Gulf	Geology/function of the Rio Grande/Nueces Basin and the Tamaulipan Plain				

River Segment Number	**Basin**	**Waterway**	**Nominating Entity**	**Location**	**Sublocation (if applicable)**	**Remarks**	**Biological function**	**Hydrological function**	**Riparian Conservation Areas**	**High Water Quality, Exceptional Aquatic Life, High Aesthetic**	**Threatened or Endangered Species, Unique Communities**	**TNRCC Segment Identification**
3	Lower Rio Grande	Rio Grande	***Project Coordinator, Zapata County***	***Rapids in 3 to 5-mile stretch, from just south of Rio Bravo in Zapata County, near Laredo***		No documentation submitted		Water-quality data indicates aeration inproves water quality below rapids				
4	Lower Rio Grande	Arroyo Colorado	TPWD Support from Rio Grande RWPG member on behalf of Cameron County Commissioner; and Texas Shrimp Association	From confluence with lower Laguna Madre upstream to Harlingen area		Selection criteria from *Ecologically Significant River & Stream Segments of the Rio Grande (Region M) Regional Water Planning Area* (TPWD)	Unique because inflow from Arroyo provides main source of freshwater to Laguna Madre; recruitment value/ productivity of estuary, importance to marine shrimp of Laguna Madre and Gulf	Downstream flood control; regulation of baseflows; protection of fisheries, water supply, groundwater; helps prevent saltwater intrusion upstream	Laguna Atascosa NWR, Goat Island Wildlife Management. Area, City of Harlingen property	High water quality/exceptional aquatic life/high aesthetic value	Brown pelican, piping plover, ocelot, jaguarundi, Texas ayenia, sheep frog, common black-hawk, Coues' rice rat, and several other state threatened species	2201
5	Lower Rio Grande	Los Olmos Creek				Only upon confir-mation stream not intermittent						

the potential impacts of stream designation on private property owners and on governmental activities other than water development. With such legislative clarification, the Rio Grande RWPG intends to re-consider the issue of ecologically unique stream segment designations in the first five-year update of the regional water plan.

6.2 RESERVOIR SITES

TWDB rules (31 TAC, Section 357.9) for the preparation of regional water supply plans provide that the regional water planning groups "…may recommend sites of unique value for construction of reservoirs by including descriptions of the sites, reasons for the unique designation and the expected beneficiaries of the water supply to be developed at the site." TWDB rules further specify that the following criteria be applied to determine whether a site is unique for reservoir construction:

1. *site-specific reservoir development is recommended as a specific water management strategy or in an alternative long-term scenario in an adopted regional water plan; and,*
2. *the location, hydrologic, geologic, topographic, water availability, water quality, environmental, cultural, and current development characteristics or other pertinent factors make the site uniquely suited for:*

a. *reservoir development to provide water supply for the current planning period; or,*

b. *where it might reasonably be needed to meet needs beyond the 50-year planning period.*

Two reservoir sites have been considered by the Rio Grande RWPG: (1) the proposed Brownsville Weir and Reservoir; and, (2) the proposed Webb County low water dam. Each project is briefly discussed below.

6.2.1 Brownsville Weir and Reservoir

An overview of the proposed Brownsville Weir and Reservoir is provided in Chapter 5 of this plan (Section 5.5.5.1). The City of Brownsville Public Utilities Board (PUB) is currently seeking required state and federal authorizations for the project and is requesting federal funding for engineering design and construction. Communication from the Brownsville PUB indicates that the project is targeted for completion in 2004.

The Brownsville Weir and Reservoir, if constructed, will provide approximately 20,000 acre-feet per year of additional dependable surface water supply for the City of Brownsville. This additional supply will meet Brownsville's projected water supply needs through the planning period and will lessen the need for additional conversions of irrigation rights to municipal use. Development of the project was recommended in the current (1997) State Water Plan. Based on the criteria established for the final recommendations for meeting the DMI shortages, Brownsville Weir and Reservoir was recommended by the Rio Grande RWPG for inclusion in the Plan.

6.2.2 Webb County Low Water Dam

Webb County has been investigating the feasibility of developing a low water dam on the Rio Grande approximately one-mile upstream of the World Trade Center Bridge. The project will not develop additional water supply. Rather, the project is proposed to improve water quality, provide a diversion location for a new regional water treatment plant, and provide hydroelectric power. Recreational amenities may also be developed. The proposed structure would be 30 feet high, which would provide a water surface elevation below the 100-year flood plain. The design and operation of the structure would not alter the normal flows of the Rio Grande. The dam would impound 20,000 acre-feet of water. Webb County intends to lease irrigation water rights for the initial filling of the reservoir.

At the request of Webb County, the Rio Grande RWPG has endorsed further investigation of the feasibility of the Webb County low water dam. This would include more detailed evaluation of project costs, benefits, impacts, and permitting requirements.

6.2.3 Recommendations

Neither the Brownsville Weir and Reservoir nor the Web County Low Water Dam are recommended for designation as a unique reservoir site at this time.

6.3 POLICY RECOMMENDATIONS

TWDB rules for SB 1 regional water planning (31 TAC Chapter 357.7(a)(9)) also provide that regional water planning groups may include in their regional water plans:

> *…regulatory, administrative, or legislative recommendations the regional water planning group believes are needed and desirable to: facilitate the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the state and the regional water planning area. The Regional Water Planning Group may develop information as to the potential impact once proposed changes in law are enacted.*

The approved scope of work for the development of the regional water plan for the Rio Grande Region includes three subtasks relating to the development of regulatory, administrative, or legislative recommendations:

1. **Subtask 6.1.1:** Assist the Rio Grande RWPG with the identification and definition of policy issues;
2. **Subtask 6.1.2:** Identify and evaluate alternatives for addressing policy issues; and,
3. **Subtask 6.1.3:** Prepare recommendations for consideration by the Rio Grande RWPG and for inclusion in the regional water plan.

Throughout the planning process, several major policy issues arose repeatedly in meetings of the Rio Grande RWPG and through various public outreach efforts. These issues are:

1. Creation of a regional water management entity;
2. Mexico’s compliance with the 1944 Treaty regarding the development of the Rio Grande;
3. Agricultural lands preservation;
4. Regionalization of water and wastewater utility services;
5. Irrigation district water allocation policies;
6. Consolidation of irrigation district operations;
7. Modification of the boundaries of the Rio Grande Region;
8. Funding for the development of a State water availability model for portions of the Rio Grande watershed;
9. Federal funding for an in-depth study of the costs and benefits of re-channelization/restoration of portions of the Rio Grande above Amistad Reservoir;
10. Additional research/development of desalination and offering financial assistance and incentives for implementation;
11. Funding for data collection, review, reporting activities and for preparation of feasibility level studies; and
12. Modifications to Planning Process.

Each of these issues is briefly discussed in the section below. Also presented are the recommendations adopted by the Rio Grande RWPG on each issue.

6.3.1 Creation of a Regional Water Management Entity

6.3.1.1 Background

The basic activities that comprise water resources management in the Rio Grande Region are largely the domain of local entities, whether municipally owned water utility systems, various types of water utility districts, non-profit water supply corporations, or irrigation districts. These activities include the ownership of the majority of surface water rights and developed groundwater resources and the ownership, operation, and maintenance of the facilities required to divert, treat, and deliver water for municipal, industrial, and agricultural uses.

Unlike many other areas of the state, the Rio Grande Region lacks a general-purpose water management institution with management authority to function as a sponsoring agency to promote the development and conservation of the region’s water resources. In many areas of the state, river authorities or other similar institutions (e.g., Tarrant Regional Water District, Northeast Texas Municipal Water District) play a major role in regional water resources development and management. The activities of such entities typically includes development of surface and/or groundwater supplies, ownership of water rights, facilitating the sale or contract of water for municipal, industrial, and agricultural water users as well as function in the capacity as local sponsor for financial grants and loans. These regional management entities have also assumed a pivotal role in water quality planning at a regional or watershed level through participation in the Texas Natural Resource Conservation Commission's (TNRCC) Texas Clean Rivers Program. River authorities are also engaged in flood protection, the provision of water and wastewater utility services, operation of irrigation conveyance and distribution systems, economic development, electric power generation, development and operation of recreational facilities, and a host of other activities.

While the existing local institutions for water resources management in the Rio Grande Region are largely effective, there are at least two functions that a regional authority could perform which might be of benefit to the region. One function would be to sponsor, finance, and implement water conservation and water supply projects. For example, a regional authority could plan a major canal rehabilitation project; obtain commitments from DMI users to purchase water supplies made available from the project; issue tax-exempt revenue bonds backed by water sale contract revenues; and use the bond proceeds to implement the project. Similarly, a regional entity could plan, finance, construct, and operate regional water supply facilities, for example, development of groundwater supplies or desalinization facilities. In essence, a regional entity would serve as type of regional water bank by providing a way for numerous DMI users to aggregate their water needs and financial resources to implement water conservation and water supply projects. Importantly, individual DMI users would gain access to additional needed water supplies without issuing debt on their own. In addition, the financing and operational capabilities of a regional entity could have many important benefits including:

- Enhancing cooperation between DMI and agricultural water users to work towards mutually beneficial approaches to meeting the region's future water supply needs;
- Addressing regional needs in a more organized manner for long-term planning, rather than the current situation of each DMI user pursuing individual strategies in a piecemeal and incremental fashion over time;
- Facilitating development of water supply and conservation projects at optimal economies of scale;
- Ensuring that smaller DMI water users have access to the water supplies generated by conservation and water supply projects;
- Allowing the creation of an interruptible water supply from water supplies generated in excess of DMI needs, which could be sold to agricultural irrigators under short-term contracts;
- Allowing direct receipt of federal and state funding for water projects, rather than passing funds through multiple state and federal agencies;
- Diminishing speculative pressures in the water rights market; and,
- Providing the ongoing functions of operation/maintenance and management of regional water projects.

The opportunity exists to coordinate the activities of a regional management entity with those of the current TNRCC Rio Grande Watermaster Program. Whereas the Watermaster currently maintains the accounting of water allocations, the management entity could work to integrate the information resources of the Watermaster into an overall data management system to better conserve the resources of the region.

Initial funding for establishing such a regional management entity may be a concern since many of these types of organizations do not have ad valorum taxing authority. The coordination with the TNRCC Watermaster might help provide a solution to this interim problem.

Within the Rio Grande Region, other important functions that might be performed by a regional water agency include soil and water conservation, water quality monitoring and planning, and aquatic weed control. A regional water agency could also become a vehicle for the consolidation of the management and operations of existing irrigation districts and potentially achieve significant economies in the management, operations, and maintenance through the consolidation of district functions. For example, the Lower Colorado River Authority now owns and operates three rice irrigation districts within their basin. A regional entity could also perform similar functions in the provision of urban water and wastewater utility services.

It is important to note that the creation of a regional entity would not preempt other local entities from pursuing water supply and conservation strategies on their own. Regional water authorities typically have only limited regulatory powers and they cannot compel other political subdivisions to participate in their projects.

The potential disadvantages of creating a new regional entity for water resources management in the Rio Grande Region include:

- Creating a new level of government and additional bureaucracy; and,
- Diminishing the ability of local entities to access water supplies on their own.

The creation of a regional water management entity will require an act of the Texas Legislature. Such legislation would define the purposes and governance of the authority, its geographic boundaries, its powers and duties, its limitations, and its sources of revenues. The general models for such legislation are the statutes under which the various river authorities were created. There are other types of regional water agencies in existence that have more narrowly defined functions than river authorities (e.g., municipal water districts). Typically, state-created “conservation and reclamation districts” are governed by boards of directors that are appointed by the governor, although there are examples of regional water authorities with elected boards or boards appointed by other political subdivisions (e.g., counties, cities). River authorities and other similar institutions are generally supported from revenues for the services they provide (e.g., water sales) and do not have taxing authority. For the Rio Grande Region, key issues that would need to be addressed in the enabling legislation for a regional water management authority include:

- Geographic boundaries (e.g., potentially making them coterminous with the area in which the Rio Grande Watermaster operates);
- Governance (e.g., appointed versus elected directors, representation of major water user groups versus geographic representation); and,
- Funding for start-up costs.

6.3.1.2 Recommendation

The Rio Grande RWPG recommends that the Texas Legislature create a regional water entity for the purposes of management of the waters of the Rio Grande; for the development of water conservation and water supply projects; for water quality monitoring and planning; and for other purposes and functions typically performed by conservation and reclamation agencies created under Article 16, Section 59 of the Texas Constitution. In developing legislation to implement this recommendation, the Rio Grande RWPG further recommends that:

- The geographic jurisdiction of the regional authority be considered to correspond to the jurisdiction of the Rio Grande Watermaster Program (i.e., Ft. Quitman to the Gulf of Mexico);
- The Legislature provide an initial appropriation of state general revenue to be used by the regional entity to establish its corporate functions; and,
- That the governance of the regional entity be provided consistent with Article 16, Section 59 of the Texas Constitution with appropriate representation based on such considerations as geography, population, and water rights.

6.3.2 Mexico’s Compliance with the 1944 Treaty

6.3.2.1 Background

Two treaties between the United States and Mexico contain basic provisions regarding the development and use of Rio Grande waters by the two countries. The 1906 Treaty[1] provides for delivery to Mexico by the United States of 60,000 acre-feet of water annually in the El Paso-Juarez Valley upstream from Fort Quitman, Texas. If shortages occur in the water supply for United States, then deliveries to Mexico are to be reduced in the same proportion as deliveries to the United States. The 1906 Treaty also includes a provision whereby Mexico "waives any and all claims to the waters of the Rio Grande for any purpose whatever between the head of the present Mexican Canal and Fort Quitman, Texas."

The 1944 Treaty between the United States and Mexico[2], which is administered by the International Boundary and Water Commission (IBWC), contains provisions relating to the reach of the Rio Grande between Fort Quitman and the Gulf of Mexico, which includes the RGWPR. This treaty provides for the allocation of all waters within this reach of the Rio Grande between the two countries and for the joint construction of as many as three major international reservoirs on the mainstem of the river for water supply and flood control purposes. Development of hydroelectric power at the reservoirs is also authorized under the treaty, with any hydropower generated divided equally between the two countries. Article 4 of the 1944 Treaty allocates the waters in the Rio Grande below Fort Quitman, Texas, between the United States and Mexico. Details regarding the Treaty are presented in Section 3.2.1.6.1.

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[1] Convention between the United States and Mexico, Equitable Distribution of the Waters of the Rio Grande; Proclaimed January 16, 1907; Washington, D. C.

[2] "Treaty Between the United States and Mexico, Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande"; February 3, 1944; Washington, D. C.

These treaty provisions are routinely applied by the IBWC to determine the ownership of waters between the United States and Mexico in the Lower and Middle Rio Grande. Historical data are available from the IBWC indicating the monthly quantities of each country's water that have flowed into the Rio Grande, that have been stored in Amistad and Falcon Reservoirs on the Rio Grande and in tributary reservoirs in each country, that have been released from the mainstem impoundments, that have been diverted from the Rio Grande, and that have passed the Brownsville streamflow gage and flowed to the Gulf of Mexico.

It is important to note that the minimum inflow requirements stipulated in paragraph B(c) of the Treaty for the United States from the six Mexican tributaries has not been satisfied by Mexico since October 1992 (see Section 3.8.3 of this report). The total deficit as of October 1999 was approximately 1,400,000 acre-feet, and Mexico's ability to repay this deficit within the terms of the 1944 Treaty now is questionable. The uncertainty related to the availability, or unavailability, of this water from Mexico obviously has a direct bearing on water supply planning for the RGWPR.

6.3.2.2 Current Mexican Water Deficits under the 1944 Treaty

As discussed above, the 1944 Treaty between the United States and Mexico contains a provision whereby Mexico is to provide the United States with a minimum of 350,000 acre-feet per year, averaged in five-year cycles, of inflows to the Rio Grande from six named tributaries, all located below Fort Quitman, Texas. The inflows from these tributaries contribute directly to the Amistad-Falcon water supply that is extensively relied upon by water users in the Rio Grande Region. Hence, when these tributary inflows are reduced, the available water supply for the region also is reduced. Detailed discussions on firm yield of the Amistad-Falcon Reservoir System and the potential impacts on firm yield of changes in historical inflows are presented in Section 3.4.3.

The IBWC is responsible for measuring the Mexican tributary inflows and performing the necessary water accounting in accordance with the provisions of the 1944 Treaty. Since October 1992, data reported by the IBWC indicate that Mexico has failed to deliver the required minimum inflows to the United States, and therefore, Mexico now has accrued deficits for the five-year accounting cycle that ended on 2 October 1997, as well as for the current five-year accounting cycle that will end on 2 October 2002. The total inflow deficit owed by Mexico for the previous five-year cycle is 1,024,000 acre-feet, and from 2 October 1997 through September 2000 of the current five-year accounting cycle, the accrued deficit is 384,100 acre-feet.

6.3.2.3 Findings and Conclusions

Because of the substantial amount of the current Mexican water deficits and because agricultural interests in the Lower Rio Grande Valley have been severely impacted during the current drought as available water supplies from Amistad and Falcon Reservoirs have diminished, there has been increased concern by all Rio Grande water users regarding the reasons for the deficits and Mexico’s ability to repay the deficits in accordance with the terms of the 1944 Treaty. To begin to address these issues, special studies were undertaken as part of this regional water planning effort for the Rio Grande Region, and preliminary results pertaining to the Mexican water deficits were presented in a separate report. For the purpose of summarizing current results from these ongoing Mexican deficit studies, a Summary of Findings is included below (for additional details refer to the Mexican deficit report[3]

1. Numerous meetings have been convened for the purpose of discussing all aspects of the Mexican water deficit situation and for the exchange of data for better management of waters of the Rio Grande Basin. Representation at these meetings has included the Rio Grande RWPG, local water rights stakeholders, the United States and Mexican Sections of the IBWC, TNRCC, TWDB, and the National Water Commission of Mexico (CNA). Mexican representatives to these meetings have presented extensive data and information for evaluation. Data provided by Mexico relating to historical rainfall during this period shows average rainfall in the Mexican tributary basins for the for the period 1993 through 1999 of over 90 percent of normal, while data provided by Mexico related to historical tributary reservoir inflows during this period shows inflows of 60 to 70 percent of normal. The inflows stored in Mexico's tributary reservoirs over this same period totaled almost 5,000,000 acre-feet as derived from positive monthly incremental changes in storage in individual reservoirs. During this same period over 3,000,000 acre-feet of water actually reached the Rio Grande for a total of approximately 8,000,000 acre-feet of stored water and water which actually reached the Rio Grande. This is an annual average of 380,000 acre-feet, U.S. share of water, which exceeds the average minimum of 350,000 acre-feet U.S. share required under the 1944 Treaty. Mexico, however, has stored inflows in tributary reservoirs to provide water supplies for use within Mexico. Mexico's stated operating policy for its tributary reservoirs is to optimize its storage capacity.
2. Paragraph B(c) of Article 4 of the 1944 Treaty between the United States and Mexico allots one-third of the flow reaching the Rio Grande from six named Mexican tributaries to the U.S., with the provision that this amount of flow shall not be less than 350,000 acre-feet annually as an average amount in cycles of five consecutive years. This provision requires Mexico to deliver to the United States in the Rio Grande a minimum of 1,750,000 acre-feet of water from named Mexican tributaries in five-year cycles. The Treaty does not contain conditional language that water needs in Mexico are a consideration with reference to this guarantee.
3. The 1944 Treaty further provides that Mexico make up any deficiencies in the amount of water delivered to the U.S. from the named tributaries during a given five-year cycle in the subsequent five-year cycle, when either "extraordinary drought or serious accident to the hydraulic systems on the measured Mexican tributaries" has occurred, "making it difficult for Mexico to make available the runoff of 350,000 acre-feet (431,721,000 cubic meters) annually" during the previous five-year cycle. When the flows in the Mexican tributaries from runoff from the tributary watersheds during a five-year cycle are insufficient to provide the minimum average annual requirement, then Mexico shall make up this deficit by delivery of flows to the Rio Grande for the U.S. during the following five-year cycle. The allotment of water to the U.S. from the Mexican tributaries is dependent upon the runoff from the tributary watersheds reaching the Rio Grande from the named tributaries.
4. The U.S. and Mexican Section of the IBWC have agreed in Minute No. 234 as to the method by which a Mexican deficit in water will be repaid during a subsequent five-year cycle. In the event there is insufficient run-off from the Mexican tributaries during a five-year cycle, which prevents

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[3] R. J. Brandes Company; "Preliminary Analysis of Mexico's Rio Grande Water Deficit Under the 1944 Treaty"; Second Draft Report to the Rio Grande Regional Water Planning Group and the Lower Rio Grande Valley Development Council; Austin, Texas; April 3, 2000.

Mexico from providing the average annual amount of 350,000 acre-feet, Minute No. 234 provides that ". . . deficiency shall be made up in the following five-year cycle, together with any quantity of water which is needed to avoid a deficiency in the aforesaid following cycle . . . ," by one or a combination of ways: (a) amounts of water reaching the Rio Grande from the Mexican tributaries in excess of the minimum 350,000 acre-feet guaranteed by the Treaty; (b) waters belonging to Mexico reaching the Rio Grande (its two-third's portion) provided the U.S. is able to conserve such water; and (c) transfer of Mexican owned water in storage in Amistad and Falcon Reservoirs provided the U.S. is able to conserve the water.

5. Based on records published annually by the IBWC regarding historical flows in the Rio Grande and its major tributaries, the deficit in the quantities of inflows allotted to the United States from the Mexican tributaries during the five-year accounting cycle ending October 2, 1997, was 1,024,000 acre-feet. From October 1997 through September 2000, the cumulative deficit in the current accounting cycle was 384,100 acre-feet, or since October 1992, the total amount of the inflow deficit that has been incurred by Mexico on the six tributaries identified in the 1944 Treaty was 1,408,100 acre-feet as of October 2000.

6. Mexico has 12 major reservoirs located in the tributary basins identified in the 1944 Treaty with a combined conservation storage capacity of over 4.4 million acre-feet. Water stored in these reservoirs is diverted and released for municipal, industrial and irrigation uses in Mexico. One of the reservoirs, Luis Leon on the Rio Conchos, also has over 400,000 acre-feet of flood control storage capacity available above its conservation pool

7. Based upon data provided by Mexico during the five-year accounting cycle ending October 1997, a total of approximately 3,600,000 acre-feet of water, as derived from positive monthly incremental changes in storage in the individual reservoirs, was stored in Mexican reservoirs located in the 1944 Treaty tributary basins, after diversions and releases by Mexico to meet its water demands at the time of storage. Through October 1999 of the current five-year accounting cycle, the total amount of excess water stored in the Mexican tributary reservoirs since October 1992 was near 5,000,000 acre-feet, after diversion and releases for use in Mexico. This 5,000,000 acre-feet stored for later use in Mexico, or over 1,600,000 acre-feet, U.S. share, is more than the total Rio Grande inflow deficit incurred by Mexico during this same period under the 1944 Treaty of 1,400,000 acre-feet. The quantities of inflows stored in the Mexican tributary reservoirs, including amounts of water in the flood pool of Luis L. Leon Reservoir, is water that would otherwise have been passed downstream in the named tributaries to the Rio Grande in order to meet the minimum allotment to the United States of an average of 350,000 acre-feet per year in accordance with the provisions of the 1944 Treaty.

8. Additional in-depth studies have been authorized and funded through the TWDB in an attempt to refine the estimates of inflows to the Rio Grande from the Mexican tributaries pursuant to the 1944 Treaty. Progress is limited, however, due to the lack of site-specific information regarding Mexico's tributary reservoirs and the specific demands for water by Mexico from each of the reservoirs. Mexico continues to provide this needed data so that it can be assembled to allow, when combined with data available to Texas, a preliminary reservoir operations model to be developed for Mexico's tributary reservoirs so that simulations of their available supplies can be made under different demand conditions and operating scenarios. Such results could contribute to the development of a long-range operating plan for the reservoirs that would both optimize the use of Mexico's available water supplies for its internal needs and assure compliance with its

1944 Treaty obligations. In the short term, such results would useful in formulating a repayment schedule for Mexico's current deficits.

6.3.2.4 Recommendation

Recognizing that Mexico's full compliance with the 1944 Treaty provisions and Minute No. 234 is essential to providing the water supply needs of the Region, the Rio Grande Regional Water Planning Group hereby strongly recommends that the government of the United States take all necessary and appropriate actions to ensure full compliance by Mexico with the terms of the 1944 Treaty and Minute No. 234 governing the development and use of the waters of the Rio Grande. This includes full and expeditious repayment of current water deficits in accordance with Minute No. 234, since Mexico has failed to come up with an acceptable repayment plan to date. It is also recommended that the dialog continue between the United States and Mexico with regard to the development of an operating plan for Mexican tributary reservoirs that will ensure full compliance with the treaty while also optimizing the amount of water supply available to Mexico for beneficial use. It is further recommended that the United States Section of the International Boundary and Water Commission continue to seek and provide opportunities for direct stakeholder participation in bi-national discussions regarding the management of the waters of the Rio Grande. In particular, the State of Texas may be represented directly by the Secretary of State's Office, the Texas Natural Resource Conservation Commission, and the Texas Water Development Board. Further, the Governor should designate one of these agencies to have the lead role in representing the State on this issue.

6.3.3 Agricultural Lands Preservation

6.3.3.1 Background

Reduction of irrigated acreage as a result of urbanization also has important implications for the operations of irrigation districts. The impacts of rapid urbanization on agricultural lands and irrigation districts, particularly in Cameron and Hidalgo counties, has been raised as an issue. In terms of water resources management, continued urbanization is projected to result in significant reductions in irrigated acreage over time. Land use projections, prepared for Phase II of the Lower Rio Grande Valley (LRGV) Integrated Water Resources Plan, indicate potential losses of nearly 300,000 acres of irrigated lands in Cameron and Hidalgo counties by 2050. From one perspective, this loss of irrigated acreage can be viewed as a benefit inasmuch as additional irrigation water rights can be expected to become available for conversion to DMI uses. However, urbanization can also significantly disrupt agricultural production activities in adjacent areas. Urban encroachment also can result in increased land values and added pressure to convert agricultural lands to urban use. In the Lower Rio Grande Valley, an added concern is that significant population growth and development is occurring in rural areas outside the boundaries of municipalities and in areas, which may lack adequate water and wastewater utility services.

The U.S. Highway 83 corridor bisects many irrigation districts, dividing them into southern and northern areas that have growing swaths of land in urban use. This may make it increasingly difficult to operate and properly maintain irrigation distribution facilities. Also, urbanization is an important factor to consider in developing plans for rehabilitation or replacement of irrigation district conveyance and distribution facilities. Finally, the degree and extent of future urbanization in some areas is such that the financial viability and political stability of some irrigation districts may be threatened.

6.3.3.2 Recommendation

The Rio Grande RWPG recommends that municipalities and irrigation districts in the Lower Rio Grande Valley coordinate more closely on matters of urbanization and its implications for both urban and agricultural water supply infrastructure planning and development.

The RPG recommends that State emphasis be placed on funding for drought and drought tolerant crop research that includes research of efficient irrigation technologies and practices through drought resistant crops. The RPG also recommends that loan and grant programs be expanded in areas for agricultural water conservation methods.

The actual economic impact of conversion of agricultural lands to urbanization has not been examined in sufficient depth to understand the impact to the Rio Grande region. The RPG recommends the State study the effect of loss of agricultural lands in this regard including legislation to establish an inventory of state agricultural lands to assess the effect of urbanization and loss of rural land on water supply.

6.3.4 Regionalization of Water and Wastewater Utility Services

6.3.4.1 Background

Regionalization of urban water supply and/or wastewater systems offers the potential for significant cost savings in acquiring water supplies for urban use, as well as the potential for reduced costs and improved reliability of water and wastewater utility services. For example, water treatment plant cost estimates, which were prepared for *the Lower Rio Grande Valley Integrated Water Resource Plan – Phase II,* showed construction costs ranging from $0.90 per gallon of capacity for large plants to $2.50 per gallon of capacity for small facilities.

Regionalization can take several forms. It can include development of regional water supply facilities, the physical interconnection or consolidation of two or more independent utility systems or the consolidated management of two or more physically separate utility systems by a single entity.

Some regionalization of water and wastewater utility services already exists and is continuing to occur within the Rio Grande Region. However, despite the potential economic benefits of regionalization, there are a number of impediments to regionalization that must be considered on a case-by-case basis. These include issues of local control and accountability, costs and cost-sharing arrangements, financing, and affordability for the end-users.

6.3.4.2 Recommendations

The Rio Grande RWPG recommends that further regionalization of water and wastewater utility services be investigated and implemented where appropriate.

6.3.5 Irrigation District Water Allocation Policies

6.3.5.1 Background

Most irrigation districts in the Rio Grande Region provide water on a first-come, first-served basis without limitations on the quantity of water available to individual irrigators. When water supplies are abundant, this approach works relatively well, allowing irrigators to make cropping decisions with little regard for water supply availability. The first-come, first-served system is also simple to administer, requiring only minimal accounting by irrigation districts.

One drawback to the practice of providing irrigation water "on demand" is that it does not provide individual irrigators with an incentive to conserve water supplies for future use and may, in fact, encourage inefficient water use based on a "use it or loose it" attitude. Because irrigators have no ownership interest in the water rights of a district, on-farm water savings under an "an demand" allocation system accrue to the district and rather than to the grower.

During periods of water supply shortage, many districts suspend the first-come, first-served approach and "go on allocation". While allocation (a.k.a. rationing) policies vary among districts, most involve the pro rata apportionment of the available supply, or a portion of the available supply, to each active irrigation account. An active account is typically defined as one that has actually used water within the prior two-year period. This policy prevents water from being tied up in allocations to lands that are not being irrigated and prevents landowners with inactive irrigation accounts from reaping a windfall from selling allocations they otherwise would not use.

Because most districts lack farm-level water measurement capabilities, allocations are typically expressed in terms of the number of "irrigations" each irrigator will be allowed during a water year or season. In the Lower Rio Grande Valley, a common rule-of-thumb is that one "irrigation" equals eight acre-inches of water measured at the river, six acre-inches at the field. For example, a district serving 20,000 irrigated acres with a storage account balance of 40,000 acre-feet could allocate three irrigations to each irrigation account. Each time an irrigator orders water, an "irrigation" is deducted from the irrigator's allocation. Additional allocations are typically made to irrigators when there are sufficient allocations of water to the district by the Rio Grande Watermaster.

Going "on allocation" is considered beneficial as a drought response measure in that it ensures an equitable apportionment of limited water supplies. State law requires water users to "share and share alike" during periods of shortage and pro rata allocation meets this statutory test. In addition, knowing how much water is available enables irrigators to make informed decisions about the types and amounts of crops to plant and provides an incentive for conservation. Some districts further strengthen this incentive to conserve by allowing irrigators to carry-over partial allocations by measurement of their actual use. For example, an irrigator might get two watering events out of a single "irrigation" by showing that measured use at the field is three rather than six acre-inches.

In addition to providing a method for equitable water distribution during periods of shortage, water allocation by irrigation districts has also enabled an active water market within the agricultural sector. Most districts allow individual irrigators to sell all or a portion of their water allocations to other irrigators within the district and, in some cases, to irrigators outside the district. Typically, about all the seller has to do is pay any water charges associated with their water allocation and notify the district of the transfer. The benefit of these agriculture-to- agriculture water transfers is that higher value water-intensive crops, such as citrus and sugar cane, can gain access to additional water over and above the allocations from an irrigation district. Arguably, the entire region benefits from these transactions as the economic impacts of water shortages are minimized by allowing a limited water supply to move from lower to higher value uses. A recent study estimates that about 120,000 acre-feet of water were transferred within the agricultural sector during the period between 1995-1996.

There are a number of potential problems with water allocation as it is commonly practiced by irrigation districts in the Rio Grande Region. One problem arises during the transition from a first-come, first-served water ordering system to "going on allocation." Typically, districts initiate allocation when their irrigation storage accounts are depleted to a pre-determined level. As the district's supplies are depleted, irrigators may make a "run on the bank" by ordering water, perhaps unnecessarily, prior to the district's implementation of allocation. Anecdotal evidence suggests that water demand increased in some districts during 1996 when irrigation districts began considering implementation of allocation. One possible remedy for this problem would be for districts to "go on allocation" permanently. However, most districts are opposed to "tying up" large amounts of water supply in allocations to individual irrigators except during periods of shortage. This concern could be addressed by designing allocation policies such that a portion of a district's storage account balance would be held back as a reserve. Farm-level water measurement and volumetric water pricing could also act to counteract the use-it-or-lose-it behavioral response triggered by impending implementation of water allocation.

Another potential problem associated with current water allocation policies is the lack of uniformity of policy between districts. For example, as noted, some irrigation districts allow transfers of allocations to irrigators outside of their districts while others do not. This represents a significant constraint on the ability of the agriculture-to-agriculture water market to redistribute limited water supplies and thereby minimize the economic impacts of water shortages. Districts that do not allow transfers of allocations to other districts often cite concerns about impacts on district revenues and operations (e.g., increased distribution losses, inadequate push water, etc.). Also, district-to-district transfers require a high-degree of coordination (i.e., the "hassle factor") between the supplying district and the receiving district to ensure accurate accounting of water use. Potential revenue impacts could be addressed by requiring payment of all water use charges for water transferred outside of a district. Operational concerns might be addressed by allowing inter-district transfers only when a district's storage account balance is above some minimum threshold.

The lack of uniformity of allocation policy among districts also presents problems for irrigators who farm in more than one district. Irrigators often must be familiar with the allocation policies of several districts, both the districts in which they farm as well as districts from which they might acquire additional supplies. However, both irrigators and irrigation district managers acknowledge that real differences exit among districts and that a "one-size-fits-all" region-wide allocation policy may not be practical.

Nonetheless, in the interest of improving the functions of the agriculture-to-agriculture water market, irrigation districts might be encouraged to voluntarily adopt more uniform policies to the extent practical.

6.3.5.2 Recommendation

The Rio Grande RWPG recommends that irrigation districts be encouraged to review their water allocation policies, procedures, and practices to facilitate water transfers among agricultural users.

6.3.6 Consolidation of Irrigation District Operations

6.3.6.1 Background

At present, there are 28 irrigation districts operating within Cameron, Hidalgo, and Willacy counties. These districts serve as few as 1,200 irrigable acres (Hidalgo County Irrigation District No. 13) to 75,000 irrigable acres (Cameron County Irrigation District No. 2). The eight largest irrigation districts combined account for over 70 percent of total irrigable acreage and 69 percent of the irrigation water rights held by districts. Over the years, the number of irrigation districts has decreased through mergers and consolidations. In addition, some of the larger districts have assumed the day-to-day management and operations of smaller adjacent districts. Further mergers and/or consolidated management of irrigation districts may provide benefits, both in terms of water savings and reduced operating costs. For example, the physical consolidation of adjacent districts may enable some inefficient water distribution facilities to be retired from service. Water savings might also result from improved operation and maintenance of water diversion and distribution facilities. Combining irrigation district administrative functions and the economies of scale that could be achieved in operations and maintenance could provide significant cost savings.

6.3.6.2 Recommendation

The Rio Grande RWPG adopted no recommendation regarding the consolidation of irrigation districts.

6.3.7 Boundaries of the Rio Grande Region

6.3.7.1 Background

The Rio Grande Region, as defined by the TWDB consists of eight counties – Cameron, Hidalgo, Jim Hogg, Maverick, Starr, Webb, Willacy, and Zapata. With the exception of Jim Hogg County, the current boundaries of the Rio Grande Region correspond to the area supplied by the Amistad-Falcon Reservoir System. However, under the current regional water planning area boundaries, Amistad Reservoir is located in the Plateau Region (J) and is therefore designated as a “special water resource” in that it lies outside of the boundaries of the region, which relies upon the water supplies it provides. Amistad Reservoir does not represent a major source of supply to the Plateau Region. Since Region M is focused on water stored in Falcon and Amistad Reservoirs and is studying and recommending strategies for Rio Grande projects associated with that supply, at least a portion of Val Verde County, which depends upon the Rio Grande for its supply, should be included in Region M so that it may be included in this regional approach.

6.3.7.2 Recommendation

The Rio Grande RWPG considered but decided not to recommend to the TWDB to extend the boundaries of the Rio Grande Region (M) to include Val Verde County for the purposes of future updates of the regional water plan.

6.3.8 Water Availability Models

6.3.8.1 Background

During 1999, the 76th Texas Legislature amended SB1 by including the following section in Texas Water Code (Section §16.012(h)), specifically addressing the Rio Grande River Basin:

> *Not later than December 31, 2003, the commission shall obtain or develop an updated water supply model for the Rio Grande. Recognizing that the Rio Grande is an international river touching on three states of the United States and five states of the United Mexican States and draining an area larger than the State of Texas, the model shall encompass to the extent practicable the significant water demands within the watershed of the river as well as the unique geology and hydrology of the region. The commission may collect data from all jurisdictions that allocate the waters of the river, including jurisdictions outside this state.*

However, no funding was appropriated during the 76th Legislative Session for the TNRCC to develop the Rio Grande Water Availability Model. The Rio Grande River Basin has water rights based on both the prior appropriation doctrine and the storage-based allocation system established by the Rio Grande Valley Water Case. A water availability model, or models, encompassing the entire Rio Grande Basin, would be of benefit to water resources management for the entire basin.

6.3.8.2 Recommendation

The Rio Grande RWPG recommends that state funding be provided for the development of a state water availability model for the Rio Grande River.

6.3.9 Re-Channelization/Restoration of the Rio Grande below Fort Quitman, Texas

6.3.9.1 Background

Section 5.10.3 of this report briefly describes previous efforts by the International Boundary and Water Commission to re-channelize/restore the portion of the Rio Grande below Fort Quitman, Texas. Previous efforts focused on improving the definition of the international boundary between the United States and Mexico. It is believed, however, that periodic removal of salt cedar and other vegetation, along with channel improvements, would increase water flows in this stretch of the Rio Grande and allow passage of more flows from upstream reaches of the river. This could serve to firm up existing water rights in the affected portions of the Rio Grande and could increase the number of events in which spills from upstream reservoirs and other floodwaters reach Amistad Reservoir. Understanding these potential water supply benefits from an on-going program of channel maintenance requires detailed study. The IBWC has requested appropriations for a study to determine whether re-channelization/restoration of the Rio Grande below Fort Quitman is technically, environmentally, and financially feasible. The restoration study would include investigation of potential water supply benefits.

6.3.9.2 Recommendation

The Rio Grande RWPG joins with the Far West Texas RWPG in recommending and requesting that federal funding be provided to the International Boundary and Water Commission for an in-depth investigation of the costs, benefits, and impacts of re-channelizing/restoring a portion of the Rio Grande upstream of the Amistad Reservoir.

6.3.10 Desalination

6.3.10.1 Background

Use of brackish groundwater as a viable supply alternative is discussed as a potential strategy for use in the Rio Grande region under Section 5.6.6. Many areas in the region consider the use of groundwater as a potential solution on a localized basis. However, sufficient historical information is not yet available to allow the local community to determine the practicality of desalination as an economic alternative.

6.3.10.2 Recommendation

The Rio Grande RWPG recommends that State funding for additional research/development of desalination and offering financial assistance and incentives for implementation be considered.

6.3.11 Funding for data collection, review, reporting activities and for preparation of feasibility level studies

6.3.11.1 Background

The fundamental component water supply planning is the availability of adequate data from which to assess the probability of costs, impacts and overall strategy success. While it is often said that you can never have enough data, in some areas of supply planning, notably groundwater conditions in rural areas, only minimal or no data exists. The US Geological Survey, the primary agency for water data collection activities, has been forced through budget reductions to reduce its data collection efforts in both stream quantity and quality measurements.

6.3.11.2 Recommendation

The Rio Grande RWPG makes the following recommendations:

The TWDB should provide funding for data collection activities in rural areas, including establishing and adequately funding the collection and distribution of groundwater availability data.

The Legislature should provide funding for the cooperative, federal-state-local program of basic water data collection. The Legislature should fund the collection, assimilation and analysis of basic data needed to assess the ground and surface water resources of each region to a 90 percent accuracy level.

The TWDB and TNRCC should facilitate access to water data essential for local and regional planning and plan implementation purposes.

The TWDB, TNRCC and RRC should expand activities in collecting, managing, and disseminating information on groundwater conditions and aquifer characteristics.

SB1 should be amended to allow state funding of ongoing regional data collection activities that are sponsored by RWPGs.

The TWDB should study the effects of groundwater consumption on springflow.

6.3.12 Modifications to Planning Process

6.3.12.1 Background

In the initial phase of regional planning, considerable time was expended by the RWPG attempting to interpret the intent of the rules and technical requirements required by the TWDB.

6.3.12.2 Recommendations

The Rio Grande RWPG supports the grass roots regional water planning process enacted by SB1 and strongly encouraging the process be continued with appropriate funding.

The TWDB and TNRCC should evaluate the effect of groundwater withdrawal on surface water availability and streamflows.

There needs to be a consistency in whether normal water conservation assumptions should be included in the supply and demand projections, or as water management strategies for conserving/developing water supplies.

The next phase of planning should include the review of population estimates immediately after 2000 census results are available and making revisions as necessary.

TWDB needs to revise its rules for regional water planning to allow multiple options to be put forth as recommended strategies for meeting the needs of individual water user groups. Current planning rules require a single scenario to be developed for meeting near-term needs. Since future permits must be consistent with the regional plan, a single state-approved scenario may hamper the ability of a water provider to make choices among viable sources of additional water supply. Instead allowing development of alternative near-term scenarios would provide more flexibility.

Water quality should play a more important role in future planning efforts.

Wildlife and environmental water needs should be established as a category of water use and should be quantified by the TPWD, at their expense, for input into the next planning phase. The Rio Grande RWPG recommends that the definition of beneficial use regarding water rights permit be expanded to include usage by natural resources, wildlife, and wildlife habitat.

As the planning process move to implementation, the TWDB should work to expedite the funding for implementing strategies on a localized level.

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CHAPTER 7.0: PUBLIC PARTICIPATION, FACILITATION AND PLAN IMPLEMENTATION

7.1 PUBLIC PARTICIPATION

The water planning process initiated by Senate Bill 1 (SB 1) in 1997 by the Texas Legislature was designed as a bottoms-up approach to developing strategies to ensure adequate supplies of water to Texans for the next half-century. In the past, state water agencies had prepared the state water plan, with stakeholder and public input, but there was not a great deal of local buy-in or ownership in the plan's recommendations. With SB 1, long-term water planning has become a regional responsibility, involving stakeholders representing a range of interests (see Table 7.1). The stakes are high: in the future, water projects are required to be consistent with the regional plans in order to receive state authorization and funding.

To ensure that all interests are represented in the regional planning process, SB 1 mandated extensive public involvement. Under Texas Water Development Board rules (31 T.A.C. §357.12), the regional water planning groups (RWPGs) are required to have at least one meeting prior to preparation of the regional water plan, provide ongoing opportunities for public participation during the planning process, and hold at least one public hearing prior to adoption of the "initially prepared regional water plan. The RWPGs are also required to comply with TWDB rules specifying how and to whom notice of public meetings and public hearings is to be provided.

Table 7.1: Voting members of the RGRWPG

Agriculture	Robert E. Fulbright*,Rancher, Hebbronville
	Ray Prewett, Texas Citrus Mutual, Mission
Counties	James R. Matz, Cameron County, Commissioners Court, Harlingen
	Mercurio Martinez, Jr., Webb County Judge, Laredo
Electric Generating Utilities	Jaime Gomez, Central Power & Light, Laredo
Environmental	Mary Lou Campbell*, Sierra Club, Mercedes
Industry	Jack Nelson, Rio Grande Valley Sugar Growers, Inc., Santa Rose
Municipalities	Roberto Gonzalez, Water Works, Eagle Pass
	William "Bart" Hines, Public Utility Council, McAllen
	Fernando Roman*, Vice-Chairman, Water Utilities, Laredo
Other	Glenn Jarvis*, Chairman, Attorney, McAllen
	Lee Kirkpatrick*, Secretary, Texas State Bank, Brownsville
Public	Mario Garcia-Rios, Texas A&M International, Laredo
Small Business	Maria Eugenia Guerra, LareDOS Newspaper, Laredo
Water Districts	Gordon R. Hill, Bayview Irrigation District #11, Los Fresnos
	Sonny Hinojosa, Hidalgo County Irrigation District No. 2, San Juan
Water Utilties	Charles "Chuck" Browning, North Alamo WSC, Edinburg

Executive Committee

The Rio Grande RWPG went well beyond the TWDB minimum requirements for public participation, providing multiple opportunities for public input and for direct participation in the planning process and development of the draft plan.

At the outset, the "initial coordinating body" for TWDB-designated "Region M", which was appointed by TWDB, held a pre-planning meeting at the McAllen International Airport conference rooms on March 25, 1998. As required by TWDB rules, notice of the pre-planning meeting was published in a newspaper of general circulation in each county within the regional water planning area. Notice also was mailed out, as required by TWDB rules, to cities, counties, public water suppliers, and water rights holders. The initial coordinating body held a second meeting at the McAllen International Airport conference rooms on 15 April 1998 to complete its responsibilities under T.A.C. Section 357.4. The initial coordinating body was then dissolved and the first meeting of the Rio Grande RWPG was convened.

For each Rio Grande RWPG meeting, media advisories were issued along with information that the meeting would provide opportunity for public comment. The media advisories were distributed throughout the regional planning area to both local media outlets and news bureaus of other major state dailies. (See media list, Appendix 7-1.)

In addition, the RWPG and its consultant team actively solicited comment from local entities on the basic data used to develop the plan. For example:

- Draft population and water demand projections were mailed to officials representing each city and county in the region in March 1999. The mailing list included county judges, city managers and public works officials.
- Revised population, water demand, and per capita water use projections were mailed to each of the cities and counties in June1999.
- Information regarding the water supply currently available to each municipal water user group was mailed out in November 1999, along with a request for comments.
- Supply and demand projections were mailed to each municipal water user group in the region with a projected water supply shortage in February 2000. These users were requested to review the water supply and demand data and provide input with regard to local water supply plans.

The consultant team also assembled several focus groups concentrated on specific issues. Two stakeholder focus group meetings were held in December 1999 and January 2000 to present information and solicit input on candidates for designation as ecologically unique stream segments (see Chapter 6). More than 200 individuals representing local, state, and federal agencies, environmental groups, and other parties with a known interest in the subject received written invitations to attend the sessions.

The consultant team also held several meetings in December 1999 and March 2000 with advisory panels representing agricultural producers and irrigation district managers to discuss problems, technology solutions, and policy options.

As data were collected and refined, the consultant team developed newsletters to provide information on each stage of the regional planning process, the region's water supplies and needs, and strategies for ensuring adequate supplies over the next 50 years. Four issues of the newsletter were developed (see

Appendix 7-2). Names on the mailing list for the newsletters were compiled from previous regional water planning efforts begun in 1995.

The consultant team also developed other public information materials so that individual member of the Rio Grande RWPG could disseminate information about the planning process in their local communities Presentation materials were prepared in three different formats: Power Point presentation, overhead transparencies, and 35-mm slides. The presentation was updated midway through the planning process and then again towards the end of the planning process in preparation for the public meetings to receive input on the draft plan. Information also was posted on the Internet at the home page of the Lower Rio Grande Valley Development Council, the administrative agency for the RWPG, and on the TWDB's website.

Members of the consultant team also made several presentations to a variety of groups with an interest in water planning, including water utility associations, citrus growers, and irrigation district boards of directors.

The Rio Grande RWPG provided extensive notice of and opportunity for public comment on the draft plan. As required by TWDB rule, copies of the draft plan were placed in at least one public library in each county within the regional planning area as well as in the office of the county clerk in each county within the regional planning area. (See Table 7.2.) Formal notice of the public hearing on the plan was placed in newspapers of general circulation in each county of the regional planning group. Although the TWDB rules stipulated only one public hearing on the draft plan, the regional planning group elected to host a series of public meetings throughout the eight-county region prior to the hearing. (See Table 7.3.)

Preparatory to the series of public meetings, a press conference was held August 23, 2000, to provide information to the media about the draft regional water. The Rio Grande RWPG asked for the media's assistance in notifying the public about the public meetings and the draft regional water plan. Media advisories also were sent out to local communities prior to each meeting and prior to the formal public hearing.

The RWPG also conducted a media campaign to raise awareness about the draft plan, the opportunities for public comment, and the public hearing process. Members of the Rio Grande RWPG appeared on a variety of local TV public affairs shows, local radio, talk shows, and visited with editorial boards of community newspapers to promote knowledge about the regional water plan and the opportunities for public comment. A list of those media events is provided in Table 7.4.

The Rio Grande RWPG also elected to promote attendance at the public meetings by purchasing display advertising space in both English and Spanish language newspapers in communities throughout the region. These ads provided more details about the planning process than the official notice and appeared in the main bodies of the newspapers. Samples of those ads are provided in Appendix 7-3.

At the public meetings, copies of the executive summary in both English and Spanish were made available, along with a question and answer fact sheet on key features of the regional water plan. Copies of the complete draft plan also were made available.

Table 7.2: Opportunities for public review of the draft Rio Grande Regional Water Plan

COUNTY	LOCATION
Cameron	County Clerk's Office, County Courthouse, 964 E. Harrison, Harlingen, 956-544-0815
	Harlingen Public Library, 410 '76 Drive, Harlingen, 956-430-6652
	Brownsville Public Library, 2600 Central Blvd., Brownsville, 956-548-1055
Hidalgo	County Clerk's Office, County Courthouse, 100 North Closner, Edinburg, 956-318-2100
	McAllen Memorial Library, 601 N. Main, McAllen ,956-682-4531
	Lower Rio Grande Valley Development Council, 311 N. 15th St., McAllen, 956-682-3481
Jim Hogg	County Clerk's Office, County Courthouse, 102 E. Tilley, Hebbronville, 361-527-3015
	Jim Hogg County Library, 210 S. Smith, Hebbronville, 361-527-3421
Maverick	County Clerk's Office, County Courthouse, 500 Quarry St., Eagle Pass, 830-773-3824
	Eagle Pass Public Library, 589 Main St., Eagle Pass, 830-773-2516
Starr	County Clerk's Office, County Courthouse, Rm. 201, 401 N. Briggon, Rio Grande City, 956-487-2101
	Starr County Library, 700 E. Canales, Rio Grande City, 956-487-4389
Webb	County Clerk's Office, County Courthouse, 1000 Houston St., Laredo, 956-721-2640
	City of Laredo Library, 1120 E. Calton St., Laredo, 956-795-2400
	South Texas Development Council, 1718 E. Calton Rd., Suite 14, Laredo, 956-722-2670
Willacy	County Clerk's Office, County Courthouse, 540 W. Hidalgo Ave., Raymondville, 956-689-2710
	Reber Memorial Library, 193 N. 4th, Raymondville, 956-689-2930
Zapata	County Clerk's Office, County Courthouse, 600 Hidalgo Blvd., Zapata, 956-765-9915
	Zapata County Library, Zapata, 901 Kennedy St., 956-765-5351

Table 7.3: Opportunities for public comment on the draft Rio Grande Regional Water Plan

COMMUNITY	DATE	TIME	LOCATION	FOCUS
Eagle Pass	Sept. 6, 2000	9:30 AM	City of Eagle Pass Multi-Purpose Center 4805 S. Adams	DMI & Irrigation
Laredo	Sept. 6, 2000	6 PM	City Council Chambers Laredo City Hall 1110 Houston St.	DMI & irrigation
McAllen	Sept. 7, 2000	1 PM	City Council Chambers McAllen City Hall, 1300 Houston St.	Irrigation
McAllen	Sept. 7, 2000	7 PM	City Council Chambers McAllen City Hall, 1300 Houston St.	DMI
Brownsville	Sept. 13, 2000	7 PM	Brownsville Public Utilities Board Board Room 1425 Robinhood Dr.	DMI & irrigations
Harlingen	Sept. 14, 2000	7 PM	Harlingen Public Library 410 '76 Dr.	DMI
Harlingen	Sept. 15, 2000	9:30 AM	Harlingen City Hall 118 E. Tyler St.	Irrigation
McAllen	Sept. 27, 2000	10:30 AM	City Council Chambers McAllen City Hall 1300 Houston St.	Formal public hearing

Table 7.4: Media Campaign on Draft Rio Grande Regional Water Plan

Date & Time	Community	Media Outlet	Format	Participants
Thu 8/24 9 am	McAllen	McAllen Public Access Channel	community affairs show	Bart Hines Ray Prewett Mary Lou Campbell
Thu 8/24 12 noon	Laredo	KVTV-TV Channel 13 (CBS)	"Laredo Live"	Fernando Roman Tomas Rodriguez
Thu 8/24 7 pm	Laredo	KGNS-TV Channel 8 (NBC)	"Issues 8"	Tomas Rodriguez Robert Fulbright; Fernando Roman
Fri 8/25 9 am	Weslaco	KRGV-TV Channel 5 (ABC)	"Eyewitness Journal"	Glenn Jarvis Ken Jones
Fri 8/25 9:30	McAllen	KURV-AM News/Talk Radio	"Davis Rankin Show"	Bart Hines Ray Prewett
Mon 8/28– Fri 9/1 (week of)	Eagle Pass	Eagle Pass News Gram	telephone interview	Roberto Gonzalez
Tue 8/29 10:30 am	Eagle Pass	Eagle Pass News-Gram	Editorial board visit	Roberto Gonzalez
Tue 8/29 12 noon	Brownsville	KBOR-AM/KTJN & KTJX-FM SPANISH	"Talking with the Community"	Carlos Rubinstein
Wed 8/30 9 am	Harlingen	KLUJ-TV Channel 44 (Trin.)	"Community Report"	James Matz & Gordon Hill; Ray Prewett & Mary Lou Campbell
Wed 8/30 10:30 am	Weslaco	KVLY-FM	"Valley Forum"	Glenn Jarvis
Wed 8/30 2 pm	Laredo	Laredo Morning Times	Editorial board visit	Fernando Roman Tomas Rodriguez Robert Fulbright
Wed 8/30 5 pm	McAllen	KIRT-AM SPANISH	drive-time talk show	Carlos Rubinstein
Thu 8/31 7 pm	Eagle Pass	KVAW-TV Channel 16 (CBS/Tele) SPANISH	live interview	Roberto Gonzalez & city official
Tue 9/5 11 am	McAllen	McAllen Monitor	editorial board visit	Bart Hines Glenn Jarvis Mary Lou Campbell
Tue 9/5 12 noon	Harlingen	KGBT-TV Channel 4	CBS noon news	James Matz Ray Prewett
Tue 9/5 5 pm	Laredo	KLDO-TV Channel 27 (Uni.) SPANISH	5-5:30 evening news	Tomas Rodriguez Fernando Roman
Wed 9/6 6 pm	Laredo	Laredo City Public Access Channel	broadcast public meeting	All attending
Thu 9/7 7 pm	McAllen	McAllen City Public Access Channel	broadcast public meeting	All attending
Tue 9/12 10:30 am	Harlingen	Valley Morning Star	editorial board visit	Mary Lou Campbell James Matz; Gordon Hill
Tue 9/12 2:30 pm	Brownsville	Brownsville Herald	editorial board visit	Mary Lou Campbell James Matz; Gordon Hill

The public meetings were geared toward the interests and needs of the local population. As noted in Table 7.3, some of the sessions were focused on issues of concern to irrigators, while others were oriented toward municipal and industrial water users. Additionally, consolidated meetings that addressed both concerns were conducted. The meetings were facilitated by the consultant team and hosted in each community by the local members of the RWPG. At each meeting, the consultant team recorded all comments on the draft plan. These comments were consolidated and presented at the formal public hearing.

The public hearing on the draft plan, held in McAllen on September 27, 2000, attracted 46 participants.

7.2 FACILITATION OF THE REGIONAL WATER PLANNING PROCESS

Facilitation of the regional water planning process for the Rio Grande Region was provided by the staff of the Lower Rio Grande Valley Development Council (LRGVDC), with assistance from the consultant team. In addition to performing administrative duties relating to the management of State funds, the LRGVDC also made all arrangements for meetings of the Rio Grande RWPG, which included posting of required meeting notices, preparation of meeting agendas, and distribution of agenda back-up materials to members of the RWPG. The LRGVDC also tape recorded all Rio Grande RWPG meetings and prepared the official meeting minutes. For non-voting Spanish-speaking members of the Rio Grande RWPG, an interpreter was provided at all RWPG meetings.

The consultant team also assisted with the facilitation of the planning process by providing presentations of technical information at RWPG meetings and by facilitating the identification of key water planning and policy issues. The consultants also assisted the Rio Grande RWPG with the formation of working groups to develop recommendations for inclusion in the regional water plan.

7.3 PLAN IMPLEMENTATION ISSUES

There are a number of key issues that will affect whether this plan is successful in achieving its primary purpose – to provide recommendations regarding strategies for meeting the near and long-term water needs of the Rio Grande Region. Many of these issues are identified and discussed in previous chapters, particularly in association with recommended water management strategies and policy issues. Generally, the key issues relating to the implementation of this plan can be grouped into three categories:

- Issues and water management strategies that require additional in-depth evaluation;
- Local buy-in and action to implement local water supply strategies; and,
- Funding for the implementation of plan recommendations.

Each of these areas of concern is briefly discussed below.

7.3.1 Additional Planning Studies

The recommendations presented in this regional water plan are based on a reconnaissance-level evaluation of projected water demands, water supply, needs, and various strategies for meeting future needs. It is important to note that additional, more detailed feasibility-level planning will be necessary prior to implementation of the many of the recommended strategies. Also, in many cases, feasibility-level planning will need to be followed by engineering design and permitting activities. For the most part the additional planning and project development activities required for strategy implementation will be the responsibility of local water suppliers (e.g., cities, water supply corporations, and irrigation districts). However, state and/or federal technical and financial assistance would greatly facilitate timely project development and implementation.

There are a number of specific issues and water management strategies that require additional investigation and which should be considered as potential candidates for state funding prior to the first update of this regional water plan. These are:

- **Water Supply Planning for Rural Areas**. The Rio Grande RWPG recommends that future updates to the regional water plan include a thorough evaluation of water supply, projected water demands, needs, and strategies for the individual public water systems currently aggregated into the "County-Other" water user groups. This evaluation should include projected water supply needs associated with serving economically distressed areas (i.e., colonias) in the rural portions of each county.

- **Assessment of Individual Irrigation Districts.** The Rio Grande RWPG recommends that the irrigation districts be evaluated as individual water user groups to better assess their water management strategies in the future updates to the regional water plan.

- **Municipal water conservation program design**. Advanced or additional municipal water conservation measures are recommended to provide a significant contribution toward meeting projected municipal water demands. Funding is needed to support the development of a detailed program implementation plan that can serve to guide local water suppliers in the implementation of these programs. Particular attention needs to be given to developing approaches for cooperative, regional implementation of municipal water conservation programs.

- **Assessment of non-potable water reuse opportunities.** As with conservation, non-potable reuse of reclaimed water is a key strategy recommended for meeting a portion of future municipal water needs and a portion of the projected supply needs for steam electric power generation. However, as discussed in Chapter 5 of this plan, estimates of the achievable municipal reuse potential in the Rio Grande Region are based on limited information and broad planning assumptions. For this strategy to achieve the recommended level of implementation, it is essential that a more comprehensive and thorough assessment be performed to identify feasible reuse applications. This assessment should examine each individual municipal water and wastewater utility system to characterize the quality of available wastewater effluent; identify potential users of reclaimed water within reasonable proximity to existing wastewater treatment facilities; evaluate the requirements of potential users (e.g., quantity and quality); and develop site-specific cost estimates for implementation of reuse projects.

- **Groundwater development**. State efforts to improve data and assess groundwater availability in the Rio Grande Region should continue. Specifically, current efforts to gather additional data on the occurrence, quantity, and quality of recoverable groundwater from the Gulf Coast aquifer and to develop a new simulation model of the Gulf Coast aquifer in South Texas should be completed expeditiously. In addition, state funding should be made available for regional facility planning studies to develop regional groundwater supply projects as a substitute source of water supply for some DMI users currently using Rio Grande supplies (e.g., municipal suppliers in Willacy County). Also, the cities of Brownsville, Eagle Pass, and Laredo are encouraged to continue their local efforts to identify and develop cost-effective sources of groundwater supply.

- **Irrigation district rehabilitation**. An extensive discussion of issues associated with the implementation of irrigation conveyance and distribution efficiency improvements is provided in Chapter 5. A key issue is the need for additional, district-specific assessments to identify cost-effective improvements and to develop comprehensive rehabilitation plans. Continuing and expanded state and federal assistance, technical and financial, is essential.

- **Use of Stormwater Runoff**. It is recommended that a study be conducted to determine the feasibility and impacts of capturing and using stormwater runoff as a supplemental water supply source in Cameron and Hidalgo counties. As described in Chapter 5, the study would investigate supply availability, potential uses, and other issues for five localized areas. The results would then be extrapolated to other areas of the two counties to develop a better estimate of the amount of stormwater that could be developed as supply source, as well as the costs of implementing the strategy on a sub0regional scale.

- **Re-channelization/Restoration of portions of the Rio Grande**. As indicated both in Chapter 5 and Chapter 6, the Rio Grande RWPG supports the International Boundary and Water Commission's request for federal appropriations to conduct a detailed assessment of the costs, benefits, and environmental impacts of improvements to the river channel above Amistad International Reservoir. Of particular interest is the quantification of the potential water supply benefits of such a project.

- **Surface water availability models.** As indicated in Chapter 6, the Rio Grande RWPG recommends that state funding be provided for the development of a water availability model for the Rio Grande watershed. In addition, the Rio Grande RWPG supports additional state funding for continued refinement of the existing Reservoir Operations Model for the Amistad/Falcon Reservoir System. Of particular interest is the expansion of the existing model to include portions of the Rio Grande watershed in Mexico that contribute inflows to the reservoir system.

- **Development of the Webb County low-water dam**. The Rio Grande RWPG supports Webb County's efforts to obtain funding for a detailed feasibility and environmental impact study of the proposed low-water dam.

- **Reservoir Sedimentation.** The Rio Grande RWPG recommends that a study be conducted to evaluate the technical and economic feasibility and potential environmental impacts of alternatives for the control and/or removal of sediment from the Amistad/Falcon Reservoir System

7.3.2 Local Water Supply Planning and Implementation

This regional water plan is best viewed as providing a framework for local action to implement strategies for meeting future water needs. The role of the Rio Grande RWPG is purely advisory. The RWPG has no authority to compel other entities to implement the actions recommended in this plan. Nor does it have the authority or resources to undertake implementation activities on its own initiative. Rather, implementation of strategies recommended for meeting future water needs is a primary responsibility of local water suppliers, which include cities, water supply corporations, other public water supply entities, and irrigation districts. With or without outside assistance, more detailed feasibility-level planning studies and engineering design is largely the responsibility of local water suppliers. Similarly, the costs of implementing water conservation and water supply strategies will be borne largely by the ratepayers served by local water suppliers. It is therefore essential that there be a strong commitment on the part of the governing bodies and management of local water suppliers to implement the strategies recommended in this plan.

7.3.3 Funding for Plan Implementation

The availability of and access to funding for the implementation of recommended water management strategies is crucial. Most local water suppliers in the Rio Grande Region are governmental or quasi-governmental entities (e.g., water supply corporations) that have the authority to charge and collect taxes and/or fees for the services they provide. These entities also have the ability to borrow money for the acquisition of additional water supplies and for water-related infrastructure development and rehabilitation. For the most part, the direct costs for the services provided by these entities should be borne by the individual water users through taxes and/or fees for services. However, it should be recognized that there is also an appropriate role for the state and federal governments in the financing of water conservation, water supply development, and infrastructure projects. At present, there are a number of state and federal financial assistance programs for water-related infrastructure projects that are available to municipal water suppliers. However, there are few programs that provide financial assistance to irrigation districts for infrastructure improvements. Because agricultural water conservation is a central element of this regional water plan – and is essential to maintaining the viability of this sector of the regional economy – the Rio Grande RWPG recommends that new public funding sources be developed to assist irrigation districts with the implementation of conservation programs.

APPENDIX 7.1

REGION M MEDIA LIST

Maverick County

Eagle Pass News Gram
T: 830-773-8610 F: 830-773-1641

Eagle Pass Business Journal
T: 830-757-2705 F: 830-757-2703

Eagle Pass News Guide
T: 830-773-2309 F: 830-773-3398

KEPS-AM/KINL-FM
T: 830-773-9247 F: 830-773-9500

Webb County

Laredo Morning Times T: 956-728-2500 F: 956-724-3036	KGNS-TV (NBC) T: 956-723-5161 F: 956-727-5336
LareDOS Magazine T: 956-791-9950 F: 956-791-4737	KLDO-TV (Uni.) T: 956-727-0027 F: 956-728-8331
El Manana/Laredo Sun T: 956-712-1122 F: 956-717-5091	KVTV-TV (CBS) T: 956-723-0777 F: 956-723-0474
El Tiempo de Laredo T: 956-728-2583 F: 956-724-3036	KLNT-AM News/Talk Radio T: 956-725-1491 F: 956-725-3424

Jim Hogg County

Hebbronville View
T: 361-527-4272 F: 361-527-5271

Jim Hogg County Enterprise
T: 361-527-3261 F: 361-527-4545

Lower Valley

Brownsville Herald
T:956-542-4301 F:956-542-0840

Valley Morning Star
T: 956-423-5511 F: 956-956-430-6233

McAllen Monitor
T: 956-686-4343 F: 956-618-0520

El Clamor
T: 956-994-3996 F: 956-994-3989

KRGV-TV Channel 5 (ABC)
T: 956-968-5555 F: 956-973-5002

KGBT-TV Channel 4 (CBS)
T: 956-421-4444 F: 956-412-3523

KURV-AM 710 News/Talk Radio
T: 956-383-2777 F: 956-383-2570

Q-Pasa Radio Q94/KVLY-FM
T: 956-968-1548 F: 956-968-1643

South Texas Business Journal
T: 956-783-0036 F: 956-787-8824

South Texas Ag. News
T: 956-585-2787 F: 956-585-2304

Raymondville Chronicle News
T: 956-689-2421 F: 956-689-6575

Houston Chronicle (James Pinkerton)
T: 956-423-8247 F: 956-428-4308

SA Express-News (Alison Gregor)
T: 956-943-6293 F: 240-359-2504

Valley AP (Megan Stack)
F: 281-872-9988

Dallas Morning News (Steve Lee)
T: 210-695-5102 F: 210-695-3975

APPENDIX 7-2:

NEWSLETTERS

APPENDIX 7-3

SAMPLE ADS FOR PUBLIC MEETINGS