CHAPTER 1: PROBLEMS, NEEDS, AND OPPORTUNITIES

I. Introduction

A. Purpose of Study

The Bureau of Reclamation (Reclamation) and the Rio Grande Regional Water Authority (RGRWA) with its 53 member entities, in collaboration with the Texas Region M Planning Group, Texas Water Development Board (TWDB), Texas Commission on Environmental Quality (TCEQ), and International Boundary and Water Commission conducted the Lower Rio Grande Basin Study (Basin Study) to evaluate the impacts of climate variability and change on water supply imbalances, and to develop adaptation and mitigation strategies to address those imbalances, within an eight-county region along the U.S./Mexico border in south Texas (Cameron, Willacy, Hidalgo, Starr, Zapata, Jim Hogg, Webb, and Maverick Counties) (figure 1-1).

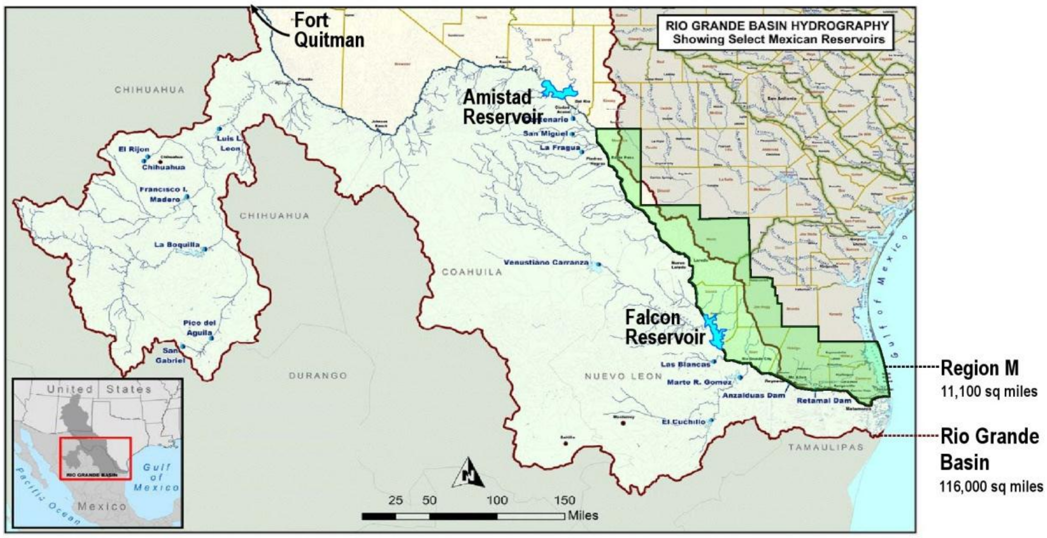

Figure 1-1: Project study area.
Source: Reclamation Project Fact Sheet, 2011.

Under the authority of the SECURE Water Act (Public Law [P.L.] 111-11), the U.S. Department of the Interior (Interior) established WaterSMART (Sustain and Manage America's Resources for Tomorrow) in February 2010 to facilitate the work of Interior's bureaus in pursuing a sustainable water supply for the Nation. The program focuses on improving water conservation and sustainability and helping water resource managers make sound decisions about water use. It identifies strategies to ensure that this and future generations will have sufficient supplies of clean water for drinking, economic activities, recreation, and ecosystem health. The program also identifies adaptive measures to address climate change and its impact on future water demands. This Basin Study, authorized under the SECURE Water Act, cost $412,798 (52 percent [%] RGWRA; 48% Federal cost share) and was completed within 24 months.

The supply issues facing the Lower Rio Grande River Basin are extremely complex, ranging from a multinational to local scale. First, because the study area is shared by both the United States and Mexico, numerous issues are presented both politically and technically. Flows within the Lower Rio Grande River are dependent upon reservoir operations and runoff emanating from both the United States and Mexico, which is complicated by issues relating to required reservoir releases pursuant to stipulations set forth in the Treaty.

The magnitude and frequency of water supply shortages within the study area are severe, even before projecting the effects of climate change. Based on analysis of currently adapted Regional and State Water Plans, while the population in the eight-county region is expected to grow from 1.7 million in 2010 to 4.0 million in 2060, the water supply shortage is expected to reach a staggering 592,084 ac-ft/yr by 2060, which would result in 35% of water demands being unmet. The study has determined that climate change may likely increase this shortage by an additional 86,438 ac-ft/yr.

As a result of severe drought conditions since 2011, several irrigation districts in the region announced this spring that agricultural deliveries were being curtailed, which also subsequently affected municipal supplies that depend on agricultural conveyance systems for water deliveries.

As a result of the climate-affected, long-range supply imbalances predicted by the study, alternative solutions have been evaluated, and the study is focused on investigating a regional BGD plan to meet planning objectives.

1. Local Planning Process

In 1997, the 75th Texas Legislature enacted Senate Bill 1 (SB 1), legislation that grew out of the drought of the early to mid-1990s and the increasing public awareness of rapidly growing water demands in the State. The issues and concerns addressed in SB 1 include State, regional, and local planning for water conservation, water supply and drought management, administration of State water rights programs, interbasin transfer policy, groundwater management and joint planning, 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 State Water Plans are prepared, establishing a "bottom up" approach based on Regional Water Plans that are prepared and adopted by appointed Regional Water Planning Groups representing 11 different stakeholder interests. The planning process is coordinated by the TWDB, which assembles the 16 Regional Water Plans into 1 comprehensive State Water Plan. Initially designated by TWDB as "Region M," the Rio Grande Regional Water Planning Area (or the Rio Grande Region) consists of the eight counties adjacent to or in proximity to the Lower Rio Grande: Cameron, Hidalgo, Jim Hogg, Maverick, Starr, Webb, Willacy, and Zapata. The planning group is tasked with developing a 50-year water supply plan in response to a repeat of the record drought. In the hydrologic models used for availability, this period occurred in the mid-1950s.

The current plan adopted by Region M is entitled *Rio Grande Regional Water Plan,* dated October 1, 2010 (2010 Region M Plan)[5]. The findings and information provided in the 2010 Region M Plan were incorporated into the current Statewide plan entitled *Water for Texas – 2012*[6] (State Water Plan 2012). There is an ongoing effort within Region M to produce a revised 2013 plan, but the data for that later plan has not yet been available for inclusion in this Basin Study. However, the development of this Basin Study has been presented at the Rio Grande Regional Water Planning Group at its meetings held every 2 months, and many of this study's findings, particularly regarding climate-affected future outcomes and planning alternatives, will be incorporated into the 2013 Region M Plan.

2. International Jurisdiction

The waters of the Lower Rio Grande are governed by the *Treaty of 1944 Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande* (Treaty) between the United States and Mexico. The Treaty distributed between the two countries the waters of the Rio Grande from Fort Quitman to the Gulf of Mexico (the upstream and downstream endpoints of the Rio Grande included in this Basin Study) and the waters of the Colorado River. Of the waters of the Rio Grande, the Treaty allocates to Mexico (1) all of the waters reaching the main channel of the Rio Grande from the San Juan and Alamo Rivers, including the return flows from the lands irrigated from those two rivers, (2) two-thirds of the flow in the main channel of the Rio Grande from the measured Conchos, San Diego, San Rodrigo, Escondido, and Salado Rivers and the Las Vacas Arroyo, subject to certain provisions, and (3) one-half of all other flows occurring in the main channel of the Rio Grande downstream from Fort Quitman. The Treaty allots to the United States (1) all of the waters reaching the main channel of the Rio Grande from the Pecos and Devils (United States) Rivers, Goodenough Spring, and Alamito, Terlingua, San Felipe, and Pinto Creeks; (2) one-third of the flow reaching the main channel of the river from the six named measured tributaries from Mexico (and provides that this one-third shall not be less, as an

[5] http://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionM/
[6] http://www.twdb.state.tx.us/wrpi/swp/swp.asp

average amount in cycles of 5 consecutive years, than 350,000 acre-feet annually); and (3) one-half of all other flows occurring in the main channel of the Rio Grande downstream from Fort Quitman.

Each section of the International Boundary and Water Commission (IBWC) gages the spring inflows from its side to the river downstream from the International Amistad Dam on the Rio Grande. The U.S. section operates 13 gaging stations for flood warning and operation of flood regulation storage in the International Amistad and Falcon Reservoirs on the Rio Grande. The U.S. section also operates and maintains 14 gaging stations on the main channel of the Rio Grande as well as 12 gaging stations on the measured tributaries in its country. In addition, the U.S. section operates several gaging stations on U.S. diversion and return flow channels. The Mexican section operates and maintains four gaging stations on the main channel of the Rio Grande, and eight gaging stations located on measured tributaries in Mexico, as well as gaging stations located on diversion and return flow channels in Mexico. The data provided by these gaging stations form the basis for joint accounting by the two sections of the waters belonging to each country. The national ownership of waters has been determined since 1953. The Water Accounting Division also oversees the operation of 10 gaging stations on the Lower Colorado River in association with deliveries of water to Mexico pursuant to the Treaty.

The Treaty further provided for the two governments to jointly construct, operate, and maintain on the main channel of the Rio Grande the dams required for the conservation, storage, and regulation of the greatest quantity of the annual flow of the river to enable each country to make optimum use of its allotted waters.

3. Social Characteristics

According to the Region M Plan, the population in the eight-county region is expected to grow from 1.7 million in 2010 to 4 million in 2060. This represents a growth rate of 2.8% per year, which is seven times faster than the State's average growth rate of 0.4% per year. The study area contains a disproportionate number of persons living below the poverty level when compared to the rest of Texas (35.7 versus 15.4%). In addition, the median household income in the area is $23,489, well below the State average of $39,927.

The impacts of not addressing the staggering water supply and demand imbalances, both current and future, in the Lower Rio Grande River Basin are severe. The study area is home to 27 irrigation districts and a multimillion dollar crop and citrus industry that drives both the local and national economy. According to the Region M Plan, the annual value of crops and citrus grown in the study area is estimated at $50 million and $200 million, respectively. Texas is the third largest citrus producer and fourth largest sugarcane producer in the United States, most of which is grown in the study area. Other prominent crops include cotton, sorghum, and corn.

Irrigation water rights in the study area are junior to municipal and industrial (M&I) rights and, as such, are subject to proration during supply shortages. This can have devastating impacts on agricultural uses and the local economy when shortages occur. For instance, the 2009 drought resulted in interrupted water diversions for some irrigation districts with junior water rights, which resulted in a 49% loss of acreage and $19 million in losses for farmers in parts of the study area[7]. In general, when agricultural shortages occur, costs to the local economy have been estimated to be about $135 million and a loss of 4,130 jobs annually.[8]

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 United States 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. At the end of the millennium, approximately 81% 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 were then imported in the United States. 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 into 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

[7] Santa Ana, R. 2009. "Drought losses top $19 million in Lower Rio Grande Valley," AgriLife NEWS, Texas A&M University. November 13, 2009.

[8] Robinson, J.R.C. et al. Water Policy 12 (2010) 114–128 Mitigating water shortages in a multiple risk environment.

value in the past decade. As will be described later in this study, oil development activities outside of the study area, but nearby, are beginning to show increased demand for water from within the study area.

The Texas Department of Tourism Web site illustrates that in 2008 the total destination spending for tourism for Cameron, Hidalgo, Willacy, Webb, and Starr Counties was over $2,000 million.[9] Tourism in Falcon State Park has a significant economic impact in Zapata and Starr Counties. In addition, water-related recreational activities such as boating, sport fishing, birdwatching, and commercial fishing in the lower Laguna Madre and adjacent waters also influence the regional economy.

The Lower Rio Grande Valley National Wildlife Refuge and Wildlife Corridor, administered by the U.S. Fish and Wildlife Service and Texas Parks and Wildlife, respectively, covers 91,000 acres in the region, with plans to expand to 132,000 acres. The study area is located within a major confluence of two flyways for migratory birds and waterfowl and is home to the World Birding Center, which is a top worldwide destination for birdwatching. According to the McAllen Chamber of Commerce, the economic impact by birdwatchers in the Rio Grande Valley is estimated to be approximately $125 million per year. Santa Ana National Wildlife Refuge attracts an estimated 99,000 birdwatchers per year, most of who have traveled from outside of the four-county area, and most from other States. These visitors inject $36 million into the local economy, with a total gross input of almost $89 million.

4. Environmental Characteristics

a. 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 degrees Fahrenheit (°F) to 98 °F. The January minimum temperature in the region ranges from about 40 °F to 49 °F. 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. The 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. 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

[9] http://travel.state.tx.us/TravelResearch.aspx

region. 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 that provide a large portion of the surface water runoff captured in water supply reservoirs within the Rio Grande Basin.

b. Water Resources

(1) Surface Water

The Rio Grande Basin extends southward from the Continental Divide in southern Colorado through New Mexico and from Texas to the Gulf of Mexico. From El Paso, Texas, to the Gulf of Mexico, 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 contribute to the Rio Grande (figure 1-2). The remainder of the basin consists of internal closed sub-basins.

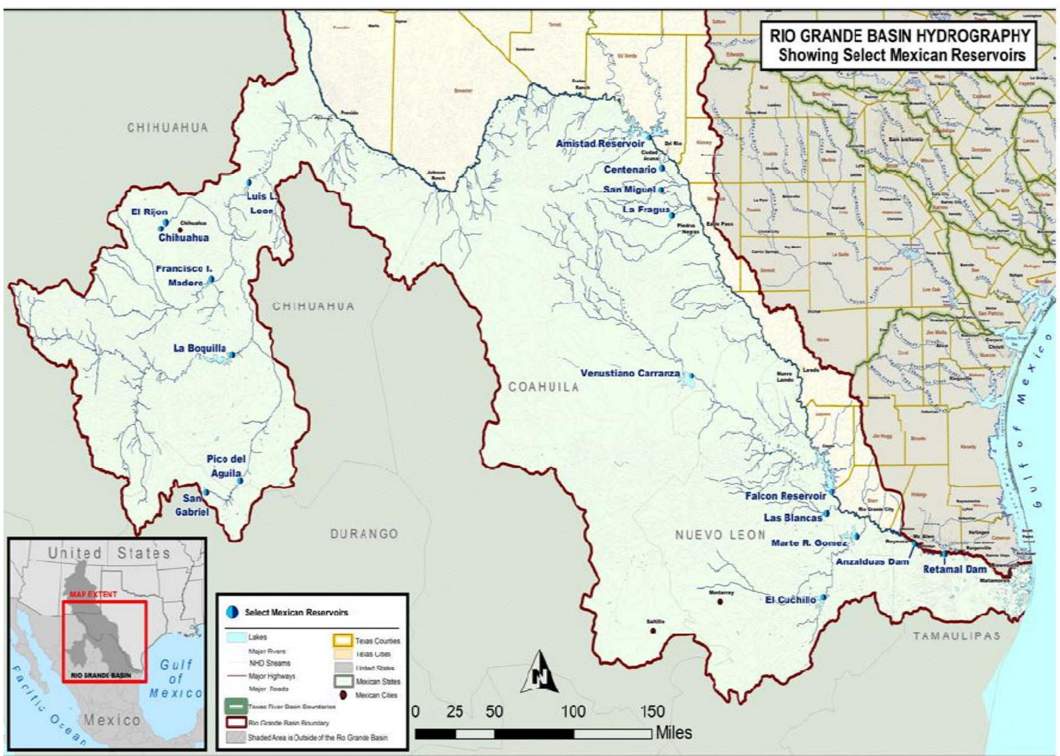

Figure 1-2: Rio Grande Basin with reservoirs.
Source: TWDB Region M Plan.

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 of 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. The Amistad-Falcon Reservoir System is designated as a special water resource by the TWDB (31 Texas Administrative Code 357.5(g)).

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. Once the river reaches Fort Quitman, Texas, downstream from El Paso, diversions to the United States and Mexico have essentially utilized all of the upstream surface waters. Therefore, for the purposes of water accounting and planning, the Rio Grande south of Fort Quitman is treated as a separate unit by the IBWC. Since waters upstream of Fort Quitman do not contribute to the Amistad and Falcon Reservoirs which serve the study area, the basin downstream from Fort Quitman comprises the hydrologic basin for this study.

Practically all of the surface water 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 IBWC for flood control and water supply purposes. These impoundments provide controlled storage for over 8 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 oxbows (locally known as “resacas”) in Hidalgo and Cameron Counties. Under drought of record conditions, surface water supplies from sources other than the Rio Grande have very little flow and are of little significance.

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 are 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. Typically, the flow rate of the existing springs is less than 20 gallons per minute, with most springs in the region flowing at a rate of only a few gallons per minute.

(2) Groundwater

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 1-3). In general, groundwater from the various aquifers in the region has total dissolved solids (TDS) concentrations exceeding 1,000 milligrams per liter (mg/L) (slightly saline) and often exceeds 3,000 mg/L (moderately saline). The salinity hazard for groundwater ranges from high to very high. Given the recent droughts and competition for surface water supplies, developing and desalinating groundwater in the study area are increasingly of interest.

c. Plants and Wildlife

Located within the Matamoran District of the Tamaulipan Biotic Province, 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.

The predominant vegetation type in this area is thorny brush, but there is an 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% of total riparian vegetation and 95% of Tamaulipan thornscrub have been cleared since the 1900s.

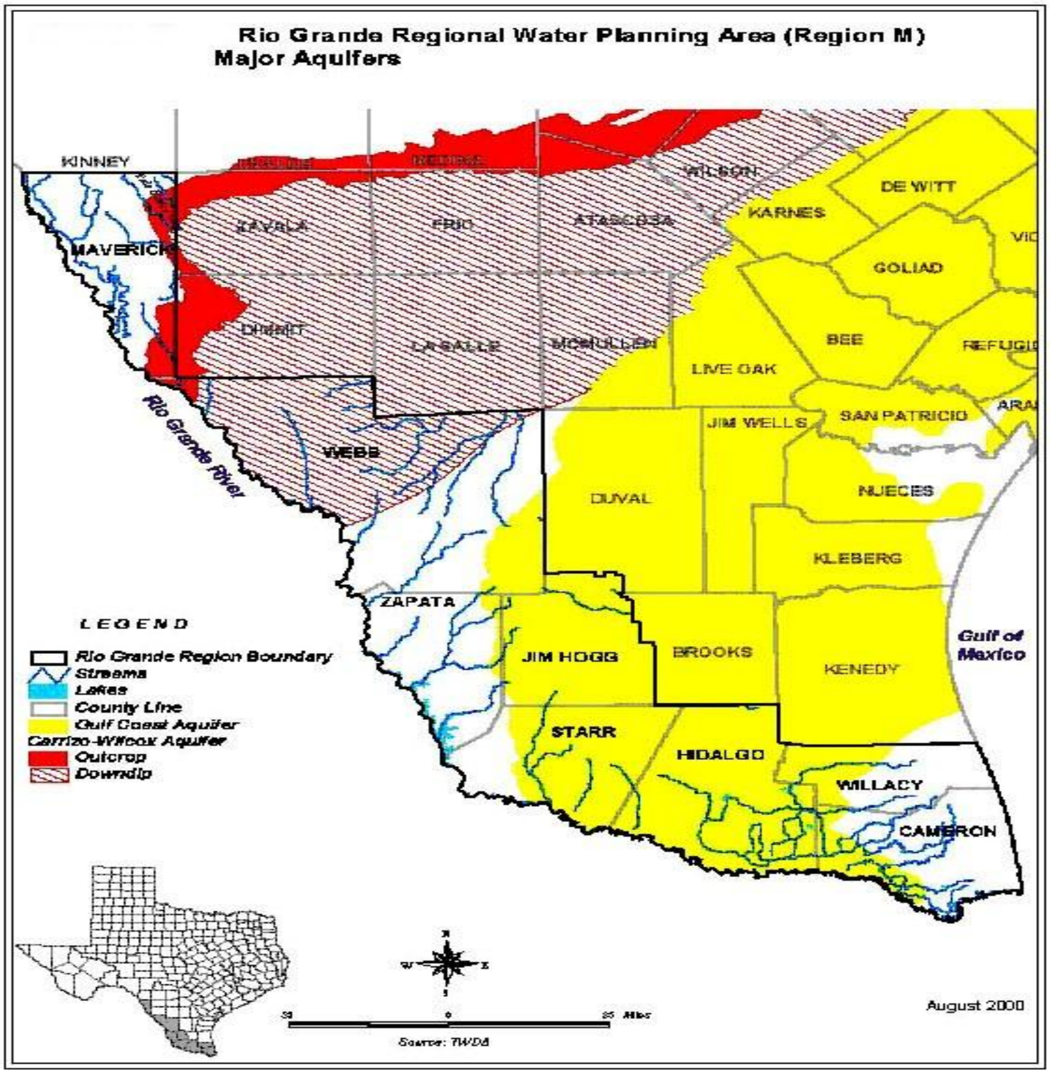

Figure 1-3: Major aquifers in the study area.
Source: TWDB Region M Plan.

Sixty-nine rare, threatened, or endangered species are supported by the Lower Rio Grande Valley National Wildlife Refuge and Wildlife Corridor. All of these sensitive resources will be subject to increased stressors in the future as water supplies become more constrained by increased demand and climate change.

d. Archeological Resources

A good chronology of the prehistoric occupation of the lower Rio Grande Delta is not available. There has been a significant amount of archeological work done in the south tip of Texas, but most of it is derived from surface surveys, and not the careful excavation of buried sites, which would provide clear definitions and a precise dating sequence. It is clear that the area has been occupied at least periodically for the last 13,000 years. The earliest period of documented occupation is the Paleo-Indian Period, which was at the end of the last ice age, when many large animals such as mammoths, extinct forms of bison, horse, and camels were common in North America. However, only sparse evidence from this period has been reported in this part of south Texas. In the following Archaic Period, investigations around Falcon Reservoir, just to the west of this area, have led some researchers to propose the “Falcon Focus.”[10] The “Aransas Focus” also has been described in the central coastal region for this period.

In the still more recent Late Prehistoric Period, two cultural units have been proposed for the Rio Grande Delta region: the Brownsville and Barril Complexes, which were described by MacNeish.[11] It has also been suggested that the “Rockport Focus,” which was described for the Coastal Bend region near Corpus Christi, may have exploited the coastal margin as far south as Willacy County. To the west, the poorly defined “Mier Focus” is also present in this Late Prehistoric timeframe.[12] The Panuco and Catan Complexes have been described to the south in Mexico.

By the time of first European contact, Native Americans in south Texas and northern Mexico included two distinct groups: the inland bands, known as the Coahuiltecans, and the coastal bands known as the Karankawas.[13] The area was also occasionally visited by the Lipan Apache in the late-prehistoric and early historic periods. Archeological sites are occasionally exposed by erosion or construction; however, they are more commonly identified by surface surveys, which record scatters of surface materials such as shell, stone flakes, fire-cracked rock, and occasionally stone tools or ceramic fragments. Once these sites are identified, they are evaluated by test excavation of areas where surface materials are recorded. Prospecting of some highly likely areas for occupation, such as the low levees adjacent to resacas and abandoned river channels, is also a possibility.

e. Historical Resources

The history of the Lower Rio Grande Valley is strongly connected to the development of water resources. Since the formulation of the planning objective for this study concentrates on the water issues of Cameron, Hidlago, and Willacy

[10] Suhm, D.A., E.B. Jelks, and A.D. Krieger. An Introductory Handbook of Texas Archeology, Bulletin of the Texas Archeological Society 25. 1954.

[11] MacNeish, Richard S. A preliminary report on coastal Tamaulipas, Mexico, American Antiquity. July 1947.

[12] Suhm, D.A., E.B. Jelks, and A.D. Krieger. An Introductory Handbook of Texas Archeology, Bulletin of the Texas Archeological Society 25. 1954.

[13] Newcomb, W.W. The Indians of Texas: From prehistoric to Modern Times Texas History Paperbacks. 1969.

Counties in the Lower Valley, historical context is best captured with excerpts from the Texas Department of Transportation's *A Field Guide to Irrigation in the Lower Rio Grande Valley*.[14]

The Spanish began settling the Lower Rio Grande Valley in the 18th century. Spanish settlers engaged primarily in livestock production. José de Escandón colonized the area known today as Hidalgo County in 1749, dividing the area along the river into 80 *porciones* (approximately a league or 4,428 acres), with larger grants to allow river frontage for each settler. As a result, these long lots measured approximately 9/13 of a mile in width and approximately 11 to 16 miles in length away from the river. In contrast, the land in Cameron County was issued in several large grants. Only three Spanish and Mexican grants were made in the area covered today by Willacy County.

Following the Texas War for Independence, the area south of the Nueces River became disputed territory with Mexico. The formation of Cameron County from San Patricio County occurred after the Mexican War (1846–1848) in which Mexico finally accepted the Rio Grande River as it border with the signing of the Treaty of Guadalupe-Hidalgo (1848). This Treaty established the boundary between Texas and Mexico at the middle of the deepest channel of the river from El Paso to the Gulf. It also allowed those Mexican citizens living on the Texas side to retain ownership of their lands. At that time, Cameron County encompassed almost all of south Texas, some 3,308 square miles, including parts of Hidalgo, Willacy, Kenedy, and Brooks Counties. Hidalgo County was subsequently established in 1852.

Throughout the early settlement period of the Lower Rio Grande Valley, cattle production dominated the economy of the semiarid region in the 18th and 19th centuries. Early attempts to irrigate the fertile lands of the delta were not commercially successful until a number of developments occurred, including: (1) a dependable form of transportation to markets through a rail line, (2) an efficient means of pumping water over the high banks of the river with centrifugal pumps, (3) an influx of capital from investors for the development of irrigation systems, (4) the arrival of farmers to purchase the irrigated farm lands, and (5) a supply of cheap farm labor. Once achieved, an agricultural boom occurred in the valley after 1904 with an explosion in the number of private land and irrigation companies investing in the area.

The Lower Rio Grande Valley experienced a period of expansion until the post-World War I years at which time undercapitalized developers could not withstand the economic impacts of the Mexican Revolution, drought and flood, and the post-war agricultural depression. Subsequently, the valley witnessed the transfer of control of irrigation from private companies to publicly owned irrigation

[14] Environmental Affairs Division, Work Authorization 576-15-SH002, Knight & Associates. 2009.

districts. The rise of the citrus industry during the 1920s produced a second land boom, resulting in the creation of a number of new developer-initiated irrigation districts for the construction of new irrigation systems that increased the number of irrigated acres in the valley.

Unfortunately, many of these new irrigation districts were created on the eve of the Depression, and the numbers of irrigated acreage steeply declined during the following years. A third agricultural boom began in 1942 at which time the lands within the existing irrigation districts were fully developed. The drought and devastating freezes of the early 1950s, coupled with the increasing demand for limited water resources by a growing agribusiness and urbanization of the valley, transformed the way water was allocated and distributed to the irrigation districts as well as to the physical appearance of the irrigation systems themselves by the 1960s. The agricultural development of the Lower Rio Grande Valley represented the most successful and the largest concentration of irrigated land in Texas until the development of the Panhandle and High Plains after World War II.

Today, the irrigation districts, which are at least 50 years old, are eligible to be listed or are listed in the National Register of Historic Places. The Reclamation cost-shared activities in renovating the irrigation systems under the Lower Rio Grande Water Conservation and Improvement Act of 2002, as amended (P.L. 107-351), and the SECURE Water Act of 2009 (P.L. 111-11) continue to be examined for their effects on these historic properties and have for the most part been determined to have no adverse effect. In some cases, additional documentation or mitigation has been required prior to the activities going forward.

5. Present Water and Related Land Development

There are many ongoing Reclamation activities in the study area. The Lower Rio Grande Water Conservation and Improvement Act of 2002, as amended (P.L. 107-351), provided Reclamation with the authority to fund 50% of the costs, up to $55 million, to plan, design, and construct water conservation improvements on 19 irrigation districts within the study area. Twelve of the 19 projects executed cost-share agreements – 9 are complete and under operation, and 2 are under construction. The remaining seven districts elected to postpone construction until additional funding becomes available for the program. New legislation (H.R. 550) has been introduced into the 112th Congress to authorize an additional 19 projects with a $42 million Federal cost share.

Reclamation also provides financial assistance to several irrigation districts and municipalities within the study area through the WaterSMART Program – a total of 13 grants have been awarded ($3.5 million Federal funding), totaling about $11 million in projects when combined with non-Federal partners' cost share. The amount of Federal funds flowing into the study area over the last decade is a testament to the urgent need that currently exists in this region to better manage and conserve water. One of the benefits of conducting a study on this region is that it includes a comprehensive evaluation of regional water supply options to meet the needs of entities that otherwise would continue to pursue "piecemeal" solutions to their individual water needs. This is not to detract from the value of implementing water conservation and improving water delivery efficiencies, but more needs to be done if the region hopes to address the projected supply deficits in the study area.

An urgent need exists to reduce dependence on the Rio Grande River and address a current and projected water supply deficit within the study area, which is one of the fastest growing and most economically depressed areas in the United States.

6. Public Involvement

Public involvement was actively sought and achieved throughout the study, primarily through Study Partner and stakeholder representation at bimonthly public meetings of the RGRWA Board of Directors. The RGRWA board consists of 18 members representing irrigation districts, the public, municipalities, water supply corporations (WSCs), and counties. Meeting agendas always included a presentation on Basin Study progress, and consensus was obtained following discussion and a formal vote on major study actions, including acceptance of the climate change-affected future conditions projections, formulation of the planning objective, evaluation of alternatives, and recommended alternative analysis. Stakeholders were specifically reminded by Reclamation at meetings that they are expected to represent all of their relevant member interests. Communications were also held on a case-by-case basis as needed to solicit input, expertise, and data. In addition, meetings of the RGRWA board also included representatives from the following:

- Texas Water Development Board
- Region M Planning Group
- Texas Commission on Environmental Quality, Office of Rio Grande Watermaster
- Texas Parks and Wildlife Department
- International Boundary Water Commission
- United States Department of Agriculture (USDA) Cooperative Extension Service
- U.S. Geological Survey (USGS)

In addition, RGRWA's consulting team, which performed the technical analyses for the study, also regularly attended the biweekly Region M Planning Group public meetings to stay abreast of water planning issues in the study area. Some member companies of the Basin Study consulting team were also subcontractors to the team contracted by the Region M Planning Group to perform the required 5-year update of the Region M Plan, which facilitated communication and coordination with the Basin Study. For example, proposed criteria emerging from the Basin Study for the location of the preferred alternative BGD plants were circulated in a Region M Plan survey on water supply strategies.

Also, Reclamation was invited to speak and conducted presentations on the study at two different meetings that involved both governmental and public attendees, which included:

- U.S. Army Corps of Engineers Conference on the Lower Rio Grande, October 2010
- IBWC Citizens' Forum , October 2012

Public involvement was also achieved through the Internet, where a link on the RGRWA Web site was be maintained to provide up-to-date information on the Basin Study.[15] The following was provided on the Web link:

- Summary and background information
- A link to the original proposal for funding
- A link to the final Plan of Study
- Updates/news releases on completed milestones
- Points of contact

The final report will also be posted on the Web site, and press releases will solicit public comment by providing a link to the document on the RGRWA Web site.

a. Quality Assurance/Quality Control and Technical Sufficiency

The Quality Assurance/Quality Control (QA/QC) Team provided policy guidance, independent oversight, and peer review over technical aspects of the study. In-progress reviews were conducted by Reclamation project team members through telephone and email communications no less frequently than every 2 weeks and 1 week in advance of each deliverable. Reclamation's team

[15] http://www.rgrwa.org/projects/lower-rio-grande-basin-study/

members had the added responsibility of ensuring that the study adhered to Reclamation policy; directives and standards; guidelines with respect to planning, engineering design, and cost estimating; hydrology; economics; environmental impacts; and any other technical aspects of the study.

(1) Quality Assurance

The application of the data for this Basin Study in modeling future supply conditions was conducted by experienced hydrologist Dr. Subhrendu Gangopadhyay, PhD, P.E., of Reclamation's Water Resources Planning and Operations Support Group. Quality assurance of Dr. Gangopadhyay's work was performed by Delbert M. Smith, Manager of Reclamation's Water Resources Planning and Operations Support Group. The QA/QC Team included individuals from various technical and nontechnical disciplines. Members included, but were not limited to:

- Rio Grande Regional Water Authority
    - Marcie Oviedo, Director of Planning for the Lower Rio Grande Valley Development Council
    - RGRWA Basin Study Technical Team, headed by Brian E. Macmanus, P.E., of East Rio Hondo Water Supply Corporation (ERHWSC)
- Reclamation
    - Kip Gjerde, Regional Planning Officer
    - Del Smith , Manager of Reclamation's Water Resources Planning and Operations Support Group
    - Jeff Gerber, Environmental Protection Specialist
    - Bob Jurenka, Plant Structures Engineer
    - Andrew Tiffenbach, Mechanical Engineer
    - Katharine Dahm, Civil Engineer
    - Collins Balcombe, Supervisory Program Coordinator
    - Steve Piper, Economist

(2) Quality Control

Data used in climate and hydrology modeling have previously been subjected to and satisfied Reclamation's Peer Review of Scientific Information and Assessments Directives and Standards during development of the West-Wide Climate Risk Assessments: Bias Corrected Spatially Downscaled Surface (BCSD) Water Projections, which utilized the BCSD climate projections and Variable Infiltration Capacity Hydrology Model (VIC).

QA/QC of preliminary cost estimates for the proposed project infrastructure developed using the TWDB's Unified Costing Model (UCM) was performed by Dr. Katharine Dahm, PhD, and Andrew Tiffenbach of Reclamation's Water Treatment Group. Reviewers evaluated the use of the UCM on the phased build-out approach developed by the contractor. Affordability calculations and discussions were reviewed by Dr. Steve Piper, PhD, of Reclamation's Economics and Resource Planning Team.

Quality assurance included the verification of proper methodology for use of a modified UCM developed to represent the complex well field, pipeline, pumping, land acquisition, and phased treatment plant build-out of the three grouped study areas. Modifications to the UCM were evaluated and developed collaboratively with reviewers to ensure that UCM assumptions and accuracy were correctly applied. The verification of cost estimates included detailed tracking of calculations through final costing to ensure the incremental phased costs were represented appropriately based on the contractor's framework. Capital and annual cost calculations were verified for each group and phase of the UCMs prepared by the contractor.

Quality control included rigorous checking of UCM inputs, such as conveyance distances, delivery volumes, pipeline elevations, well field drawdown, groundwater well development, source water quality, treatment plant efficiency, land cost, and operation and maintenance (O&M) criteria, specifically power and pumping requirements, to properly calculate preliminary cost information. Copies of the UCM were exchanged among reviewers and the contractor until all input assumptions were verified. Due to the preliminary nature of the estimates, reviewers provided a memorandum to Reclamation project leads assessing the technical sufficiency of the preliminary engineering analysis and outlining suggested areas of additional investigation in the next phase of this project (appendix A).