WATER FOR TEXAS 2012 STATE WATER PLAN

# 2012
# Water for Texas

TEXAS WATER DEVELOPMENT BOARD

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January 2012

Texas Water Development Board
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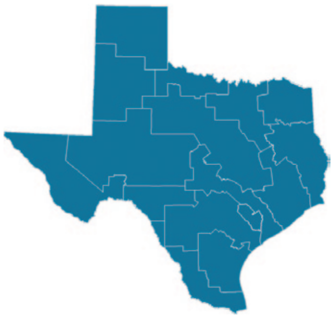
To the People of Texas:

Texas is currently experiencing what has been described as the worst one-year drought in the state's history, again emphasizing the importance of long-range planning to meet the state's water needs. The 2012 State Water Plan is the third plan that incorporates 16 regional water plans developed under Texas Water Code, Section 16.053. Reflecting the dedicated work of over 400 voting and nonvoting members of the regional water planning groups, this plan was developed between January 2006 and December 2011. This document provides recommended actions to provide long-term water supply solutions to meet water supply needs during drought of record conditions. The State Drought Preparedness Plan is developed by the Drought Preparedness Council for managing and coordinating the state's response. The State Drought Preparedness Plan outlines measures to prepare for, respond to, and mitigate the effects of drought and can be found at http://www.txdps.state.tx.us/dem/CouncilsCommittees/droughtCouncil/droughtPrepPlan.pdf .

**The primary message of the 2012 State Water Plan is a simple one: In serious drought conditions, Texas does not and will not have enough water to meet the needs of its people, its businesses, and its agricultural enterprises. This plan presents the information regarding the recommended conservation and other types of water management strategies that would be necessary to meet the state's needs in drought conditions, the cost of such strategies, and estimates of the state's financial assistance that would be required to implement these strategies. The plan also presents the sobering news of the economic losses likely to occur if these water supply needs cannot be met. As the state continues to experience rapid growth and declining water supplies, implementation of the plan is crucial to ensure public health, safety, and welfare and economic development in the state.**

Respectfully submitted,

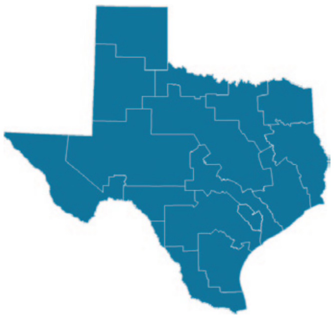
Edward G. Vaughan, Chairman



# Acknowledgments

The 2012 State Water Plan would not have been possible without the time and expertise of numerous people and organizations throughout the state of Texas. The Texas Water Development Board (TWDB) would like to express its sincere appreciation to all of those that participated in the development of the 16 regional plans and this state water plan: the more than 400 regional water planning group members, consultants, and administrative agencies; staff of the TWDB; Texas Parks and Wildlife Department, Texas Department of Agriculture, Texas Commission on Environmental Quality, and other state and federal agencies; and the individuals and organizations that provided public input during the planning process.

Finally, we would like to thank the leadership of the state of Texas for their consistent support and recognition of the importance of water planning.



# Table of Contents

## TABLE OF CONTENTS

## LIST OF FIGURES

# LIST OF TABLES

# Quick Facts

The population in Texas is expected to increase 82 percent between the years 2010 and 2060, growing from 25.4 million to 46.3 million people.

Water demand in Texas is projected to increase by only 22 percent, from about 18 million acre-feet per year in 2010 to about 22 million acre-feet per year in 2060.

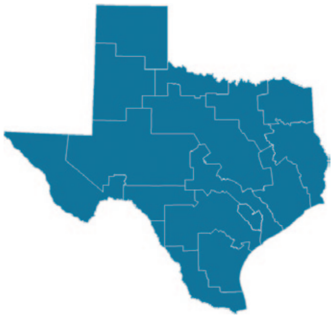
Existing water supplies — the amount of water that can be produced with current permits, current contracts, and existing infrastructure during drought — are projected to decrease about 10 percent, from about 17.0 million acre-feet in 2010 to about 15.3 million acre-feet in 2060, due primarily to Ogallala Aquifer depletion and reduced reliance on the Gulf Coast Aquifer.

If Texas does not implement new water supply projects or management strategies, then homes, businesses, and agricultural enterprises throughout the state are projected to need 8.3 million acre-feet of additional water supply by 2060.

Annual economic losses from not meeting water supply needs could result in a reduction in income of approximately $11.9 billion annually if current drought conditions approach the drought of record, and as much as $115.7 billion annually by 2060, with over a million lost jobs.

The regional planning groups recommended 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought, resulting in a total, if implemented, of 9.0 million acre-feet per year in additional water supplies by 2060.

The capital cost to design, construct, or implement the recommended water management strategies and projects is $53 billion. Municipal water providers are expected to need nearly $27 billion in state financial assistance to implement these strategies.



# Executive Summary

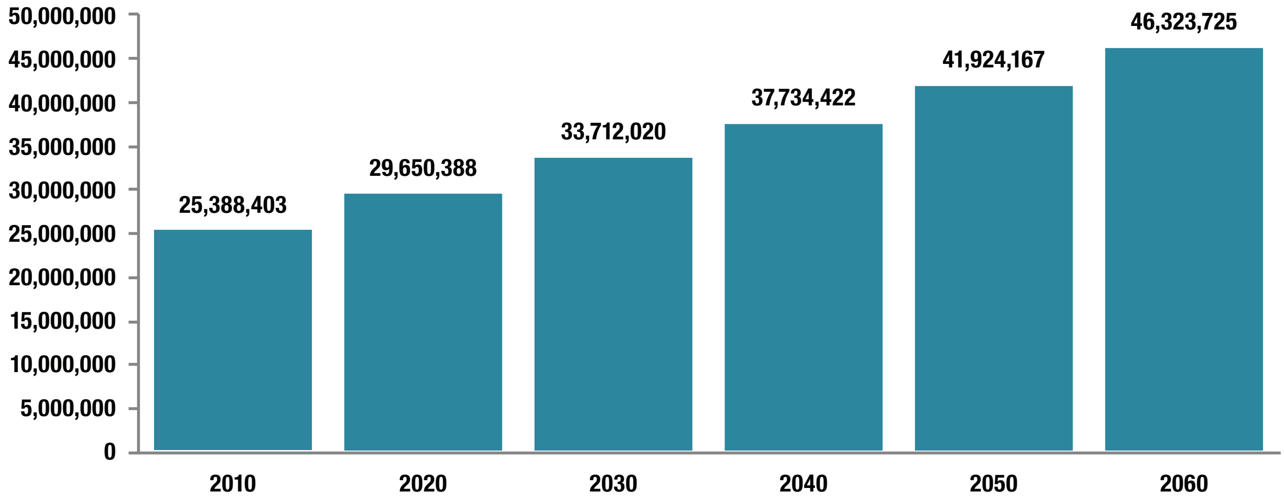
**“If Texans cannot change the weather, they can at least, through sound, farsighted planning, conserve and develop water resources to supply their needs.”**
**— A Plan for Meeting the 1980 Water Requirements of Texas, 1961**

## WHY DO WE PLAN?

This plan is designed to meet the state’s needs for water during times of drought. Although droughts have always plagued Texas, the one that occurred in the 1950s was particularly devastating. It was, in fact, the worst in our state’s recorded history and is still considered Texas’ “drought of record.” The purpose of this plan is to ensure that our state’s cities, rural communities, farms, ranches, businesses, and industries will have enough water to meet their needs during a repeat of this great drought.

As recognized by the Texas Legislature upon passage of omnibus water planning legislation in 1997, water—more than any other natural resource—challenges the state’s future. Scarcity and competition for water, environmental concerns, and the cost of new water supplies have made sound water planning and management increasingly important. With the state’s population expected to grow by 82 percent in the next 50 years, the availability of water supplies during times of drought is essential for not only the Texans of today but for those of tomorrow as well.

## FIGURE ES.1. PROJECTED POPULATION GROWTH.




## HOW DO WE PLAN?

Water planning in Texas starts at the regional level with 16 regional water planning groups, 1 for each of the 16 designated planning areas in the state. Each planning group consists of about 20 members that represent at least 11 interests, as required by Texas statute, including **Agriculture, Industry, Public, Environment, Municipalities, Business, Water Districts, River Authorities, Water Utilities, Counties, and Power Generation.**

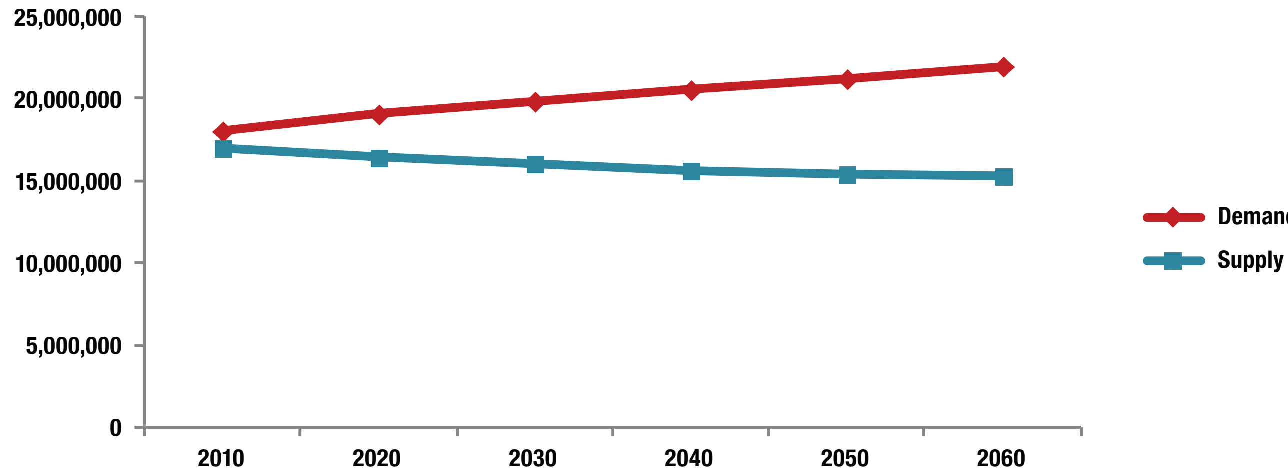
During each five-year planning cycle, planning groups evaluate population projections, water demand projections, and existing water supplies that would be available during times of drought. Planning groups identify water user groups that will not have enough water during times of drought, recommend strategies that could be implemented to address shortages, and estimate the costs of these strategies. While carrying out these tasks, planning groups assess risks and uncertainties in the planning process and evaluate potential impacts of water management strategies on the state's water, agricultural, and natural resources.

Once the planning groups adopt their regional water plans, they are sent to the Texas Water Development Board (TWDB)—the state's water supply planning and financing agency—for approval. TWDB then compiles the state water plan, which serves as a guide to state water policy, with information from the regional water plans and policy recommendations to the Texas Legislature. Each step of the process is open to the public and provides numerous opportunities for public input.

## HOW MANY TEXANS WILL THERE BE?

The population in Texas is expected to increase significantly between the years 2010 and 2060, growing from 25.4 million to 46.3 million people. Growth rates vary considerably across the state, with some planning areas more than doubling over the planning horizon and others growing only slightly or not at all (Figure ES.1). Thirty counties and 225 cities are projected to at least double their population by 2060, but another 52 counties and 158 cities are expected to lose population or remain the same. The rest are expected to grow slightly.

FIGURE ES.2. PROJECTED WATER DEMAND AND EXISTING SUPPLIES (ACRE-FEET PER YEAR).




## HOW MUCH WATER WILL WE REQUIRE?

Although the population is projected to increase 82 percent over 50 years, water demand in Texas is projected to increase by only 22 percent, from about 18 million acre-feet per year in 2010 to a demand of about 22 million acre-feet per year in 2060 (Figure ES.2). Demand for municipal water (including rural county-other) is expected to increase from 4.9 million acre-feet in 2010 to 8.4 million acre-feet in 2060. However, demand for agricultural irrigation water is expected to decrease, from 10 million acre-feet per year in 2010 to about 8.4 million acre-feet per year in 2060, due to more efficient irrigation systems, reduced groundwater supplies, and the transfer of water rights from agricultural to municipal uses. Water demands for manufacturing, steam-electric power generation, and livestock are expected to increase, while mining demand is expected to remain relatively constant.

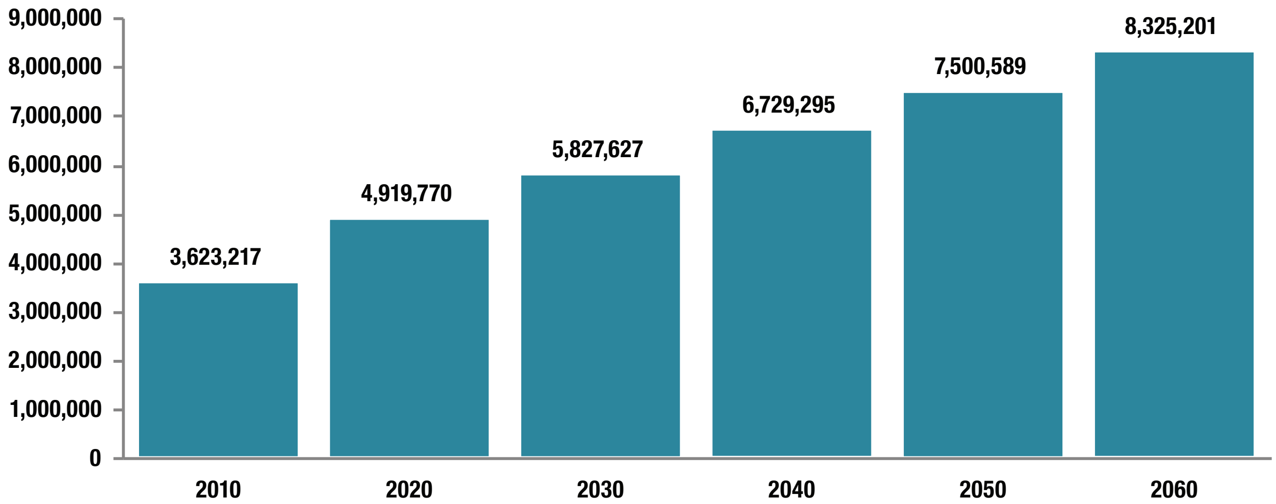
## HOW MUCH WATER DO WE HAVE NOW?

Existing water supplies—categorized as surface water, groundwater, and reuse water—are projected to decrease about 10 percent, from about 17.0 million acre-feet in 2010 to about 15.3 million acre-feet in 2060. For planning purposes, existing supplies are those water supplies that are physically and legally available, defined as the amount of water that can be produced with current permits, current contracts, and existing infrastructure during drought.

Groundwater supplies are projected to decrease 30 percent, from about 8 million acre-feet in 2010 to about 5.7 million acre-feet in 2060. This decrease is primarily due to reduced supply from the Ogallala Aquifer as a result of its depletion over time and reduced supply from the Gulf Coast Aquifer due to mandatory reductions in pumping to prevent land subsidence.

Surface water supplies are projected to increase by about 6 percent, from about 8.4 million acre-feet in 2010 to about 9.0 million acre-feet in 2060. In a departure from the convention employed in previous regional water plans, some surface water supplies were added to the accounting of existing supplies only in the decade when an existing contract was expanded to call on the increased amount of supply, as the increase

## FIGURE ES.3. PROJECTED NEED FOR ADDITIONAL WATER IN TIMES OF DROUGHT (ACRE-FEET PER YEAR).




would only then become "legally" available. With the adoption of this convention by some planning groups, existing surface water supplies are projected to increase over the planning horizon. In previous plans the full amount of supply was shown from the first decade, and supplies were shown to decrease over time as a result of sedimentation of reservoirs.

Existing supply from water reuse is expected to increase from 482,000 acre-feet per year in 2010 to about 614,000 thousand acre-feet per year by 2060. This represents an increase of about 65 percent in 2060 reuse supplies, as compared to the 2007 State Water Plan.

## DO WE HAVE ENOUGH WATER FOR THE FUTURE?

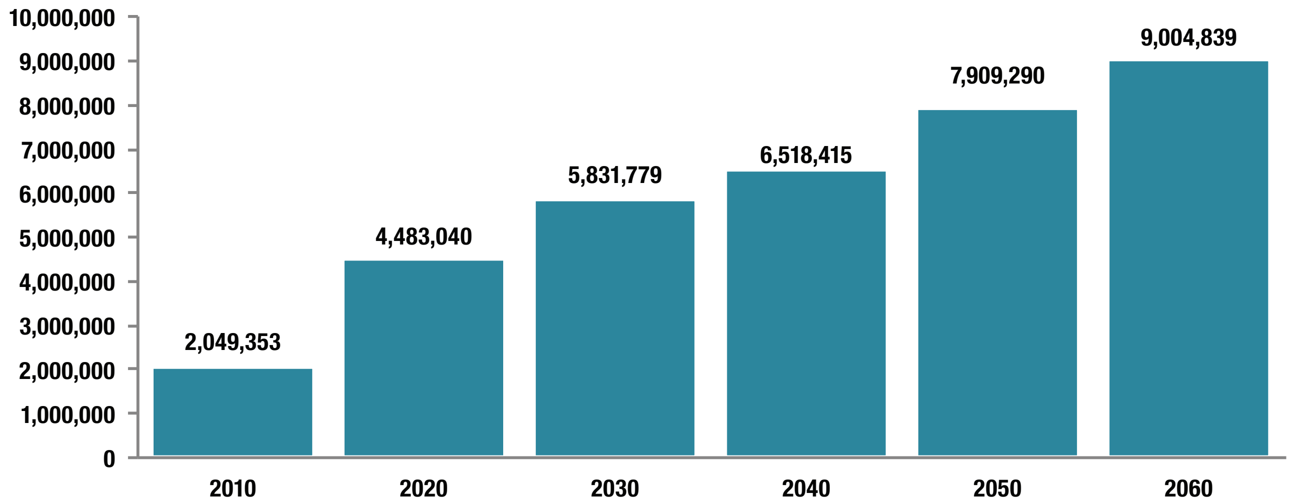
We do not have enough existing water supplies today to meet the demand for water during times of drought. In the event of severe drought conditions, the state would face an immediate need for additional water supplies of 3.6 million acre-feet per year with 86 percent of that need in irrigation and about 9 percent associated directly with municipal water users. Total needs are projected to increase by 130 percent between 2010 and 2060 to 8.3 million acre-feet per year (Figure ES.3). In 2060, irrigation represents 45 percent of the total needs and municipal users account for 41 percent of needs.

## WHAT CAN WE DO TO GET MORE WATER?

When projected demands for water exceed the projected supplies available during drought conditions, the planning groups recommended water management strategies—specific plans to increase water supply or maximize existing supply. These strategies included 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought (this figure is lower than presented in previous plans because it does not separately count each entity participating in a given project).

The strategies recommended by regional water planning groups would provide, if implemented, 9.0 million acre-feet per year in additional water supplies by 2060 (Figure ES.4). Water management strategies can include conservation, drought management,

#### FIGURE ES.4. WATER SUPPLIES FROM WATER MANAGEMENT STRATEGIES IN THE STATE WATER PLAN (ACRE-FEET PER YEAR).




reservoirs, wells, water reuse, desalination plants, and others. About 34 percent of the volume of these strategies would come from conservation and reuse, about 17 percent from new major reservoirs, and about 34 percent from other surface water supplies.

Some planning groups recommend water management strategies that would provide more water than would be needed during a repeat of the drought of record. This "cushion" of additional supplies helps address risks and uncertainties that are inherent in the planning process, such as:

- greater population growth or higher water demands than projected;
- climate variability, including a drought worse than the one experienced during the 1950s; and
- difficulties in financing and implementing projects.

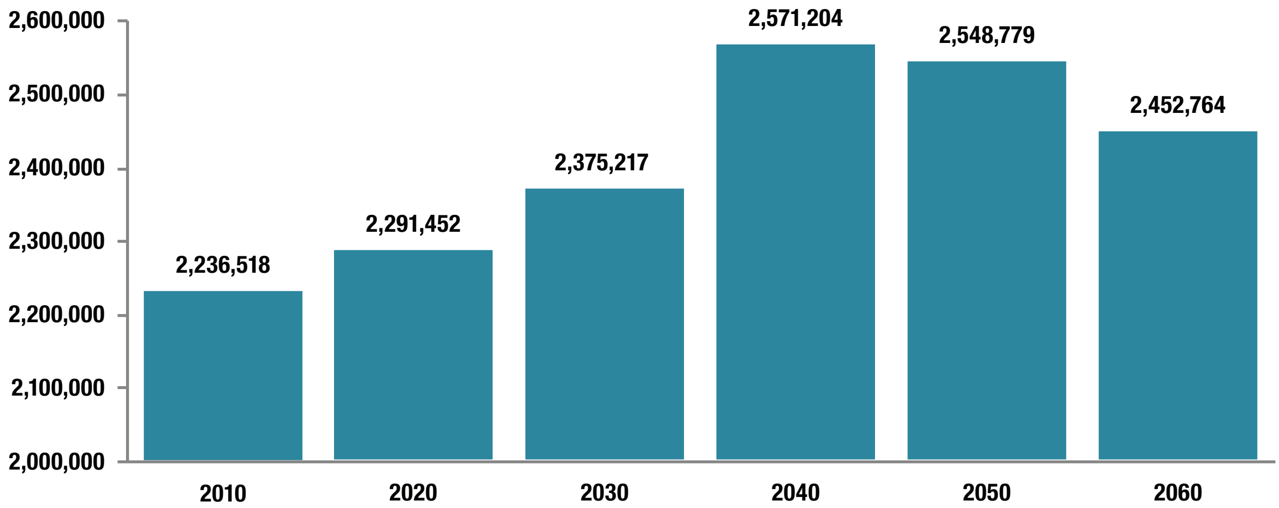
## ARE ALL THE WATER SUPPLY NEEDS MET?

Four planning groups were able to identify strategies to meet all of the needs for water identified in their regions, including municipal, manufacturing, mining, irrigation, steam-electric power generation, and livestock. Twelve planning groups were unable to meet all water supply needs for each water user group in their planning areas. Approximately 2.2 million acre-feet of water supply needs are unmet in 2010, increasing to approximately 2.5 million acre-feet in 2060 (Figure ES.5). Unmet water supply needs occur for all categories of water user groups, with the exception of manufacturing. Irrigation represents the vast majority (98-99 percent) of unmet needs in all decades. The major reason for not meeting a water user group's water supply need is that the planning group did not identify an economically feasible water management strategy to meet the water supply need.

## HOW MUCH WILL IT COST?

The estimated total capital cost of the 2012 State Water Plan, representing the capital costs of all water management strategies recommended in the 2011 regional water plans, is $53 billion. This amount represents about a quarter of the total needs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years (Figure ES.6). These costs consist primarily of the funds needed to permit, design, and construct projects that implement

FIGURE ES.5. UNMET WATER SUPPLY NEEDS (ACRE-FEET PER YEAR).




recommended strategies, with the majority of the costs (about $46 billion) going toward meeting municipal needs; that is, the needs of residential, commercial, and institutional water users in cities and rural communities. Based on surveys conducted as part of the planning process, water providers will need nearly $27 billion in state financial assistance to implement strategies for municipal water user groups.

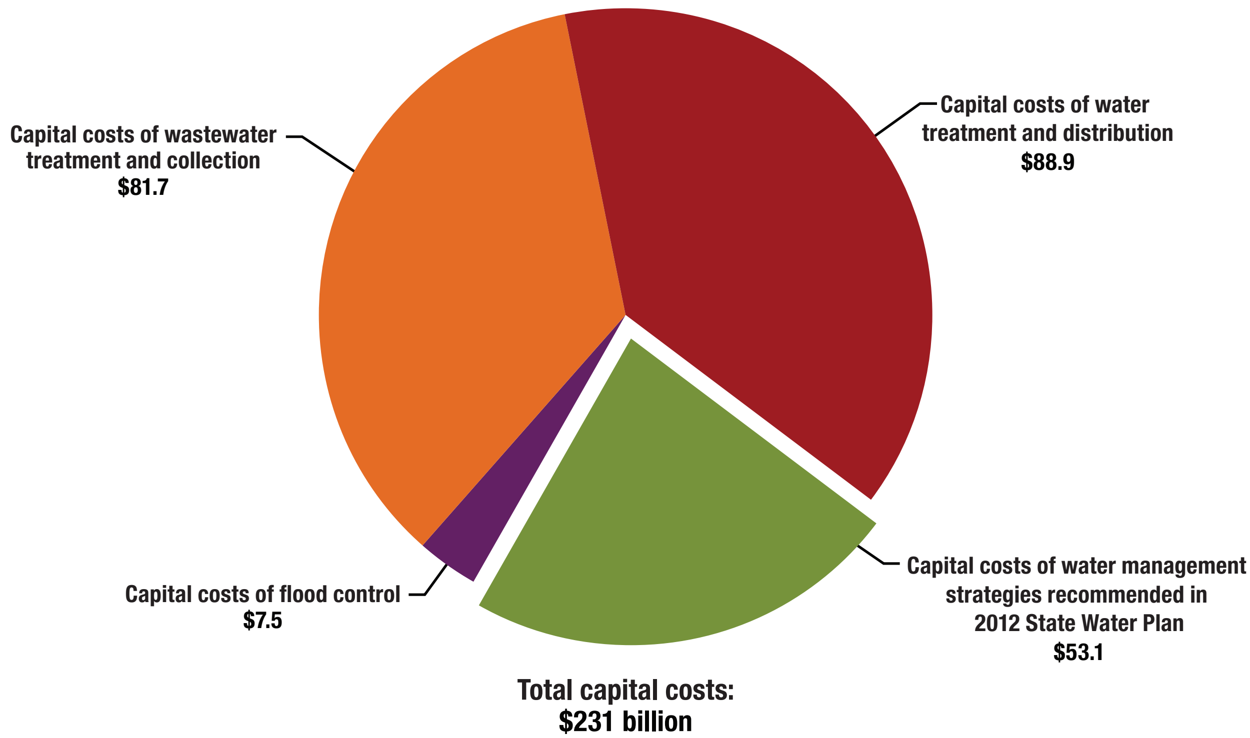
## WHAT IF WE DO NOTHING?

If drought of record conditions recur and water management strategies identified in regional water plans are not implemented, the state could suffer significant economic losses. If a drought affected the entire state like it did in the 1950s, economic models show that Texas businesses and workers could have lost almost $12 billion in income in 2010. By 2060 lost income increases to roughly $116 billion. Foregone state and local business taxes associated with lost commerce could amount to $1.1 billion in 2010 and $9.8 billion in 2060. Lost jobs total approximately 115,000 in 2010 and 1.1 million in 2060. By 2060, the state's projected population growth could be reduced by about 1.4 million people, with 403,000 fewer students in Texas schools. If we do nothing, over 50 percent of the state's population in 2060 would face a water need of at least 45 percent of their demand during a repeat of drought of record conditions.

## WHAT MORE CAN WE DO NOW TO PREPARE FOR TIMES OF DROUGHT?

The state and regional water plans must be implemented to meet the state's need for water during a severe drought. Water providers surveyed during the planning process reported an anticipated need of $26.9 billion in state financial assistance to implement municipal water management strategies in their planning areas. This amount represents about 58 percent of the total capital costs for water supply management strategies recommended for municipal water user groups in the 2011 regional water plans. Of the total reported needs for state financial assistance, nearly $15.7 billion is expected to occur between the years 2010 and 2020, $4.2 billion will occur between 2020 and 2030, and $4.1 billion between 2030 and 2040.

**FIGURE ES.6. TOTAL CAPITAL COSTS FOR WATER SUPPLIES, WATER TREATMENT AND DISTRIBUTION, WASTEWATER TREATMENT AND COLLECTION, AND FLOOD CONTROL (BILLIONS OF DOLLARS).**




About $400 million would be for projects in rural and economically distressed areas of the state.

The planning groups also made a number of regulatory, administrative, and legislative recommendations that they believe are needed to better manage our water resources and to prepare for and respond to droughts. Based on these recommendations and other policy considerations, the TWDB makes the following recommendations to facilitate the implementation of the 2012 State Water Plan:

### ISSUE 1: RESERVOIR SITE AND STREAM SEGMENT DESIGNATION

The legislature should designate the three additional sites of unique value for the construction of reservoirs recommended in the 2011 regional water plans (Turkey Peak Reservoir, Millers Creek Reservoir Augmentation, and Coryell County Reservoir) for protection under Texas Water Code, Section 16.051 (g). These sites are shown in Figure ES.7.

The legislature should designate the nine river or stream segments of unique ecological value recommended in the 2011 regional water plans (Pecan Bayou, Black Cypress Creek, Black Cypress Bayou, Alamito Creek, Nueces River, Frio River, Sabinal River, Comal River, and San Marcos River) for protection under Texas Water Code, Section 16.051. The sites are shown in Figure ES.8.

### ISSUE 2: RESERVOIR SITE ACQUISITION

The legislature should provide a mechanism to acquire feasible reservoir sites so they are available for development of additional surface water supplies to meet future water supply needs of Texas identified in the 2011 regional water plans and also water supply needs that will occur beyond the 50-year regional and state water planning horizon.

### ISSUE 3: INTERBASIN TRANSFERS OF SURFACE WATER

The legislature should enact statutory provisions that eliminate unreasonable restrictions on the voluntary transfer of surface water from one basin to another.

### ISSUE 4: PETITION PROCESS ON THE REASONABLENESS OF DESIRED FUTURE CONDITIONS

The legislature should remove TWDB from the petition process concerning the reasonableness of a desired future condition except for technical review and comment.

### ISSUE 5: WATER LOSS

The legislature should require all retail public utilities to conduct water loss audits on an annual basis, rather than every five years.

### ISSUE 6: FINANCING THE STATE WATER PLAN

The legislature should develop a long-term, affordable, and sustainable method to provide financing assistance for the implementation of state water plan projects.

## WHAT HAVE WE DONE ALREADY TO IMPLEMENT WATER MANAGEMENT STRATEGIES FROM PREVIOUS PLANS?

In response to the 2007 State Water Plan, the 80th and 81st Texas Legislatures provided funding to implement $1.47 billion in state water plan projects through three of TWDB's financial assistance programs. To date, TWDB has provided over $1 billion in low-interest loans and grants to implement 46 projects across the state, all of which represent water management strategies in the 2006 regional water plans and the 2007 State Water Plan. Once fully implemented, these projects will supply over 1.5 million acre-feet of water needed during times of drought to millions of Texans. In 2011, the 82nd Texas Legislature authorized additional funding to finance approximately $100 million in state water plan projects. These funds will be available during state fiscal years 2012 and 2013. TWDB has also provided over $500 million in funding to implement water management strategies recommended in the 2007 State Water Plan through other loan programs.

To provide a measure of the progress made in implementing the strategies included in the 2007 State Water Plan, TWDB surveyed project sponsors of recommended municipal water management strategies. Of the 497 projects for which responses were received on behalf of the sponsoring entities, 139 of them (28 percent) reported some form of progress on strategy implementation. Of these, 65 (13 percent) reported that strategies had been fully implemented. Of the 74 projects (15 percent) that reported incomplete progress, 13 (3 percent) reported that project construction had begun. The number of fully implemented projects—65—represents a significant increase from the 21 projects that the 2007 State Water Plan reported had been implemented from the 2002 State Water Plan. The implementation of many of these projects would not have been possible without the funding provided by the Texas Legislature through TWDB's financial assistance programs.

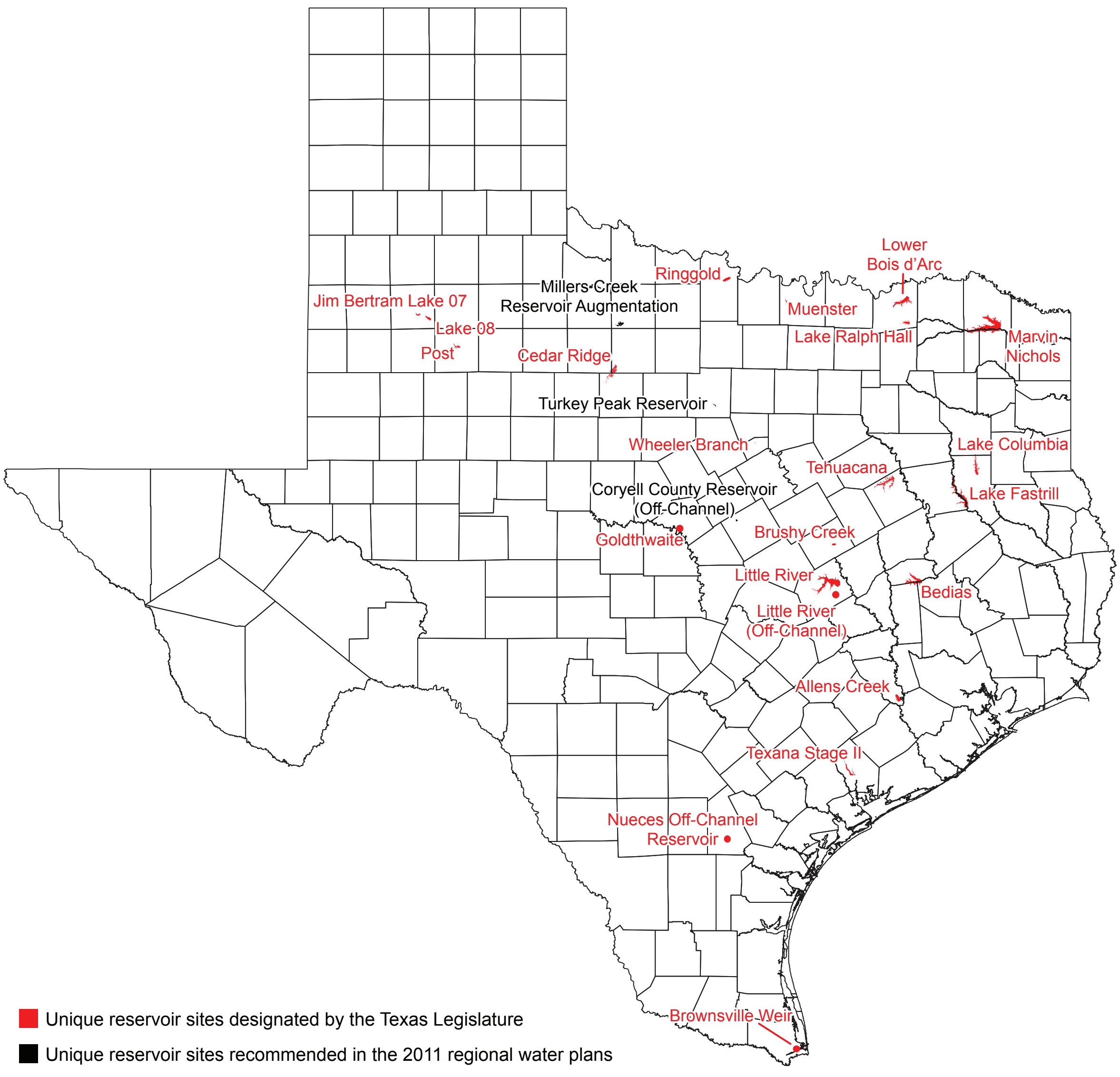
Like all planning efforts, state water plans have made recommendations based on the needs of the times during which they were developed. When times change, so do plans. Some projects that were once recommended may be no longer feasible or necessary due to advances in technology or changes in water availability, population and demographics, or state or federal policies. The five-year state and regional water planning cycle is designed to address risks, uncertainties, and emerging needs in our ever-changing state. So if we cannot change the weather, Texas will have a plan to meet the needs of our communities for water when the next drought inevitably arrives.

## POTENTIAL FUTURE PLANNING ISSUES

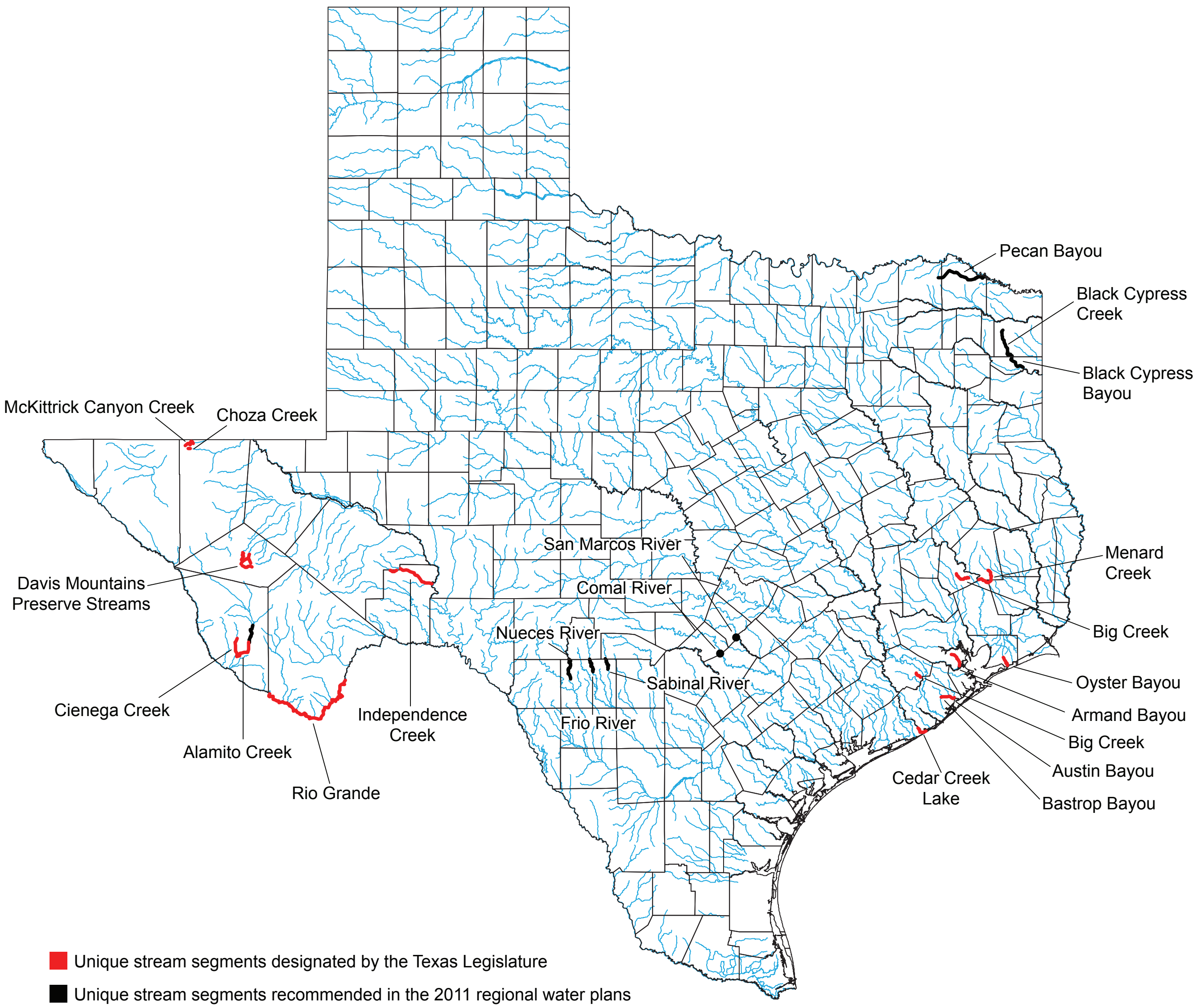
During every planning cycle, new issues emerge that influence the development of regional water plans and the state water plan. The following issues, discussed in further detail in the 2012 State Water Plan, are potentially among some of the issues that will impact future rounds of planning:

- Changes in population projections based on the results of the 2010 U.S. Census (Chapter 3, Population and Water Demand Projections).
- Changes in water demand projections from population growth or varying water use activities, such as the increased use of water for hydraulic fracturing mining operations (Chapter 3, Population and Water Demand Projections) or expanded production of biofuels (Chapter 10, Challenges and Uncertainty).
- Impacts to water availability from new environmental flow standards or modeled available groundwater numbers based on the desired future conditions of aquifers (Chapter 5, Water Supplies).
- Limitations of groundwater permitting processes that provide for term-permits or that allow for reductions in a permit holder's allocations, which could impact the feasibility of water management strategies (Chapter 5, Water Supplies).
- Lack of sufficient financial assistance to aid in implementation of recommended water management strategies (Chapter 9, Financing Needs).
- Other uncertain potential future challenges such as natural disasters or climate variability (Chapter 10, Challenges and Uncertainty).

## FIGURE ES.7. DESIGNATED AND RECOMMENDED UNIQUE RESERVOIR SITES.



## FIGURE ES.8. DESIGNATED AND RECOMMENDED UNIQUE STREAM SEGMENTS.



# 1 Introduction

## The purpose of this plan is to ensure that all of our communities have adequate supplies of water during times of drought.

The availability of water has always influenced patterns of settlement, and communities in Texas originally grew where water was plentiful. But as many of our communities have grown, they have outgrown their water supplies, making it more and more necessary to make efficient use of our local water resources, to work cooperatively with one another on regional solutions to water problems, and to move water around the state when necessary to meet the needs of all our communities. The purpose of this plan is to ensure that all of our communities have adequate supplies of water during times of drought.

The 2012 State Water Plan is Texas' ninth state water plan and the third to be developed through the regional water planning process, initiated by the Texas Legislature in 1997. When the first state water plan was published in 1961, the population of Texas was less than half the size it is today, with 9.6 million residents. At the time the plan was adopted, only a third of Texans lived in urban areas and 79 percent of the communities in Texas obtained their water supplies from groundwater wells. Now there are over 25 million Texans. Our population has become older, less rural, and more diverse. Communities in the state obtain much more of their water supplies from surface water such as rivers and lakes, but also from new sources such as reuse and desalination. While a lot has changed since the first water plan, much remains the same. All or part of the state is often too wet or too dry, and planning for times of drought is every bit as relevant today as it was then.

The 2012 State Water Plan is based on regional water plans that are updates to the 2006 regional water plans. During this planning cycle, the regional water plans were focused primarily on changed conditions, since new population data from the U.S. Census Bureau was not available to significantly update projections of future water demands. The last state water plan, *Water for Texas—2007*, included population and water demand projections based on newly released 2000 U.S. Census data, and its adoption coincided with the 50th anniversary of TWDB and the commencement of the 80th Texas Legislative session. It also included comprehensive summaries of all of the river basins and aquifers in the state. These summaries are still current and are included by reference in the 2012 State Water Plan.

Since this plan is adopted over 50 years after the first state water plan, a special effort has been made to look back at past plans and to reflect on the evolution of water planning over time. Newer plans have placed greater emphasis on conservation and on innovative strategies that were largely unknown to the planners of the 1950s and 1960s. Plans have included everything from small local projects to importing surplus water from the Mississippi River. But the reality of drought and the needs for water to sustain our cities, rural communities, farms, ranches, businesses, industries, and our environment have remained unchanged.

This plan references numerous studies and reports with multiple findings and recommendations. Reference of these studies and reports does not constitute an endorsement by TWDB of their findings and recommendations.

## 1.1 A BRIEF HISTORY OF TEXAS WATER PLANNING

Droughts—periods of less than average precipitation over a period of time—have plagued Texas since well before the first Spanish and Anglo settlers began arriving in the 1700s (Dunn, 2011). While some oversight of our state's water resources began with these first settlers, the modern age of water management began around the mid to late 1800s with the earliest regulations and recordkeeping. The creation of management agencies after the turn of the past century, along with the collection of rainfall and streamflow data, began a new era of water management in the state.

When reviewing the history of weather events, it is easy to see that the major policy changes in the management of Texas' water resources have largely corresponded to cycles of droughts and floods. Droughts are unique among climate phenomena in that they develop slowly but can ultimately have consequences as economically devastating as hurricanes, tornadoes, and floods (TBWE, 1958).

In each decade of the past century, at least some part of the state has experienced a severe drought. During development of the 2012 State Water Plan, all of Texas was in some form of drought. As of September 2011, 99 percent of the state was experiencing severe, extreme, or exceptional drought conditions. The majority of Texas counties had outdoor burn bans, 902 public water supply systems were imposing voluntary or mandatory restrictions on their customers, and the Texas Commission on Environmental Quality had suspended the use of certain water rights in several of the state's river basins. As of the fall, the drought of 2011 ranks as the worst one-year drought in Texas' history.

### 1.1.1 EARLY HISTORY OF WATER MANAGEMENT IN TEXAS

Formal water supply planning at the state level did not begin in earnest until the 1950s, but the legislature progressively began assigning responsibility for the management and development of the state's water resources to various entities starting in the early 20th century. Partly as a result of a series of devastating droughts and floods, the early 1900s saw a flurry of activity. In 1904, a constitutional amendment was adopted authorizing the first public development of water resources. The legislature authorized the creation of drainage districts in 1905; the Texas Board of Water Engineers in 1913; conservation and reclamation districts (later known as river authorities) in 1917; freshwater supply districts in 1919; and water control and improvement districts in 1925.

The creation of the Texas Board of Water Engineers, a predecessor agency to both the Texas Commission on Environmental Quality and TWDB, played a significant role in the early history of water management in the state. The major duties of the Board of Water Engineers were to approve plans for the organization of irrigation and water supply districts, approve the issuance of bonds by these districts, issue water right permits for storage and diversion of water, and make plans for storage and use of floodwater. Later, the legislature gave the agency the authority to define and designate groundwater aquifers; authorize underground water conservation districts; conduct groundwater and surface water studies; and approve federal projects, including those constructed by the U.S. Army Corps of Engineers.

In 1949, Lyndon Johnson, then a U.S. Senator, wrote a letter to the U.S. Secretary of the Interior requesting that the federal government help guide Texas in achieving "a comprehensive water program that will take into account the needs of the people of my State." Four years later, the U.S. Bureau of Reclamation responded by publishing "Water Supply and the Texas Economy: An Appraisal of the Texas Water Problem" (USBR, 1953). The report divided the state into four planning regions and evaluated existing and projected municipal and industrial water requirements up to the year 2000. The analysis assumed an available water supply under streamflow conditions experienced in 1925, when a short drought affected most of the eastern two-thirds of the state (TBWE, 1959). The appraisal identified "problem areas," presented water supply plans as potential solutions, and made a number of observations on state and federal policy. Most significantly, it recommended that Texas consider forming a permanent water planning and policy agency to represent state interests.

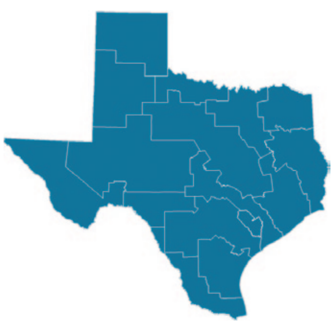
The idea of a dedicated water planning agency came to fruition not long after the state experienced the worst drought in recorded history. For Texas as a whole, the drought began in 1950 and by the end of 1956, all but one of Texas' 254 counties were classified as disaster areas. Ironically, the drought ended in the spring of 1957 with massive rains that resulted in the flooding of every major river and tributary in the state. This drought represents the driest seven-year period in the state's recorded history and is still considered Texas' "drought of record" upon which most water supply planning in the state is based.

The drought of the 1950s was unique in that a majority of Texans felt the impacts of a reduced water supply during some point during the decade. Not only did they feel the impact, but residents were at times called into action to help fix water problems in their communities (see Sidebar: Byers, Texas). Small and large cities alike faced dire situations. By the fall of 1952, Dallas faced a severe water shortage and prohibited all but necessary household use of water. In 1953 alone, 28 municipalities were forced to use emergency sources of water supply, 77 were rationing water, and 8 resorted to hauling in water from neighboring towns or rural wells. The development of additional facilities during the course of the drought reduced the number of communities with shortages during later years of the drought, but still more municipalities were forced to haul in water before it was over (TBWE, 1959). The drought of the 1950s cost the state hundreds of millions of dollars, and was followed by floods that caused damages estimated at $120 million (TBWE, 1958).

### 1.1.2 WATER PLANNING ON THE STATE LEVEL (1957 TO 1997)

The legislature responded early in the drought by establishing the Texas Water Resources Committee in 1953 to survey the state's water problems (UT Institute of Internal Affairs, 1955). While dry conditions persisted, the joint committee of both state senators and house members worked to develop a long-range water policy in response to the emergency situations. As a result of some of the committee's recommendations, the Texas Legislature passed a resolution authorizing $200 million in state bonds to help construct water conservation and supply projects. The legislature created TWDB to administer the funds from the bond sale. Then, during a following special session called by Governor Price Daniel, the legislature passed the Water Planning Act of 1957. The act created the Texas Water Resources Planning Division of the Board of Water Engineers, which was assigned the responsibility of water resources

## Byers, Texas



In April 1953, after many months of drought, the town of Byers ran out of water. With the reservoir dry, the mayor declared an emergency and cut off water service to 200 customers and the school system. Word of the emergency spread fast and offers for help quickly poured in from neighboring communities. Most of Byers' 542 residents, along with a detail of men from Sheppard Air Force Base, laid a 2-mile pipeline from a spring on a nearby farm to the town's reservoir. Disaster was averted, but the events in Byers, and in other Texas communities affected by drought, were not soon forgotten (Lewiston Evening Journal, 1953).

Byers is now considered a municipal water user group in the Region B regional water planning area. Thanks to two sources of water supply identified in the 2011 Region B Regional Water Plan—the Wichita Lake system and the Seymour Aquifer—the town is far better positioned today. If the drought of the 1950s were to recur within the next 50 years, Byers would not only be better prepared but would have a surplus of water.

planning on a statewide basis. The voters of Texas subsequently approved a constitutional amendment authorizing TWDB to administer a $200 million water development fund to help communities develop water supplies.

In June of 1960, Governor Daniel called a meeting in Austin to request that the Board of Water Engineers prepare a planning report with projects to meet the projected municipal and industrial water requirements of the state in 1980. Work quickly began on statewide studies to develop the first state water plan. The first plan—A Plan for Meeting the 1980 Water Requirements of Texas—was published in 1961. The plan described historical and present uses of surface and groundwater by municipalities, industries, and irrigation; summarized the development of reservoirs; estimated the 1980 municipal and industrial requirements of each area of the state; provided a plan for how to meet those requirements by river basin; and discussed how the plan could be implemented.

Later plans were developed by the state and adopted in 1968, 1984, 1990, 1992, and 1997. All of the plans have recognized the growth of the state's population and the need to develop future water supplies. Earlier plans placed more reliance on the federal government, while later plans developed at the state level increasingly emphasized the importance of conservation and natural resource protection. The 1968 State Water Plan recommended that the federal government continue to fund feasibility studies on the importation of surplus water from the lower Mississippi River. (A later study found that the project was not economically feasible.) The 1984 State Water Plan was the first to address water quality, water conservation and water use efficiency, and environmental water needs in detail.

While previous plans were organized by river basin, the 1990 State Water Plan projected water demands, supplies, and facility needs for eight regions in the state. The 1997 State Water Plan— developed by TWDB through a consensus process with the Texas Parks and Wildlife Department and the Texas Commission on Environmental Quality—divided the state into 16 planning regions.

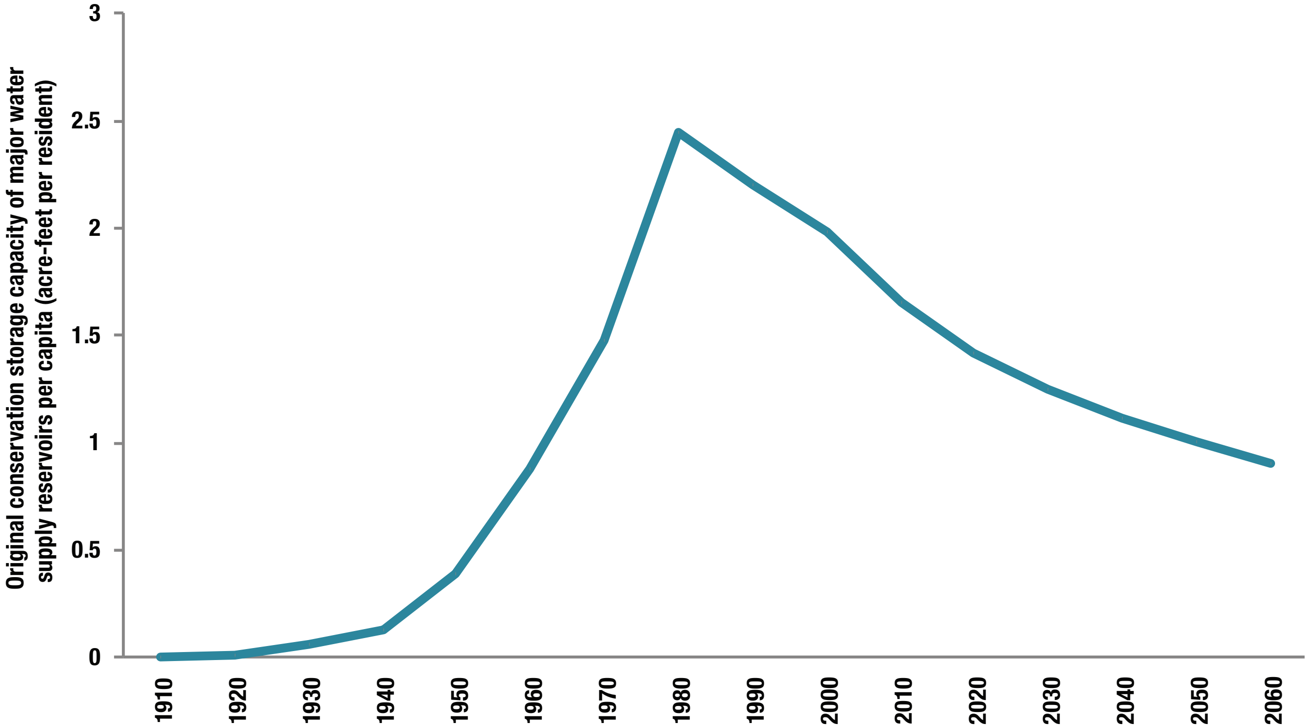
## RESERVOIR DEVELOPMENT IN TEXAS

Texas has 15 major river basins and 8 coastal basins along with 9 major and 21 minor groundwater aquifers, but water supplies vary widely from year to year and place to place. Because of the unpredictability of rainfall and streamflows in the state, communities have historically relied on reservoirs to supply water during times of drought, capturing a portion of normal flow as well as floodwaters. Prevention of flooding and conservation of water for use during droughts, together with an efficient distribution system, have always been important goals in water resources planning (TBWE, 1958).

When the Texas Board of Water Engineers was originally created in 1913, the state had only 8 major reservoirs—those with a total conservation storage capacity of 5,000 acre-feet or greater (TBWE, 1959). Of these eight reservoirs, three were for municipal water supply, four were for irrigation, and one was for the generation of hydroelectric power. Lake Travis, constructed between 1937 and 1941, was the first multipurpose reservoir to provide water storage for municipal, irrigation, and mining uses; recreation; hydroelectric power generation; and flood control.

*(continued on next page...)*

## FIGURE 1.1. RESERVOIR STORAGE PER CAPITA OVER TIME.

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During the mid 20th century, the federal government constructed a number of major reservoirs primarily for flood control but also with water supply storage. In many instances these reservoirs have prevented flood losses far exceeding the cost of their construction. (Amistad Dam on the Rio Grande retained a 1954 flood shortly after it was completed, preventing catastrophic flooding in the Lower Rio Grande Valley (TBWE, 1958).) In 1950, the state had 53 major water supply reservoirs; by 1980, the state had 179; and today, Texas has 188 major water supply reservoirs, with only a handful in some stage of planning or implementation.

Reservoir construction has slowly declined since the 1980s. While fewer reservoirs are recommended now than in early state water plans, they still play an important role in meeting needs for water during a drought. The 2012 State Water Plan recommends 26 reservoirs that would provide 1.5 million acre-feet of water during a repeat of drought of record conditions in 2060. In the absence of these reservoirs, other water management strategies would simply not be enough to meet the needs of Texans during a severe drought.

As shown in Figure 1.1, reservoir storage per person in the state has declined from a peak of 2.4 acre-feet of conservation storage per person in 1980 to 1.7 acre-feet of conservation storage per person today. If no additional reservoirs are constructed in the next 50 years, the amount of reservoir storage would decline to less than 1 acre-foot per person by 2060, the lowest amount since immediately following the 1950s drought of record.

### 1.1.3 THE ADVENT OF REGIONAL WATER PLANNING

The same circumstances that led to the beginning of state water planning served as the impetus for one of the most significant changes in how Texas conducts water planning. In the mid 1990s, Texas suffered an intense 10-month drought. Reservoirs and aquifer levels declined sharply and farmers suffered widespread crop failure, with estimated economic losses in billions of dollars. Some cities had to ration water for several months and others ran out of water entirely.

The drought of 1996 was relatively short-lived, but it lasted long enough to remind Texans of the importance of water planning. When the legislature met in 1997, Lieutenant Governor Bob Bullock declared that the primary issue for the 75th Texas Legislature would be water. After lengthy debate and numerous amendments, Senate Bill 1 was passed to improve the development and management of the water resources in the state. Among other provisions relating to water supplies, financial assistance, water data collection and dissemination, and other water management issues, the bill established the regional water planning process: a new framework that directed that water planning be conducted from the ground up.

## 1.2 THE REGIONAL WATER PLANNING PROCESS TODAY

Senate Bill 1 outlined an entirely new process where local and regional stakeholders were tasked with developing consensus-based regional plans for how to meet water needs during times of drought. TWDB would then develop a comprehensive state water plan—based on the regional water plans—every five years. One of the most important aspects of the legislation specified that TWDB could provide financial assistance for water supply projects only if the needs to be addressed by the project were addressed in a manner that is consistent with the regional water plans and the state water plan. This same provision also applied to the granting of water right permits by the Texas Commission on Environmental Quality.

Following passage of the legislation in 1997, TWDB initiated regional water planning with administrative rules to guide the process. TWDB designated 16 regional water planning areas (Figure 2.1), taking into consideration river basin and aquifer delineations, water utility development patterns, socioeconomic characteristics, existing regional water planning areas, state political subdivision boundaries, public comments, and other factors. TWDB is required to review and update the planning area boundaries at least once every five years, but no changes have been made to date.

Each regional water planning area has its own planning group responsible for developing a regional water plan every five years. Regional water planning groups are required to have at least 11 interests represented, including the public, counties, municipalities, industries, agriculture, environment, small businesses, electric-generating utilities, river authorities, water districts, and water utilities. Planning groups must have at least one representative from each interest, and can designate representatives for other interests that are important to the planning area. Planning groups also have non-voting members from federal, state, and local agencies and have members that serve as liaisons with planning groups in adjacent areas. (Legislation passed during the 82nd Legislative Session now requires that groundwater conservation districts in each groundwater management area located in the regional water planning area to appoint one representative to serve on the regional water planning group.) Each planning group approves bylaws to govern its methods of conducting business and designates a political subdivision of the state.

The regional water planning process consists of 10 tasks:

- **Describing the regional water planning area:** Descriptions include information on major water providers, current water use, sources of groundwater and surface water, agricultural and natural resources, the regional economy, summaries of local water plans, and other information.
- **Quantifying current and projected population and water demand over a 50-year planning horizon:** Planning groups review projections provided by TWDB and propose revisions resulting from changed conditions or new information. TWDB consults with the Texas Department of Agriculture, Texas Commission on Environmental Quality, and Texas Parks and Wildlife Department before formally approving requests for revisions.
- **Evaluating and quantifying current water supplies:** Planning groups determine the water supplies that would be physically and legally available from existing sources during a repeat of the drought of record or worse. To estimate the existing water supplies, the planning groups use the state's surface water and groundwater availability models, when available.
- **Identifying surpluses and needs:** Planning groups compare existing water supplies with current and projected water demands to identify when and where additional water supplies are needed for each identified water user group and wholesale water provider.
- **Evaluating and recommending water management strategies to meet the needs:** Planning groups must address the needs of all water users, if feasible. If existing supplies do not meet future demand, they recommend specific water management strategies to meet water supply needs, such as conservation of existing water supplies, new reservoir and groundwater development, conveyance facilities to move available or newly developed water supplies to areas of need, water reuse, and others.
- **Evaluating impacts of water management strategies on water quality:** Planning groups describe how implementing recommended and alternative water management strategies could affect water quality in Texas.
- **Describing how the plan is consistent with long-term protection of the state's water, agricultural, and natural resources:** Planning groups estimate the environmental impacts of water management strategies. They identify specific resources important to their planning areas and describe how these resources are protected through the regional water planning process.
- **Recommending regulatory, administrative, and legislative changes:** Along with general policy and statutory recommendations, planning groups make recommendations for designating unique reservoir sites and stream segments of unique ecological value. The legislature is responsible for making the official designations of these sites.
- **Describing how sponsors of water management strategies will finance projects:** Planning groups survey water providers on how they propose to pay for water infrastructure projects in the plan and identify needs for state financing.
- **Adopting the plan:** All meetings are held in accordance with the Texas Open Meetings Act. Planning groups hold public meetings when planning their work and hold hearings before adopting their regional water plans. Members

adopt plans by vote in accordance with each group's respective bylaws.

After planning groups adopt their regional water plans, they are sent to TWDB for approval. As required by statute, TWDB then begins development of the state water plan. The state water plan incorporates information from the regional water plans, but it is more than just the sum of the regional plans. The state water plan serves as a guide to state water policy; it also explains planning methodology, presents data for the state as a whole, identifies statewide trends, and provides recommendations to the state legislature. Prior to adoption of the final state water plan, TWDB releases a draft for public comment, publishes its intent to adopt the state water plan in the Texas Register, notifies the regional water planning groups, and holds a public hearing in Austin.

The 2012 State Water Plan is the third plan developed through the regional water planning process. In response to issues identified in the 2007 State Water Plan, the legislature made several policy changes that impacted water planning. The 79th Texas Legislature passed Senate Bill 3, which created a process to address environmental flows and designated unique reservoir sites and sites of unique ecological value. The legislature also provided appropriations to allow $1.2 billion of funding to implement water management strategies recommended in the 2006 regional water plans and the 2007 State Water Plan. Priority was given to entities with the earliest recommended implementation date in the state and regional water plans and that have already demonstrated significant water conservation savings or would achieve significant water conservation by implementing a proposed project. Later chapters of this plan discuss these issues in detail.

## 1.3 STATE AND FEDERAL WATER SUPPLY INSTITUTIONS

While TWDB is the state's primary water planning agency, a number of state and federal agencies in Texas have responsibility for the management of water resources and participate in the regional planning process directly and indirectly. Texas Parks and Wildlife Department, the Texas Commission on Environmental Quality, and the Texas Department of Agriculture all have non-voting representation on each planning group. They actively participate in the development of population projections and are given the opportunity to comment on the state water plan early in its development and are consulted in the development and amendment of rules governing the planning process. The water-related responsibilities of these agencies, along with other state and federal entities that indirectly participate in the regional water planning process, are described in the following sections.

### 1.3.1 STATE ENTITIES

TWDB, as created in 1957, is the state's primary water supply planning and financing agency. TWDB supports the development of the 16 regional water plans and is responsible for developing the state water plan every five years. The agency provides financial assistance to local governments for water supply and wastewater treatment projects, flood protection planning and flood control projects, agricultural water conservation projects, and groundwater district creation expenses. TWDB collects data and conducts studies of the fresh water needs of the state's bays and estuaries and is responsible for all aspects of groundwater studies. The agency also maintains the Texas Natural Resources Information System, the clearinghouse for geographic data in the state. TWDB provides technical support to the environmental flows process and is a member of the Texas Water Conservation Advisory Council, providing administrative support to the council.

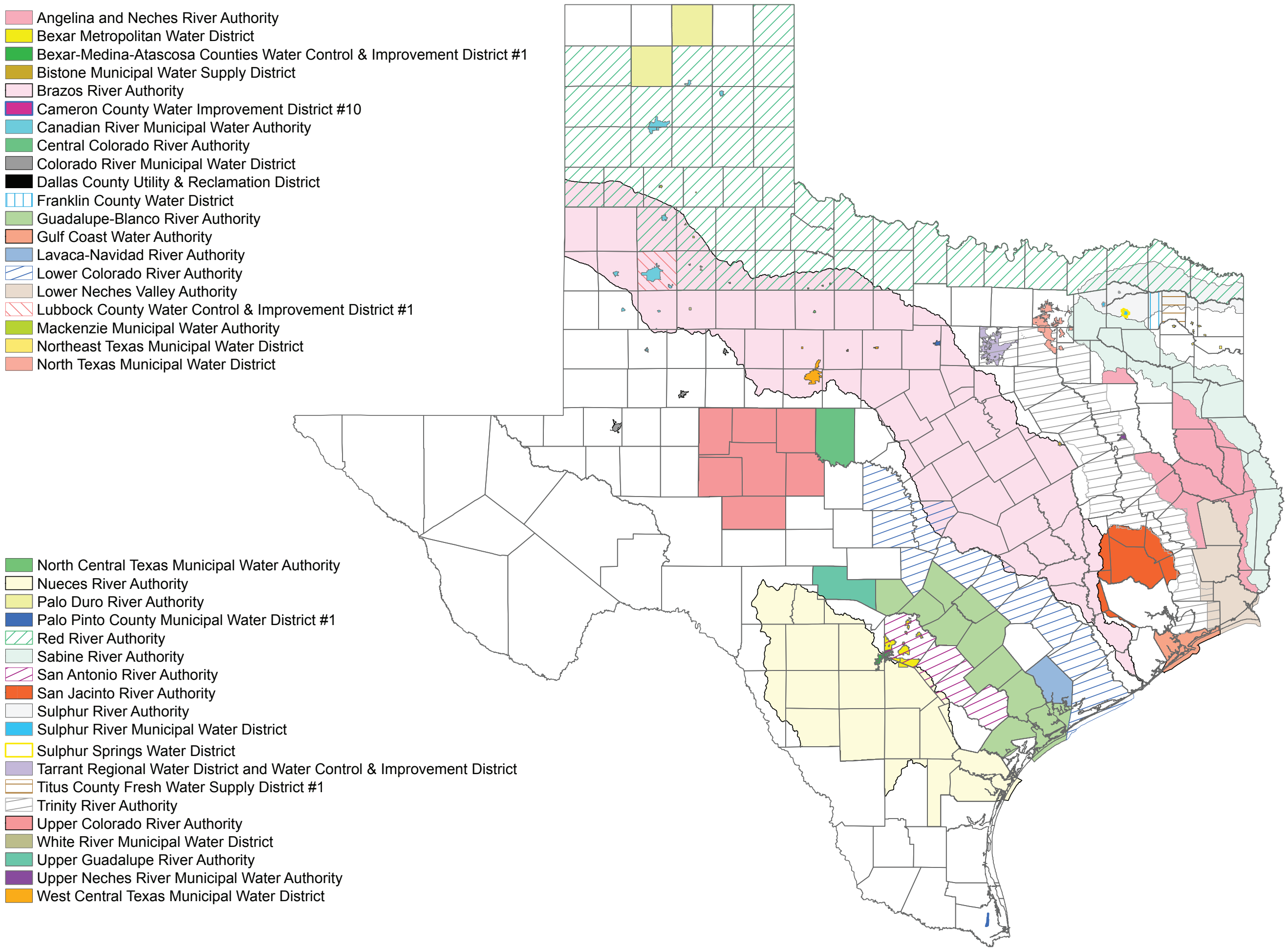
The State Parks Board, originally created in 1923, was later merged with other state entities and renamed the **Texas Parks and Wildlife Department.** Today, the agency has primary responsibility for conserving, protecting, and enhancing the state's fish and wildlife resources. It maintains a system of public lands, including state parks, historic sites, fish hatcheries, and wildlife management areas; regulates and enforces commercial and recreational fishing, hunting, boating, and nongame laws; and monitors, conserves, and enhances aquatic and wildlife habitat. Texas Parks and Wildlife Department reviews and makes recommendations to minimize or avoid impacts on fish and wildlife resources resulting from water projects. The agency works with regional and state water planning stakeholders and regulatory agencies to protect and enhance water quality and to ensure adequate environmental flows for rivers, bays, and estuaries. It also provides technical support to the environmental flows process and is a member of the Texas Water Conservation Advisory Council.

In 1992, to make natural resource protection more efficient, the legislature consolidated several programs into one large environmental agency now known as the **Texas Commission on Environmental Quality**. The Texas Commission on Environmental Quality is the environmental regulatory agency for the state, focusing on water quality and quantity through various state and federal programs. The agency issues permits for the treatment and discharge of industrial and domestic wastewater and storm water; reviews plans and specifications for public water systems; and conducts assessments of surface water and groundwater quality. The Texas Commission on Environmental Quality regulates retail water and sewer utilities, reviews rate increases by investor-owned water and wastewater utilities, and administers a portion of the Nonpoint Source Management Program. In addition, it administers the surface water rights permitting program and a dam safety program; delineates and designates Priority Groundwater Management Areas; creates some groundwater conservation districts; and enforces the requirements of groundwater management planning. The agency also regulates public drinking water systems and is the primary agency for enforcing the federal Safe Drinking Water Act. The Texas Commission on Environmental Quality provides support to the environmental flows process and adopts rules for environmental flow standards. The Texas Commission on Environmental Quality is a member of the Texas Water Conservation Advisory Council.

The **Texas Department of Agriculture**, established by the Texas Legislature in 1907, is headed by the Texas Commissioner of Agriculture. The agency supports protection of agricultural crops and livestock from harmful pests and diseases; facilitates trade and market development of agricultural commodities; provides financial assistance to farmers and ranchers; and administers consumer protection, economic development, and healthy living programs, and is a member of the Texas Water Conservation Advisory Council.

Created in 1939, the **Texas State Soil and Water Conservation Board** administers Texas' soil and water conservation law and coordinates conservation and nonpoint source pollution abatement programs. The agency also administers water quality and water supply enhancement programs and is a member of the Texas Water Conservation Advisory Council.

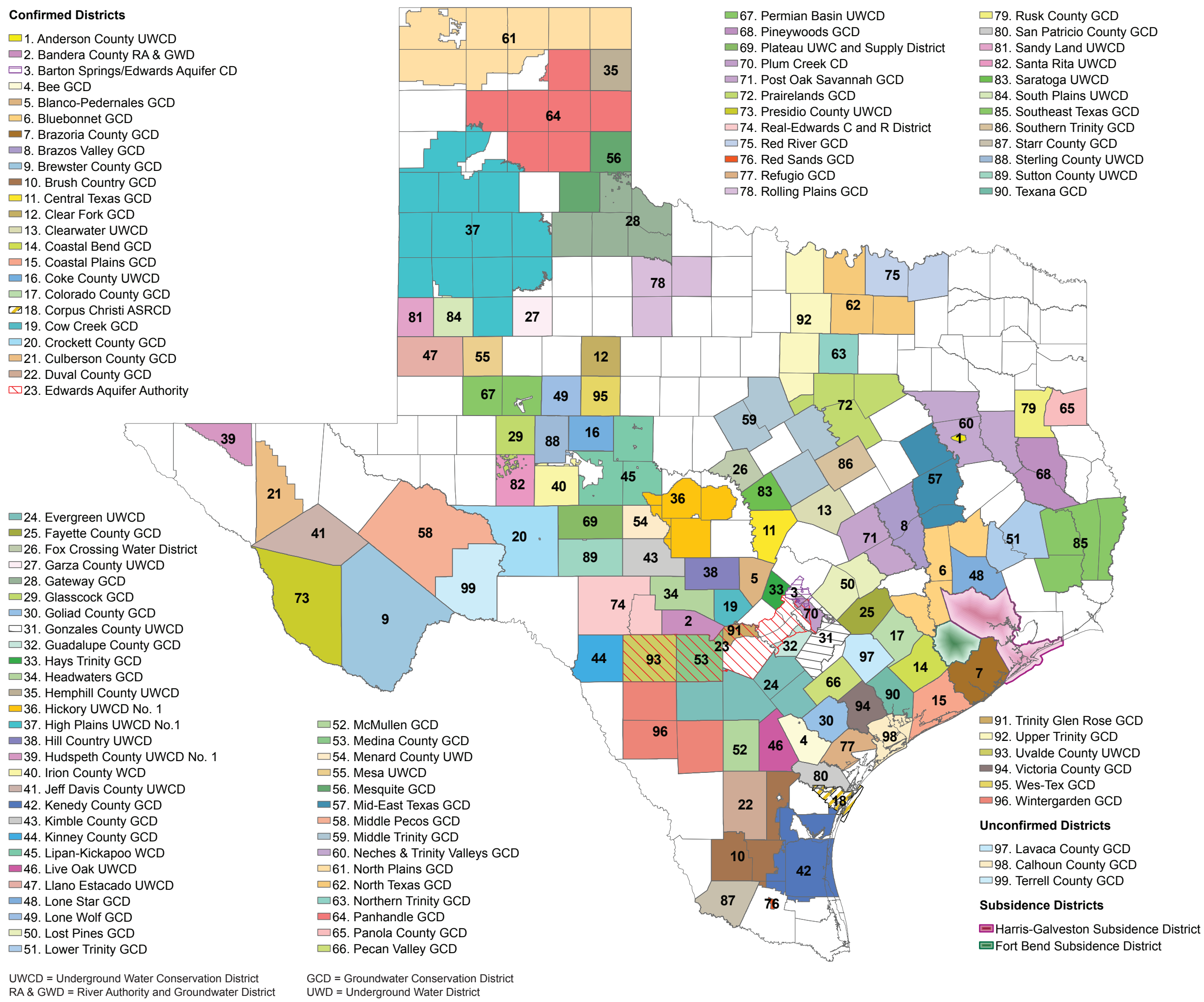
## FIGURE 1.2. RIVER AUTHORITIES AND SPECIAL LAW DISTRICTS IN TEXAS.




First authorized by the legislature in 1917, river authorities could be created and assigned the conservation and reclamation of the state's natural resources, including the development and management of water. They generally operate on utility revenues generated from supplying energy, water, wastewater, and other community services. The 17 river authorities in Texas, along with similar special law districts authorized by the legislature, are shown in Figure 1.2.

The formation of **groundwater conservation districts** was first authorized by the legislature in 1949 to manage and protect groundwater at the local level. Groundwater conservation districts are governed by a local board of directors, which develops a management plan for the district with technical support from TWDB, the Texas Commission on Environmental Quality, and other state agencies. Because most groundwater conservation districts are based on county lines and do not manage an entire aquifer, one aquifer may be managed by several groundwater districts. Each district must plan with the other districts within their common groundwater management areas to determine the desired future conditions of the aquifers within the groundwater management areas. As of 2011, 96 groundwater

## FIGURE 1.3. GROUNDWATER CONSERVATION DISTRICTS IN TEXAS.




conservation districts have been established in Texas covering all or part of 173 counties (Figure 1.3).

Other entities at the regional and local levels of government construct, operate, and maintain water supply and wastewater infrastructure. These include municipalities; water supply, irrigation, and municipal utility districts; flood and drainage districts; subsidence districts; and non-profit water supply and sewer service corporations.

### 1.3.2 FEDERAL AGENCIES

Federal civil works projects played a major role in the early development of the state's water resources (TBWE, 1958). Texas historically relied heavily on federal funds to finance water development projects, with local commitments used to repay a portion of the costs. Federal agencies such as the Soil Conservation Service, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers constructed a number of surface water reservoirs in Texas. These reservoirs were built for the primary purpose of flood control, but provide a large portion of the state's current water supply. The pace of federal spending on reservoir construction has declined considerably since the 1950s and 1960s, and current federal policy recognizes a declining federal interest in the long-term management of water supplies.

Several federal agencies are responsible for the management of the nation's water resources. The U.S. Army Corps of Engineers investigates, develops, and maintains the nation's water and related environmental resources. Historically, the **U.S. Army Corps of Engineers** has been responsible for flood protection, dam safety, and the planning and construction of water projects, including reservoirs. Pursuant to the Clean Water Act and the Rivers and Harbors Act, the Corps operates a program that regulates construction and other work in the nation's waterways.

Within the U.S. Department of the Interior, the **U.S. Geological Survey** conducts natural resources studies and collects water-related data, and the **U.S. Bureau of Reclamation** conducts water resource planning studies and manages water resources primarily in the western United States. The **U.S. Fish and Wildlife Service**, also part of the Department of the Interior, protects fish and wildlife resources through various programs and carries out provisions of the Endangered Species Act.

The **Natural Resources Conservation Service**, part of the U.S. Department of Agriculture and successor to the Soil Conservation Service, implements soil conservation programs and works at the local level through conservation planning and assistance programs. The **U.S. Environmental Protection Agency** regulates and funds federal water quality, solid waste, drinking water, and other programs pursuant to the Clean Water Act, the Safe Drinking Water Act, and other federal laws and regulations. The **International Boundary and Water Commission** manages the waters of the Rio Grande between the United States and Mexico.

## 1.4 THE MANAGEMENT OF WATER IN TEXAS

Unlike scientists who recognize that all water is interconnected, Texas law divides water into several classes for the purpose of regulation. Different rules govern each class, determining who is entitled to use the water, in what amount, and for what purpose. Texas' complicated system arose from Spanish and English common law, the laws of other western states, and state and federal case law and legislation.

To understand how regional water planning groups plan for water needs during a drought, it is helpful to have some understanding of how water is managed in the state. Each regional water plan must be consistent with all laws, rules, and regulations applicable to water use in the planning area. The following sections briefly describe how the state manages surface and groundwater, water quality, drinking water, and interstate waters, all important considerations when planning for drought.

### 1.4.1 SURFACE WATER

In Texas, all surface water is held in trust by the state, which grants permission to use the water to different groups and individuals. Texas recognizes two basic doctrines of surface water rights: the riparian doctrine and the prior appropriation doctrine. Under the riparian doctrine, landowners whose property is adjacent to a river or stream have the right to make reasonable use of the water. The riparian doctrine was introduced in Texas over 200 years ago with the first Spanish settlers. In 1840, the state adopted the common law of England, which included a somewhat different version of the riparian doctrine (Templer, 2011). The state later began to recognize the need for a prior appropriation system, which had developed in response to the scarcity of water in the western United States (BLM, 2011). The prior appropriation system, first adopted by Texas in 1895, has evolved into the modern system used today. Landowners who live on many of the water bodies in the state are allowed to divert and use water for domestic and livestock purposes (not to exceed 200 acre-feet per year), but these are some of the last riparian rights still in place.

In 1913, the legislature extended the prior appropriation system to the entire state. It also established the Texas Board of Water Engineers, the agency that had original jurisdiction over all applications for appropriated water. Because different laws governed the use of surface waters at different times in Texas history, claims to water rights often conflicted with one another. As a result of these historic conflicts, in 1967 the state began to resolve claims for water rights. A "certificate of adjudication" was issued for each approved claim, limiting riparian and other unrecorded rights to a specific quantity of water. The certificate also assigned a priority date to each claim, with some dates going back to the time of the first Spanish settlements (TCEQ, 2009).

The adjudication of surface water rights gave the state the potential for more efficient management of surface waters (Templer, 2011). With only a few exceptions, water users today need a permit in the form of an appropriated water right from the Texas Commission on Environmental Quality. The prior appropriations system recognizes the "doctrine of priority," which gives superior rights to those who first used the water, often known as "first in time, first in right." In most of the state, water rights are prioritized only by the date assigned to them and not by the purpose for which the water will be used. Only water stored in Falcon and Amistad reservoirs in the middle and lower Rio Grande river basin is prioritized by the purpose of its use, with municipal and industrial rights having priority over irrigation rights during times of drought.

When issuing a new water right, the Texas Commission on Environmental Quality assigns a priority date, specifies the volume of water that can be used each year, and may allow users to divert or impound the water. Water rights do not guarantee that water will be available, but they are considered property interests that may be bought, sold, or leased. The agency also grants term permits and temporary permits, which do not have priority dates and are not considered property rights. The water rights system works hand in hand with the regional water planning process: the agency may not issue a new water right unless it addresses a water supply need in a manner that is consistent with the regional water plans and the state water plan.

Texas relies on the honor system in most parts of the state to protect water rights during times of drought. But in three areas, the Texas Commission on Environmental Quality has appointed a "watermaster" to oversee and continuously monitor streamflows, reservoir levels, and water use. There are two watermasters in Texas: the Rio Grande Watermaster, who among other things, coordinates releases from the Amistad and Falcon reservoir system, and the South Texas Watermaster, who serves the Nueces, San Antonio, Guadalupe, and Lavaca river and coastal basins, and who also serves as the Concho Watermaster, who serves the Concho River and its tributaries in the Colorado River Basin.

In general, Texas has very little water remaining for appropriation to new users. In some river basins, water is over appropriated, meaning that the rights already in place amount to more water than is typically available during drought. This lack of "new" surface water makes the work of water planners all the more important. Now more than ever, regional water plans must make efficient use of the water that is available during times of drought.

### 1.4.2 GROUNDWATER

Groundwater in the state is managed in an entirely different fashion than surface water. Historically, Texas has followed the English common law rule that landowners have the right to capture or remove all of the water that can be captured from beneath their land. This "rule of capture" doctrine was adopted by the Texas Supreme Court in its 1904 decision *Houston & T.C. Railway Co. v. East*. In part, the rule was adopted because the science of quantifying and tracking the movement of groundwater was so poorly developed at the time that it would be practically impossible to administer any set of legal rules to govern its use. The *East* case and later court rulings established that landowners, with few exceptions, may pump as much water as they choose without liability. Today, Texas is the only western state that continues to follow the rule of capture.

In an attempt to balance landowner interests with limited groundwater resources, in 1949 the legislature authorized the creation of groundwater conservation districts for local management of groundwater. While the science of groundwater is much better developed (TWDB has groundwater availability models for all of the major aquifers and most of the minor aquifers in the state that are used to support local site-specific modeling), its use is still governed by the rule of capture, unless under the authority of a groundwater conservation district. Senate Bill 1 in 1997 reaffirmed state policy that groundwater conservation districts are the state's preferred method of groundwater management.

Since the original legislation creating groundwater districts in 1949, the legislature has made several changes to the way groundwater is managed in the state while still providing for local management. Most significantly, legislation in 2005 required groundwater conservation districts to meet regularly and to define the "desired future conditions" of the groundwater resources within designated groundwater management areas. Based on these desired future conditions, TWDB delivers modeled available groundwater values to groundwater conservation districts and regional water planning groups for inclusion in their plans.

Groundwater districts can be created by four possible methods: action of the Texas Legislature, petition by property owners, initiation by the Texas Commission on Environmental Quality, or addition of territory to an existing district. Districts may regulate both the location and production of wells, with certain voluntary and mandatory exemptions. They are also required to adopt management plans that include goals that provide for the most efficient use of groundwater. The goals must also address drought, other natural resources issues, and adopted desired future conditions. The management plan must include estimates of modeled available groundwater based on desired future conditions and must address water supply needs and water management strategies in the state water plan.

Several state agencies are involved in implementing the groundwater management plan requirements, including TWDB, the Texas Commission on Environmental Quality, and others. Along with determining values for modeled available groundwater based on desired future conditions of the aquifer, TWDB provides technical and financial support to districts, reviews and administratively approves management plans, performs groundwater availability and water-use studies, and is responsible for the delineation and designation of groundwater management areas.

The Texas Commission on Environmental Quality provides technical assistance to districts and is responsible for enforcing the adoption, approval, and implementation of management plans. The agency also evaluates designated priority groundwater management areas, areas that are experiencing or are expected to experience critical groundwater problems within 50 years, including shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies.

### 1.4.3 SURFACE WATER QUALITY

The Texas Commission on Environmental Quality is charged with managing the quality of the state's surface water resources. Guided by the federal Clean Water Act and state regulations, the agency classifies water bodies and sets water quality standards for managing surface water quality. Water quality standards consist of two parts: 1) the purposes for which surface water will be used (aquatic life, contact recreation, water supply, or fish consumption) and 2) criteria that will be used to determine if the use is being supported. Water quality data are gathered regularly to monitor the condition of the state's surface waters and to determine if standards are being met. Through the Texas Clean Rivers Program, the Texas Commission on Environmental Quality works in partnership with state, regional, and federal entities to coordinate water quality monitoring, assessment, and stakeholder participation to improve the quality of surface water within each river basin.

Every two years, Texas submits a report to the U.S. Environmental Protection Agency that lists the status of all the waters in the state and identifies those that do not meet water quality standards. When water bodies do not meet standards, the Texas Commission on Environmental Quality may develop a restoration plan, evaluate the appropriateness of the standard, or collect more data and information. For water bodies with significant impairments, the agency must develop a scientific allocation called a "total maximum daily load" to determine the maximum amount of a pollutant that a water body can receive from all sources, including point and nonpoint sources, and still maintain water quality standards set for its use.

### 1.4.4 DRINKING WATER

The Texas Commission on Environmental Quality is also responsible for protecting the quality and safety of drinking water through primary and secondary standards. In accordance with the federal Safe Drinking Water Act and state regulations, primary drinking water standards protect public health by limiting the levels of certain contaminants; secondary drinking water quality standards address taste, color, and odor. Public drinking water systems must comply with certain construction and operational standards and they must continually monitor water quality and file regular reports with the Texas Commission on Environmental Quality.

The Texas Commission on Environmental Quality is also responsible for licensing operators that supervise a public water system's production, treatment, and distribution facilities. The agency also issues certificates of convenience and necessity, which delineate the service area of a water or sewer utility and authorizes the utility the exclusive right to provide service to that area. A utility that holds a certificate of convenience and necessity must provide continuous and adequate service to every customer who requests service in that area.

### 1.4.5 INTERSTATE WATERS

Texas is a member of five interstate river compacts with neighboring states for the management of the Rio Grande, Pecos, Canadian, Sabine, and Red rivers. The compacts, as ratified by the legislature of each participating state and the U.S. Congress, represent agreements that establish how water should be allocated. Each compact is administered by a commission of state representatives and, in some cases, a representative of the federal government appointed by the president. Compact commissioners protect the states' rights under the compacts, oversee water deliveries from one state to another, and work to prevent and resolve any disputes over water. The compact commissions are authorized to plan for river operations, monitor activities affecting water quantity and quality, and engage in water accounting and rulemaking. To administer the five compacts in Texas, the Texas Commission on Environmental Quality provides administrative and technical support to each commission and maintains databases of river flows, diversions, and other information.

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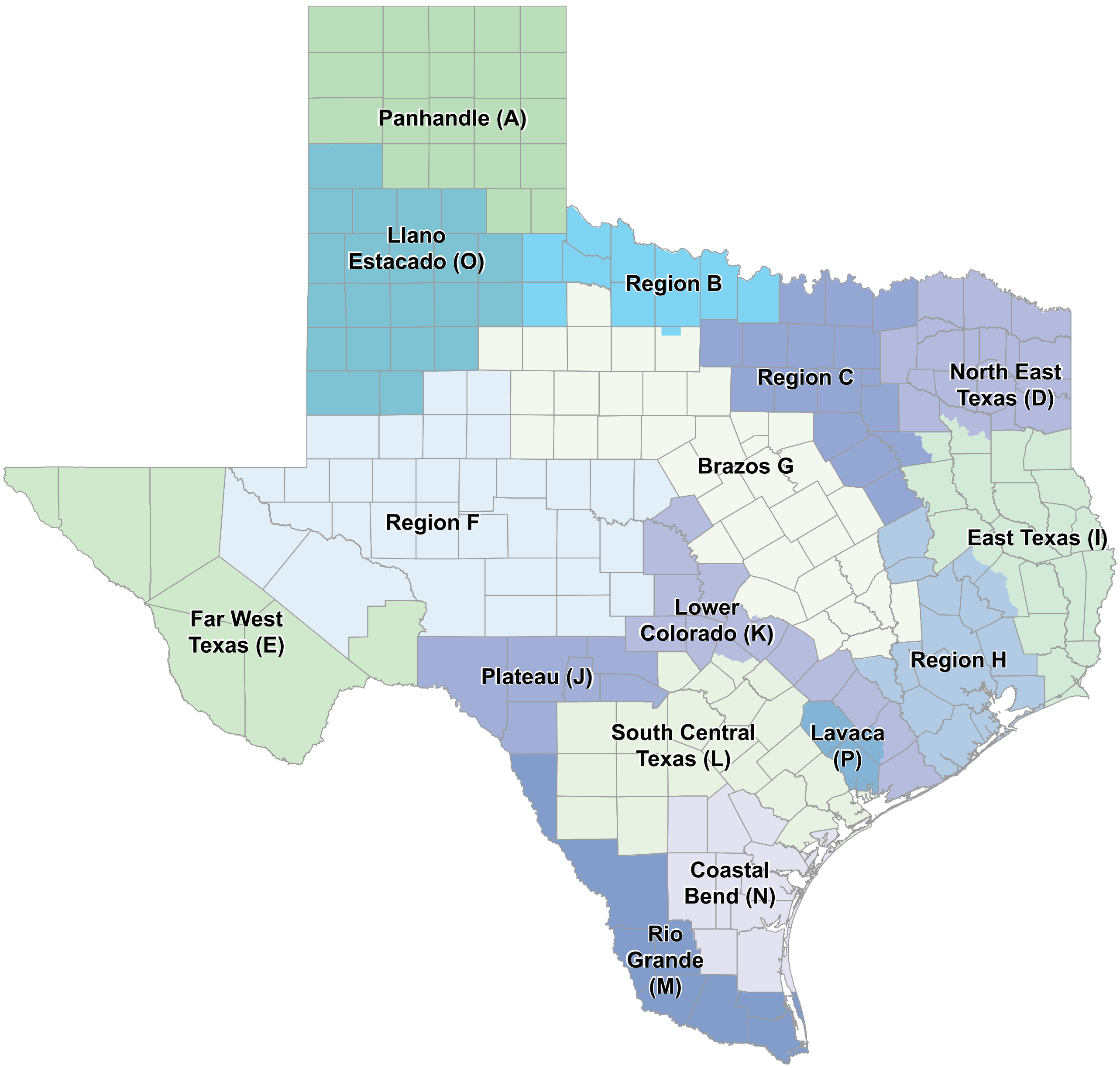
## FIGURE 2.1. REGIONAL WATER PLANNING AREAS.



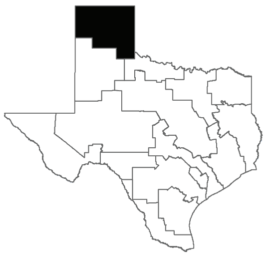
# 2 Regional Summaries

The 16 regional water planning groups are the foundation for developing the regional water plans and the state water plan. With technical and administrative assistance from TWDB, each group worked to create a regional water plan that would meet the water supply needs of their planning area during a drought of record. Chapter 2 of this report summarizes key findings from each regional plan including

- a brief description of each region;
- highlights of each plan;
- population and water demand projections;
- existing water supplies, including groundwater, surface water, and reuse;
- future water supply needs;
- recommended water management strategies and their costs;
- water conservation recommendations;
- select major water management strategies;
- a description of region-specific studies; and
- planning group members and interests represented.

Individual regional water plans and a comprehensive database of regional water plan information are available on the TWDB's website. In addition, Appendix A contains a detailed table of recommended and alternative water management strategies for each region, including total capital and unit costs for each strategy and water supply volumes projected for each strategy by decade.

# 2 Summary of the Panhandle (A) Region



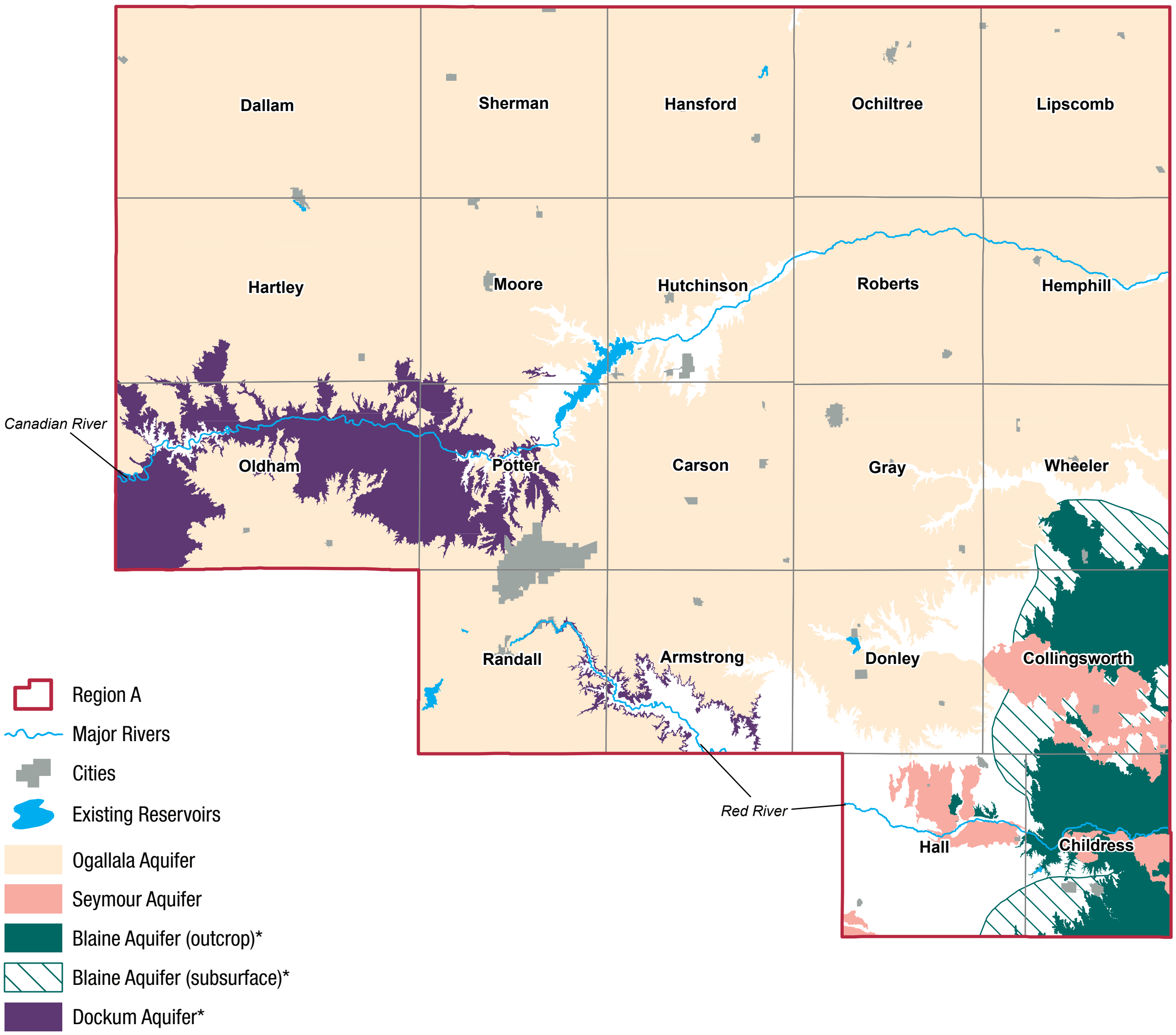
**The Panhandle Regional Water Planning Area includes 21 counties split between the Canadian and Red River basins.**

The Panhandle Regional Water Planning Area includes 21 counties split between the Canadian and Red River basins (Figure A.1). The major cities in the region include Amarillo, Pampa, Borger, and Dumas. Groundwater from the Ogallala Aquifer is the region's primary source of water and is used at a rate that exceeds recharge. The economy of this region is grounded in agribusiness. The 2011 Panhandle (A) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionA/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—418,414 acre-feet per year
- Recommended water management strategy volume in 2060—648,221 acre-feet per year
- Total capital cost—$739 million
- Conservation accounts for 86 percent of 2060 strategy volumes
- Conservation primarily associated with irrigation
- Significant groundwater development
- Significant unmet irrigation needs in near-term

## FIGURE A.1. PANHANDLE (A) REGIONAL WATER PLANNING AREA.




* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 2 percent of the state's total population resided in the Panhandle Region in the year 2010. Between 2010 and 2060, population is projected to increase 39 percent to 541,035. The region's total water demands, however, are projected to decrease, driven by a decline in agricultural irrigation, which is by far the largest water user in the region (Table A.1, Figure A.2).

## EXISTING WATER SUPPLIES

The region primarily relies upon groundwater supply sources, with approximately 88 percent (Table A.1) of the existing water supply in the Panhandle Region coming from the Ogallala Aquifer. Other aquifers (Blaine, Dockum, Seymour, and Rita Blanca) provide approximately 7 percent of the total supply, and surface water, including Lake Meredith and Greenbelt Lake, contributes another 3 percent of supplies. Reuse contributes the remaining 2 percent of existing water supply in the planning area. Within the region, of the supplies available from the Ogallala Aquifer, 85 percent is used for irrigation purposes (Table A.1, Figure A.2). Based on the region's adopted water management policy, annual water supplies for the region from the Ogallala Aquifer are projected to decline 37 percent by 2060.

## NEEDS

In the event of drought, water needs occur across the region in all decades (Table A.1, Figure A.2). The majority of the needs are in irrigation, with some other, smaller needs, primarily in municipal and manufacturing.

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Panhandle Planning Group recommended water management strategies focused on conservation and groundwater development. It also recommended connecting to the Palo Duro Reservoir. In all, the strategies would provide 648,221 acre-feet of additional water supply by the year 2060 (Figure A.3) at a total capital cost of $739 million (Appendix A). However, the Canadian River Municipal Water Authority will provide some of this water to customers in the Llano Estacado Region. Because there were no economically feasible strategies identified to meet their needs, up to six counties in the region have unmet irrigation needs across the planning horizon, and 30,307 acre-feet of unmet irrigation needs in 2060.

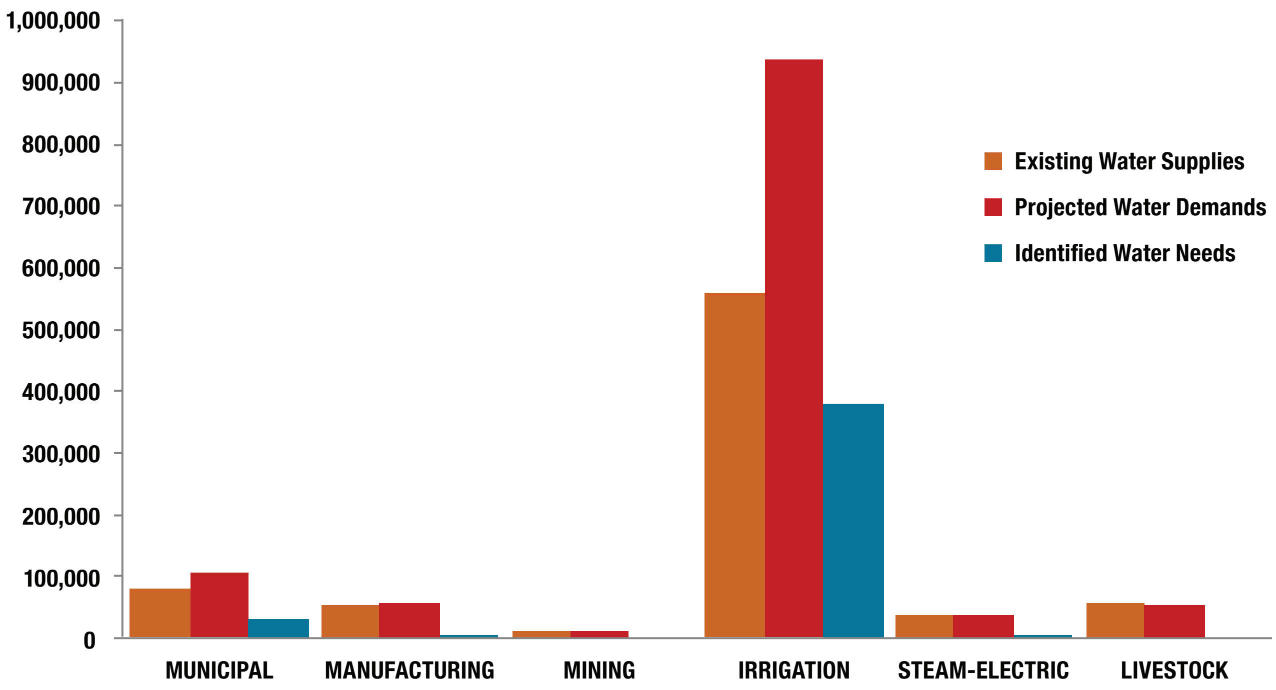
## CONSERVATION RECOMMENDATIONS

Conservation strategies represent 86 percent of the total volume of water associated with all recommended strategies (Figures A.3 and A.4). Water conservation was recommended for every municipal need and for all irrigation water user groups in the region. Irrigation conservation would be achieved through irrigation equipment improvements, conservation tillage practices, and the adoption of drought-resistant crop varieties.

## TABLE A.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 388,104 | 423,380 | 453,354 | 484,954 | 516,729 | 541,035 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 40,636 | 47,381 | 47,348 | 47,284 | 47,189 | 47,043 |
| Groundwater | 1,131,151 | 1,018,554 | 951,799 | 877,961 | 790,795 | 714,438 |
| Reuse | 25,129 | 28,928 | 30,620 | 32,528 | 34,598 | 37,577 |
| **Total Water Supply** | **1,196,916** | **1,094,863** | **1,029,767** | **957,773** | **872,582** | **799,058** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 68,137 | 72,793 | 76,638 | 80,648 | 84,614 | 87,658 |
| County-other | 9,468 | 11,097 | 12,550 | 14,035 | 15,516 | 16,584 |
| Manufacturing | 43,930 | 47,275 | 49,998 | 52,612 | 54,860 | 58,231 |
| Mining | 14,012 | 14,065 | 13,218 | 11,696 | 10,495 | 9,542 |
| Irrigation | 1,429,990 | 1,311,372 | 1,271,548 | 1,203,332 | 1,066,736 | 936,929 |
| Steam-electric | 25,139 | 26,996 | 29,116 | 30,907 | 33,163 | 37,415 |
| Livestock | 37,668 | 43,345 | 45,487 | 47,842 | 50,436 | 53,285 |
| **Total Water Demands** | **1,628,344** | **1,526,943** | **1,498,555** | **1,441,072** | **1,315,820** | **1,199,644** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 0 | 967 | 7,354 | 13,968 | 20,492 | 25,712 |
| County-other | 0 | 108 | 1,190 | 2,663 | 4,235 | 5,502 |
| Manufacturing | 173 | 800 | 1,317 | 2,845 | 4,212 | 5,866 |
| Irrigation | 454,628 | 452,144 | 477,338 | 482,226 | 433,155 | 381,180 |
| Steam-electric | 75 | 99 | 117 | 128 | 136 | 154 |
| **Total Water Needs** | **454,876** | **454,118** | **487,316** | **501,830** | **462,230** | **418,414** |

## FIGURE A.2. 2060 PANHANDLE REGION EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Roberts County Well Field (City of Amarillo) would provide up to 22,420 acre-feet per year of groundwater in the year 2060 with a capital cost of $287 million.
- Roberts County Well Field (Canadian River Municipal Water Authority) would provide 15,000 acre-feet per year of groundwater starting in 2030 with a capital cost of $22 million.
- Potter County Well Field would provide up to 11,182 acre-feet per year of groundwater starting in 2020 with a capital cost of $129 million.
- Irrigation conservation would provide up to 552,385 acre-feet per year of water in 2060 with no capital cost.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed one region-specific study during the initial phase of the third planning cycle. The final report documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#a.

- Ogallala Recharge Study – Groundwater Recharge in Central High Plains of Texas: Roberts and Hemphill Counties

## PANHANDLE PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

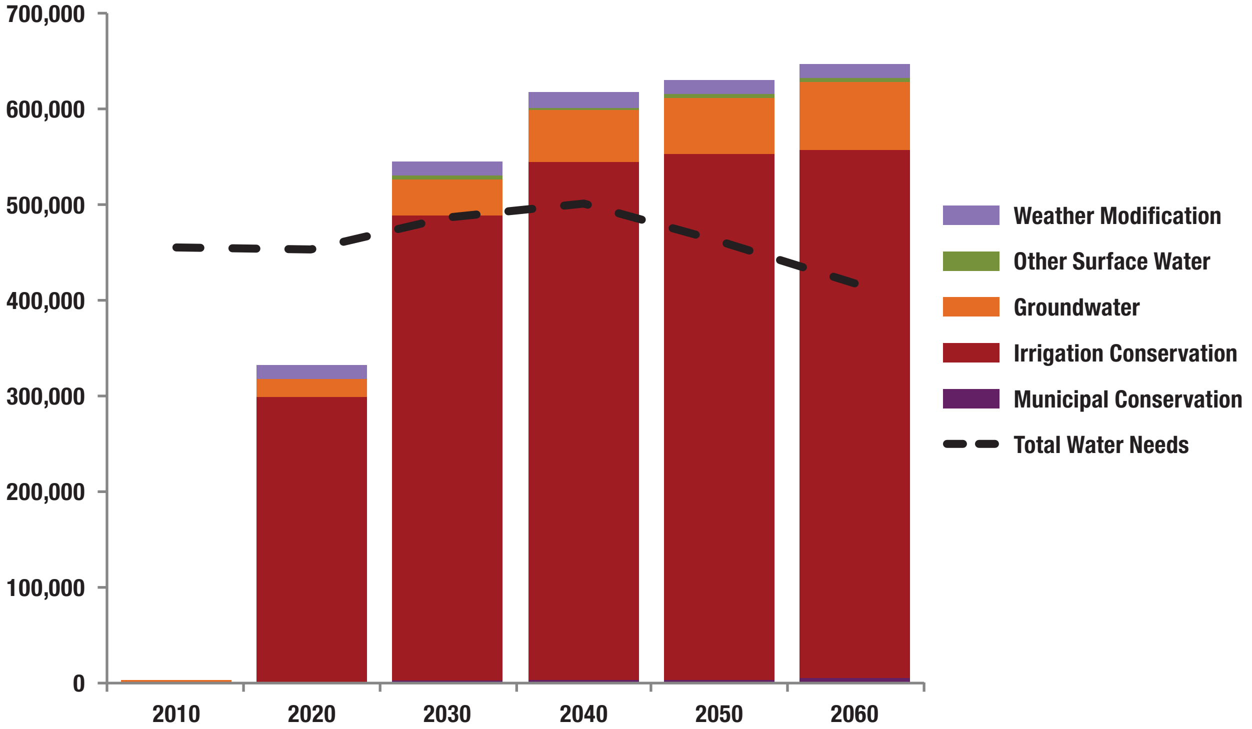
***Voting members during adoption of the 2011 Regional Water Plan:***

C. E. Williams (Chair), water districts; Emmett Autry, municipalities; Tom Bailiff, water districts; Joe Baumgardner, agriculture; Cole Camp, environmental; Nolan Clark, environmental; Vernon Cook, county; Charles Cooke, water utilities; Jim Derington, river authorities; Rusty Gilmore, small business; Janet Guthrie, public; Bill Hallerberg, industries; Kendall Harris, agriculture; Gale Henslee, electric generating utilities; Denise Jett, industries; David Landis, municipalities; Grady Skaggs, environmental; John M. Sweeten, higher education; Janet Tregellas, agriculture; Steve Walthour, water districts; Ben Weinheimer, agriculture; John C. Williams, water districts

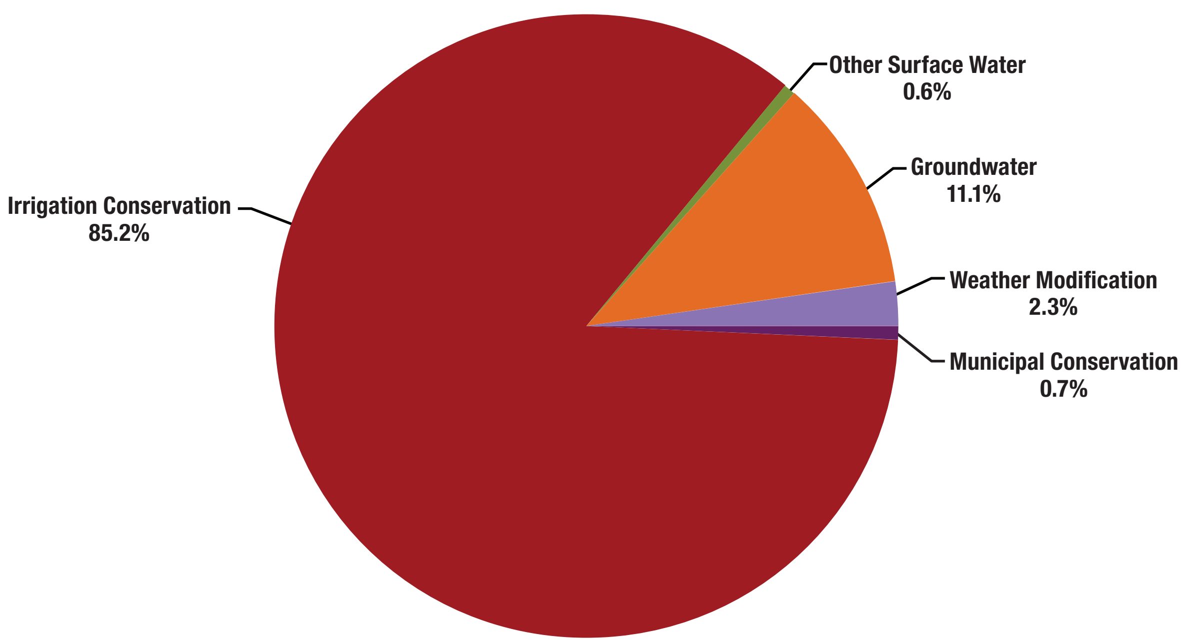
***Former voting members during the 2006 – 2011 planning cycle:***

Richard Bowers, water districts; Dan Coffey, municipalities; B.A. Donelson, agriculture; Bobbie Kidd, water districts; Inge Brady Rapstine, environmental; Rudie Tate, agriculture

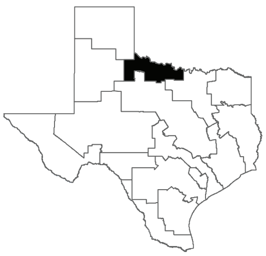
## FIGURE A.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE A.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Region B



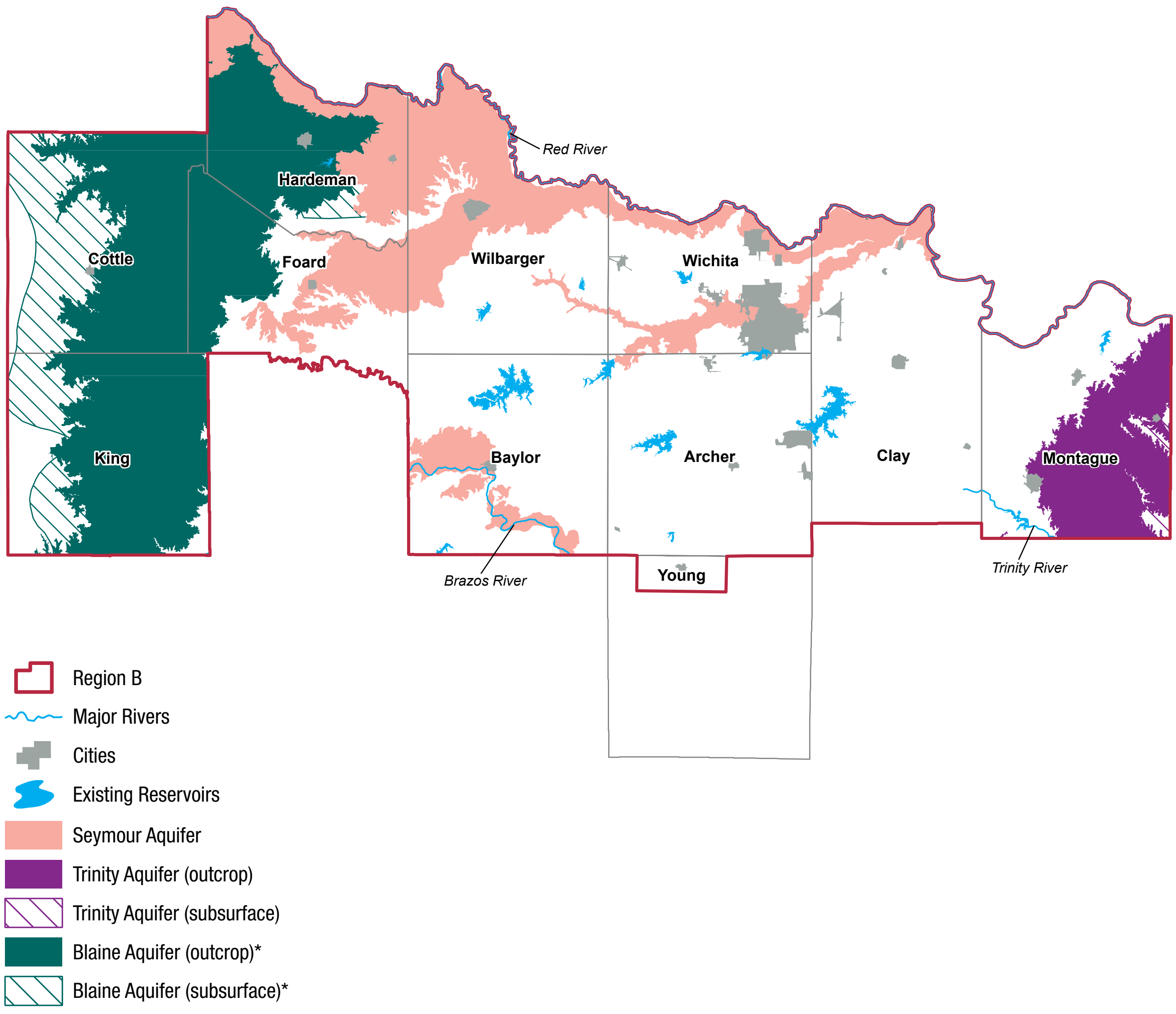
**The Region B Regional Water Planning Area encompasses all or parts of 11 counties in north central Texas bordering the Red River.**

The Region B Regional Water Planning Area encompasses all or parts of 11 counties in north central Texas bordering the Red River. Parts of three river basins (Red, Brazos, and Trinity) lie within the region (Figure B.1). The major cities in the region include Wichita Falls, Burkburnett, and Vernon. The main components of the region's economy are farming, mineral production, and ranching. The 2011 Region B Regional Water Plan can be found on the TWDB Web site at: https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionB/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—40,397 acre-feet per year
- Recommended water management strategy volume in 2060—77,003 acre-feet per year
- Total capital cost—$499 million
- Conservation accounts for 19 percent of 2060 strategy volumes
- One new major reservoir (Ringgold)
- Limited unmet irrigation needs in 2010

## FIGURE B.1. REGION B REGIONAL WATER PLANNING AREA.




* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Just less than 1 percent of the state's total population resided in Region B in the year 2010. Between 2010 and 2060, its population is projected to increase 5 percent to 221,734. However, total water demands are projected to decrease slightly, by approximately 1 percent (Table B.1, Figure B.2.) Agricultural irrigation is the largest share of the regional demand but decreases over the planning period by 9 percent due to anticipated future irrigation efficiency. Municipal water demands account for the second largest water use in Region B and are expected to decrease by 5 percent over the planning cycle.

## EXISTING WATER SUPPLIES

The region relies on both surface and groundwater sources. Its total existing water supply is projected to decline by 12 percent to 152,582 acre-feet in 2060 (Table B.1, Figure B.2). Surface water supplies to the region come from 12 reservoirs within the region and one reservoir (Greenbelt) located in the Panhandle Region. The Lake Kemp and Lake Diversion System represent the largest single source of surface water to Region B, providing 33 percent of the region's supplies in 2010.

The Seymour Aquifer is the source of the majority of the groundwater in the region, providing 29 percent of the region's projected supplies in 2060. Other aquifers, including the Blaine and Trinity aquifers, are projected to provide 9 percent of the region's supply in 2060. Significant water quality issues impact both surface and groundwater sources in the region. In the headwater region of the Wichita River, saline springs affect the quality of surface water supplies. In addition, users of the Seymour Aquifer have had to treat for elevated nitrate concentrations in the water.

## NEEDS

The majority of Region B water needs are associated with irrigation and steam-electric uses. Irrigation water needs account for 97 percent of Region B water needs in 2010. By 2060 irrigation water use will account for 72 percent of needs and 27 percent of needs will be associated with steam-electric (Table B.1, Figure B.2). County-other and mining needs also exist throughout the planning cycle.

The region also emphasized planning for municipal and manufacturing entities that had little or no supplies above their projected water demands. This additional planning was considered necessary because of uncertainty related to the potential for droughts worse than the drought of record and for uncertainty associated with potential climate change. For these entities, Region B considered providing additional supplies equivalent to 20 percent of their projected demands. This Region B planning criterion identified water needs for six additional water user groups.

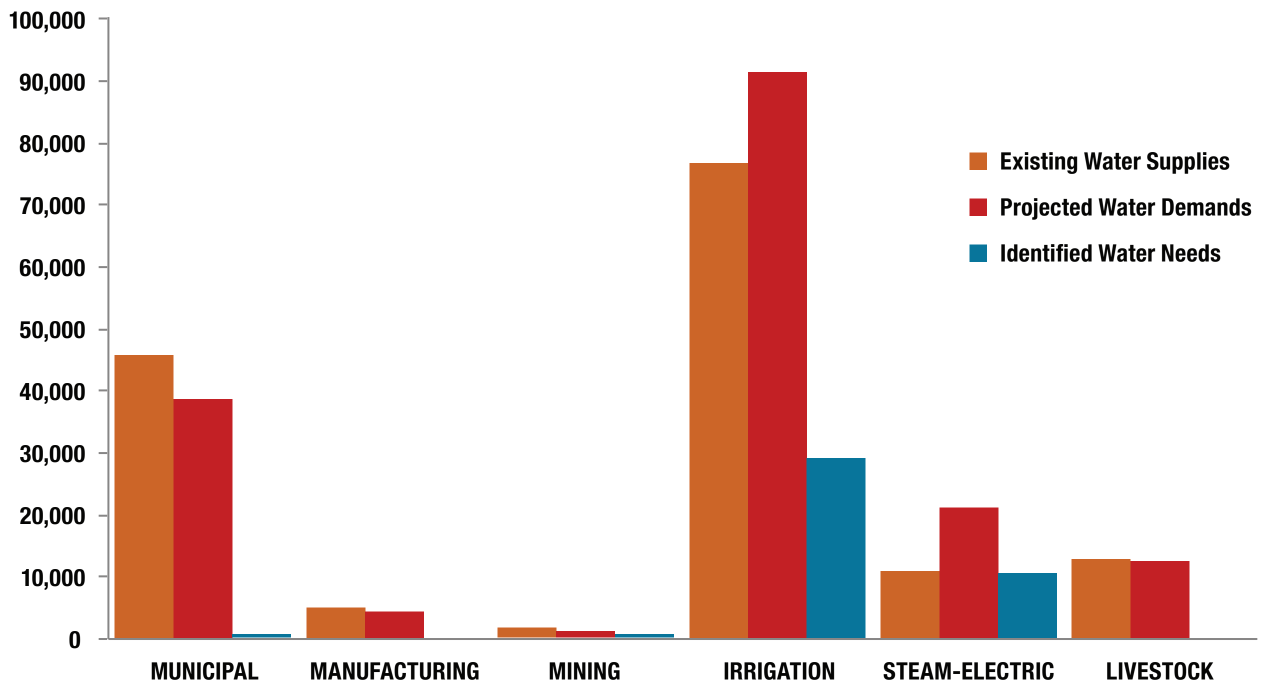
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Region B Planning Group recommended water management strategies including groundwater development, direct reuse, reservoir system operation changes, and construction of Lake Ringgold. In all, the strategies would provide 77,003 acre-feet of additional water supply by the year 2060 (Figures B.3 and B.4) at a total capital cost of

## TABLE B.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Projected Population | 210,642 | 218,918 | 223,251 | 224,165 | 223,215 | 221,734 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 115,509 | 111,239 | 106,991 | 102,724 | 98,477 | 94,179 |
| Groundwater | 58,456 | 58,439 | 58,431 | 58,410 | 58,403 | 58,403 |
| **Total Water Supply** | **173,965** | **169,678** | **165,422** | **161,134** | **156,880** | **152,582** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 36,695 | 35,394 | 35,964 | 35,532 | 35,107 | 34,964 |
| County-other | 4,269 | 4,261 | 4,232 | 4,132 | 3,855 | 3,732 |
| Manufacturing | 3,547 | 3,755 | 3,968 | 4,260 | 4,524 | 4,524 |
| Mining | 909 | 845 | 811 | 785 | 792 | 792 |
| Irrigation | 99,895 | 97,702 | 95,537 | 93,400 | 91,292 | 91,292 |
| Steam-electric | 13,360 | 17,360 | 21,360 | 21,360 | 21,360 | 21,360 |
| Livestock | 12,489 | 12,489 | 12,489 | 12,489 | 12,489 | 12,489 |
| **Total Water Demands** | **171,164** | **171,806** | **174,361** | **171,958** | **169,419** | **169,153** |
| **Needs (acre-feet per year)** | | | | | | |
| County-other | 437 | 468 | 491 | 502 | 460 | 462 |
| Mining | 177 | 153 | 145 | 149 | 162 | 162 |
| Irrigation | 22,945 | 23,926 | 24,909 | 25,893 | 26,876 | 29,058 |
| Steam-electric | 0 | 3,800 | 8,529 | 9,258 | 9,987 | 10,715 |
| **Total Water Needs** | **23,559** | **28,347** | **34,074** | **35,802** | **37,485** | **40,397** |

## FIGURE B.2. 2060 REGION B EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



$499.2 million (Appendix A). Implementing the recommended water management strategies will meet regional needs projected to occur for 2020 and beyond.

## CONSERVATION RECOMMENDATIONS

Conservation strategies for municipal and irrigation water users represent 19 percent of the total volume of water associated with all recommended strategies in 2060. Municipal water conservation was recommended for every municipal and county-other water user group with a need. Irrigation conservation is planned to be accomplished through an irrigation canal lining strategy.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Construction of Lake Ringgold would provide 27,000 acre-feet per year of water starting in the year 2050 with a capital cost of $383 million.
- Increasing the water conservation pool at Lake Kemp would provide up to 24,834 acre-feet per year of water in 2020 with a capital cost of $130,000.
- Enclosing canal laterals for surface water conveyance in pipe would provide 13,034 acre-feet per year starting in the year 2010 with a capital cost of $7.7 million.
- Wichita Basin Chloride Control Project would contribute to the provision of 26,500 acre-feet per year of surface water starting in 2010 with a capital cost of $95 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed one region-specific study during the initial phase of the third planning cycle. The final report documenting the findings can be found on the TWDB Web-site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#b.

- Wichita County Water Improvement District Number 2 Water Conservation Implementation Plan

## REGION B PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

*Voting members during adoption of the 2011 Regional Water Plan:*

Curtis Campbell (Chair), river authorities; Jimmy Banks, water districts; Charlie Bell, counties; J.K. Rooter Brite, environmental; Ed Garnett, municipalities; Dale Hughes, agriculture; Robert Kincaid, municipalities; Kenneth Liggett, counties; Mike McGuire, water districts; Dean Myers, small business; Kenneth Patton, electric generating utilities; Jerry Payne, public; Wilson Scaling, agriculture; Tom Stephens, industries; Pamela Stephens, environmental; Russell Schreiber, municipalities; Jeff Watts, water utilities

*Former voting members during the 2006 – 2011 planning cycle:*

Mark Barton, electric generating utilities; Kelly Couch, municipalities; Paul Hawkins, public; Tommy Holub, water utilities; Norman Horner, environmental; Joe Johnson, Jr., industries; Kenneth McNabb, counties

FIGURE B.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).

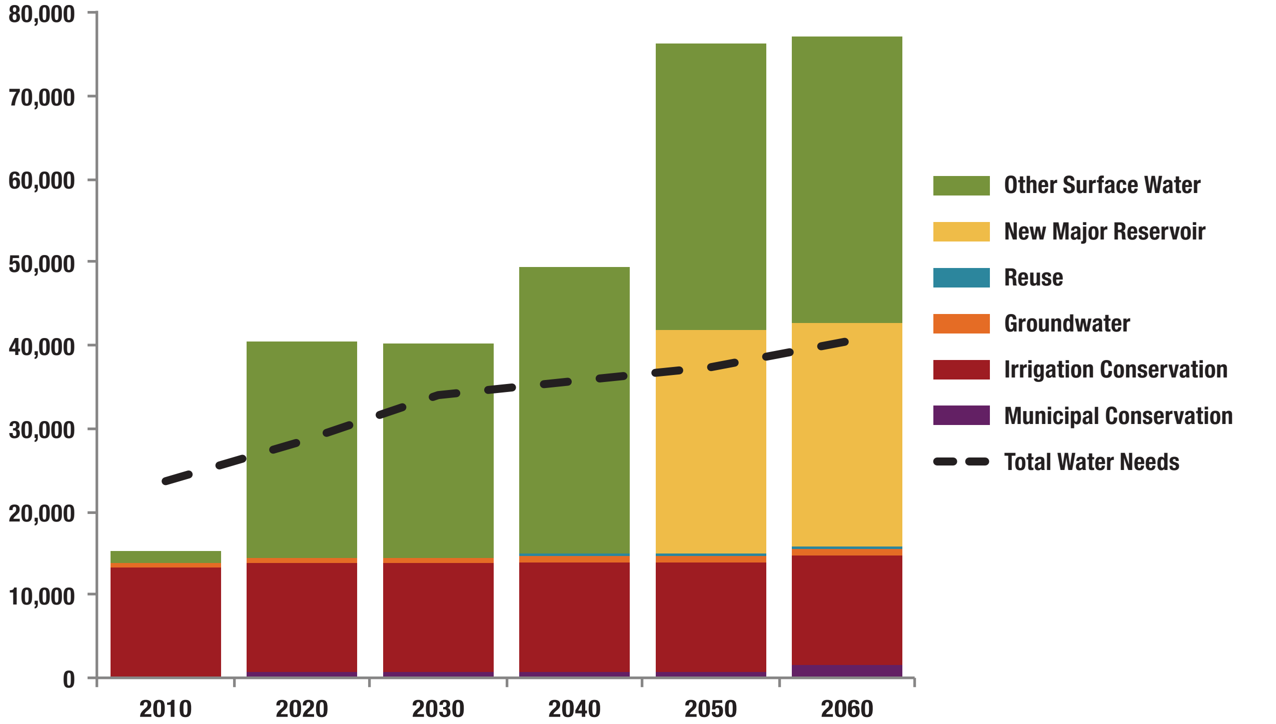
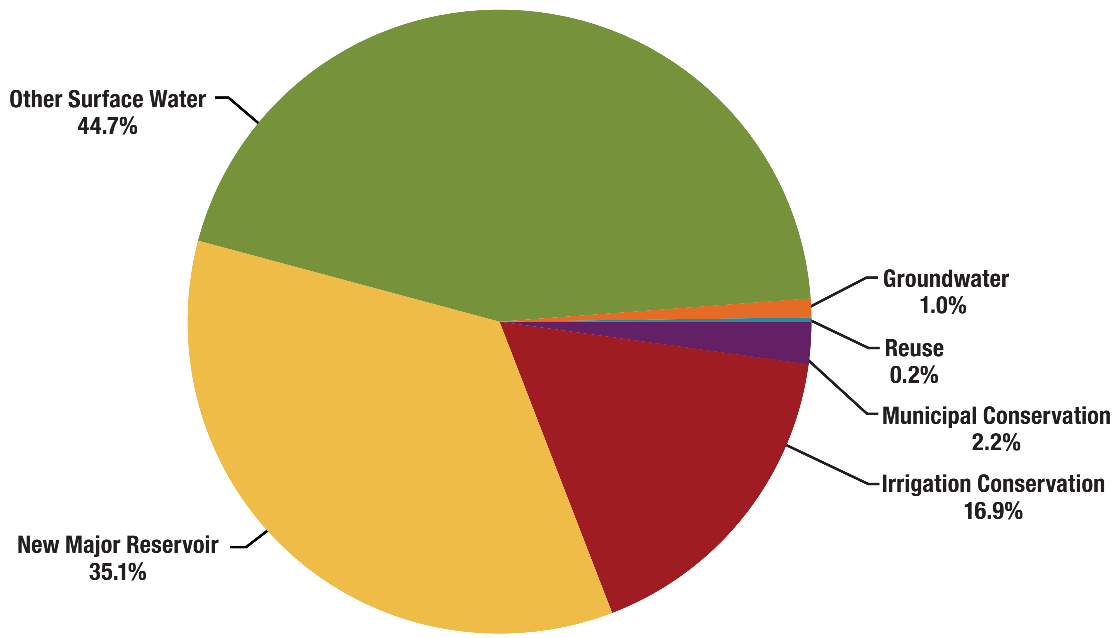
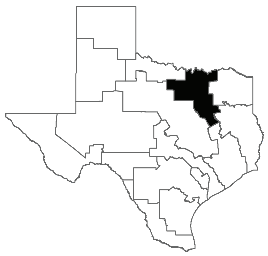



FIGURE B.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Region C



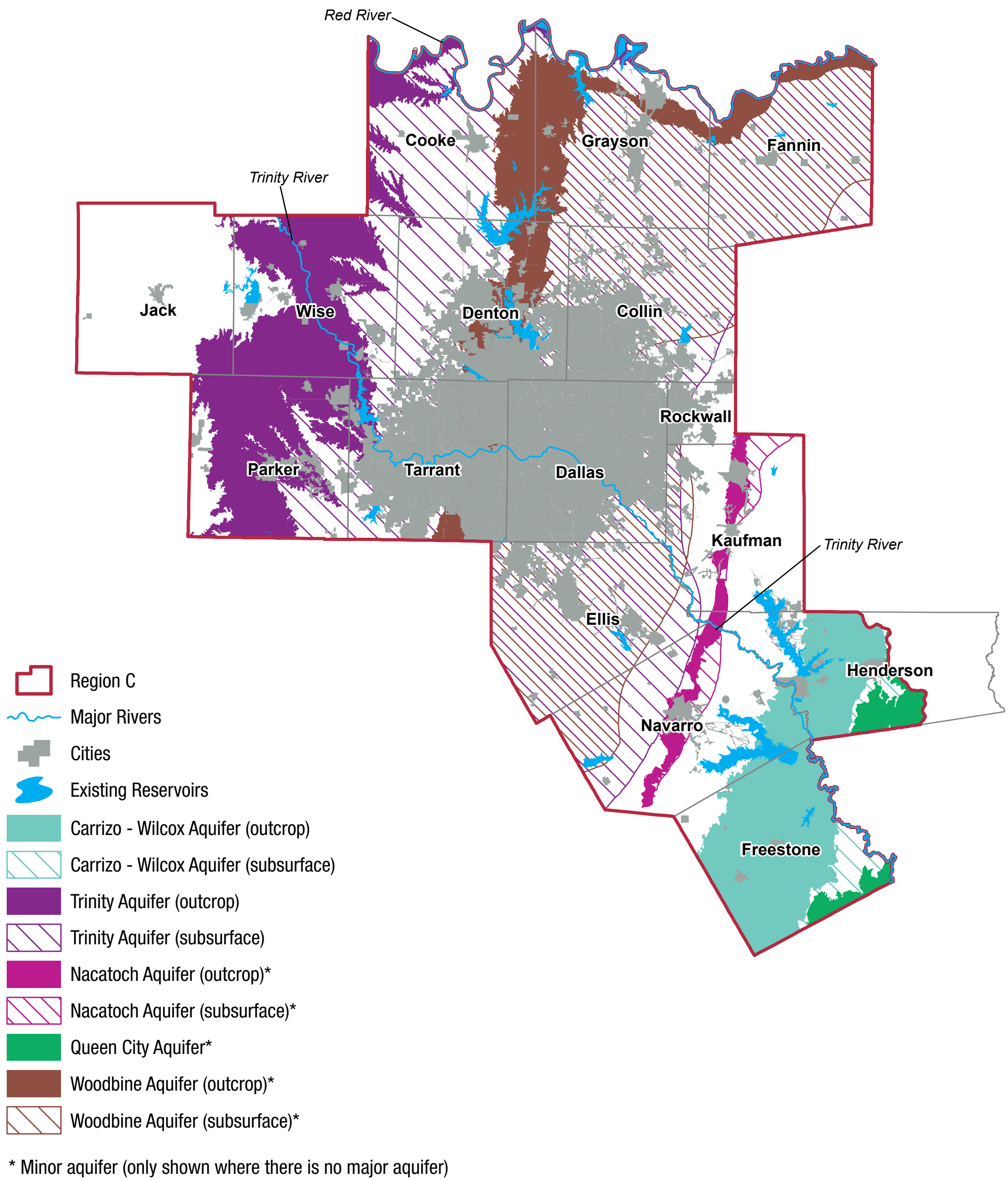
**The Region C Regional Water Planning Area includes all or parts of 16 counties.**

The Region C Regional Water Planning Area includes all or parts of 16 counties (Figure C.1). Overlapping much of the upper portion of the Trinity River Basin, Region C also includes smaller parts of the Red, Brazos, Sulphur, and Sabine river basins. The Dallas-Fort Worth metropolitan area is centrally located in the region, and its surrounding counties are among the fastest growing in the state. Major economic sectors in the region include service, trade, manufacturing, and government. The 2011 Region C Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionC/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—1,588,236 acre-feet per year
- Recommended water management strategy volume in 2060—2,360,302 acre-feet per year
- Total capital cost—$21.5 billion
- Conservation accounts for 12 percent of 2060 strategy volumes
- Reuse accounts for 11 percent of 2060 strategy volumes
- Four new major reservoirs (Ralph Hall, Lower Bois d'Arc, Marvin Nichols, Fastrill Replacement Project)
- Significant costs associated with numerous conveyance projects

## FIGURE C.1. REGION C REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

Approximately 26 percent of Texas' population resided in Region C in the year 2010. By 2060, the population of the region is projected to grow 96 percent to 13,045,592. Projections indicate that by 2060 Region C water demands will increase 86 percent (Table C.1). Municipal demands are projected to increase by 91 percent by 2060 and will account for 88 percent of the total projected Region C demands. With the exception of livestock demands, which remain constant, all categories of water demands are projected to increase over the planning horizon (Table C.1, Figure C.2).

## EXISTING WATER SUPPLIES

The total water supply in Region C is projected to decline by about 3 percent by 2060 (Table C.1, Figure C.2). This projected decline is due to reservoir sedimentation. Existing reservoirs within Region C are projected to provide nearly 58 percent of total water supplies in the region, while surface water supplies located outside of the region account for another 22 percent. Groundwater from the Trinity Aquifer and several minor aquifers provides approximately 7 percent of supplies. Currently authorized reuse provides 10 percent of the available supply to Region C. The remaining 2 percent of the water supply comes from local sources, such as run-of-river permits.

## NEEDS

The majority of water supply needs in Region C are for municipal uses (Table C.1, Figure C.2). By 2060, water supply needs in the region are projected to total 1,588,236 acre-feet. Ninety-two percent of this projected need (1,459,025 acre-feet) is for municipal users and county-other.

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

Region C considered a variety of water management strategies to meet needs. In all, the strategies provide an additional 2.4 million acre-feet by 2060 (Figures C.3 and C.4), with a total capital cost of $21.5 billion (Appendix A) if all the recommended water management strategies are implemented. The plan recommends four new major reservoirs: Lower Bois d'Arc, Ralph Hall, Marvin Nichols, and Fastrill Replacement Project.

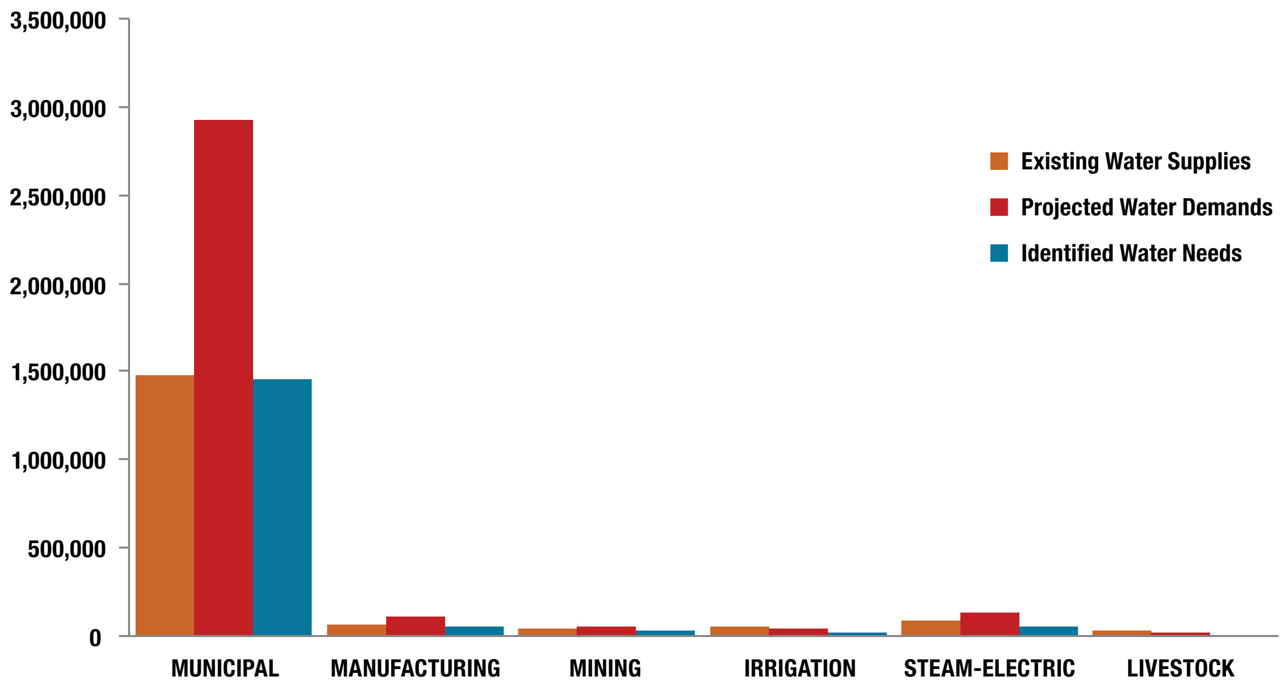
## CONSERVATION RECOMMENDATIONS

Conservation strategies account for approximately 12 percent (290,709 acre-feet) of the total volume of water associated with all recommended strategies. A basic conservation package, including education, pricing structure, water waste prohibitions, water system audits, and plumbing code changes, was recommended for all municipal water user groups in Region C. An expanded conservation package, including additional strategies such as landscape irrigation restrictions and residential water audits, was recommended for some municipal water user groups.

## TABLE C.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Projected Population | 6,670,493 | 7,971,728 | 9,171,650 | 10,399,038 | 11,645,686 | 13,045,592 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 1,481,272 | 1,406,598 | 1,359,808 | 1,343,319 | 1,328,097 | 1,305,588 |
| Groundwater | 125,939 | 121,827 | 121,916 | 122,074 | 122,117 | 122,106 |
| Reuse | 182,686 | 231,816 | 273,003 | 293,292 | 300,143 | 307,129 |
| **Total Water Supplies** | **1,789,897** | **1,760,241** | **1,754,727** | **1,758,685** | **1,750,357** | **1,734,823** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 1,512,231 | 1,796,086 | 2,048,664 | 2,304,240 | 2,571,450 | 2,882,356 |
| County-other | 34,738 | 37,584 | 38,932 | 39,874 | 40,725 | 41,800 |
| Manufacturing | 72,026 | 81,273 | 90,010 | 98,486 | 105,808 | 110,597 |
| Mining | 41,520 | 38,961 | 41,630 | 44,486 | 47,435 | 50,200 |
| Irrigation | 40,776 | 40,966 | 41,165 | 41,373 | 41,596 | 41,831 |
| Steam-electric | 40,813 | 64,625 | 98,088 | 107,394 | 116,058 | 126,428 |
| Livestock | 19,248 | 19,248 | 19,248 | 19,248 | 19,248 | 19,248 |
| **Total Water Demands** | **1,761,352** | **2,078,743** | **2,377,737** | **2,655,101** | **2,942,320** | **3,272,460** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 67,519 | 362,099 | 614,610 | 859,838 | 1,127,749 | 1,445,025 |
| County-other | 87 | 5,158 | 7,931 | 10,118 | 12,295 | 14,302 |
| Manufacturing | 557 | 11,946 | 21,151 | 30,369 | 39,640 | 48,894 |
| Mining | 414 | 4,909 | 10,036 | 14,782 | 19,445 | 23,779 |
| Irrigation | 510 | 2,588 | 3,412 | 4,007 | 4,492 | 4,913 |
| Steam-electric | 0 | 13,217 | 29,696 | 34,835 | 40,997 | 51,323 |
| **Total Water Needs** | **69,087** | **399,917** | **686,836** | **953,949** | **1,244,618** | **1,588,236** |

## FIGURE C.2. 2060 REGION C EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Toledo Bend Reservoir supply would provide up to 400,229 acre-feet per year of water with a capital cost of $2.4 billion (with Region I entities responsible for 20 percent of cost).
- Marvin Nichols Reservoir would provide up to 472,300 acre-feet per year of water with a capital cost of $3.4 billion.
- Reallocation of the flood pool of Wright Patman Lake would provide 112,100 acre-feet per year of water starting in the year 2040 with a capital cost of $897 million.
- The Lake Tawakoni pipeline project would provide up to 77,994 acre-feet per year of water in 2010 with a capital cost of $496 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed seven region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#c.

- Water Supply Study for Ellis County, Johnson County, Southern Dallas County, and Southern Tarrant County
- Water Supply Study for Parker and Wise Counties
- Direct, Non-Potable Reuse Guidance Document
- Indirect Reuse Guidance Document
- Region C Water Conservation and Reuse Study
- County-Wide Meetings Memorandum
- Toledo Bend Pipeline Project Coordination Activities Technical Memorandum

## REGION C PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

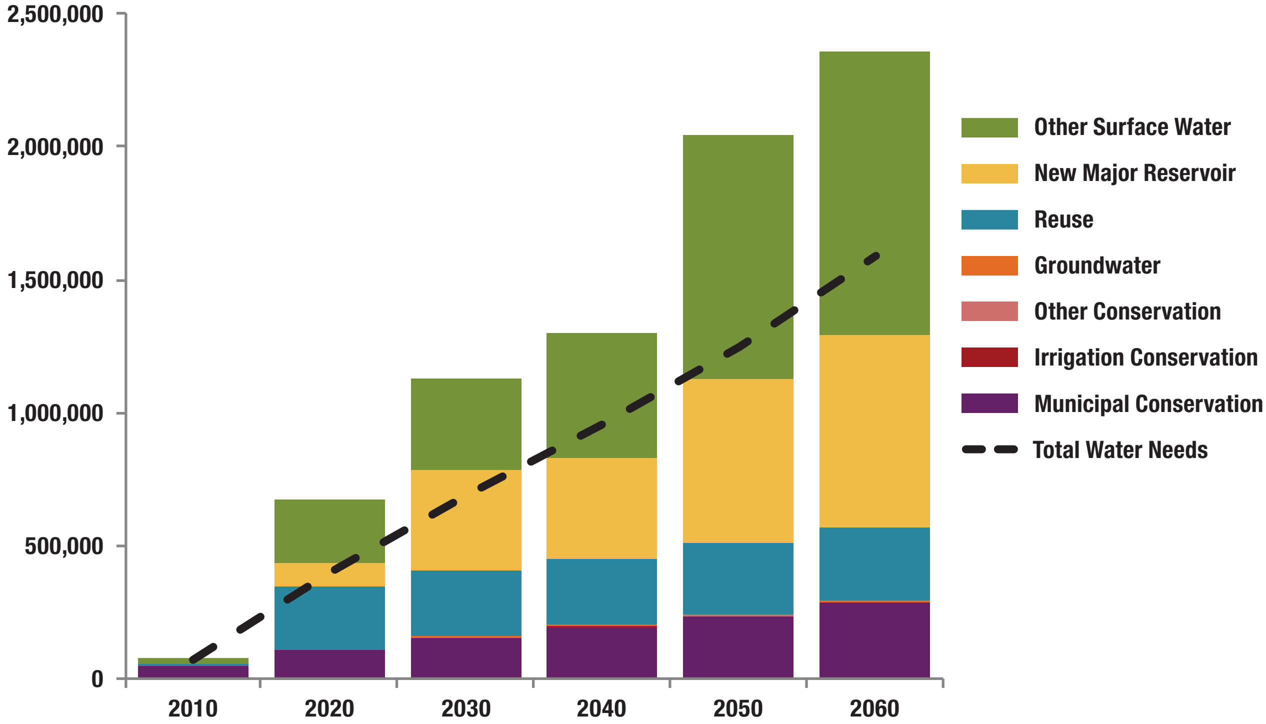
*Voting members during adoption of the 2011 Regional Water Plan:*

James (Jim) Parks (Chair), water districts; Steve Berry, environmental; Bill Ceverha, public; Jerry W. Chapman, water districts; Frank Crumb, municipalities; Russell Laughlin, industries; Bill Lewis, small business; G.K. Maenius, counties; Howard Martin, municipalities; Jim McCarter, water utilities; Paul Phillips, municipalities; Jody Puckett, municipalities; Robert O. Scott, environmental; Gary Spicer, electric generating utilities; Connie Standridge, water utilities; Jack Stevens, water districts; Danny Vance, river authorities; Mary E. Vogelson, public; Tom Woodward, agriculture

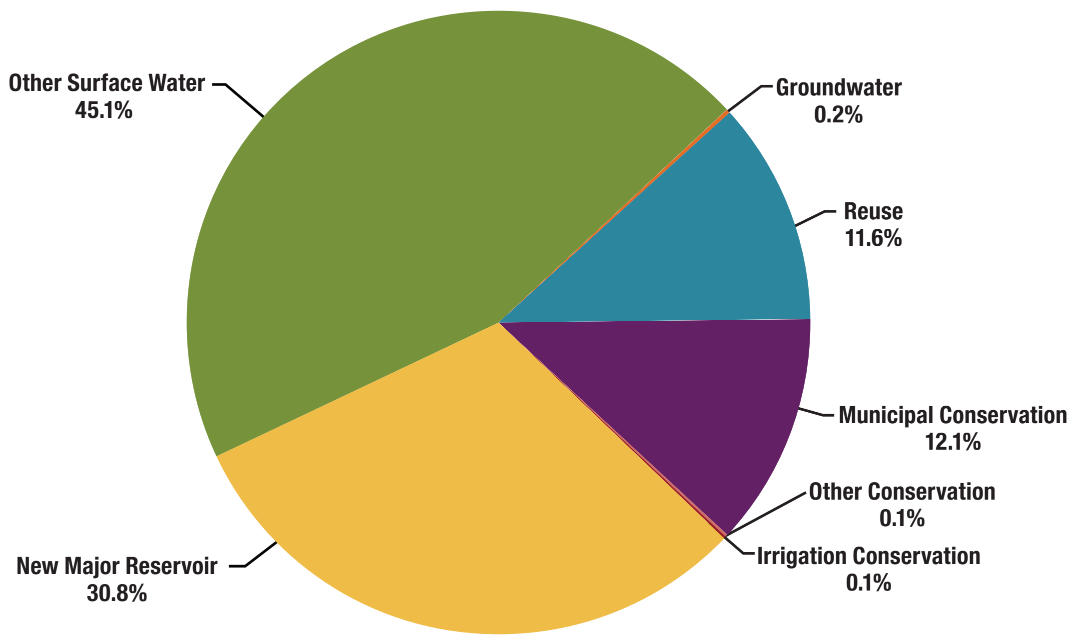
*Former voting members during the 2006 – 2011 planning cycle:*

Brad Barnes, agriculture; Roy Eaton, small business; Dale Fisseler, municipalities; Bob Johnson, municipalities; Jerry Johnson, electric generating utilities; Elaine Petrus, environmental; Marsh Rice, public; Paul Zweicker, electric generating utilities

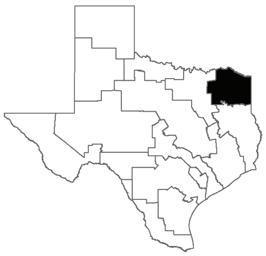
## FIGURE C.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE C.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of North East Texas (D) Region



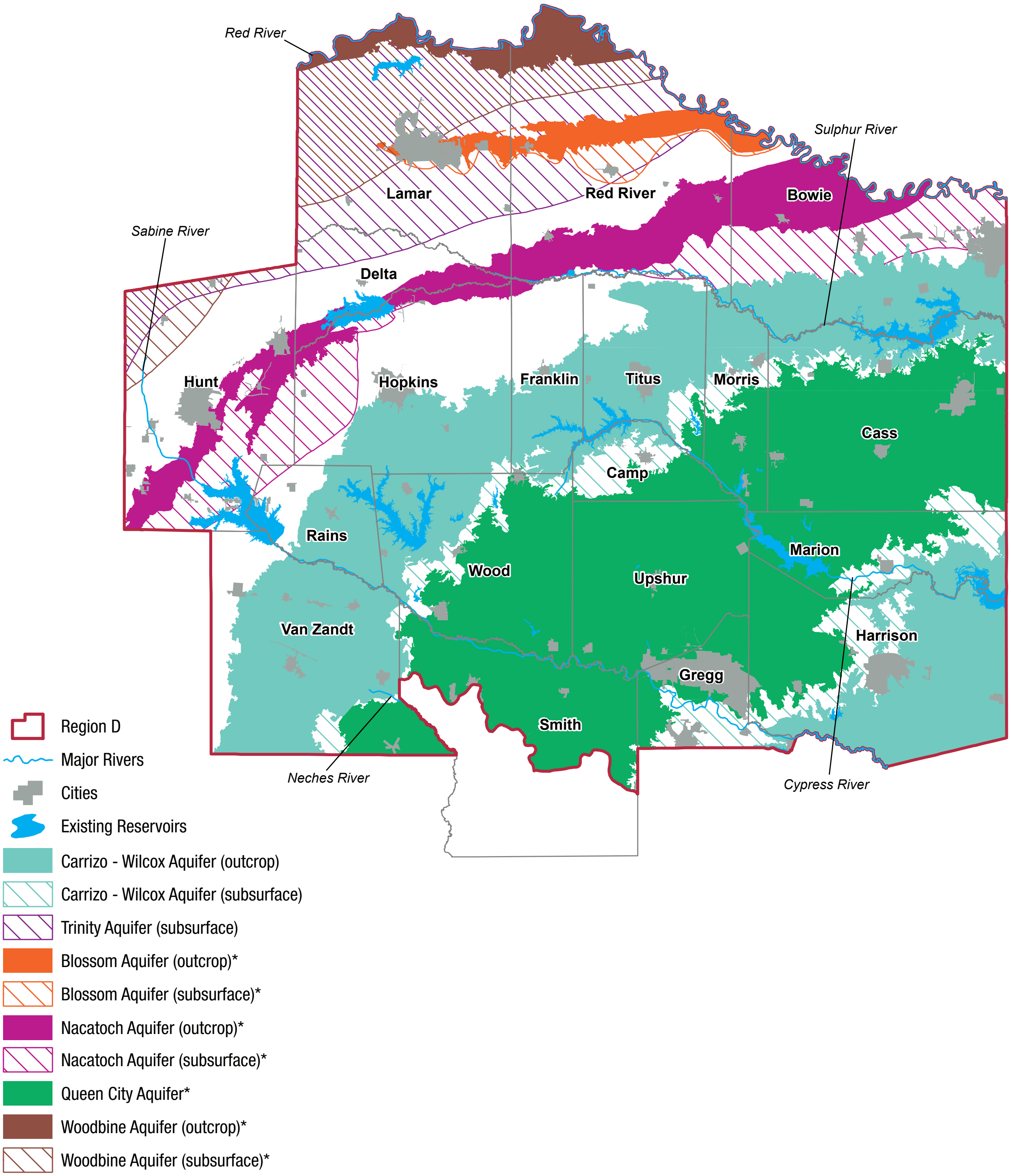
**The North East Texas Regional Water Planning Area encompasses all or parts of 19 counties.**

The North East Texas Regional Water Planning Area encompasses all or parts of 19 counties (Figure D.1). While largely rural, the region includes the cities of Longview, Texarkana, and Greenville. The planning area overlaps large portions of the Red, Sulphur, Cypress, and Sabine river basins and smaller parts of the Trinity and Neches river basins. The North East Texas Region's main economic base is agribusiness, including a variety of crops, as well as cattle and poultry production. Timber, oil and gas, and mining are significant industries in the eastern portion of the region. In the western portion of the region, many residents are employed in the Dallas-Fort Worth metropolitan area. The 2011 North East Texas (D) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionD/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—96,142 acre-feet per year
- Recommended water management strategy volume in 2060—98,466 acre-feet per year
- Total capital cost—$39 million
- Limited unmet irrigation needs
- Surface water contract strategies to meet most needs including contracting for water from new reservoir in Region C
- Opposition to Marvin Nichols Reservoir
- Three unique stream segments recommended for designation (Figure ES.8)

## FIGURE D.1. NORTH EAST TEXAS (D) REGIONAL WATER PLANNING AREA.




* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 3 percent of the state's total population resided in the North East Texas Region in the year 2010. By 2060, the region's population is projected to grow 57 percent to 1,213,095. Water demands for the region are projected to increase 50 percent (Table D.1). Throughout the planning period, manufacturing makes up the largest portion of demands, with the total volume of its demands increasing by 40 percent (Table D.1). Steam-electric and municipal demands will also increase significantly. By 2060, demand for steam-electric power generation is projected to more than double, and municipal demand will increase about 51 percent (Table D.1, Figure D.2).

## EXISTING WATER SUPPLIES

The total existing water supply for the North East Texas Region was estimated to be approximately 999,745 acre-feet in 2010, increasing to 1,036,488 acre-feet in 2060 (Table D.1, Figure D.2). Existing supplies increase over the planning horizon to reflect new uses, including groundwater wells and surface water contracts. In 2010, surface water, primarily from the Sabine, Cypress, and Sulphur river basins, was projected to provide 83 percent of existing supplies, and the remaining 17 percent was equally divided between groundwater and reuse. Major aquifers include the Carrizo-Wilcox Aquifer in the central and southern part of the region and the Trinity Aquifer in the north.

## NEEDS

In 2010, the total water supply volume was not accessible to all users in the region. As a result, the North East Texas Region was projected to have a water supply need of 10,252 acre-feet, with steam-electric power generation needs making up approximately 84 percent of the total, or 8,639 acre-feet (Table D.1, Figure D.2). By 2060, water supply needs are projected to total 96,142 acre-feet. Steam-electric power generation needs will account for nearly 81 percent of the total needs, while the remaining needs will affect municipal, rural, and irrigated agriculture users.

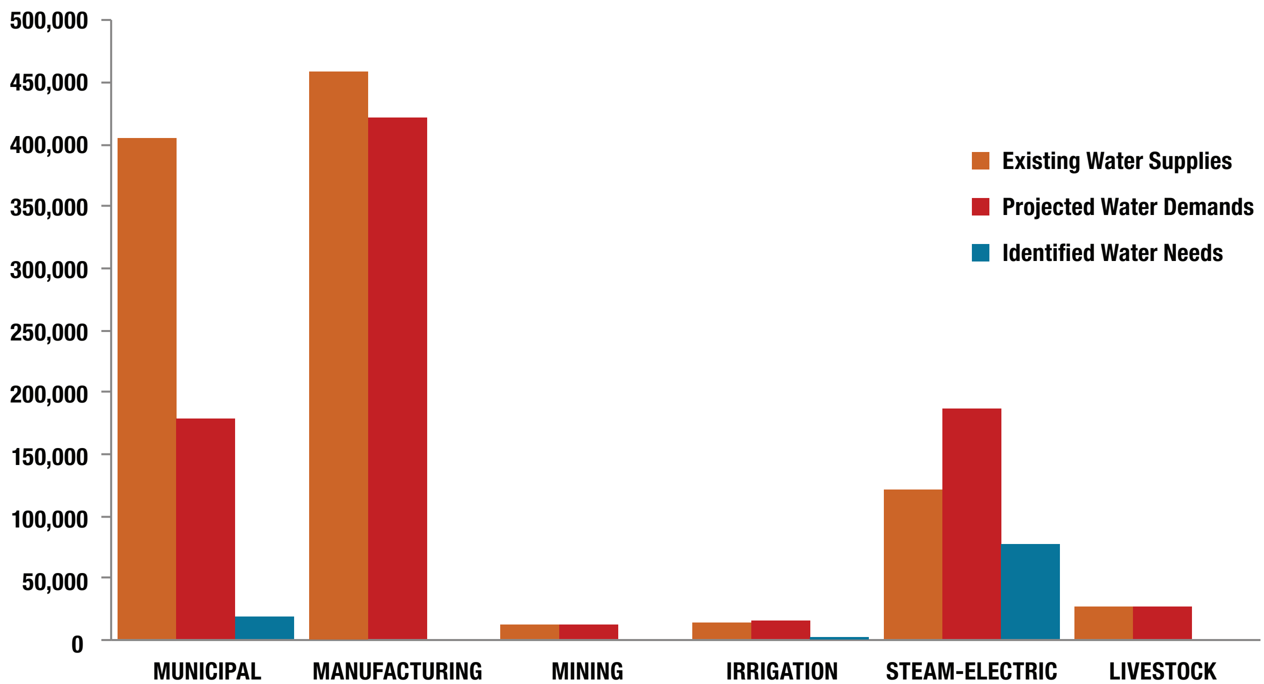
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

Of the 61 identified shortages in the region, 21 are the result of contract expirations. However, the planning group assumed that all contracts would be renewed. For the remaining projected shortages, the planning group recommended two types of water management strategies to meet needs: new groundwater wells and new surface water purchases. If fully implemented, recommended water management strategies would provide an additional 98,466 acre-feet of supply in the year 2060 (Figures D.3 and D.4) at a total capital cost of $38.5 million (Appendix A). Although groundwater will provide more individual water user groups with water, surface water constitutes approximately 93 percent of the total volume of supply from recommended water management strategies (Figure D.4).

## TABLE D.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 772,163 | 843,027 | 908,748 | 978,298 | 1,073,570 | 1,213,095 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 831,239 | 838,379 | 843,707 | 848,652 | 855,180 | 864,067 |
| Groundwater | 84,864 | 87,501 | 89,332 | 90,800 | 92,361 | 94,786 |
| Reuse | 83,642 | 78,247 | 72,821 | 67,505 | 68,761 | 77,635 |
| **Total Water Supplies** | **999,745** | **1,004,127** | **1,005,860** | **1,006,957** | **1,016,302** | **1,036,488** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 90,171 | 96,359 | 102,345 | 109,227 | 119,821 | 135,811 |
| County-other | 29,780 | 32,352 | 34,404 | 36,177 | 38,637 | 42,367 |
| Manufacturing | 301,091 | 328,568 | 351,427 | 373,504 | 392,387 | 421,496 |
| Mining | 8,802 | 9,605 | 10,108 | 10,595 | 11,111 | 11,625 |
| Irrigation | 15,504 | 15,415 | 15,329 | 15,182 | 14,949 | 14,728 |
| Steam-electric | 89,038 | 96,492 | 112,809 | 132,703 | 156,951 | 186,509 |
| Livestock | 26,690 | 26,736 | 26,785 | 26,698 | 26,554 | 26,441 |
| **Total Water Demands** | **561,076** | **605,527** | **653,207** | **704,086** | **760,410** | **838,977** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 1,404 | 2,082 | 2,834 | 3,856 | 8,190 | 16,711 |
| County-other | 153 | 276 | 411 | 587 | 748 | 1,574 |
| Irrigation | 56 | 0 | 14 | 115 | 238 | 388 |
| Steam-electric | 8,639 | 12,366 | 15,437 | 27,396 | 50,829 | 77,469 |
| **Total Water Needs** | **10,252** | **14,724** | **18,696** | **31,954** | **60,005** | **96,142** |

## FIGURE D.2. 2060 NORTH EAST TEXAS (D) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

The North East Texas Planning Group considered conservation strategies for each water user group with a need and a per capita water use greater than 140 gallons per capita per day. Because costs of conservation strategies were relatively high due to the small size of the entities and amounts of water involved, the region did not recommend conservation as a water management strategy.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Increasing existing contracts would provide up to 59,473 acre-feet per year of surface water, and some groundwater, in the year 2060 with no capital costs, only annual costs of contracts.
- New surface water contracts would provide up to 32,231 acre-feet per year of water in 2060 with a capital cost of $6.3 million.
- Drilling new wells would provide 6,757 acre-feet per year of water in 2060 with a capital cost of $32.3 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed two region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#d.

- Further Evaluation of Sub-Regional Water Supply Master Plans
- Brackish Groundwater Study

## NORTH EAST TEXAS PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

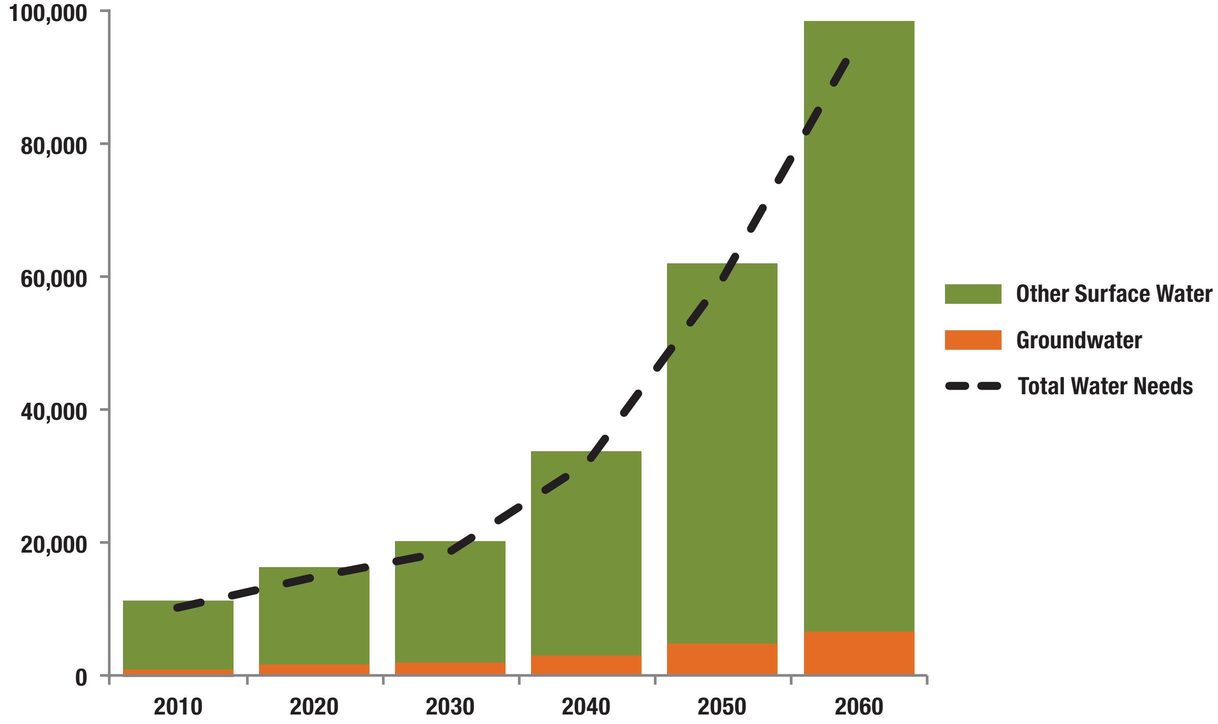
***Voting members during adoption of the 2011 Regional Water Plan:***

Richard LeTourneau (Chair), environmental; Max Bain, counties; Keith Bonds, municipalities; Adam Bradley, agriculture; Greg Carter, electric generating utilities; Gary Cheatwood, public; Nancy Clements, agriculture; Darwin Douthit, agriculture; Mike Dunn, municipalities; Jim Eidson, environmental; Scott Hammer, industries; Troy Henry, river authorities; Don Hightower, counties; Sam Long, counties; Bret McCoy, small business; Sharron Nabors, agriculture; Jim Nickerson, industries; Don Patterson, counties; Ken Shaw, industries; Shirley Shumake, public; Bob Staton, small business; Doug Wadley, industries; David Weidman, water districts; Richard Zachary, water utilities

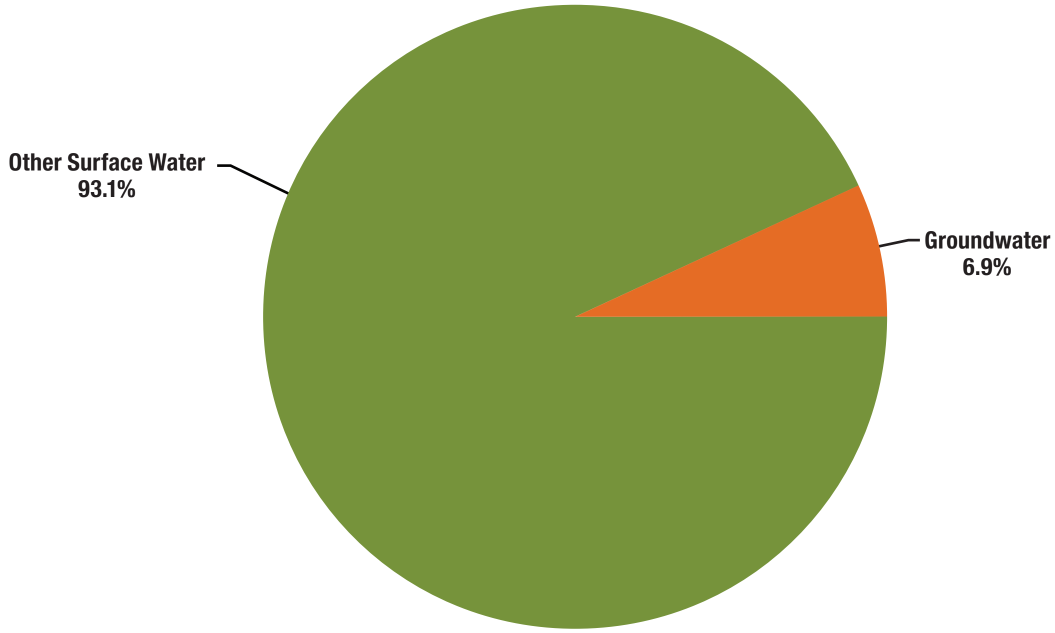
***Former voting members during the 2006 – 2011 planning cycle:***

John Bryan, public; Larry Calvin, environmental; Dean Carrell, municipalities; Jimmy Clark, environmental; George Frost, public; Mendy Rabicoff, small business; Jim Thompson, agriculture

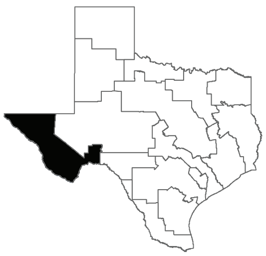
## FIGURE D.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE D.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Far West Texas (E) Region



**The Far West Texas Regional Water Planning Area includes seven counties and lies within the Rio Grande Basin.**

The Far West Texas Regional Water Planning Area includes seven counties and lies within the Rio Grande Basin (Figure E.1). The largest economic sectors in the region are agriculture, agribusiness, manufacturing, tourism, wholesale and retail trade, government, and military. About 97 percent of the people in this planning area reside in El Paso County. The 2011 Far West Texas (E) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionE/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—226,569 acre-feet per year
- Recommended water management strategy volume in 2060—130,526 acre-feet per year
- Total capital cost—$842 million
- Conservation accounts for 40 percent of 2060 strategy volumes
- Significant unmet irrigation needs
- Groundwater desalination accounts for 21 percent of 2060 strategy volumes
- One additional unique stream segment recommended for designation (Figure ES.8)

## FIGURE E.1. FAR WEST TEXAS (E) REGIONAL WATER PLANNING AREA.

## POPULATION AND WATER DEMANDS

Less than 4 percent of the state's total population resided in the Far West Texas Region in 2010. By 2060, the regional population is projected to increase 79 percent (Table E.1). Regional water demands, however, will increase less dramatically. By 2060, the total water demands for the region are projected to increase 8 percent (Table E.1). Agricultural irrigation water use makes up the largest share of these demands in all decades even though it is projected to decrease 10 percent over the planning period (Table E.1). Municipal water demand is projected to increase 60 percent by 2060 (Table E.1, Figure E.2).

## EXISTING WATER SUPPLIES

The total water supply for 2010 is estimated to be 514,593 acre-feet (Table E.1, Figure E.2). Other than some irrigation use and El Paso municipal use, the region relies on groundwater for most of its water supply. Approximately 75 percent of the region's existing water supply consists of groundwater from two major aquifers (Edwards-Trinity [Plateau] outcrop and the Hueco-Mesilla Bolsons) and six minor aquifers. The principal surface water sources are the Rio Grande and the Pecos River, although both are limited, by river system operations and water quality, respectively. Although no reservoirs are located in the planning area, a reservoir system in New Mexico, administered by the U.S. Bureau of Reclamation, regulates the Rio Grande and, thus, a portion of the area's water supplies. Direct reuse provides another 6,000 acre-feet. Because of treaty and compact agreements, as well as groundwater management district regulations, the total surface and groundwater supply is projected to remain relatively constant throughout the planning period.

## NEEDS

In 2010, total water needs during drought of record conditions for the region were projected to be an estimated 209,591 acre-feet, all in irrigation (Table E.1, Figure E.2). By 2060, water needs are projected to increase to 226,569 acre-feet, with irrigation making up the largest share of the needs (75 percent). Municipal needs are projected to constitute 14 percent of the total 2060 needs (Table E.1). Manufacturing, steam-electric power generation, and county-other categories are also projected to face needs.

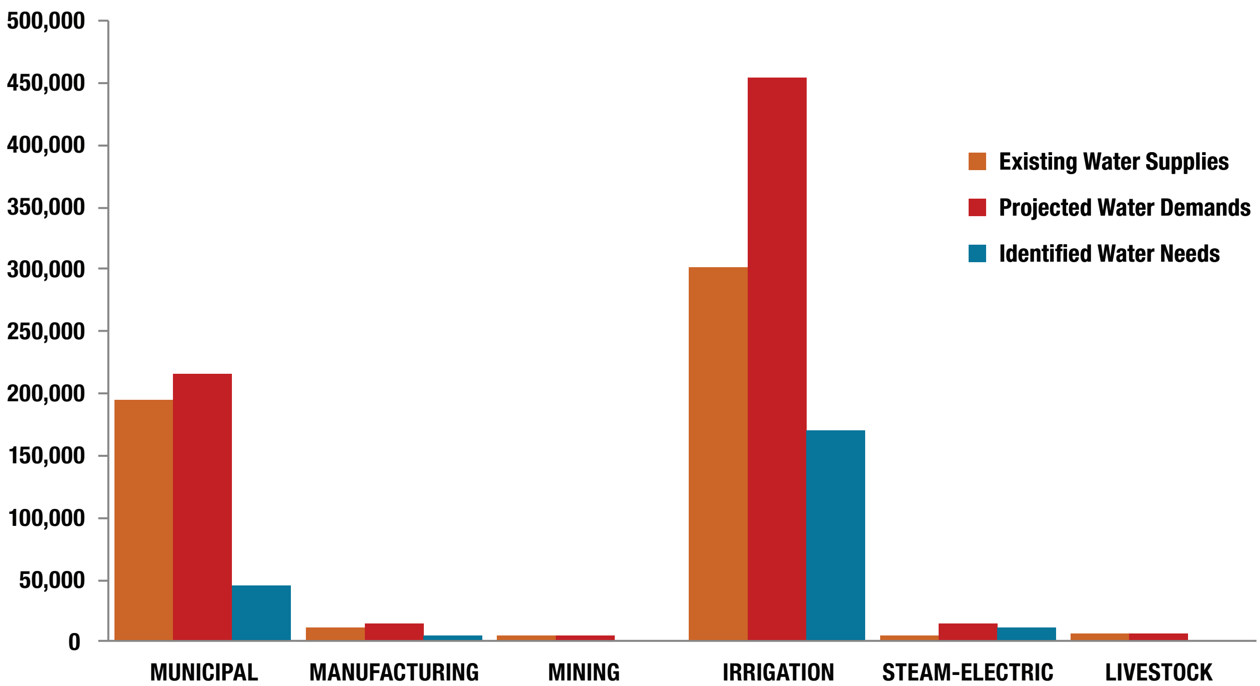
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Far West Texas Planning Group recommended a variety of water management strategies, including municipal conservation, direct reuse of reclaimed water, increases from the Rio Grande managed conjunctively with local groundwater, and imports of additional desalinated groundwater from more remote parts of the planning area. In all, the strategies would provide 130,526 acre-feet of additional water supply by the year 2060 (Figures E.3 and E.4) at a total capital cost of $842.1 million (Appendix A). The Far West Texas Region recommended an integrated water management strategy to meet needs in El Paso, which represents combinations of various sources. Because there were no economically feasible strategies identified, three counties have unmet irrigation needs during drought of record conditions ranging from 209,591 acre-feet in 2010 to 161,775 acre-feet by 2060.

## TABLE E.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 863,190 | 1,032,970 | 1,175,743 | 1,298,436 | 1,420,877 | 1,542,824 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 85,912 | 85,912 | 85,912 | 85,912 | 85,912 | 85,912 |
| Groundwater | 384,650 | 384,650 | 384,650 | 384,650 | 384,650 | 384,650 |
| Reuse | 44,031 | 44,031 | 44,031 | 44,031 | 44,031 | 44,031 |
| **Total Water Supplies** | **514,593** | **514,593** | **514,593** | **514,593** | **514,593** | **514,593** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 122,105 | 140,829 | 156,086 | 168,970 | 181,995 | 194,972 |
| County-other | 7,371 | 10,479 | 12,968 | 14,894 | 16,877 | 19,167 |
| Manufacturing | 9,187 | 10,000 | 10,698 | 11,373 | 11,947 | 12,861 |
| Mining | 2,397 | 2,417 | 2,424 | 2,432 | 2,439 | 2,451 |
| Irrigation | 499,092 | 489,579 | 482,538 | 469,084 | 460,402 | 451,882 |
| Steam-electric | 3,131 | 6,937 | 8,111 | 9,541 | 11,284 | 13,410 |
| Livestock | 4,843 | 4,843 | 4,843 | 4,843 | 4,843 | 4,843 |
| **Total Water Demands** | **648,126** | **665,084** | **677,668** | **681,137** | **689,787** | **699,586** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 0 | 3,867 | 7,675 | 10,875 | 19,239 | 31,584 |
| County-other | 0 | 3,114 | 5,625 | 7,589 | 9,584 | 11,876 |
| Manufacturing | 0 | 813 | 1,511 | 2,186 | 2,760 | 3,674 |
| Irrigation | 209,591 | 201,491 | 195,833 | 183,734 | 176,377 | 169,156 |
| Steam-electric | 0 | 3,806 | 4,980 | 6,410 | 8,153 | 10,279 |
| **Total Water Needs** | **209,591** | **213,091** | **215,624** | **210,794** | **216,113** | **226,569** |

## FIGURE E.2. 2060 FAR WEST TEXAS EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

Conservation strategies for municipal and irrigation water users represent 40 percent of the total volume of water associated with all recommended water management strategies in 2060. Municipal conservation strategies recommended for the City of El Paso have a goal of 140 gallons per capita per day of water use. Total water conservation savings in the plan, including savings from efficient plumbing fixtures as well as improved irrigation scheduling, are projected to be 52,275 acre-feet by 2060.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Importation of groundwater from Dell Valley is expected to produce up to 20,000 acre-feet per year in the year 2060 with a capital cost of $214 million.
- Importation of groundwater from Diablo Farms is projected to produce 10,000 acre-feet per year of water starting in 2040 with a capital cost of $246 million.
- Irrigation District surface water system delivery improvements are anticipated to produce 25,000 acre-feet per year of water starting in 2020 with a capital cost of $148 million.
- Conjunctive use with additional surface water is projected to produce 20,000 acre-feet per year of water with a capital cost of $140 million.

## REGION-SPECIFIC STUDIES

The Far West Texas Regional Water Planning Group developed four region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#e.

- Water Conservation Conference for Far West Texas Water Plan Region E
- Evaluation of Irrigation Efficiency Strategies for Far West Texas: Feasibility, Water Savings, and Cost Considerations
- Conceptual Evaluation of Surface Water Storage in El Paso County
- Groundwater Data Acquisition in Far West Texas

## FAR WEST TEXAS PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

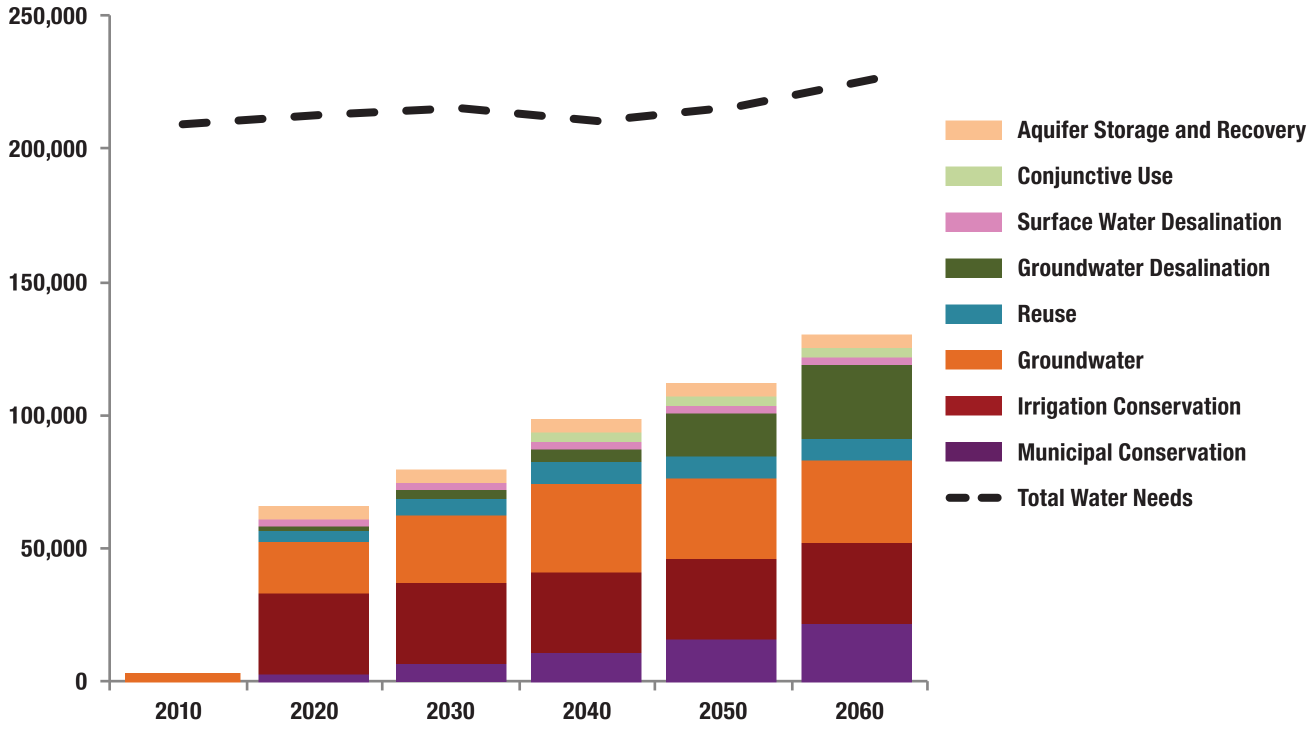
*Voting members during adoption of the 2011 Regional Water Plan:*

Tom Beard (Chair), agriculture; Janet Adams, groundwater districts; Ann Allen, industries; Ed Archuleta, municipalities; Randy Barker, groundwater districts; Jeff Bennett, environmental; Rebecca L. Brewster, municipalities; Sterry Butcher, public; Michael Davidson, travel/tourism; David Etzold, building/real estate; Sylvia Borunda Firth, municipalities; Willie Gandara, counties; Dave Hall, public; Mike Livingston, small business; Albert Miller, water utilities; Jim Ed Miller, water districts; Kenn Norris, counties; Juana Padilla, legislative representative; Jesus “Chuy” Reyes, water districts; Rick Tate, agriculture; Teresa Todd, legislative representative; Teodora Trujillo, public; Paige Waggoner, economic development; Carlos Zuazua, electric generating utilities

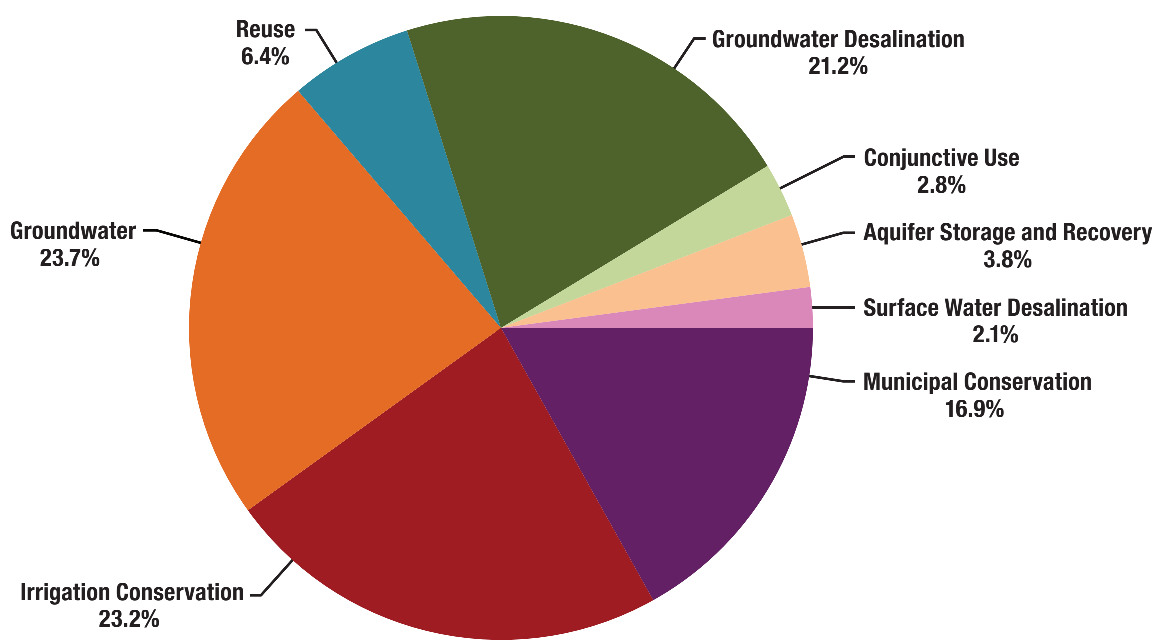
*Former voting members during the 2006 – 2011 planning cycle:*

Jesse Acosta, counties; Loretta Akers, other; Jerry Agan, counties; Cedric Banks, Fort Bliss; Elza Cushing, public; Howard Goldberg, industries; Luis Ito, electric generating utilities; Carl Lieb, environmental; E. Anthony Martinez, legislative representative; Ralph Meriwether, small business; Brad Newton, counties; Adrian Ocegueda, municipalities; Al Riera, Fort Bliss; Charles Stegall, counties; Jim Voorhies, electric generating utilities

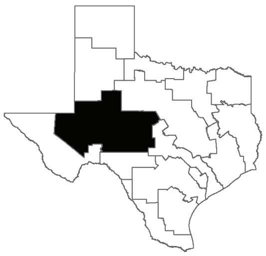
## FIGURE E.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE E.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Region F



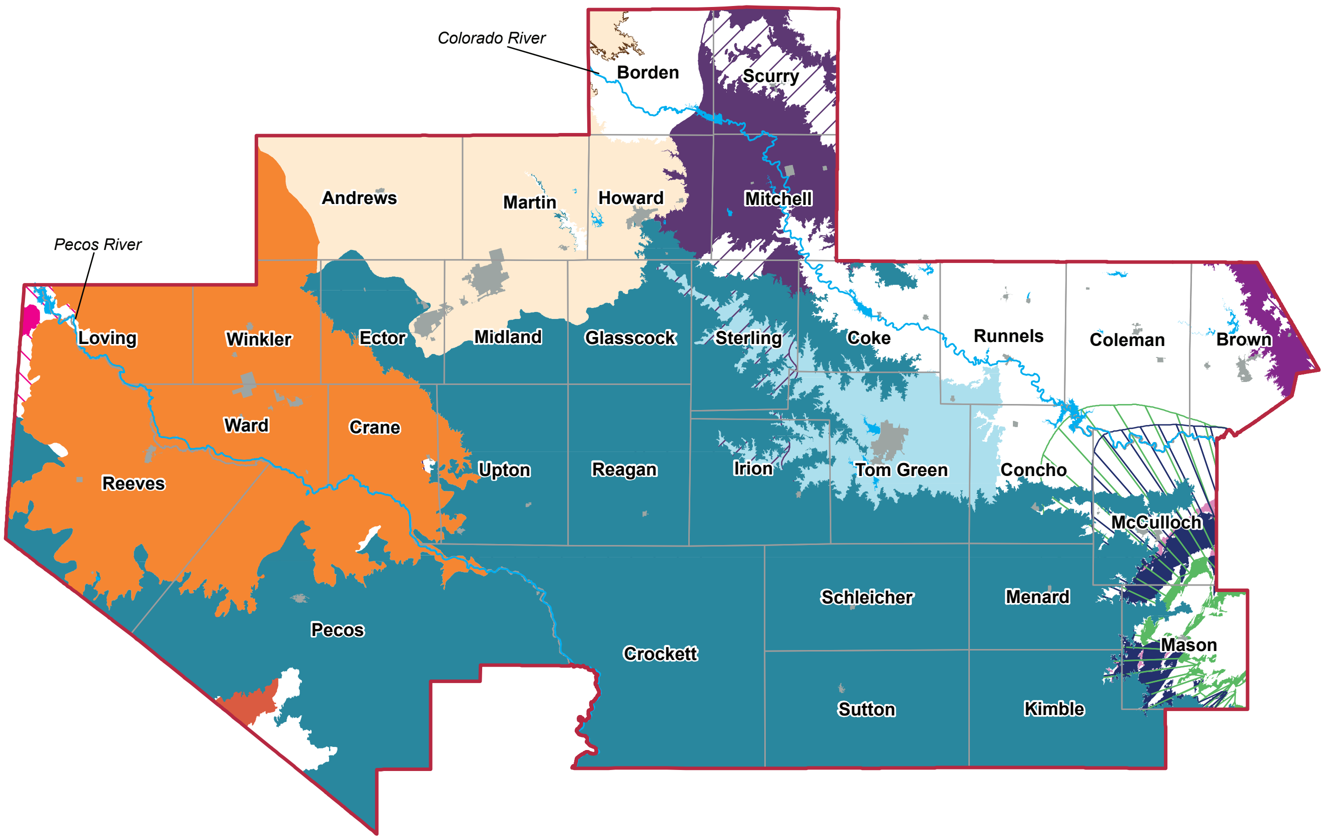
**The Region F Regional Water Planning Area is located in the Edwards Plateau and encompasses 32 counties.**

The Region F Regional Water Planning Area is located in the Edwards Plateau encompassing 32 counties (Figure F.1). Intersected by the Pecos River to the south and the Colorado River to the north, most of the region is located in the upper portion of the Colorado River Basin and Pecos portion of the Rio Grande Basin; a small portion is in the Brazos Basin. The major cities in the region include Midland, Odessa, and San Angelo. The region's economy relies heavily on healthcare and social assistance, mining, manufacturing, agriculture, and oil and gas employment sectors. The 2011 Region F Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionF/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—219,995 acre-feet per year
- Recommended water management strategy volume in 2060—235,198 acre-feet per year
- Total capital cost—$915 million
- Conservation accounts for 35 percent of 2060 strategy volumes
- Subordination of downstream senior water rights as strategy to increase reliability of significant supply volume
- Unmet needs in irrigation and steam-electric power

## FIGURE F.1. REGION F REGIONAL WATER PLANNING AREA.




- Region F
- Major Rivers
- Cities
- Existing Reservoirs
- Edwards - Trinity (Plateau) Aquifer (outcrop)
- Ogallala Aquifer
- Pecos Valley Aquifer
- Trinity Aquifer (outcrop)
- Trinity Aquifer (subsurface)
- Capitan Reef Complex Aquifer*
- Dockum Aquifer (outcrop)*
- Dockum Aquifer (subsurface)*
- Edwards -Trinity (High Plains) Aquifer*
- Ellenburger - San Saba Aquifer (outcrop)*
- Ellenburger - San Saba Aquifer (subsurface)*
- Hickory Aquifer (outcrop)*
- Hickory Aquifer (subsurface)*
- Lipan Aquifer (outcrop)*
- Marble Falls Aquifer*
- Rustler Aquifer (outcrop)*
- Rustler Aquifer (subsurface)*
- Igneous Aquifer*

* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 2 percent of the state's total population lived in Region F in 2010, and between 2010 and 2060 its population is projected to increase by 17 percent (Table F.1). Despite projected population growth in the region, total water demands for the region are projected to remain relatively constant throughout the planning period. Agricultural irrigation makes up the largest share of these demands in all decades, although it is projected to decrease 5 percent by 2060 (Table F.1). Steam-electric generation demands are projected to have the greatest increase (84 percent), while municipal demands are projected to increase 11 percent (Table F.1, Figure F.2).

## EXISTING WATER SUPPLIES

Seventy-five percent of the region's existing water supply in 2010 is projected to consist of groundwater from four major aquifers (Ogallala, Edwards-Trinity [Plateau], Trinity, and Pecos Valley) and seven minor aquifers (Table F.1, Figure F.2). Reservoirs provide 17 percent of supply and run-of-river supplies and alternative sources, such as desalination and wastewater reuse, account for 7 percent.

## NEEDS

Total regional needs are projected to increase 15 percent by 2060 (Table F.1). Irrigation is projected to have the largest need in all decades, but decline in magnitude to 144,276 acre-feet in 2060. By 2060, municipal needs are projected to account for 23 percent of total needs and steam-electric 9 percent (Table F.1, Figure F.2).

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

Region F recommended a variety of water management strategies to meet water supply needs (Figures F.3 and F.4). In all, the strategies would provide 235,198 acre-feet of additional water supply by the year 2060 at a total capital cost of $914.6 million (Appendix A). Because economically feasible strategies could not be identified, 94,108 acre-feet of irrigation needs in 15 counties and steam-electric needs of 14,935 acre-feet in three counties are unmet in 2060.

## CONSERVATION RECOMMENDATIONS

Conservation strategies, including municipal and advanced irrigation, provide the largest volume of supply for all strategies in the region. By 2060, they account for 35 percent of the total volume associated with all recommended strategies. The bulk of conservation savings are provided by advanced irrigation strategies that represent over 72,244 acre-feet of savings, 31 percent of the total in 2060.

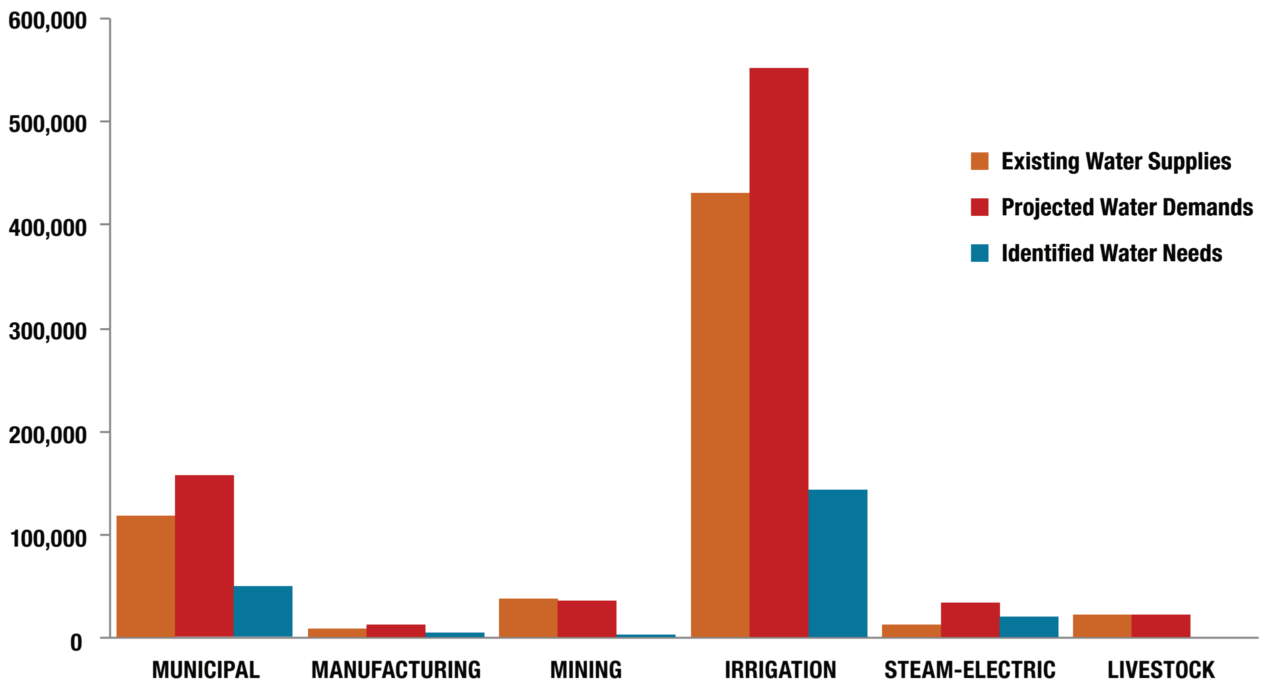
## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Irrigation conservation would provide up to 72,244 acre-feet per year of water starting in 2030 with a capital cost of $69 million.
- Groundwater desalination would provide up to 16,050 acre-feet per year of water in 2060 with a capital cost of $214 million.
- Reuse projects would provide up to 12,490 acre-feet per year of water starting in 2040 with a capital cost of $131 million.

## TABLE F.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 618,889 | 656,480 | 682,132 | 700,806 | 714,045 | 724,094 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 138,352 | 137,285 | 136,063 | 134,929 | 133,840 | 132,821 |
| Groundwater | 483,937 | 480,479 | 481,658 | 478,331 | 478,624 | 478,805 |
| Reuse | 19,015 | 19,309 | 19,459 | 19,609 | 19,759 | 19,909 |
| **Total Water Supplies** | **641,304** | **637,073** | **637,180** | **632,869** | **632,223** | **631,535** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 122,593 | 127,135 | 129,747 | 131,320 | 133,361 | 135,597 |
| County-other | 19,372 | 20,693 | 21,533 | 21,886 | 21,979 | 22,035 |
| Manufacturing | 9,757 | 10,595 | 11,294 | 11,960 | 12,524 | 13,313 |
| Mining | 31,850 | 33,097 | 33,795 | 34,479 | 35,154 | 35,794 |
| Irrigation | 578,606 | 573,227 | 567,846 | 562,461 | 557,080 | 551,774 |
| Steam-electric | 18,138 | 19,995 | 22,380 | 25,324 | 28,954 | 33,418 |
| Livestock | 23,060 | 23,060 | 23,060 | 23,060 | 23,060 | 23,060 |
| **Total Water Demands** | **803,376** | **807,802** | **809,655** | **810,490** | **812,112** | **814,991** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 21,537 | 30,464 | 35,442 | 43,088 | 45,923 | 49,060 |
| County-other | 501 | 811 | 658 | 618 | 588 | 559 |
| Manufacturing | 3,537 | 4,138 | 3,747 | 4,403 | 4,707 | 5,152 |
| Mining | 503 | 660 | 29 | 143 | 232 | 375 |
| Irrigation | 157,884 | 154,955 | 152,930 | 149,472 | 146,995 | 144,276 |
| Steam-electric | 7,095 | 9,840 | 11,380 | 13,294 | 16,347 | 20,573 |
| **Total Water Needs** | **191,057** | **200,868** | **204,186** | **211,018** | **214,792** | **219,995** |

## FIGURE F.2. 2060 REGION F EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed six region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#f.

- Irrigation Survey: Glasscock, Midland, Regan, Pecos, Reeves, and Tom Green Counties
- Refinement of Groundwater Supplies and Identification of Potential Projects
- Evaluation of Supplies in the Pecan Bayou Watershed
- Municipal Conservation Survey
- Region K Surface Water Availability Coordination
- Study of the Economics of Rural Water Distribution and Integrated Water Supply Study

## REGION F PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

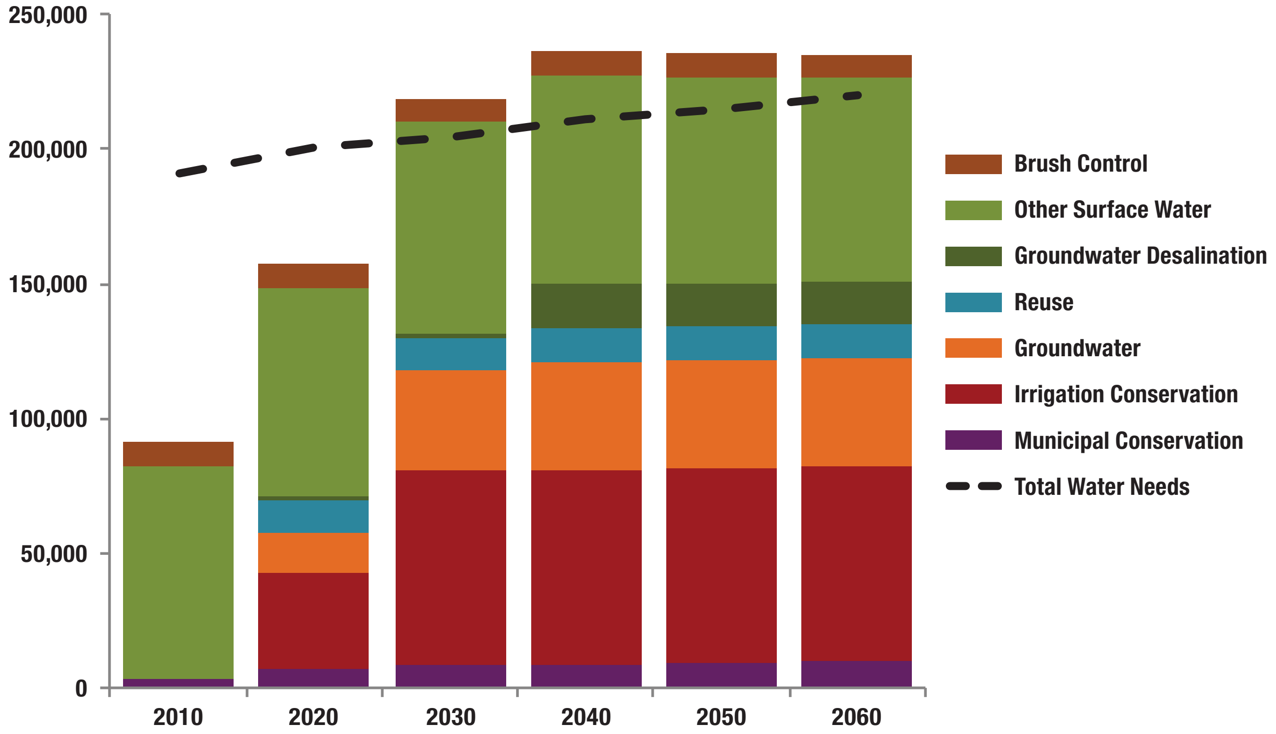
***Voting members during adoption of the 2011 Regional Water Plan:***

John Grant (Chair), water districts; Woody Anderson, agriculture; Stephen Brown, river authorities; Kenneth Dierschke, agriculture; Richard Gist, water utilities; Charles Hagood, small business; Scott Holland, water districts; Wendell Moody, public; Robert Moore, counties; Caroline Runge, environmental; John Shepard, municipalities; Ben Sheppard, industries; Terry Scott, agriculture; Merle Taylor, municipalities; Larry Turnbough, water districts; Tim Warren, electric generating utilities; Paul Weatherby, water districts; Will Wilde, municipalities; Len Wilson, public

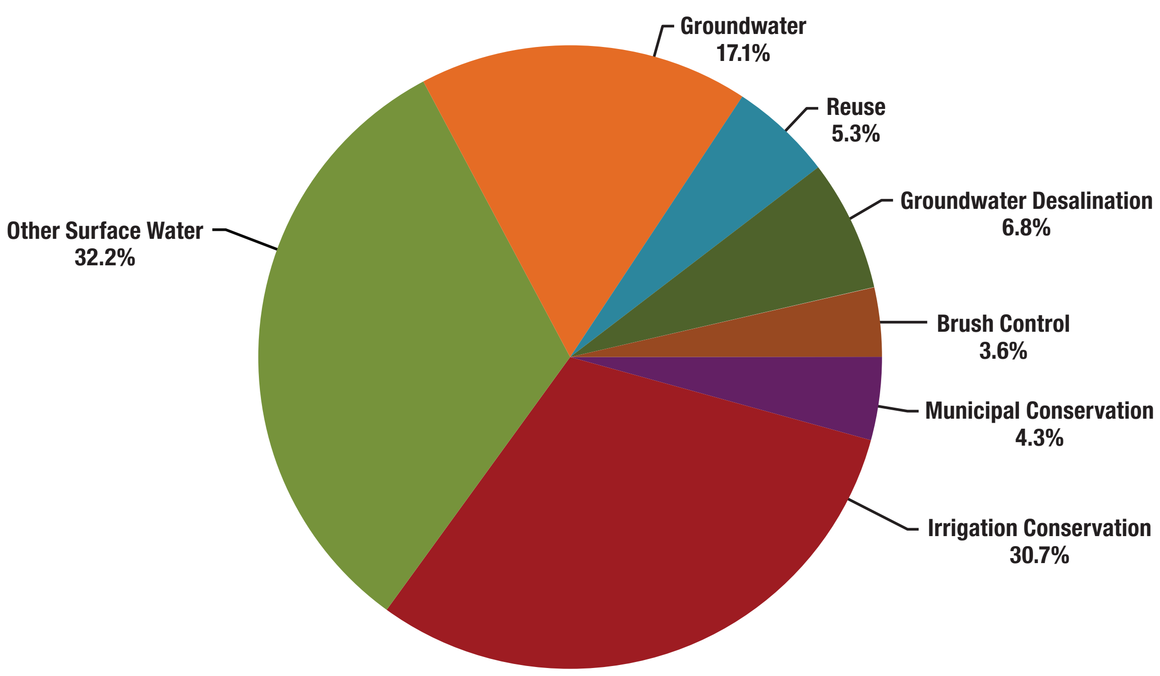
***Former voting members during the 2006 – 2011 planning cycle:***

Jerry Bearden, counties; Dennis Clark, water districts; Stuart Coleman, small business; Marilyn Egan, counties; Steven Hofer, environmental; Jared Miller, municipalities; Buddy Sipes, industries; Andrew Valencia, electric generating utilities

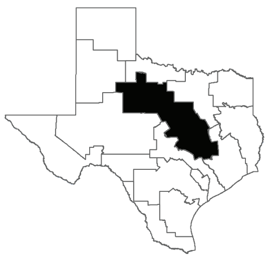
## FIGURE F.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE F.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Brazos G Region



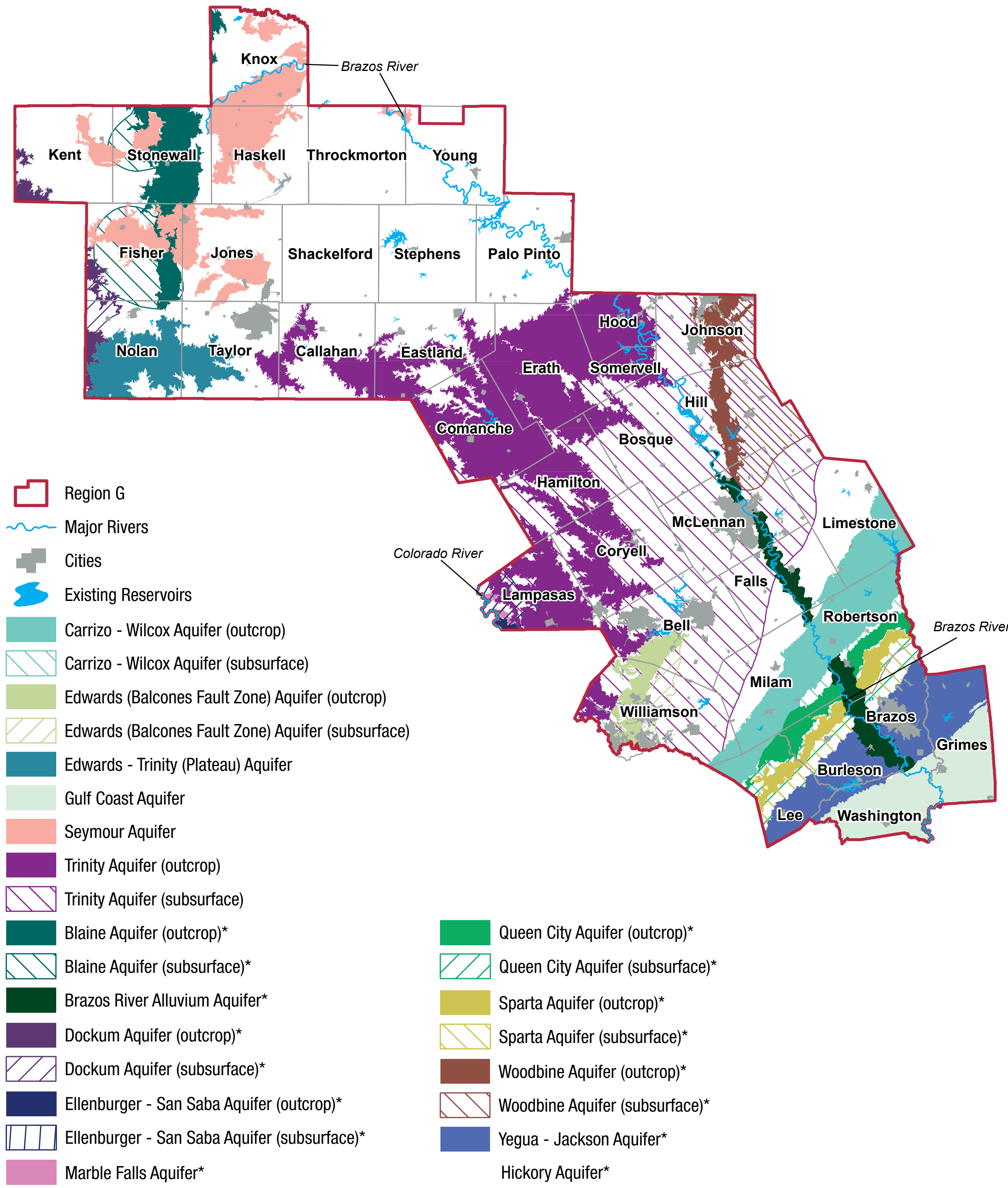
## The Brazos G Regional Water Planning Area includes all or parts of 37 counties.

The Brazos G Regional Water Planning Area includes all or parts of 37 counties (Figure G.1). Over 90 percent of the region lies within the Brazos River Basin, with the Brazos River being the region's primary source of water. The largest economic sectors in the region are service, manufacturing, and retail trade. Major cities in the region include Abilene, Bryan, College Station, Killeen, Round Rock, Temple, and Waco. The 2011 Brazos (G) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionG/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—390,732 acre-feet per year
- Recommended water management strategy volume in 2060—587,084 acre-feet per year
- Total capital cost—$3.2 billion
- Conservation accounts for 7 percent of 2060 strategy volumes
- Five new major reservoirs (Brushy Creek, Cedar Ridge, Millers Creek Augmentation,* Turkey Peak*, Coryell County Reservoir*); three sites indicated * also recommended for designation as unique reservoir sites (Figure ES.7)
- Conjunctive use strategies account for 12 percent of 2060 strategy volumes
- Brazos River Authority System Operation strategy accounts for 14 percent of strategy volumes
- Unmet irrigation and mining needs in all decades; limited unmet steam-electric power and municipal needs in 2010 decade

## FIGURE G.1. BRAZOS G REGIONAL WATER PLANNING AREA.




* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 8 percent of the state's 2010 population resided in the Brazos G Region. Between 2010 and 2060, the region's population is projected to increase 76 percent (Table G.1). By 2060, the total water demands for the region are projected to increase 43 percent (Table G.1). Municipal water use makes up the largest share of these demands in all decades and is projected to increase by 75 percent (Table G.1). Manufacturing and steam-electric power generation demands are also projected to grow by 61 percent and 90 percent, respectively (Table G.1). Irrigation water demand, however, declines 10 percent by 2060 because of projected reductions in irrigated land and technological advances in irrigation techniques (Table G.1, Figure G.2).

## EXISTING WATER SUPPLIES

The Brazos G Region has a large number of surface water and groundwater supply sources, with over three-fourths of the existing water supply in the region associated with surface water (Table G.1). The principal surface water sources are the Brazos River, its tributaries, and the 40 major reservoirs throughout the region. There are six major aquifers in the region: the Seymour and Edwards-Trinity (Plateau) aquifers in the western portion of the region, the Trinity and Edwards (Balcones Fault Zone) aquifers in the central portion, and the Carrizo-Wilcox and Gulf Coast aquifers in the eastern portion. Although the surface water portion of total supply is expected to increase slightly over time due to increased return-flows, by 2060 the total water supply is projected to decline a little more than 1 percent (Table G.1, Figure G.2). This projected decline in groundwater supply is due to a greater emphasis on sustainable use of groundwater resources in the region.

## NEEDS

Although on a region-wide basis it might appear that the Brazos G Region has enough water supply to meet demands through 2040, with only small deficits in 2050 and 2060, the total water supply volume is not accessible to all water users throughout the region (Table G.1). Consequently, in the event of drought, Region G would be projected to have a total water supply need of 131,489 acre-feet in 2010 (Table G.1). Irrigation accounts for nearly half of those needs at 59,571 acre-feet. By 2060, overall water needs are expected to increase to 390,732 acre-feet, with almost half of this need associated with municipal users (Table G.1, Figure G.2).

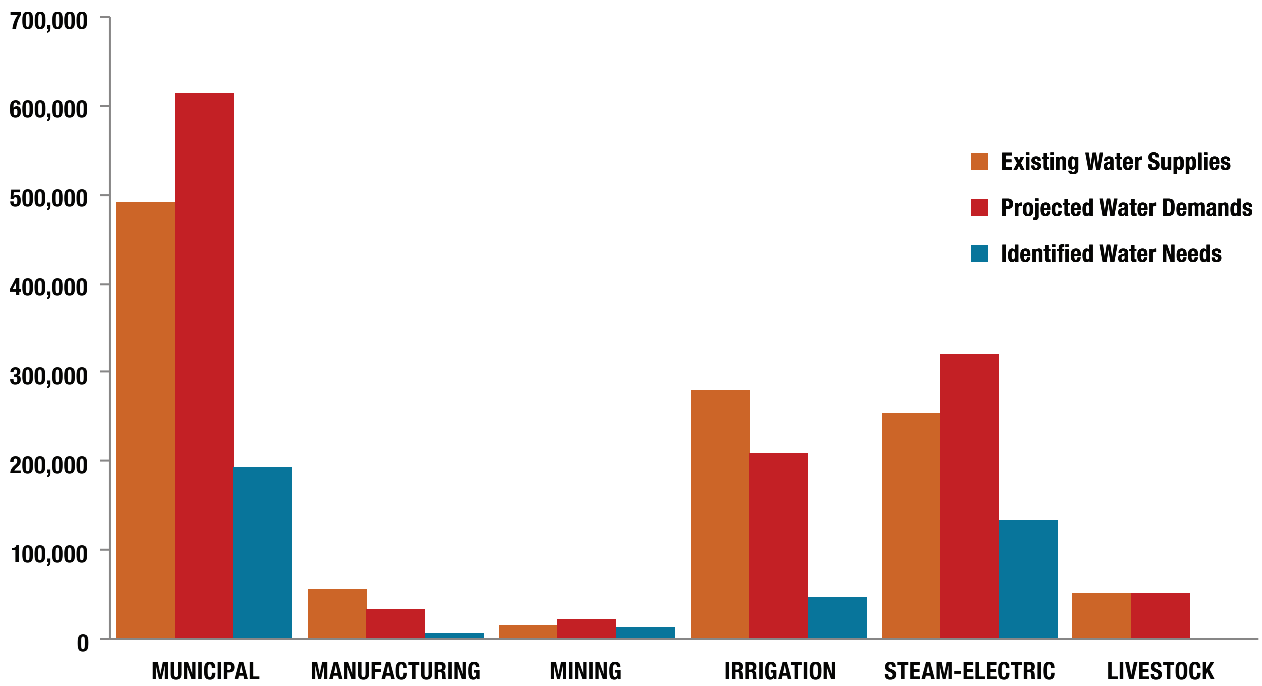
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Brazos G Planning Group recommended a variety of water management strategies that would provide more water than is required to meet future needs (Figures G.3 and G.4). In all, the strategies would provide 587,084 acre-feet of additional water supply by the year 2060 at a total capital cost of $3.2 billion (Appendix A). Some of this water could be made available to other regions with needs. Because there were no economically feasible strategies identified to meet their needs, six counties in the region have unmet irrigation needs (ranging from 49,973 acre-feet in 2010 to 33,932 acre-feet by 2060). Some mining needs go unmet in each decade (ranging from 1,800 acre-feet in 2010 to 2,567 acre-feet in 2060) due to a lack of feasible strategies. Some municipal (Abilene, Round Rock, and Cedar Park) needs (totaling 2,196 acre-feet) and some steam-electric needs (36,086 acre-feet) would be unmet in case of drought in 2010 because infrastructure is not yet in place to access the supply.

## TABLE G.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 1,957,767 | 2,278,243 | 2,576,783 | 2,873,382 | 3,164,776 | 3,448,879 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 790,543 | 787,031 | 791,011 | 792,331 | 792,252 | 792,258 |
| Groundwater | 355,337 | 355,256 | 355,151 | 344,052 | 336,931 | 336,798 |
| Reuse | 17,344 | 17,344 | 17,344 | 17,344 | 17,344 | 17,344 |
| **Total Water Supplies** | **1,163,224** | **1,159,631** | **1,163,506** | **1,153,727** | **1,146,527** | **1,146,400** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 328,006 | 382,974 | 430,635 | 477,748 | 524,700 | 572,602 |
| County-other | 33,413 | 34,488 | 35,471 | 37,403 | 40,327 | 42,881 |
| Manufacturing | 19,787 | 23,201 | 25,077 | 26,962 | 30,191 | 31,942 |
| Mining | 36,664 | 37,591 | 38,037 | 27,251 | 20,744 | 21,243 |
| Irrigation | 232,541 | 227,697 | 222,691 | 217,859 | 213,055 | 208,386 |
| Steam-electric | 168,193 | 221,696 | 254,803 | 271,271 | 300,859 | 319,884 |
| Livestock | 51,576 | 51,576 | 51,576 | 51,576 | 51,576 | 51,576 |
| **Total Water Demands** | **870,180** | **979,223** | **1,058,290** | **1,110,070** | **1,181,452** | **1,248,514** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 20,549 | 53,971 | 76,295 | 109,962 | 147,780 | 188,632 |
| County-other | 395 | 361 | 299 | 997 | 2,753 | 3,835 |
| Manufacturing | 2,762 | 3,441 | 4,108 | 4,783 | 5,393 | 6,054 |
| Mining | 9,670 | 10,544 | 10,963 | 11,301 | 11,704 | 12,158 |
| Irrigation | 59,571 | 56,961 | 54,422 | 51,942 | 49,527 | 47,181 |
| Steam-electric | 38,542 | 71,483 | 82,891 | 93,599 | 117,616 | 132,872 |
| **Total Water Needs** | **131,489** | **196,761** | **228,978** | **272,584** | **334,773** | **390,732** |

## FIGURE G.2. 2060 BRAZOS (G) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

Conservation strategies represent 7 percent of the total volume of water associated with all recommended strategies in 2060. Water conservation was recommended for every municipal water user group that had both a need and water use greater than 140 gallons per capita per day.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Groundwater/Surface Water Conjunctive Use (Lake Granger Augmentation) will provide up to 70,246 acre-feet per year of water starting in the year 2010 with a capital cost of $644 million.
- Brazos River Authority Systems Operations Permit will provide up to 84,899 acre-feet year of water in 2060 with a capital cost of $204 million.
- (Lake) Belton to Stillhouse (Lake) Pipeline will provide 30,000 acre-feet per year of water starting in 2020 with a capital cost of $36 million.
- Millers Creek Augmentation (new dam) will provide 17,582 acre-feet per year of water starting in 2010 with a capital cost of $47 million.
- Cedar Ridge Reservoir will provide 23,380 acre-feet per year of water starting in 2020 with a capital cost of $285 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed five region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#g.

- Updated Drought of Record and Water Quality Implications for Reservoirs Upstream of Possum Kingdom Reservoir
- Groundwater Availability Model of the Edwards-Trinity (Plateau) and Dockum Aquifer in Western Nolan and Eastern Mitchell Counties, Texas
- Regionalization Strategies to Assist Small Water Systems in Meeting New Safe Drinking Water Act Requirements
- Brazos G Activities in Support of Region C's Water Supply Study for Ellis, Johnson, Southern Dallas, and Southern Tarrant Counties (Four County Study)
- Updated Water Management Strategies for Water User Groups in McLennan County

## BRAZOS G PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

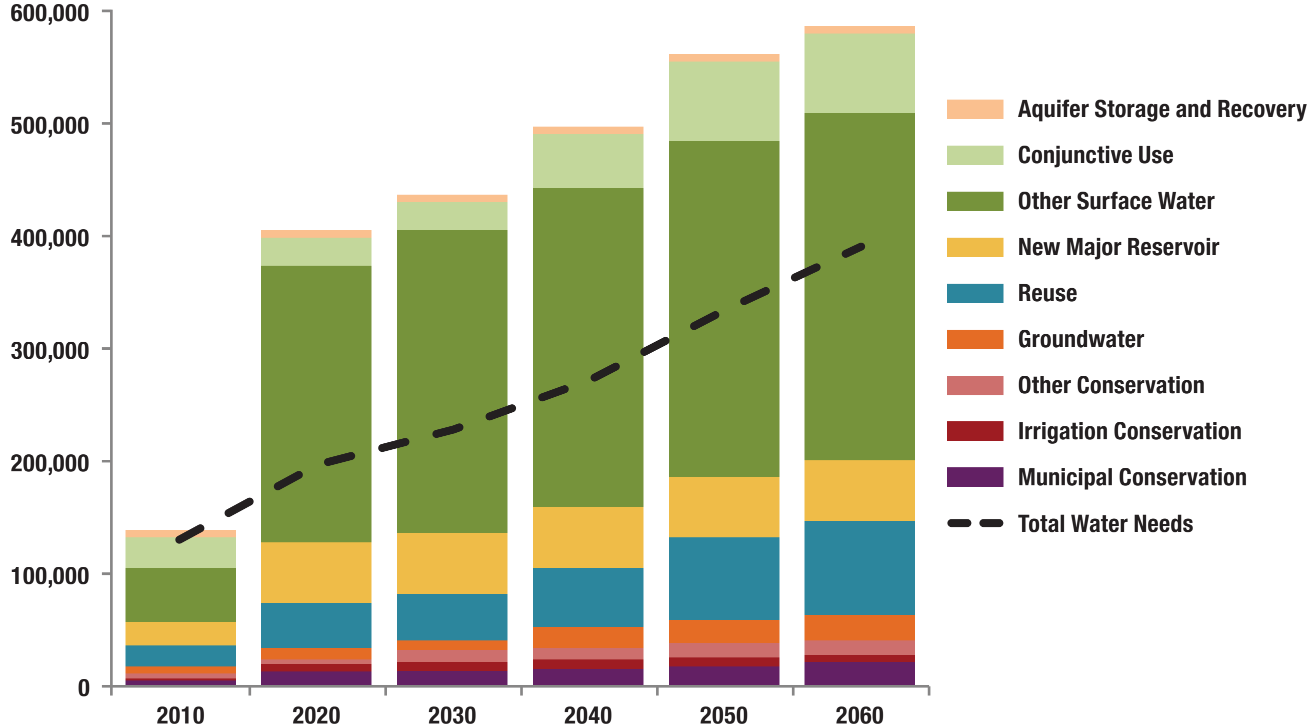
*Voting members during adoption of the 2011 Regional Water Plan:*

Dale Spurgin (Chair), agriculture; Tom Clark, municipalities; Alva Cox, municipalities; Scott Diermann, electric generating utilities; Phil Ford, river authorities; Scott Mack, public; Mike McGuire, water districts; Tommy O'Brien, municipalities; Gail Peek, small business; Sheril Smith, environmental; Wiley Stem, III, municipalities; Mike Sutherland, counties; Randy Waclawczyk, industries; Kathleen J. Webster, water districts; Wayne Wilson, agriculture

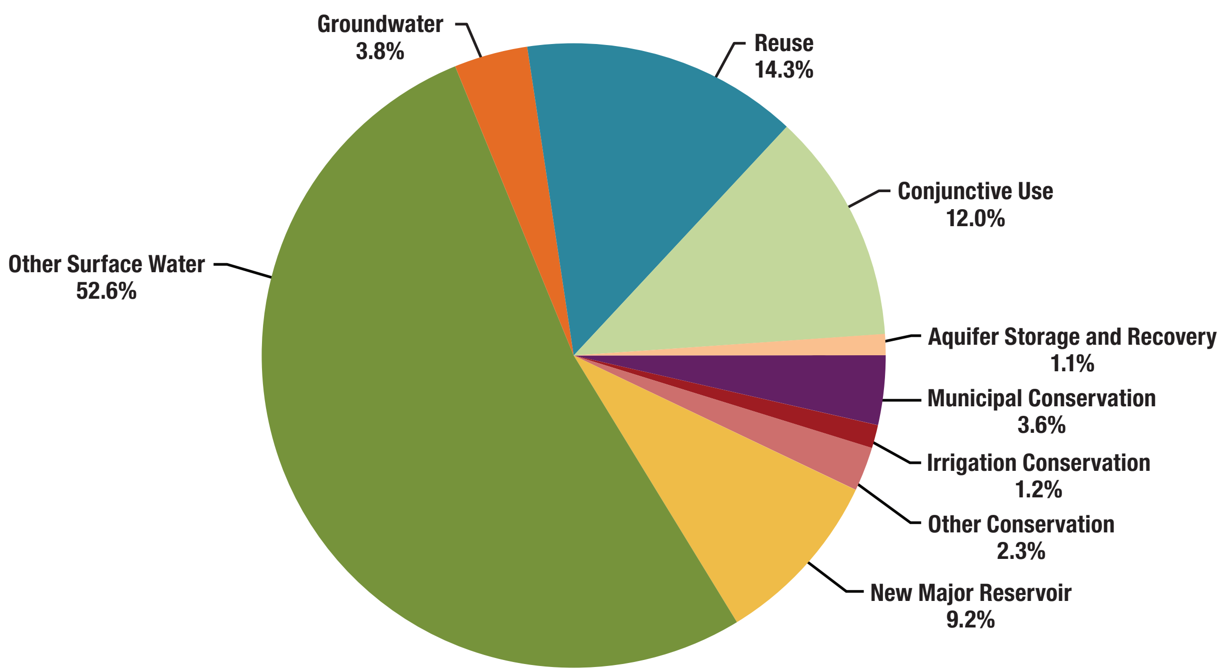
*Former voting members during the 2006 – 2011 planning cycle:*

Jon Burrows, counties; Stephen Stark, environmental; Scott Mack, public; Horace Grace, small business; Terry Kelley, water districts; Kent Watson, water utilities

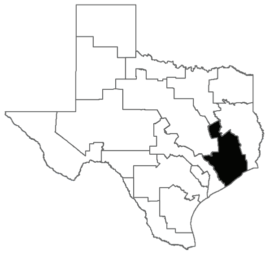
## FIGURE G.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE G.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Region H



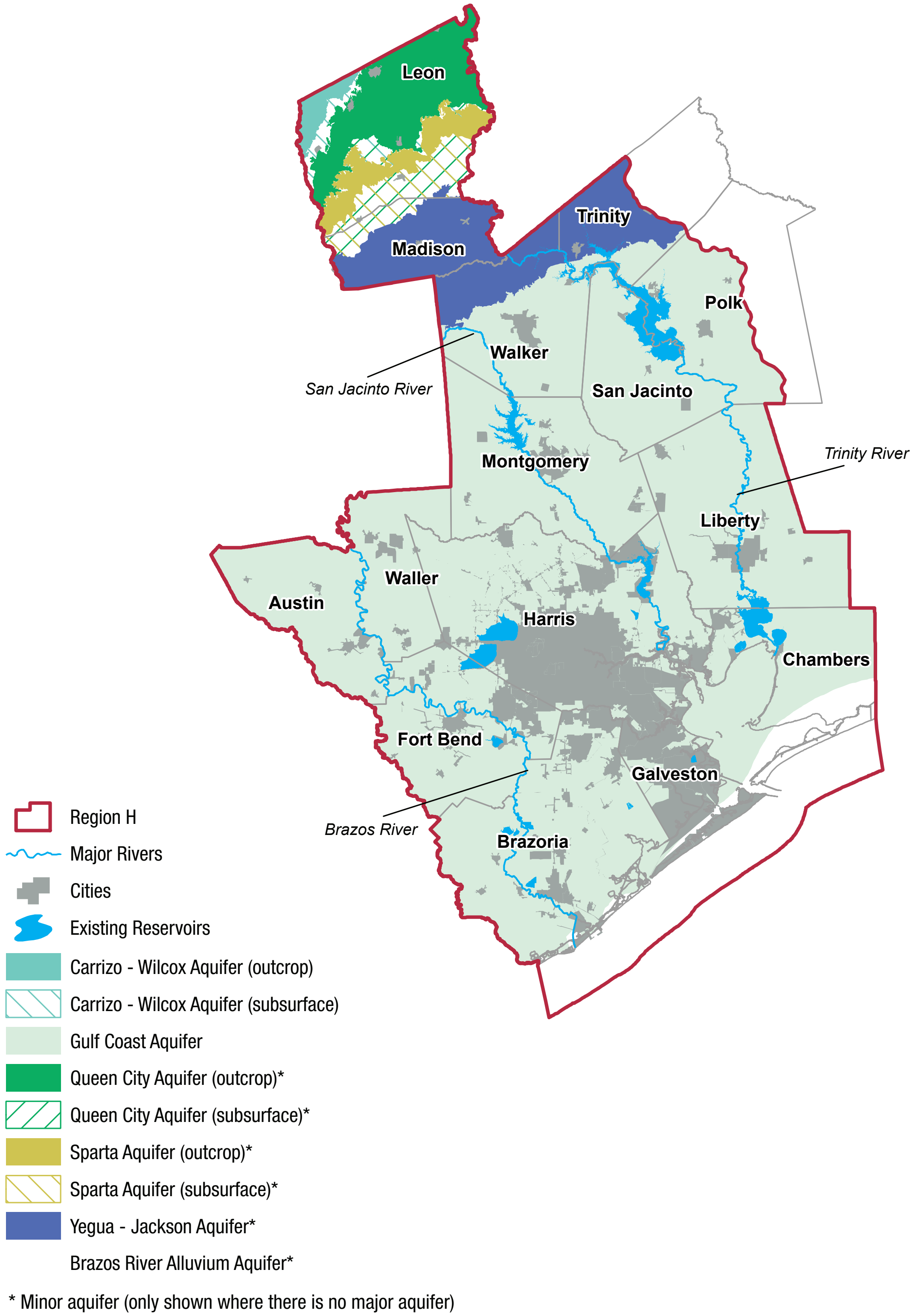
**The Region H Regional Water Planning Area is composed of all or parts of 15 counties and includes portions of the Trinity, San Jacinto, Brazos, Neches, and Colorado river basins.**

The Region H Regional Water Planning Area is composed of all or parts of 15 counties and includes portions of the Trinity, San Jacinto, Brazos, Neches, and Colorado river basins (Figure H.1). The Houston metropolitan area is located within this region. The largest economic sector in Region H is the petrochemical industry, which accounts for two-thirds of the petrochemical production in the United States. Other major economic sectors in the region include medical services, tourism, government, agriculture, fisheries, and transportation, with the Port of Houston being the nation's second largest port. The 2011 Region H Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionH/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—1,236,335 acre-feet per year
- Recommended water management strategy volume in 2060—1,501,180 acre-feet per year
- Total capital cost—$12 billion
- Conservation accounts for 12 percent of 2060 strategy volumes
- Five new major reservoirs (Allens Creek, Dow Off-Channel, Gulf Coast Water Authority Off-Channel, Brazoria Off-Channel, Fort Bend Off-Channel)
- Reuse accounts for 19 percent of 2060 strategy volumes

## FIGURE H.1. REGION H REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

Approximately 24 percent of the state's population was projected to reside in the region in 2010. By 2060, Region H is projected to grow 89 percent to 11.3 million. Total demand for the region is projected to increase 48 percent by 2060 (Table H.1). The largest consumers of water in the region are municipal entities, and municipal demand is expected to grow 61 percent by 2060 (Table H.1). Manufacturing also constitutes a large share of the region's demand and is projected to grow 31 percent over the planning period (Table H.1, Figure H.2).

## EXISTING WATER SUPPLIES

In 2010, the total water supply was projected to be 2,621,660 acre-feet, decreasing by approximately 0.6 percent by 2060 (Table H.1). The region's reliance on groundwater from the Gulf Coast Aquifer will be reduced primarily because of subsidence district regulations. The decline in groundwater supply will be offset by the increased use of surface water to meet future needs. In 2010, surface water was projected to provide 1,843,815 acre-feet of supplies and groundwater 777,845 acre-feet (Table H.1). By 2060, surface water is projected to provide 2,021,690 acre-feet, groundwater 569,361 acre-feet, and reuse 14,866 acre-feet of supplies (Table H.1, Figure H.2). The largest supply of available surface water in the region comes from the Lake Livingston/Wallisville System in the Trinity River Basin and run-of-river water rights in the Trinity and Brazos river basins.

## NEEDS

In 2010, Region H was projected to have a need of 290,890 acre-feet, with municipalities accounting for approximately 19 percent of the total and irrigated agriculture accounting for 52 percent (Table H.1). By 2060, water supply needs are projected to total 1,236,335 acre-feet. Municipal users will account for 61 percent of that need and irrigated agriculture will account for 12 percent. Total manufacturing needs are projected to be 26 percent of total needs in 2010 and 21 percent of total needs by 2060 (Table H.1, Figure H.2).

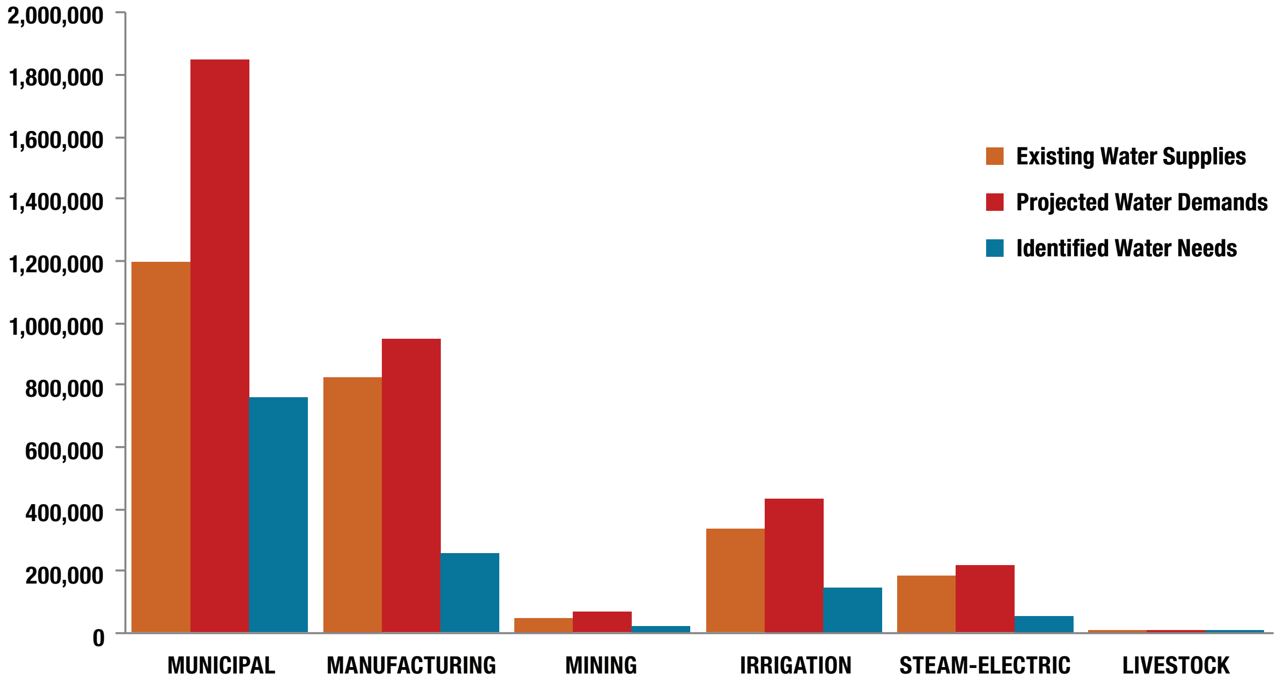
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Region H Planning Group's recommended water management strategies would provide 1,501,180 acre-feet of additional water supply to meet all projected needs by the year 2060 (Figures H.3 and H.4) at a total capital cost of $12 billion (Appendix A). Contracts and conveyance of existing supplies provide the largest share of strategy supply in the region, followed by reuse projects and new supplies from five new major reservoirs in the lower Brazos basin. Recommended strategies also include new groundwater supplies, conservation programs, and seawater desalination at a facility in Freeport (Figures H.3 and H.4).

## TABLE H.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 6,020,078 | 6,995,442 | 7,986,480 | 8,998,002 | 10,132,237 | 11,346,082 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 1,843,815 | 1,899,087 | 1,932,954 | 1,971,925 | 2,013,605 | 2,021,690 |
| Groundwater | 777,845 | 641,359 | 591,590 | 586,814 | 578,644 | 569,361 |
| Reuse | 0 | 0 | 438 | 14,799 | 14,840 | 14,866 |
| **Total Water Supplies** | **2,621,660** | **2,540,446** | **2,524,982** | **2,573,538** | **2,607,089** | **2,605,917** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 968,949 | 1,117,677 | 1,236,037 | 1,341,483 | 1,444,026 | 1,558,706 |
| County-other | 73,915 | 75,235 | 102,549 | 144,360 | 211,236 | 286,111 |
| Manufacturing | 722,873 | 783,835 | 836,597 | 886,668 | 927,860 | 950,102 |
| Mining | 57,043 | 60,782 | 63,053 | 65,285 | 67,501 | 69,457 |
| Irrigation | 450,175 | 438,257 | 433,686 | 430,930 | 430,930 | 430,930 |
| Steam-electric | 91,231 | 112,334 | 131,332 | 154,491 | 182,720 | 217,132 |
| Livestock | 12,228 | 12,228 | 12,228 | 12,228 | 12,228 | 12,228 |
| **Total Water Demands** | **2,376,414** | **2,600,348** | **2,815,482** | **3,035,445** | **3,276,501** | **3,524,666** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 42,081 | 206,131 | 317,539 | 367,712 | 428,499 | 534,252 |
| County-other | 13,070 | 21,975 | 42,697 | 85,430 | 150,770 | 224,682 |
| Manufacturing | 75,164 | 131,531 | 168,597 | 202,219 | 231,118 | 255,604 |
| Mining | 5,992 | 10,595 | 13,850 | 16,278 | 18,736 | 20,984 |
| Irrigation | 151,366 | 141,232 | 137,995 | 137,113 | 140,733 | 144,802 |
| Steam-electric | 3,203 | 12,609 | 18,058 | 24,726 | 34,976 | 55,972 |
| Livestock | 14 | 64 | 40 | 40 | 40 | 39 |
| **Total Water Needs** | **290,890** | **524,137** | **698,776** | **833,518** | **1,004,872** | **1,236,335** |

## FIGURE H.2. 2060 REGION H EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

The planning group considered conservation strategies for water user groups with needs. Recommended municipal, irrigation, and industrial water conservation strategies provide savings of 183,933 acre-feet per year. Municipal conservation accounts for up to 105,494 acre-feet of savings; irrigation conservation is recommended to save up to 77,881 acre-feet; and industrial conservation will save 588 acre-feet per year by 2060.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Luce Bayou Transfer of Trinity River Supplies would convey up to 270,742 acre-feet per year of water in the year 2060 with a capital cost of $253.9 million.
- Indirect Reuse by the City of Houston would provide up to 128,801 acre-feet per year of water in 2060 with a capital cost of $721.8 million.
- Allens Creek Reservoir would provide up to 99,650 acre-feet per year of water in 2060 with a capital cost of $222.8 million.
- Four off-channel reservoirs in Brazoria and Fort Bend Counties would collectively provide up to 131,243 acre-feet per year of water in 2060 with a total capital cost of $698.3 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed three region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#h.

- Interruptible Supply Study
- Environmental Flows Study
- Drought Management Study

## REGION H PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

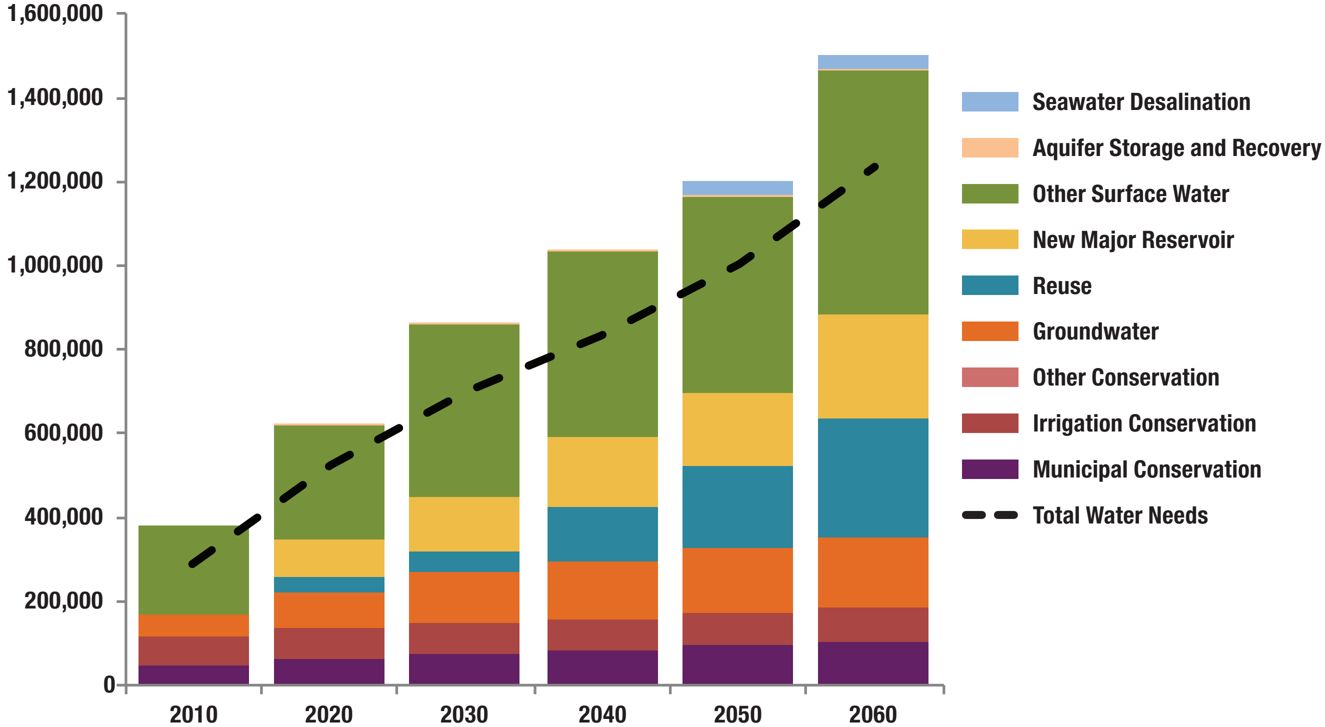
***Voting members during adoption of the 2011 Regional Water Plan:***

Mark Evans (Chair), counties; Roosevelt Alexander, public; John R. Bartos, environmental; John Blount, counties; Robert Bruner, agriculture; Jun Chang, municipalities; Reed Eichelberger, P.E., river authorities; Robert Hebert, small business; Art Henson, counties; John Hofmann, river authorities; John Howard, small business; Robert Istre, municipalities; Gena Leathers, industries; Glynna Leiper, industries; Ted Long, electric generating utilities; Marvin Marcell, water districts; James Morrison, water utilities; Ron J. Neighbors, water districts; Jimmie Schindewolf, water districts; William Teer, P.E., water utilities; Steve Tyler, small business; Danny Vance, river authorities; C. Harold Wallace, water utilities; George "Pudge" Wilcox, agriculture

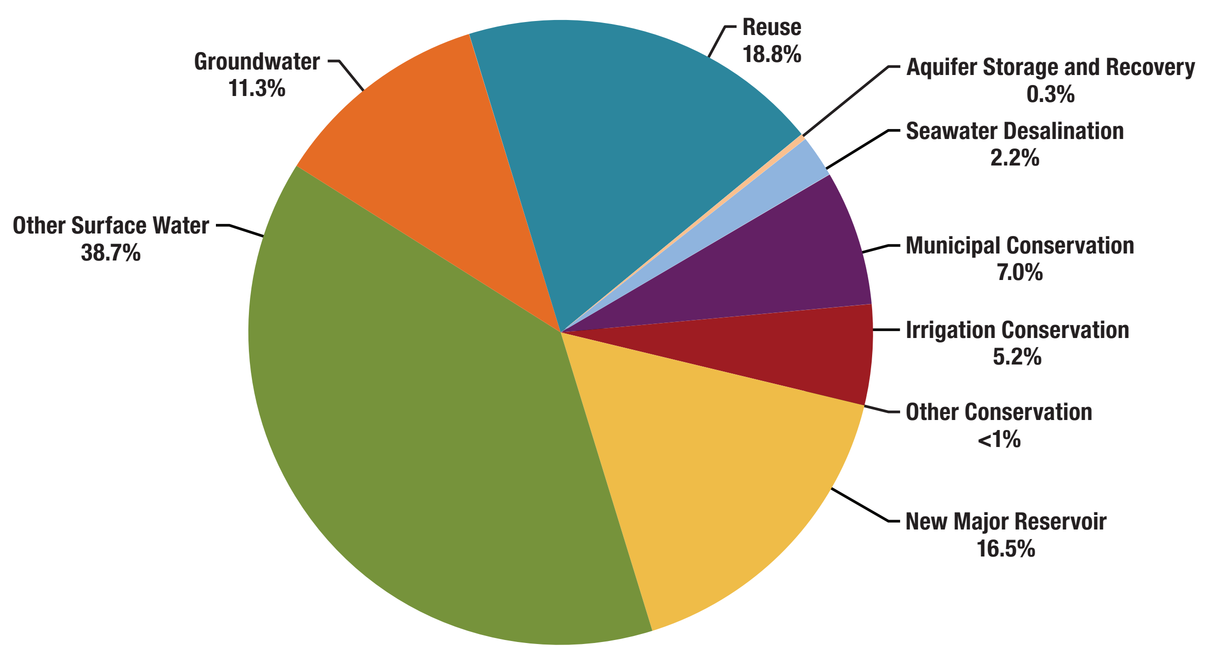
***Former voting members during the 2006 – 2011 planning cycle:***

Jim Adams, river authorities; John Baker, river authorities; Jason Fluharty, electric generating utilities; Mary Alice Gonzalez, small business; Jack Harris, counties; David Jenkins, agriculture; Carolyn Johnson, industries; James Murray, industries; Jeff Taylor, municipalities; Mike Uhl, industries

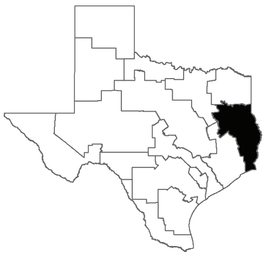
## FIGURE H.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE H.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of East Texas (I) Region



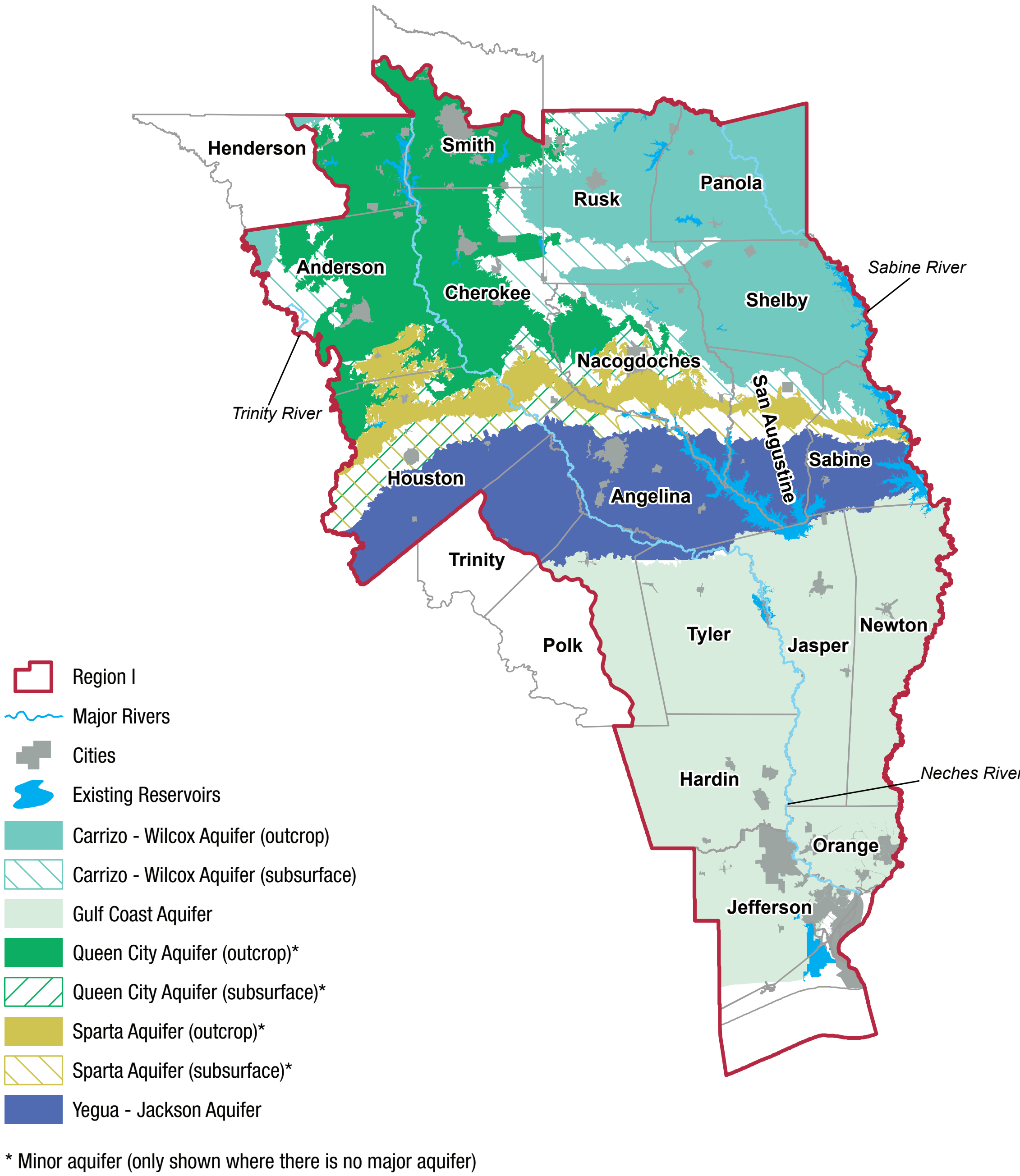
## The East Texas Regional Water Planning Area is composed of all or parts of 20 counties.

The East Texas Regional Water Planning Area is composed of all or parts of 20 counties (Figure I.1). The largest cities include Beaumont, Tyler, Port Arthur, Nacogdoches, and Lufkin. The major economic sectors are petrochemical, timber, and agriculture. The principal surface water sources are the Sabine and Neches Rivers and their tributaries. The 2011 East Texas (I) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionI/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—182,145 acre-feet per year
- Recommended water management strategy volume in 2060—638,076 acre-feet per year
- Total capital cost—$885 million
- Conservation accounts for 7 percent of 2060 strategy volumes
- Two new major reservoirs (Lake Columbia, Fastrill Replacement Project)
- Limited unmet steam-electric power and mining needs

## FIGURE I.1. EAST TEXAS (I) REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

Approximately 4 percent of the state's population resided in the East Texas Region in 2010. By 2060, the region's population is projected to grow 36 percent to 1,482,448 (Table I.1). Water demands in the region are projected to more than double by 2060 (Table I.1). The greatest increase is in manufacturing water demand, which is projected to grow 198 percent by 2060 (Table I.1). Over the planning horizon, steam-electric power generation water demand is projected to increase 246 percent and municipal water demand is expected to grow 23 percent (Table I.1, Figure I.2).

## EXISTING WATER SUPPLIES

The existing water supply in the East Texas Region is projected to increase over the planning horizon (Table I.1). Surface water supplies, which account for 74 percent of the total existing water supply in 2010, increase by 537,258 acre-feet, primarily due to additional surface water for manufacturing being made available through existing contracts. Groundwater from the Gulf Coast, Carrizo-Wilcox, and other aquifers remains relatively constant (Table I.1, Figure I.2).

## NEEDS

Although the region as a whole appears to have enough supply to meet demands through 2040, the total water supply is not readily available to all water users. Between 2010 and 2060, the region's water needs will increase from 28,856 acre-feet to 182,145 acre-feet (Table I.1). The largest needs are projected for the steam-electric power generation industry with 85,212 acre-feet of needs by 2060, about half of the total needs for the region. The next largest volume of needs in 2060 is for the manufacturing sector, 49,588 acre-feet, or approximately 27 percent of total needs (Table I.1, Figure I.2).

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

Water management strategies recommended in the East Texas Regional Water Plan result in 638,076 acre-feet of additional water supply to meet most projected needs by the year 2060 (Figures I.3 and I.4) at a total capital cost of $884.8 million (Appendix A). Because no feasible water management strategies could be identified, a portion of steam-electric needs in 2010 and mining needs in all decades in Hardin County, totaling 10,770 acre-feet by 2060, were not met.

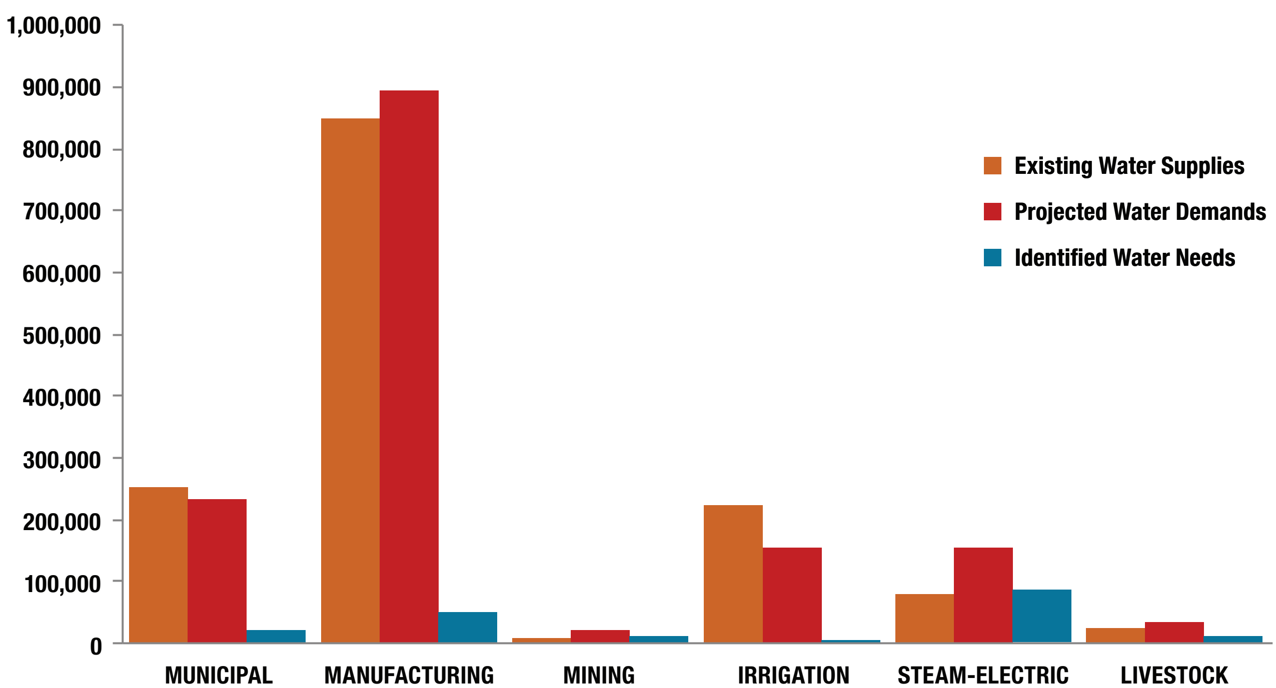
## CONSERVATION RECOMMENDATIONS

Water conservation was evaluated for every municipal water user group with a need and water use greater than 140 gallons per capita per day. Municipal conservation accounts for 1,701 acre-feet of savings by 2060, and most municipal needs will be partially met through conservation. Water conservation in the East Texas Regional Water Planning Area is driven largely by economics, and is not always the most cost-effective strategy for a water user group with a need where plentiful supplies are available.

## TABLE I.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 1,090,382 | 1,166,057 | 1,232,138 | 1,294,976 | 1,377,760 | 1,482,448 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 661,511 | 941,613 | 1,123,982 | 1,151,585 | 1,172,399 | 1,198,769 |
| Groundwater | 220,676 | 220,883 | 220,855 | 220,805 | 220,753 | 220,689 |
| Reuse | 18,077 | 15,220 | 15,233 | 15,246 | 15,257 | 15,271 |
| **Total Water Supplies** | **900,264** | **1,177,716** | **1,360,070** | **1,387,636** | **1,408,409** | **1,434,729** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 153,520 | 159,266 | 164,327 | 169,332 | 178,627 | 191,273 |
| County-other | 36,039 | 37,562 | 38,434 | 38,861 | 40,078 | 42,349 |
| Manufacturing | 299,992 | 591,904 | 784,140 | 821,841 | 857,902 | 893,476 |
| Mining | 21,662 | 37,297 | 17,331 | 18,385 | 19,432 | 20,314 |
| Irrigation | 151,100 | 151,417 | 151,771 | 152,153 | 152,575 | 153,040 |
| Steam-electric | 44,985 | 80,989 | 94,515 | 111,006 | 131,108 | 155,611 |
| Livestock | 23,613 | 25,114 | 26,899 | 29,020 | 31,546 | 34,533 |
| **Total Water Demands** | **730,911** | **1,083,549** | **1,277,417** | **1,340,598** | **1,411,268** | **1,490,596** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 3,340 | 5,548 | 7,042 | 9,049 | 12,214 | 16,408 |
| County-other | 1,072 | 1,803 | 2,272 | 2,584 | 3,152 | 4,101 |
| Manufacturing | 3,392 | 16,014 | 24,580 | 33,256 | 40,999 | 49,588 |
| Mining | 14,812 | 29,744 | 9,395 | 10,075 | 10,748 | 11,276 |
| Irrigation | 1,675 | 1,805 | 2,156 | 2,536 | 2,955 | 3,416 |
| Steam-electric | 3,588 | 25,922 | 33,615 | 43,053 | 62,778 | 85,212 |
| Livestock | 977 | 2,196 | 4,093 | 6,347 | 9,020 | 12,144 |
| **Total Water Needs** | **28,856** | **83,032** | **83,153** | **106,900** | **141,866** | **182,145** |

## FIGURE I.2. 2060 EAST TEXAS (I) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Lake Columbia will provide 75,700 acre-feet per year of water starting in the year 2020 with a capital cost of $232 million
- New wells in the Carrizo Wilcox Aquifer will provide up to 21,403 acre-feet per year of water in 2060 with a capital cost of $40 million.
- Lake Palestine Infrastructure (diversion facilities and pipelines) will provide 16,815 acre-feet per year of water starting in 2030 with a capital cost of $79 million.
- Lake Kurth Regional System will provide up to 18,400 acre-feet per year of water starting in 2010, with a capital cost of $56 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed five region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#i.

- Inter-Regional Coordination on the Toledo Bend Project
- Regional Solutions for Small Water Suppliers
- Study of Municipal Water Uses to Improve Water Conservation Strategies and Projections
- Lake Murvaul Study
- Liquefied Natural Gas and Refinery Expansions Jefferson County

## EAST TEXAS PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

*Voting members during adoption of the 2011 Regional Water Plan:*

Kelley Holcomb (Chair), water utilities; David Alders, agriculture; Jeff Branick, counties; David Brock, municipalities; George P. Campbell, other; Jerry Clark, river authorities; Josh David, other; Chris Davis, counties; Scott Hall, river authorities; Michael Harbordt, industries; William Heugel, public; Joe Holcomb, small business; Bill Kimbrough, other; Glenda Kindle, public; Duke Lyons, municipalities; Dale Peddy, electric generating utilities; Hermon E. Reed, Jr., agriculture; Monty Shank, river authorities; Darla Smith, industries; Worth Whitehead, water districts; J. Leon Young, environmental; Mark Dunn, small business

*Former voting members during the 2006 – 2011 planning cycle:*

Ernest Mosby, small business; Mel Swoboda, industries; John Windham, small business

FIGURE I.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).

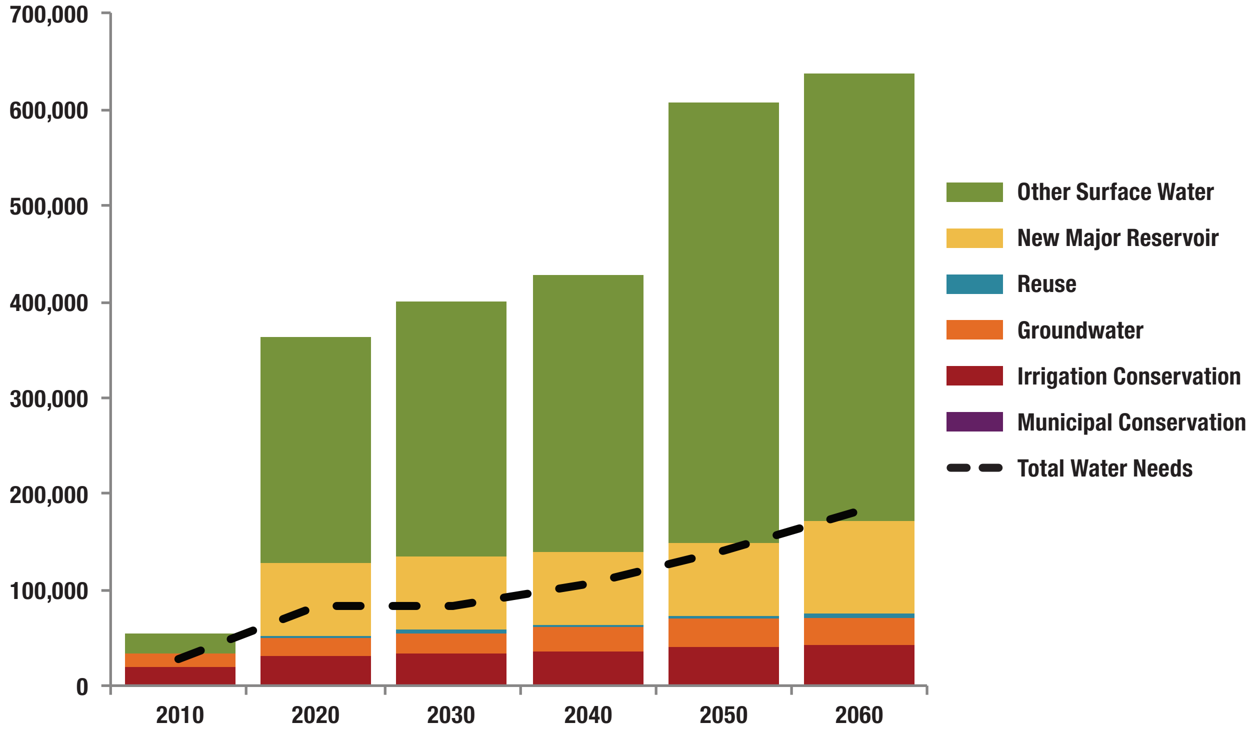
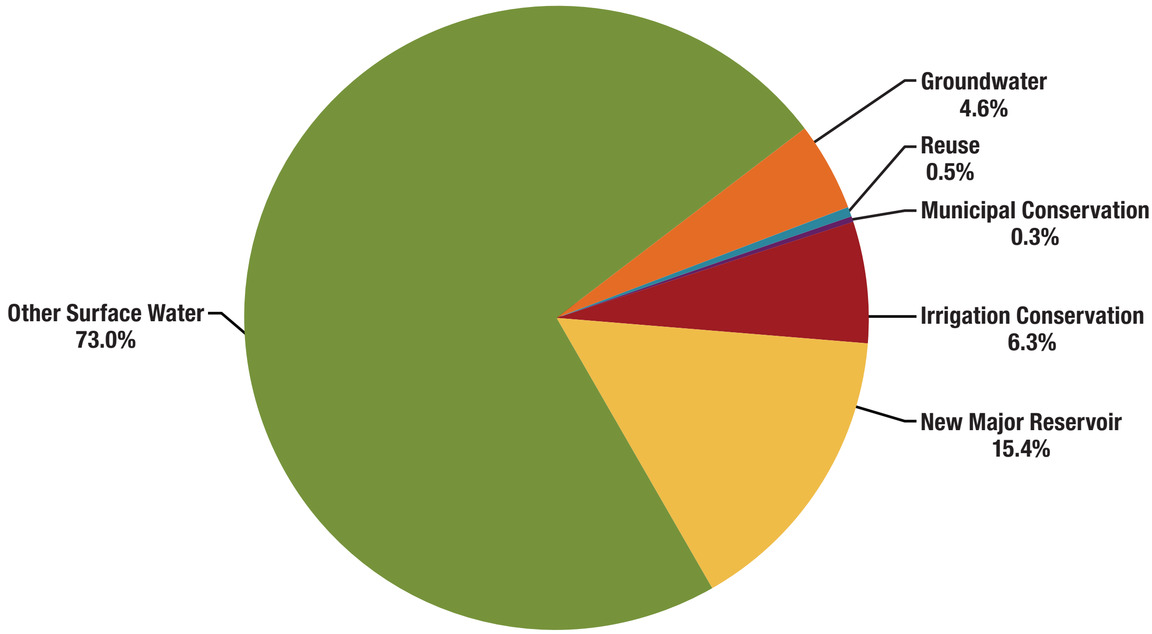
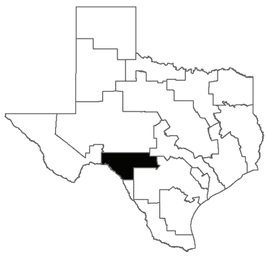



FIGURE I.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Plateau (J) Region



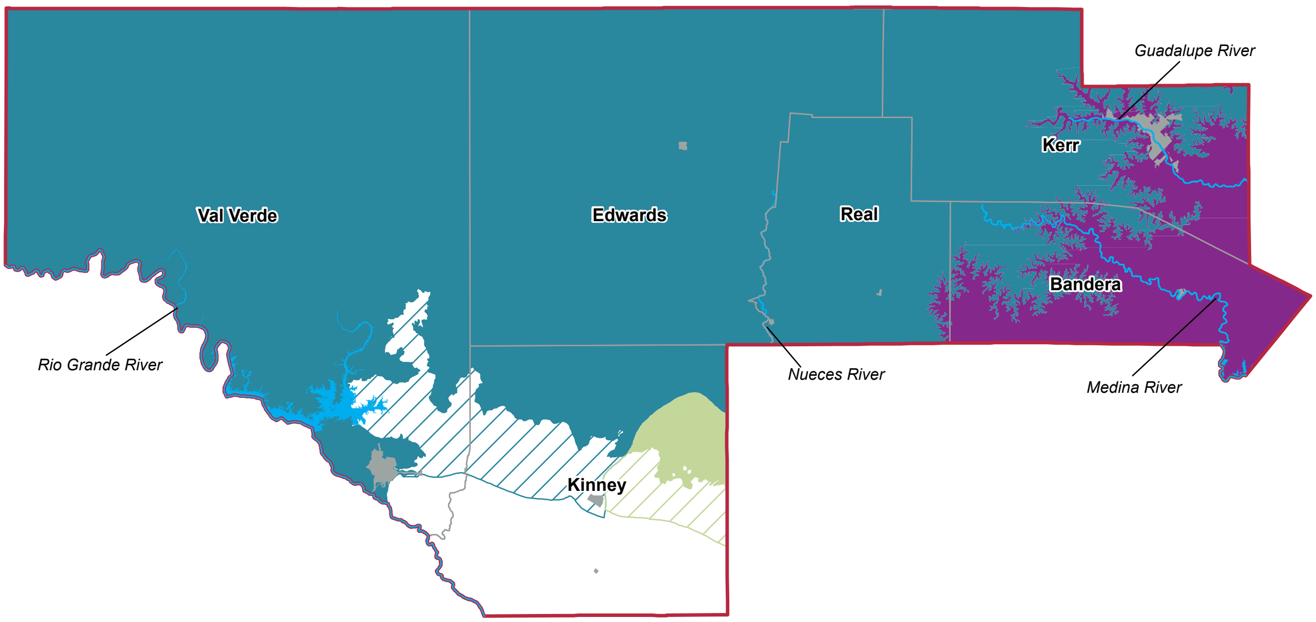
**Located on the southern edge of the Edwards Plateau, the Plateau Regional Water Planning Area covers six counties.**

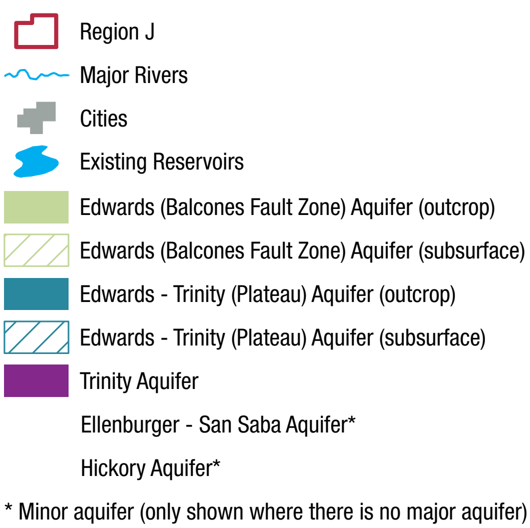
Located on the southern edge of the Edwards Plateau, the Plateau Regional Water Planning Area covers six counties (Figure J.1). The region includes portions of the Colorado, Guadalupe, Nueces, Rio Grande, and San Antonio river basins. Land use in the western portion of the planning area is primarily range land, while the eastern portion is a mix of forest land, range land, and agricultural areas. The economy of this region is based primarily on tourism, hunting, ranching, and government (primarily Laughlin Air Force Base in Del Rio). Major cities in the region include Kerrville and Del Rio. The 2011 Plateau (J) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionJ/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—2,389 acre-feet per year
- Recommended water management strategy volume in 2060—23,010 acre-feet per year
- Total capital cost—$55 million
- Conservation accounts for 3 percent of 2060 strategy volumes
- Brush control strategy supply not available during drought of record conditions
- Aquifer Storage and Recovery accounts for 21 percent of 2060 strategy volumes

## FIGURE J.1. PLATEAU (J) REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

Less than 1 percent of the state's population resided in the Plateau Region in 2010. By 2060, the region's population is projected to increase 52 percent (Table J.1). The greatest area of population growth is projected to occur in Bandera County, with an anticipated 129 percent increase in population by 2060, which will primarily be associated with areas around San Antonio. Total water demands, however, will increase by only 13 percent by 2060 (Table J.1). The greatest increase is in county-other demand (68 percent), followed by municipal water demand, increasing over the planning horizon by 21 percent (Table J.1, Figure J.2).

## EXISTING WATER SUPPLIES

Over 80 percent of the region's existing water supply is obtained from groundwater. Throughout the planning period, the Plateau Planning Group estimates that regional groundwater and surface water supplies will remain constant at 85,439 acre-feet and 19,269 acre-feet, respectively (Table J.1, Figure J.2). There are three aquifers in the region: the Edwards-Trinity (Plateau) Aquifer, underlying much of the region; the Trinity Aquifer in the southeastern portions of Kerr and Bandera counties; and the Edwards (Balcones Fault Zone) Aquifer in southern Kinney County. The principal sources of surface water in the region are San Felipe Springs, Las Moras Creek, the Frio River, the Upper Guadalupe River, Cienagas Creek, and the Nueces River.

## NEEDS

Although the region as a whole appears to have enough water supply to meet demands during drought of record conditions, the total existing water supply is not accessible to all water users. The cities of Kerrville and Camp Wood are projected to have needs in all decades, up to 2,389 acre-feet by 2060 (Table J.1, Figure J.2).

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

Water management strategies recommended by the Plateau Planning Group include municipal conservation, groundwater development, brush control, and aquifer storage and recovery. These recommended strategies result in 13,713 acre-feet of water in 2010 and 23,010 acre-feet of additional water supply available by the year 2060 to meet all needs (Figures J.3 and J.4) at a total capital cost of $54.8 million (Appendix A).

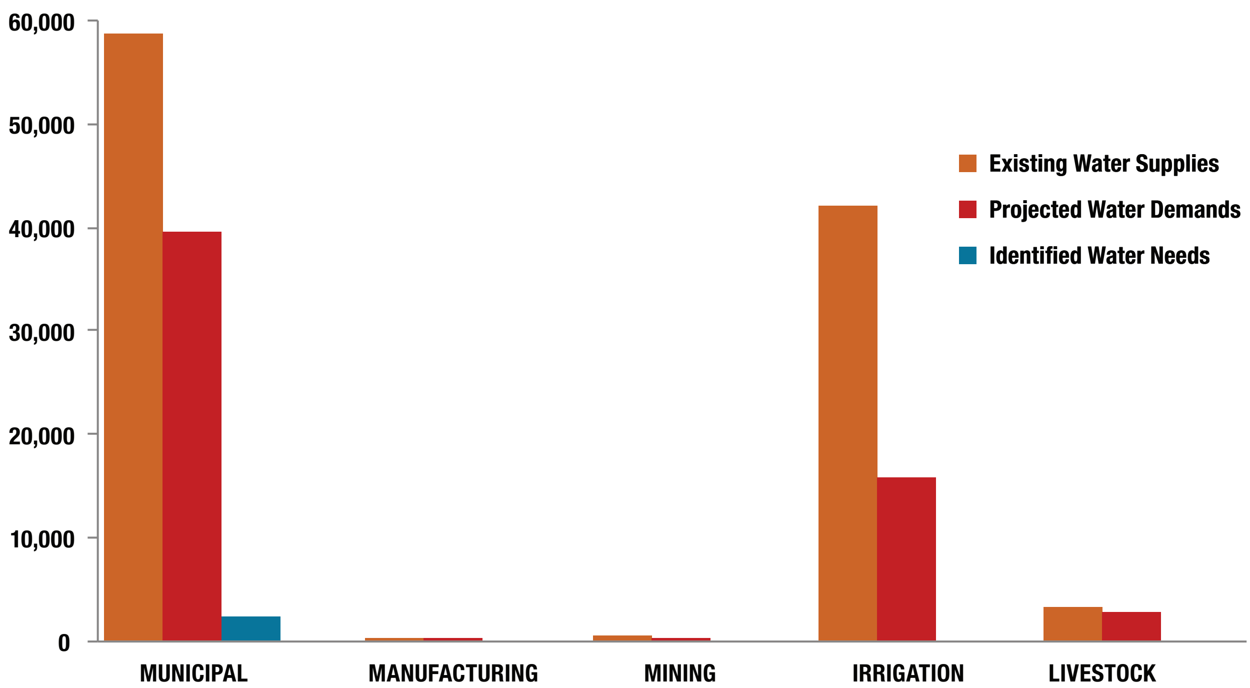
## CONSERVATION RECOMMENDATIONS

Conservation strategies represent 3 percent of the total volume of water associated with all recommended strategies. Municipal water conservation was recommended for municipal water user groups with identified needs, which is anticipated to result in water savings of 579 acre-feet in the 2010 decade and 681 acre-feet by 2060.

## TABLE J.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 135,723 | 158,645 | 178,342 | 190,551 | 198,594 | 205,910 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 19,269 | 19,269 | 19,269 | 19,269 | 19,269 | 19,269 |
| Groundwater | 85,439 | 85,439 | 85,439 | 85,439 | 85,439 | 85,439 |
| **Total Water Supplies** | **104,708** | **104,708** | **104,708** | **104,708** | **104,708** | **104,708** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 20,695 | 22,068 | 23,101 | 23,795 | 24,563 | 25,106 |
| County-other | 8,625 | 10,515 | 12,170 | 13,178 | 13,836 | 14,526 |
| Manufacturing | 30 | 33 | 36 | 39 | 41 | 44 |
| Mining | 403 | 394 | 389 | 385 | 381 | 378 |
| Irrigation | 19,423 | 18,645 | 17,897 | 17,183 | 16,495 | 15,837 |
| Livestock | 2,752 | 2,752 | 2,752 | 2,752 | 2,752 | 2,752 |
| **Total Water Demands** | **51,928** | **54,407** | **56,345** | **57,332** | **58,068** | **58,643** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 1,494 | 1,878 | 2,044 | 2,057 | 2,275 | 2,389 |
| **Total Water Needs** | **1,494** | **1,878** | **2,044** | **2,057** | **2,275** | **2,389** |

## FIGURE J.2. 2060 PLATEAU (J) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Surface water acquisition, treatment, and aquifer storage and recovery is projected to produce up to 2,624 acre-feet per year of water in the year 2060 with a capital cost of $37 million.
- Additional groundwater wells are expected to produce 222 acre-feet per year of water starting in 2010 with a capital cost of $240,350.

## REGION-SPECIFIC STUDIES

The Plateau Water Planning Group developed three region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#j.

- Groundwater Data Acquisition in Edwards, Kinney, and Val Verde Counties, Texas
- Aquifer Storage and Recovery Feasibility in Bandera County
- Water Rights Analysis and Aquifer Storage and Recovery Feasibility in Kerr County

## PLATEAU PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

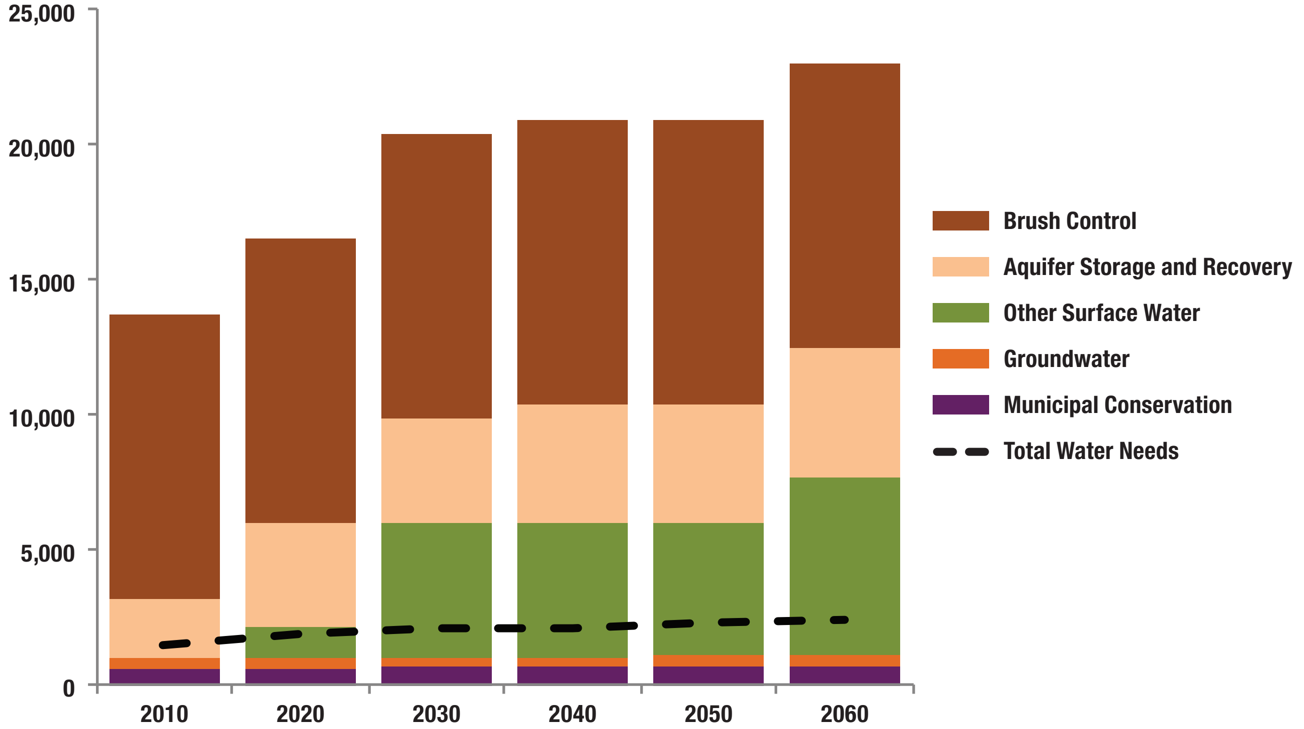
*Voting members during adoption of the 2011 Regional Water Plan:*

Jonathan Letz (Chair), small business; Stuart Barron, municipalities; Ray Buck, river authorities; Perry Bushong, water districts; Zack Davis, agriculture; Otila Gonzalez, municipalities; Howard Jackson, municipalities; David Jeffery, water districts; Mitch Lomas, municipalities; Kent Lowery, water districts; Ronnie Pace, industries; Thomas M. Qualia, public; Tully Shahan, environmental; Jerry Simpton, other; Homer T. Stevens, Jr., travel/tourism; Lee Sweeten, counties; Charlie Wiedenfeld, water utilities; Gene Williams, water districts; William Feathergail Wilson, other

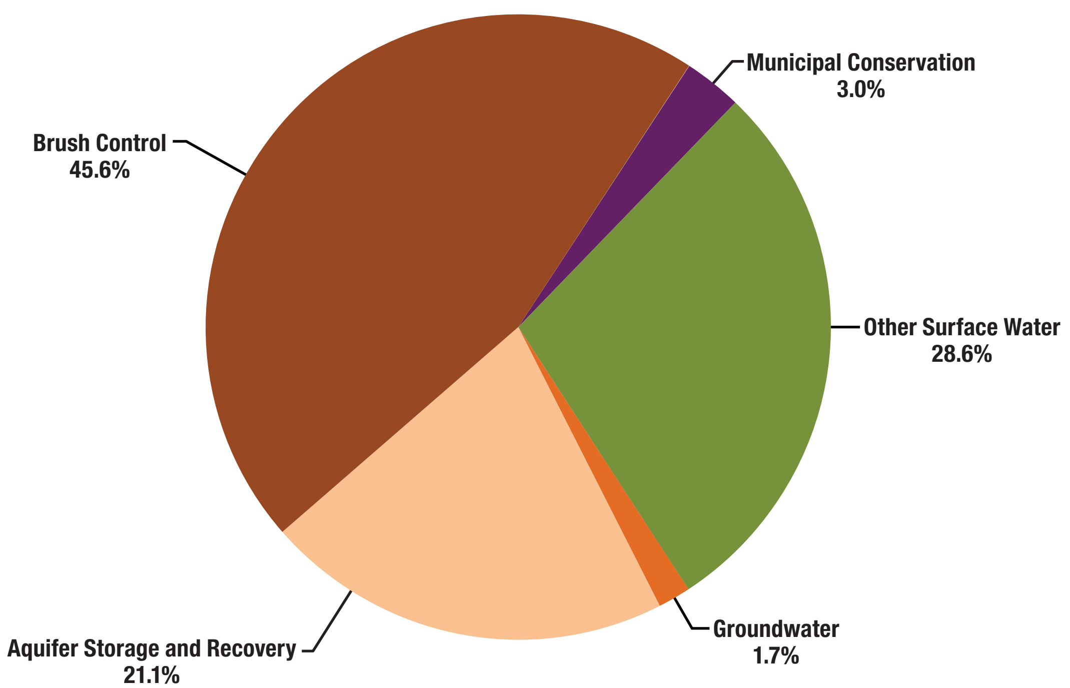
*Former voting members during the 2006 – 2011 planning cycle:*

Alejandro A. Garcia, municipalities; Lon Langley, water districts; Carl Meek, municipalities; W.B. Sansom, counties; Cecil Smith, water districts; Gene Smith, municipalities; Diana Ward, water districts

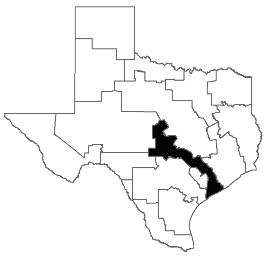
## FIGURE J.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE J.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Lower Colorado (K) Region



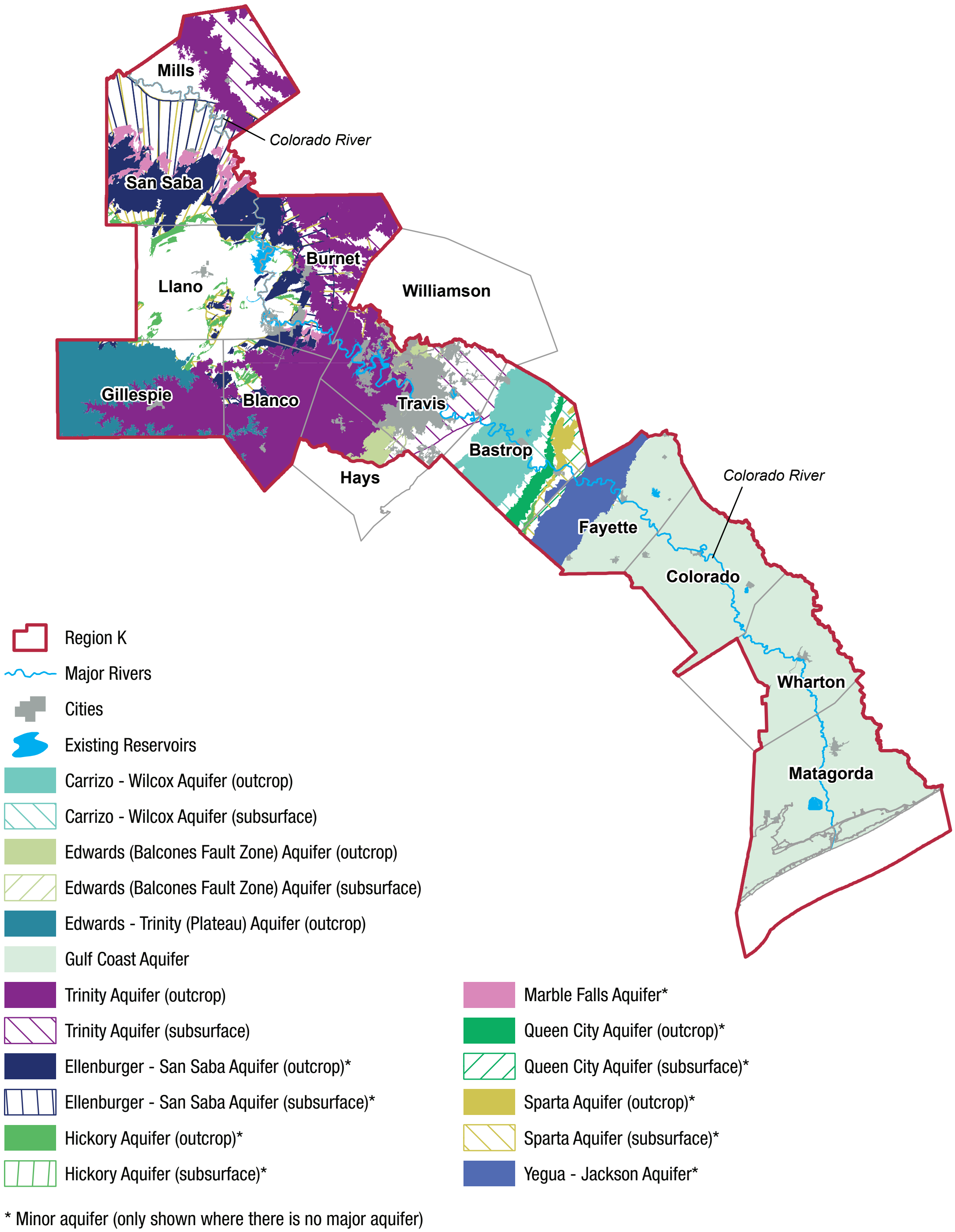
**The Lower Colorado Regional Water Planning Area is composed of all or parts of 14 counties, portions of 6 river and coastal basins, and Matagorda Bay.**

The Lower Colorado Regional Water Planning Area is composed of all or parts of 14 counties, portions of 6 river and coastal basins, and Matagorda Bay (Figure K.1). Most of the region is located in the Colorado River Basin. Major cities in the region include Austin, Bay City, Pflugerville, and Fredericksburg. The largest economic sectors in the region include agriculture, government, service, manufacturing, and retail trade. The manufacturing sector is primarily concentrated in the technology and semiconductor industry in the Austin area. Oil, gas, petrochemical processing and mineral production are found primarily in Wharton and Matagorda counties near the coast. The 2011 Lower Colorado (K) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionK/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—367,671 acre-feet per year
- Recommended water management strategy volume in 2060—646,167 acre-feet per year
- Total capital cost—$907 million
- Conservation accounts for 37 percent of 2060 strategy volumes
- One new major reservoir (Lower Colorado River Authority/San Antonio Water System Project Off-Channel)
- Reuse accounts for 21 percent of 2060 strategy volumes

## FIGURE K.1. LOWER COLORADO (K) REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

In 2010, nearly 6 percent of the state's total population resided in the Lower Colorado Region, and between 2010 and 2060 its population is projected to increase by 100 percent to 2,831,937. Water demands, however, are projected to increase less significantly. By 2060, the region's total water demand is projected to increase by 27 percent (Table K.1, and Figure K.1). Agricultural irrigation water use accounts for the largest share of demands through 2050, but by 2060, municipal demand in all forms (including county-other) is expected to surpass irrigation (Table K.1; Figure K.1). Demands for manufacturing and steam-electric generation are also projected to increase substantially.

## EXISTING WATER SUPPLIES

The region has a large number of surface water and groundwater sources available. In 2010, surface water was projected to provide about 77 percent of supplies and groundwater about 23 percent. The principal surface water supply sources are the Colorado River and its tributaries, including the Highland Lakes system. There are nine reservoirs in the Lower Colorado region that provide water supply. In determining water supply from the Colorado River, the planning group assumed that its major senior water rights would not exercise a priority call on water rights in Region F and would otherwise honor agreements with certain Region F water right holders. Except where formal agreements exist to support these assumptions, these planning assumptions used to determine existing supplies from the Colorado River have no legal effect. There are 11 major and minor aquifers that supply groundwater to users in the region. The five major aquifers providing groundwater supplies are the Edwards-Trinity (Plateau) and Trinity in the western portion of the region, the Edwards (Balcones Fault Zone) and Carrizo-Wilcox in the central portion, and the Gulf Coast in the eastern portion. The total supply to the planning area is estimated to be 1,162,884 acre-feet in 2010, increasing less than 1 percent to 1,169,071 acre-feet in 2060, because of an expected increase in small, local water supplies (Table K.1, Figure K.2).

## NEEDS

Water user groups in the Lower Colorado Region were anticipated to need 255,709 acre-feet of additional water in 2010 and 367,671 acre-feet by 2060 under drought conditions (Table K.1, Figure K.2). All six water use sectors show needs for additional water by 2060. In 2010, the agricultural irrigation sector would have the largest needs in the event of drought (92 percent of total). However, by 2060, municipal needs are expected to increase, largely due to population growth over the planning period, and irrigation needs are expected to decline. These sectors would each represent approximately 37 percent of the total needs.

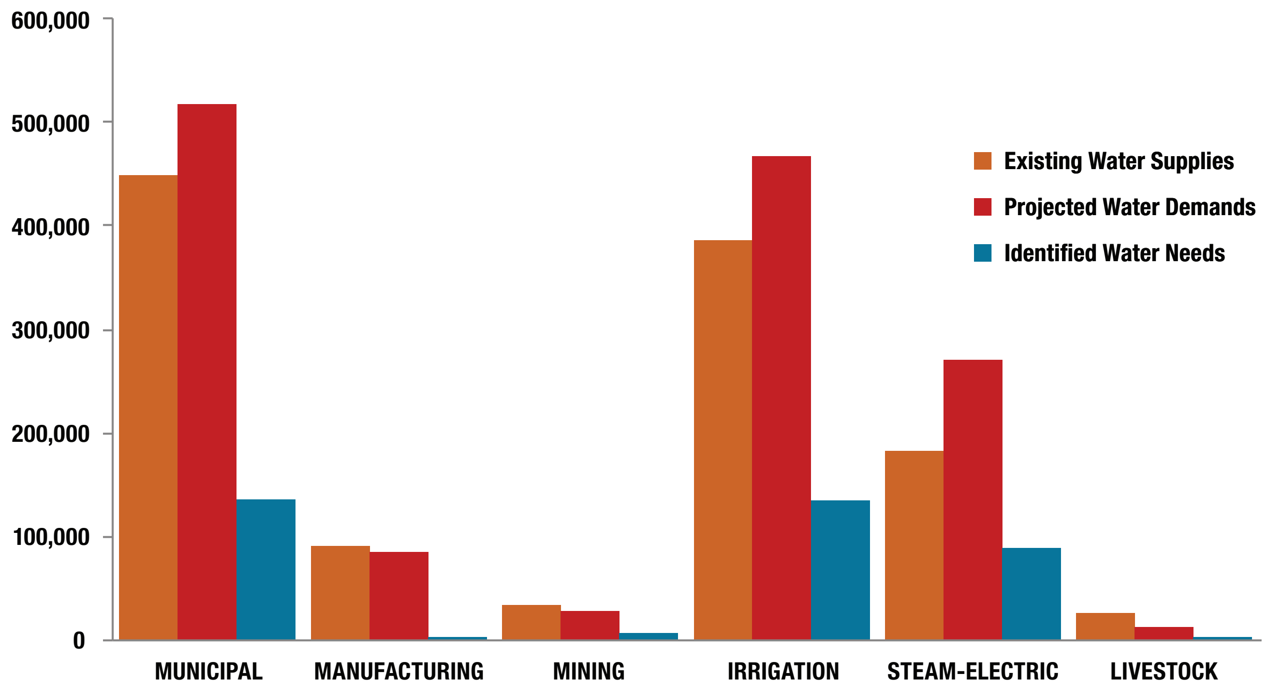
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

Water management strategies included in the Lower Colorado regional water plan would provide 646,167 acre-feet of additional water supply by the year 2060 (Figures K.3 and K.4) at a total capital cost of $907.2 million for the region's portion of the project (Appendix A). The primary recommended water management strategy is the Lower Colorado River Authority/San Antonio Water System project that consists of off-channel reservoirs, agricultural water conservation, additional groundwater development, and new and/or amended surface water rights. The costs associated with this project would be paid for by San Antonio and are included in the 2011 South Central Texas Regional Water Plan. If this project is not implemented jointly by the participants, a number of the individual components are recommended as alternate water management strategies to meet Lower Colorado Region needs. There are no unmet needs in the plan.

## TABLE K.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 1,412,834 | 1,714,282 | 2,008,142 | 2,295,627 | 2,580,533 | 2,831,937 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 892,327 | 892,689 | 894,886 | 897,359 | 900,286 | 900,477 |
| Groundwater | 270,557 | 270,268 | 269,887 | 268,936 | 268,527 | 268,594 |
| **Total Water Supplies** | **1,162,884** | **1,162,957** | **1,164,773** | **1,166,295** | **1,168,813** | **1,169,071** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 239,013 | 288,152 | 336,733 | 382,613 | 428,105 | 467,075 |
| County-other | 29,630 | 33,820 | 36,697 | 40,438 | 44,673 | 49,273 |
| Manufacturing | 38,162 | 44,916 | 56,233 | 69,264 | 77,374 | 85,698 |
| Mining | 30,620 | 31,252 | 31,613 | 26,964 | 27,304 | 27,598 |
| Irrigation | 589,705 | 567,272 | 545,634 | 524,809 | 504,695 | 468,763 |
| Steam-electric | 146,167 | 201,353 | 210,713 | 258,126 | 263,715 | 270,732 |
| Livestock | 13,395 | 13,395 | 13,395 | 13,395 | 13,395 | 13,395 |
| **Total Water Demands** | **1,086,692** | **1,180,160** | **1,231,018** | **1,315,609** | **1,359,261** | **1,382,534** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 6,671 | 17,867 | 25,289 | 36,420 | 76,771 | 120,999 |
| County-other | 223 | 1,725 | 4,347 | 8,128 | 11,610 | 14,892 |
| Manufacturing | 146 | 298 | 452 | 605 | 741 | 934 |
| Mining | 13,550 | 13,146 | 12,366 | 6,972 | 5,574 | 5,794 |
| Irrigation | 234,738 | 217,011 | 198,717 | 181,070 | 164,084 | 135,822 |
| Steam-electric | 193 | 53,005 | 53,175 | 76,430 | 81,930 | 89,042 |
| Livestock | 188 | 188 | 188 | 188 | 188 | 188 |
| **Total Water Needs** | **255,709** | **303,240** | **294,534** | **309,813** | **340,898** | **367,671** |

## FIGURE K.2. 2060 LOWER COLORADO (K) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

Conservation strategies represent up to 37 percent of the total amount of water resulting from all recommended water management strategies. Water conservation was included as a strategy for every municipal water user group with a need and water use greater than 140 gallons per capita per day. A demand reduction of 1 percent per year was assumed until the water user reached 140 gallons per capita per day. Conservation was recommended beginning in 2010 regardless of the decade when needs first occur to have significant effects on demand by the time the needs were realized. In addition to municipal conservation, the plan recommends significant irrigation conservation programs and projects.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Off-channel reservoir project (Lower Colorado River Authority/San Antonio Water System) would provide 47,000 acre-feet per year of water in the year 2060 at no cost to the region if it is paid for by project sponsors located in Region L (see Region L summary for cost assumptions).
- Wastewater return flows would provide up to 78,956 acre-feet per year of water in 2060 with no assumed capital cost since no additional infrastructure is needed.
- Municipal conservation and enhanced municipal/industrial conservation would provide up to 76,594 acre-feet per year of water in 2060 with no assumed capital cost, while irrigation conservation would provide up to 124,150 acre-feet per year of water in 2060 at a capital cost of approximately $3.8 million.
- Reuse of treated wastewater would provide up to 58,783 acre-feet per year of water in 2060 with a capital cost in excess of $620 million.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed three region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#k.

- Surface Water Availability Modeling Study
- Environmental Impacts of Water Management Strategies Study
- Evaluation of High Growth Areas Study

## LOWER COLORADO PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

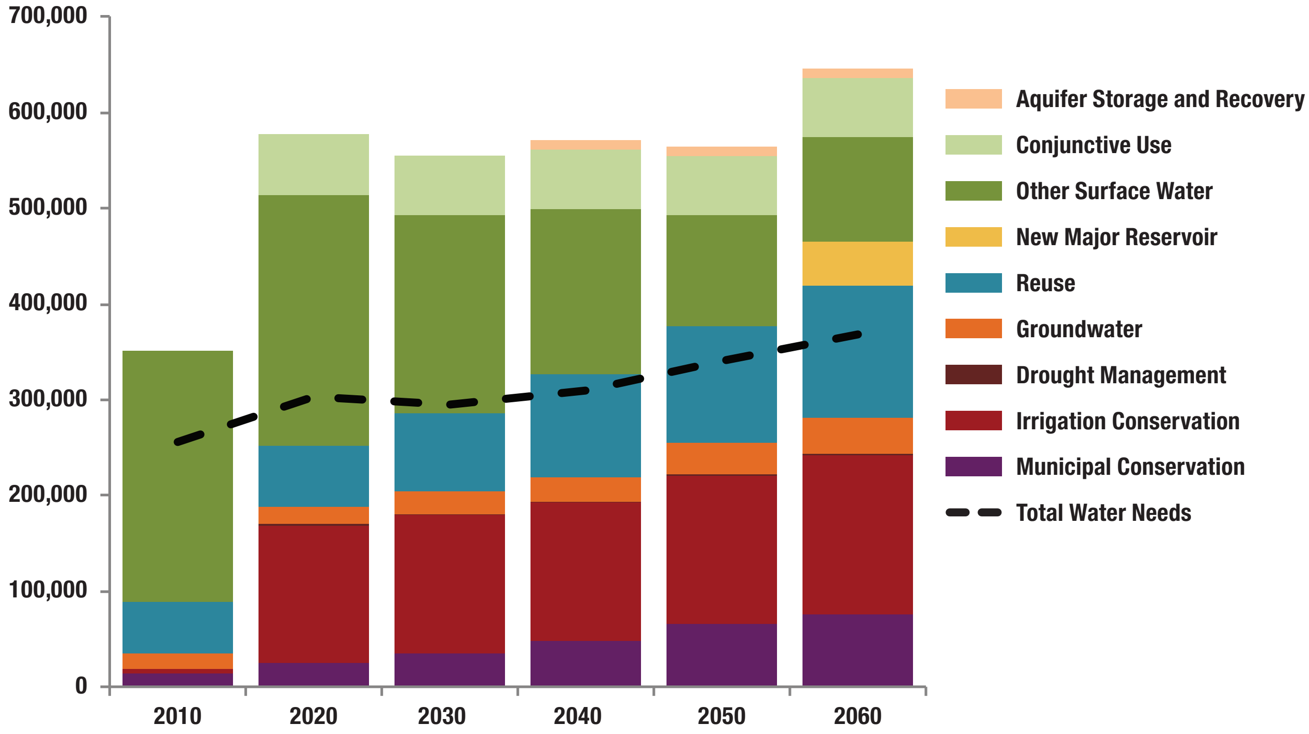
*Voting members during adoption of the 2011 Regional Water Plan:*

John E. Burke (Chair), water utilities; Jim Barho, environmental; Sandra Dannhardt, electric generating utilities; Finley deGraffenried, municipalities; Ronald G. Fieseler, water districts; Ronald Gertson, small business; Karen Haschke, public; Barbara Johnson, industries; James Kowis, river authorities; Teresa Lutes, municipalities; Bill Neve, counties; W.R. (Bob) Pickens, other; Doug Powell, recreation; W.A. (Billy) Roeder, counties; Rob Ruggiero, small business; Haskell Simon, agriculture; James Sultemeier, counties; Byron Theodosis, counties; Paul Tybor, water districts; David Van Dresar, water districts; Roy Varley, other; Jennifer Walker, environmental

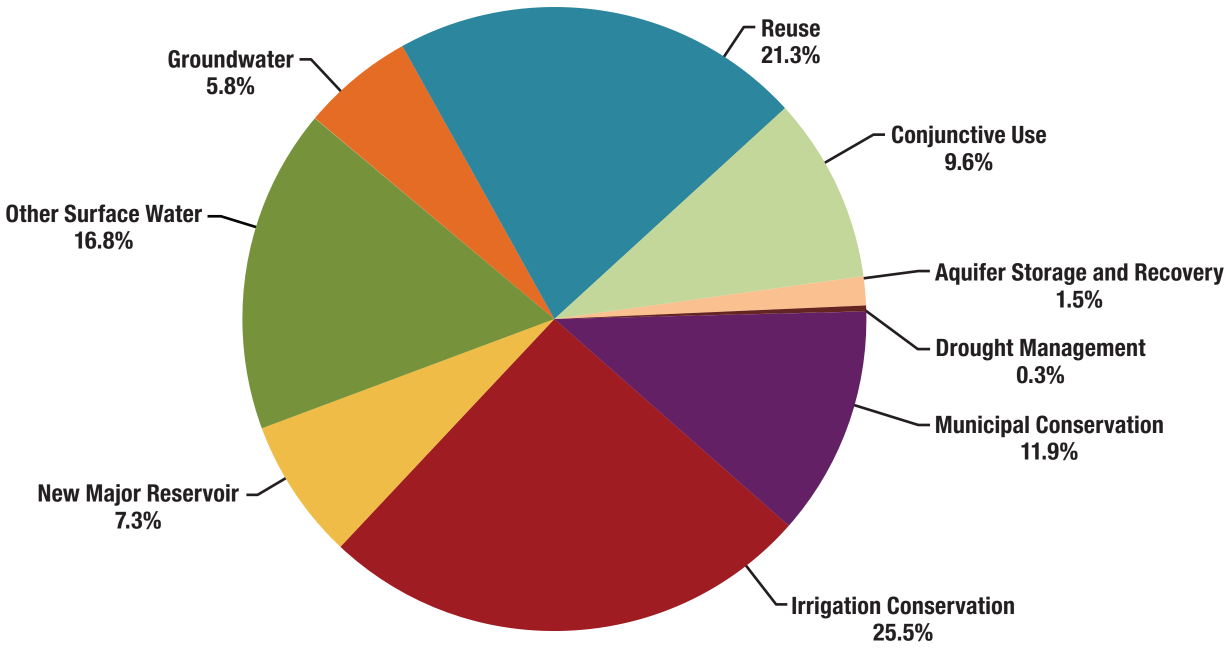
*Former voting members during the 2006 – 2011 planning cycle:*

David Deeds, municipalities; Rick Gangluff, electric generating utilities; Mark Jordan, river authorities; Chris King, counties; Julia Marsden, public; Laura Marbury, public; Bill Miller, agriculture; Harold Streicher, small business; Del Waters, recreation

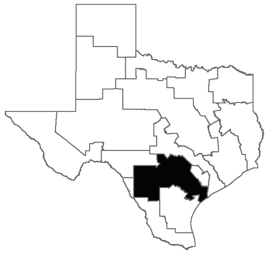
## FIGURE K.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE K.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of South Central Texas (L) Region



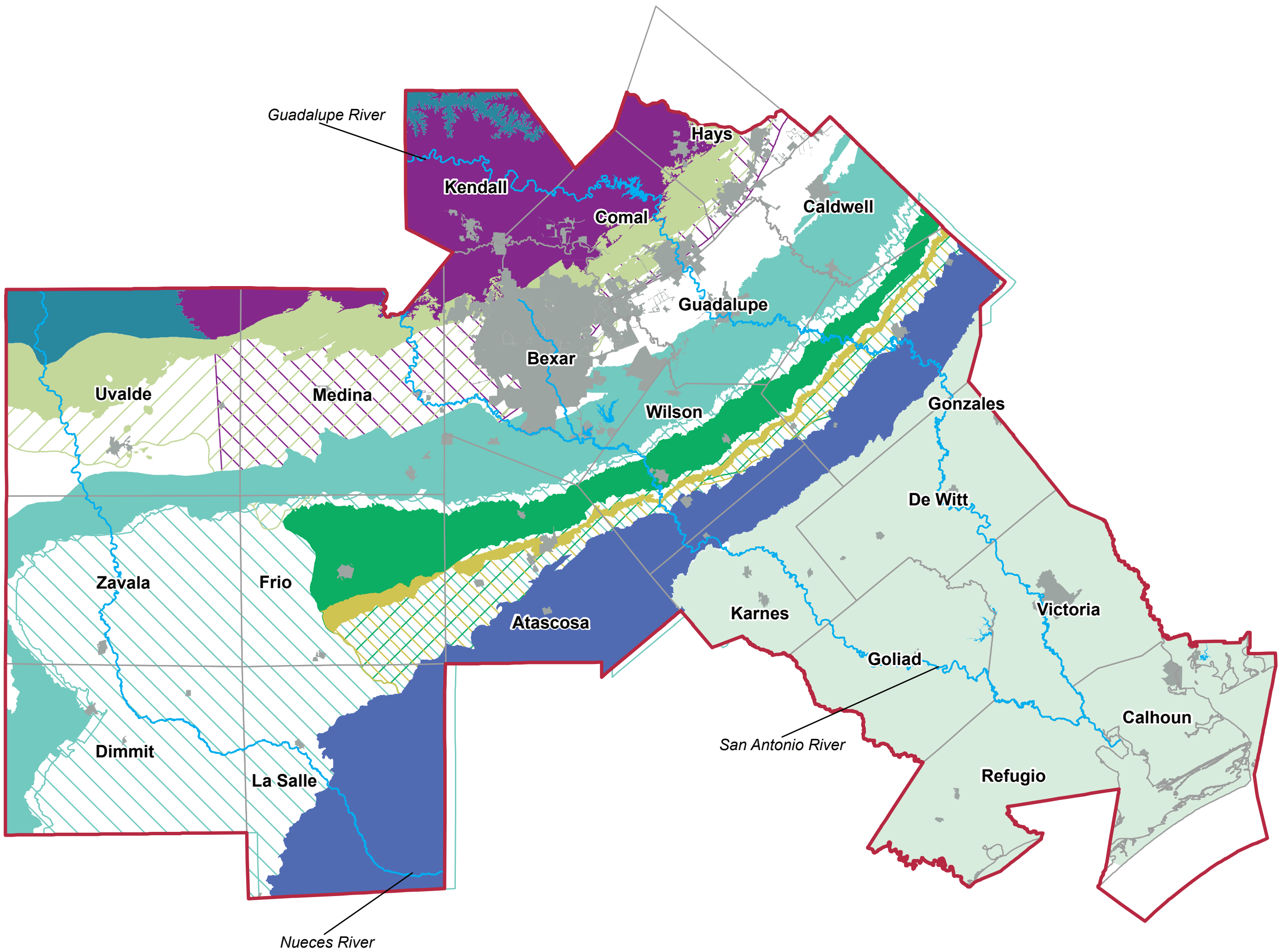
**The South Central Texas Regional Water Planning Area includes all or parts of 21 counties, portions of nine river and coastal basins, the Guadalupe Estuary, and San Antonio Bay.**

The South Central Texas Regional Water Planning Area includes all or parts of 21 counties, portions of nine river and coastal basins, the Guadalupe Estuary, and San Antonio Bay (Figure L.1). The largest cities in the region are San Antonio, Victoria, San Marcos, and New Braunfels. The region's largest economic sectors are tourism, military, medical, service, manufacturing, and retail trade. The region contains the two largest springs in Texas: Comal and San Marcos. Water planning in the region is particularly complex because of the intricate relationships between the region's surface and groundwater resources. The 2011 South Central Texas (L) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionL/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—436,751 acre-feet per year
- Recommended water management strategy volume in 2060—765,738 acre-feet per year
- Total capital cost—$7.6 billion
- Conservation accounts for 11 percent of 2060 strategy volumes
- Five new, major off-channel reservoirs (Guadalupe-Blanco River Authority: Mid-Basin, Exelon, and Lower Basin New Appropriation Projects; Lower Colorado River Authority/San Antonio Water System Project Off-Channel; Lavaca Off-Channel)
- Significant Carrizo-Wilcox Aquifer development
- Five unique stream segments recommended for designation (Figure ES.7)
- Limited unmet irrigation needs

## FIGURE L.1. SOUTH CENTRAL TEXAS (L) REGIONAL WATER PLANNING AREA.




Region L

Major Rivers

Cities

Existing Reservoirs

Carrizo - Wilcox Aquifer (outcrop)

Carrizo - Wilcox Aquifer (subsurface)

Edwards (Balcones Fault Zone) Aquifer (outcrop)

Edwards (Balcones Fault Zone) Aquifer (subsurface)

Edwards - Trinity (Plateau) Aquifer

Gulf Coast Aquifer

Trinity Aquifer (outcrop)

Trinity Aquifer (subsurface)

Queen City Aquifer (outcrop)*

Queen City Aquifer (subsurface)*

Sparta Aquifer (outcrop)*

Sparta Aquifer (subsurface)*

Yegua - Jackson Aquifer*

Ellenburger - San Saba Aquifer*

Hickory Aquifer*

* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 10 percent of the state's total population resided in Region L in the year 2010, and between 2010 and 2060 its population is projected to increase by 75 percent (Table L.1). By 2060, the total water demands for the region are projected to increase 32 percent (Table L.1). Starting in 2020, municipal water use makes up the largest share of these demands in all decades and is projected to experience the greatest increase over the planning period; a 62 percent increase (Table L.1, Figure L.2). Agricultural irrigation water demand will remain significant but is projected to decline 20 percent over the planning period.

## EXISTING WATER SUPPLIES

The Edwards Aquifer is projected to provide approximately half of the region's existing groundwater supply in 2010, with the Carrizo-Wilcox Aquifer providing approximately 40 percent of the groundwater supplies. There are five major aquifers supplying water to the region, including the Edwards (Balcones Fault Zone), Carrizo-Wilcox, Trinity, Gulf Coast, and Edwards-Trinity (Plateau). The two minor aquifers supplying water are the Sparta and Queen City aquifers. The region includes portions of six river basins and three coastal basins. The principal surface water sources in the region are the Guadalupe, San Antonio, Lavaca, and Nueces rivers. The region's existing water supply is expected to decline slightly between 2010 and 2060 as groundwater use is reduced in certain areas (Table L.1, Figure L.2).

## NEEDS

Because total water supplies are not accessible by all water users throughout the region, in the event of drought, the South Central Texas Region faces water supply needs of up to 174,235 acre-feet as early as 2010 (Table L.1, Figure L.2). In 2010 these water supply needs consist primarily of municipal (55 percent) and irrigated agricultural needs (39 percent). By the year 2060, the water needs are significantly larger and are dominated to an even greater extent (68 percent) by municipal water users.

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The South Central Texas Planning Group recommended a variety of water management strategies to meet water supply needs (Figures L.3 and L.4). Implementing all the water management strategies recommended in the Region L plan would result in 765,738 acre-feet of additional water supplies in 2060 at a total capital cost of $7.6 billion (Appendix A). Because there were no economically feasible strategies identified to meet the needs, Atascosa and Zavala Counties have limited projected unmet irrigation needs.

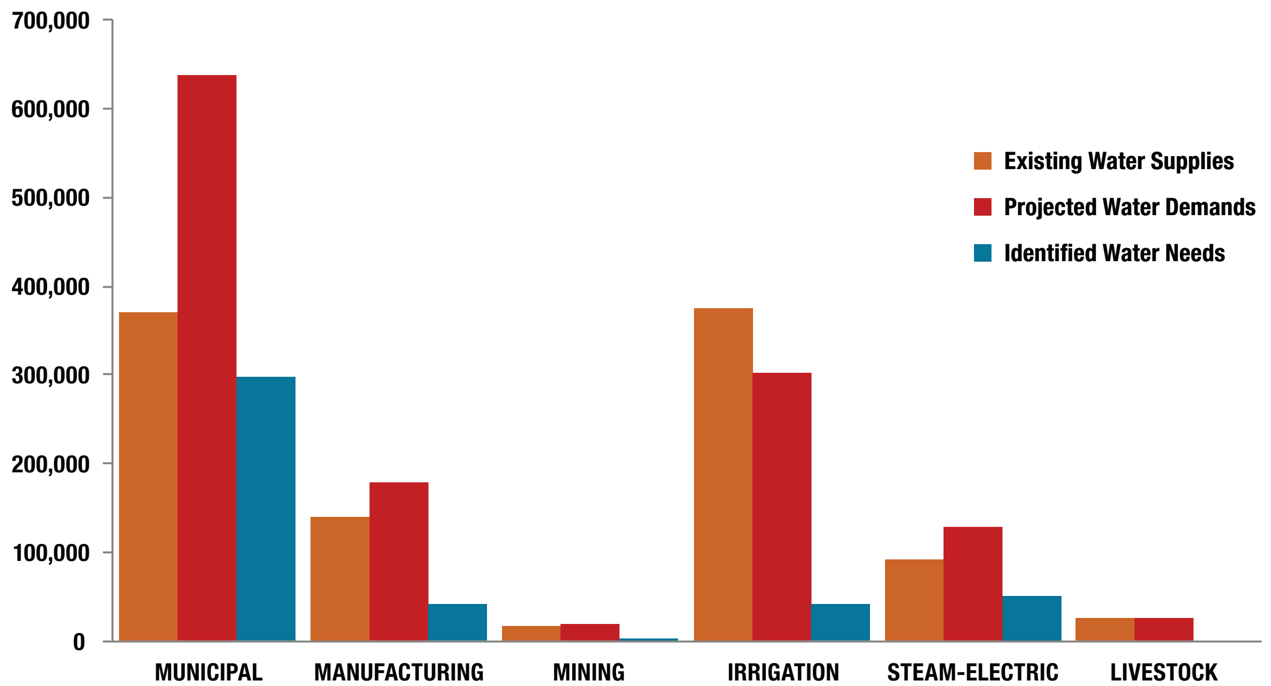
## CONSERVATION RECOMMENDATIONS

Conservation strategies account for 11 percent of the total amount of water that would be provided by the region's recommended water management strategies. Water conservation was recommended in general for all municipal and non-municipal water user groups. In instances where the municipal water conservation goals could be achieved through anticipated use of low-flow plumbing fixtures, additional conservation measures were not recommended.

## TABLE L.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 2,460,599 | 2,892,933 | 3,292,970 | 3,644,661 | 3,984,258 | 4,297,786 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 301,491 | 301,475 | 299,956 | 295,938 | 295,922 | 295,913 |
| Groundwater | 717,263 | 716,541 | 712,319 | 711,521 | 710,539 | 709,975 |
| Reuse | 16,049 | 16,049 | 16,049 | 16,049 | 16,049 | 16,049 |
| **Total Water Supplies** | **1,034,803** | **1,034,065** | **1,028,324** | **1,023,508** | **1,022,510** | **1,021,937** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 369,694 | 422,007 | 471,529 | 512,671 | 555,281 | 597,619 |
| County-other | 26,302 | 29,104 | 31,846 | 34,465 | 37,062 | 39,616 |
| Manufacturing | 119,310 | 132,836 | 144,801 | 156,692 | 167,182 | 179,715 |
| Mining | 14,524 | 15,704 | 16,454 | 17,212 | 17,977 | 18,644 |
| Irrigation | 379,026 | 361,187 | 344,777 | 329,395 | 315,143 | 301,679 |
| Steam-electric | 46,560 | 104,781 | 110,537 | 116,068 | 121,601 | 128,340 |
| Livestock | 25,954 | 25,954 | 25,954 | 25,954 | 25,954 | 25,954 |
| **Total Water Demands** | **981,370** | **1,091,573** | **1,145,898** | **1,192,457** | **1,240,200** | **1,291,567** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 94,650 | 134,541 | 173,989 | 212,815 | 249,735 | 288,618 |
| County-other | 2,003 | 3,073 | 4,228 | 5,430 | 7,042 | 8,768 |
| Manufacturing | 6,539 | 13,888 | 20,946 | 27,911 | 34,068 | 43,072 |
| Mining | 521 | 726 | 1,771 | 1,992 | 2,293 | 2,493 |
| Irrigation | 68,465 | 62,376 | 56,519 | 50,894 | 45,502 | 41,782 |
| Steam-electric | 2,054 | 50,962 | 50,991 | 51,021 | 51,657 | 52,018 |
| Livestock | 3 | 1 | 0 | 0 | 0 | 0 |
| **Total Water Needs** | **174,235** | **265,567** | **308,444** | **350,063** | **390,297** | **436,751** |

## FIGURE L.2. 2060 SOUTH CENTRAL TEXAS (L) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Three Brackish Groundwater Desalination (Wilcox Aquifer) projects would provide a total of up to 42,220 acre-feet per year of water in the year 2060 with a capital cost of $378 million.
- Hays/Caldwell Public Utility Agency Project would provide up to 33,314 acre-feet per year of groundwater (Carrizo Aquifer) in 2060 with a capital cost of $308 million.
- Guadalupe-Blanco River Authority Mid-Basin Project would provide 25,000 acre-feet per year of Guadalupe run-of-river supplies stored in an off-channel reservoir starting in 2020 with a capital cost of $547 million.
- Off-channel reservoir project (Lower Colorado River Authority/San Antonio Water System) would provide 90,000 acre-feet per year of water starting in 2030 with a capital cost of $2 billion.
- Recycled Water Programs would provide up to 41,737 acre-feet per year of water in 2060 with a capital cost of $465 million.
- Seawater Desalination Project would provide 84,012 acre-feet per year of water in 2060 with a capital cost of $1.3 billion.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed five region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#l.

- Lower Guadalupe Water Supply Project for Guadalupe-Blanco River Authority Needs
- Brackish Groundwater Supply Evaluation
- Enhanced Water Conservation, Drought Management, and Land Stewardship
- Environmental Studies
- Environmental Evaluations of Water Management Strategies

## SOUTH CENTRAL TEXAS PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

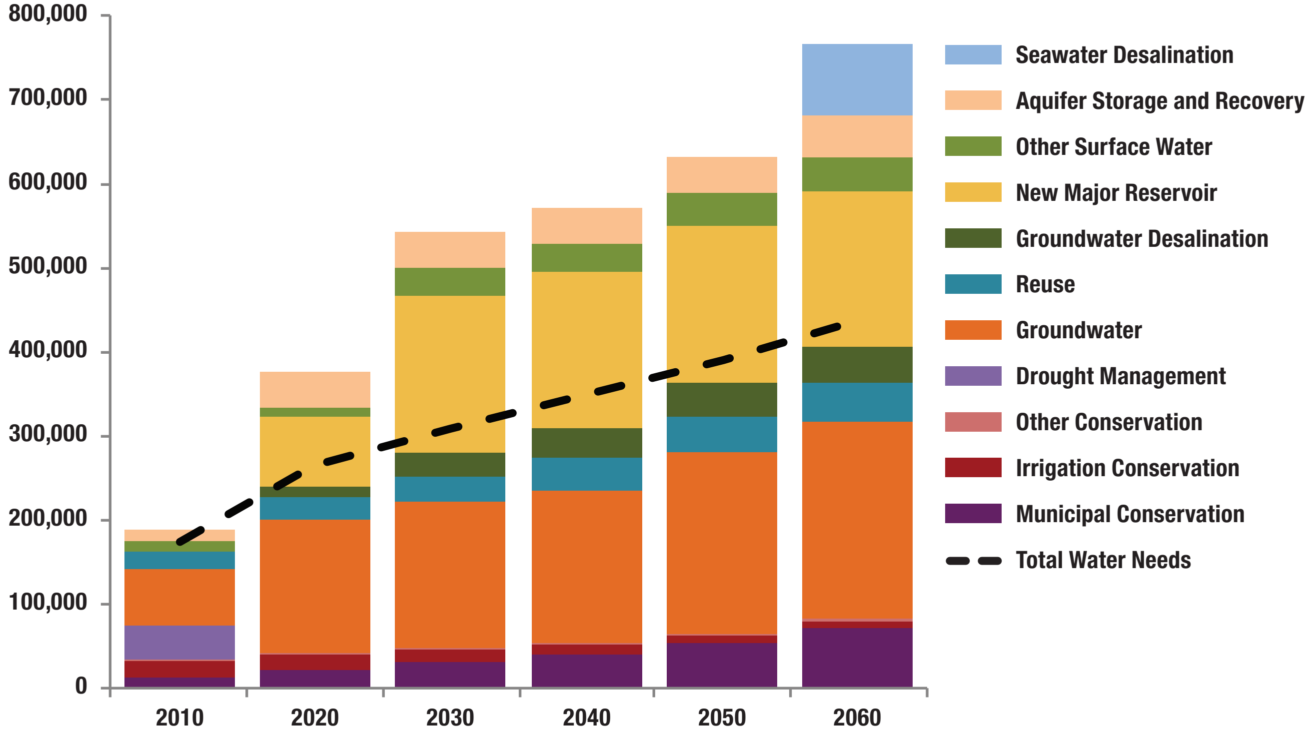
*Voting members during adoption of the 2011 Regional Water Plan:*

Con Mims (Chair), river authorities; Jason Ammerman, industries; Tim Andruss, water districts; Donna Balin, environmental; Evelyn Bonavita, public; Darrell Brownlow, Ph.D., small business; Velma Danielson, water districts; Garrett Engelking, water districts; Mike Fields, electric generating utilities; Bill Jones, agriculture; John Kight, counties; David Langford, agriculture; Mike Mahoney, water districts; Gary Middleton, municipalities; Jay Millikin, counties; Ron Naumann, water utilities; Illiana Pena, environmental; Robert Puente, municipalities; Steve Ramsey, water utilities; Suzanne B. Scott, river authorities; Milton Stolte, agriculture

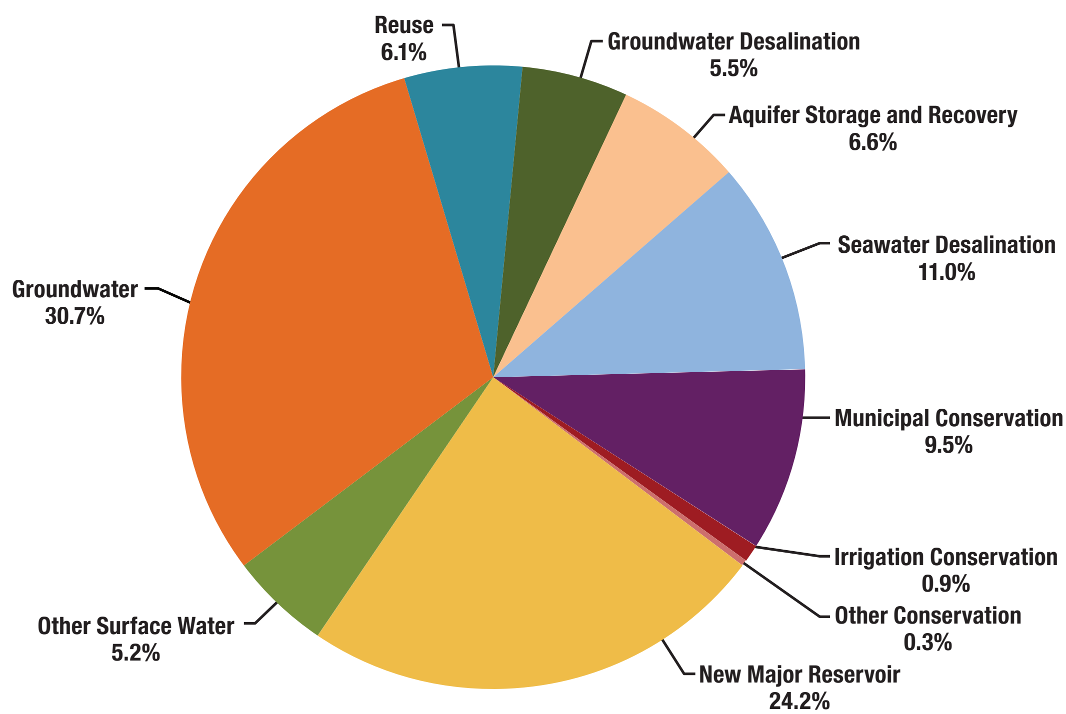
*Former voting members during the 2006 – 2011 planning cycle:*

Doug Miller, small business; David Chardavoynne, municipalities; Gil Olivares, water districts

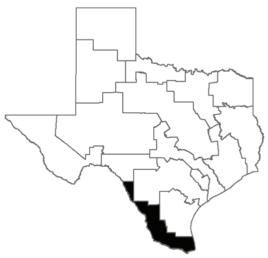
## FIGURE L.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE L.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Rio Grande (M) Region



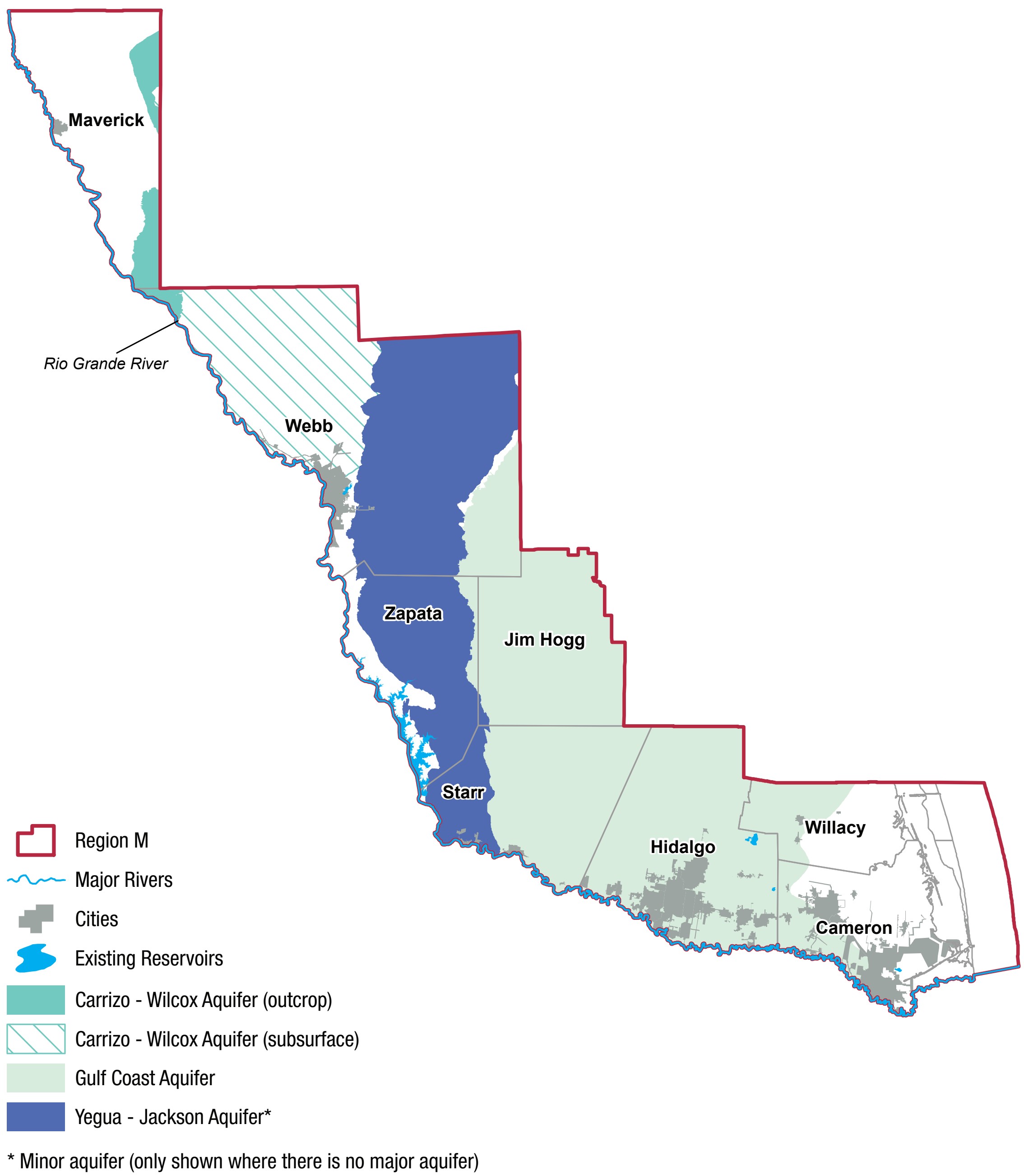
**The Rio Grande Regional Water Planning Area includes eight counties, with over 60 percent of the region lying within the Rio Grande Basin.**

The Rio Grande Regional Water Planning Area includes eight counties, with over 60 percent of the region lying within the Rio Grande Basin (Figure M.1). Its major cities include Brownsville, McAllen, and Laredo. The international reservoirs of the Rio Grande are the region's primary source of water. Portions of two major aquifers, the Gulf Coast and the Carrizo-Wilcox, lie under a large portion of the Rio Grande Region. The largest economic sectors in the region are agriculture, trade, services, manufacturing, and hydrocarbon production. The 2011 Rio Grande (M) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionM/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—609,906 acre-feet per year
- Recommended water management strategy volume in 2060—673,846 acre-feet per year
- Total capital cost—$2.2 billion
- Conservation accounts for 43 percent of 2060 strategy volumes
- Two new major reservoirs (Brownsville Weir, Laredo Low Water Weir)
- Significant unmet irrigation needs

## FIGURE M.1. RIO GRANDE (M) REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

Approximately 6 percent of the state's total population resided in the Rio Grande Region in the year 2010, and between 2010 and 2060 the regional population is projected to increase 142 percent (Table M.1). By 2060, the total water demands for the region are projected to increase 13 percent (Table M.1). Agricultural irrigation water demand makes up the largest share of these demands in all decades and is projected to decrease 16 percent over the planning period due largely to urbanization (Table M.1, Figure M.2). Municipal water demand, however, is projected to increase 124 percent and county-other demand 126 percent by 2060.

## EXISTING WATER SUPPLIES

Surface water provides over 90 percent of the region's water supply. The principal surface water source is the Rio Grande, its tributaries, and two major international reservoirs, one of which is located upstream above the planning area's northern boundary. The United States' share of the firm yield of these reservoirs is over 1 million acre-feet; however, sedimentation will reduce that yield by 3 percent (about 31,000 acre-feet of existing supply) over the planning period. About 87 percent of the United States' surface water rights in the international reservoirs go to the lower two counties in the planning area, Cameron and Hidalgo. There are two major aquifers in the region: the Carrizo-Wilcox and Gulf Coast. A large portion of the groundwater found in Region M's portion of the Gulf Coast Aquifer is brackish. By 2060, the total surface water and groundwater supply is projected to decline 2 percent (Table M.1, Figure M.2).

## NEEDS

The region's surface water supplies from the Rio Grande depend on an operating system that guarantees municipal and industrial users' supplies over other categories (particularly agriculture). Thus, the total water supply volume is not accessible to all water users throughout the region, resulting in significant water needs occurring during drought across the region. In the event of drought conditions, total water needs of 435,922 acre-feet could have occurred across the region as early as 2010, and by 2060 these water needs are projected to increase to 609,906 acre-feet. The majority of the Rio Grande Region water needs are associated with irrigation and municipal uses. Irrigation accounted for 93 percent of the Rio Grande Region's total water needs in 2010 and is projected to decrease to 42 percent by 2060. During the same time period, municipal water needs increase from 6 percent to 54 percent of the region's total water needs. (Table M.1, Figure M.2).

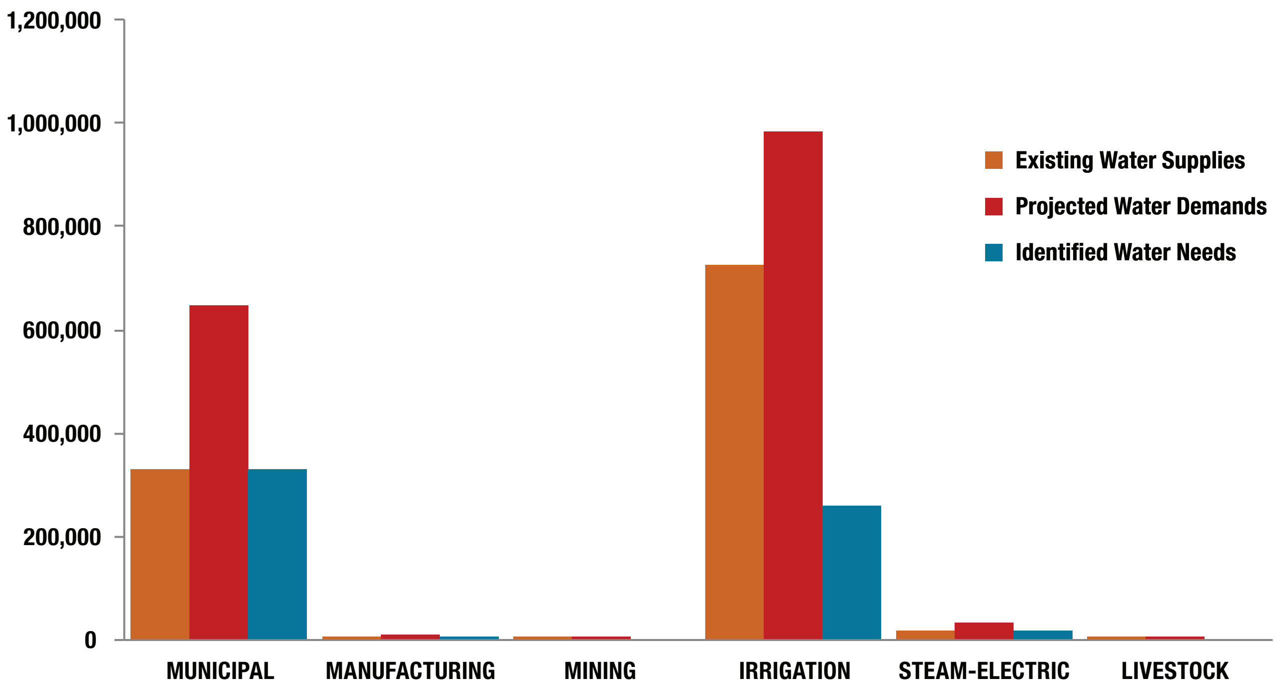
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Rio Grande Planning Group recommended a variety of water management strategies to meet future needs including municipal and irrigation conservation, reuse, groundwater development, desalination, and surface water reallocation (Figures M.3 and M.4). The total needs for Region M are projected to decrease between 2010 and 2030 due to the rate of irrigation demand decrease being larger than the rate of municipal demand increase. However, after the year 2030 the rate of change for increasing municipal demand surpasses that of the decreasing irrigation demand resulting in the steady increase of total needs through the year 2060. Implementation of the recommended strategies will meet all regional needs (including all the needs associated with municipalities) for water users identified in the plan except for a significant portion of the region's irrigation needs, for which no economically feasible strategies were identified. This is estimated to be up to 394,896 acre-feet of unmet irrigation needs in 2010. In all, the recommended strategies would provide over 673,846 acre-feet of additional water supply by the year 2060 at a total capital cost of $2.2 billion (Appendix A).

## TABLE M.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 1,628,278 | 2,030,994 | 2,470,814 | 2,936,748 | 3,433,188 | 3,935,223 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 1,008,597 | 1,002,180 | 996,295 | 990,244 | 983,767 | 977,867 |
| Groundwater | 81,302 | 84,650 | 86,965 | 87,534 | 87,438 | 87,292 |
| Reuse | 24,677 | 24,677 | 24,677 | 24,677 | 24,677 | 24,677 |
| **Total Water Supplies** | **1,114,576** | **1,111,507** | **1,107,937** | **1,102,455** | **1,095,882** | **1,089,836** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 259,524 | 314,153 | 374,224 | 438,453 | 508,331 | 581,043 |
| County-other | 28,799 | 35,257 | 42,172 | 49,405 | 57,144 | 64,963 |
| Manufacturing | 7,509 | 8,274 | 8,966 | 9,654 | 10,256 | 11,059 |
| Mining | 4,186 | 4,341 | 4,433 | 4,523 | 4,612 | 4,692 |
| Irrigation | 1,163,634 | 1,082,232 | 981,748 | 981,748 | 981,748 | 981,748 |
| Steam-electric | 13,463 | 16,864 | 19,716 | 23,192 | 27,430 | 32,598 |
| Livestock | 5,817 | 5,817 | 5,817 | 5,817 | 5,817 | 5,817 |
| **Total Water Demands** | **1,482,932** | **1,466,938** | **1,437,076** | **1,512,792** | **1,595,338** | **1,681,920** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 20,889 | 53,849 | 98,933 | 154,514 | 221,595 | 292,700 |
| County-other | 5,590 | 10,428 | 16,786 | 23,491 | 30,698 | 37,925 |
| Manufacturing | 1,921 | 2,355 | 2,748 | 3,137 | 3,729 | 4,524 |
| Irrigation | 407,522 | 333,246 | 239,408 | 245,896 | 252,386 | 258,375 |
| Steam-electric | 0 | 1,980 | 4,374 | 7,291 | 11,214 | 16,382 |
| **Total Water Needs** | **435,922** | **401,858** | **362,249** | **434,329** | **519,622** | **609,906** |

## FIGURE M.2. 2060 RIO GRANDE (M) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

Conservation strategies for municipal and irrigation water users account for approximately 43 percent of the water associated with the region's recommended strategies. Irrigation conservation strategies account for the majority of these savings, through Best Management Practices including water district conveyance system improvements and on-farm conservation practices. Municipal water conservation was recommended for almost all municipal water user groups with a need. Conservation was also recommended for several communities that do not anticipate a municipal water need during the planning horizon.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Acquisition of water rights through purchase is projected to provide up to 151,237 acre-feet per year of water in the year 2060 with a capital cost of $631 million.
- Brackish Groundwater Desalination is expected to provide up to 92,212 acre-feet per year of water in 2060 with a capital cost of $267 million.
- Brownsville Weir and Reservoir is projected to provide up to 23,643 acre-feet per year of surface water in 2060 at a capital cost of $98 million.
- Seawater Desalination is projected to provide up to 7,902 acre-feet per year of water in 2060 at a capital cost of $186 million.
- Irrigation Conveyance System Conservation is expected to provide up to 139,217 acre-feet per year of water in 2060 at a capital cost of $132 million.

## REGION-SPECIFIC STUDIES

The Rio Grande Regional Water Planning Group developed three region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#m.

- Evaluation of Alternate Water Supply Management Strategies Regarding the Use and Classification of Existing Water Rights on the Lower and Middle Rio Grande
- Classify Irrigation Districts as Water User Groups
- Analyze Results of Demonstration Projects

## RIO GRANDE PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

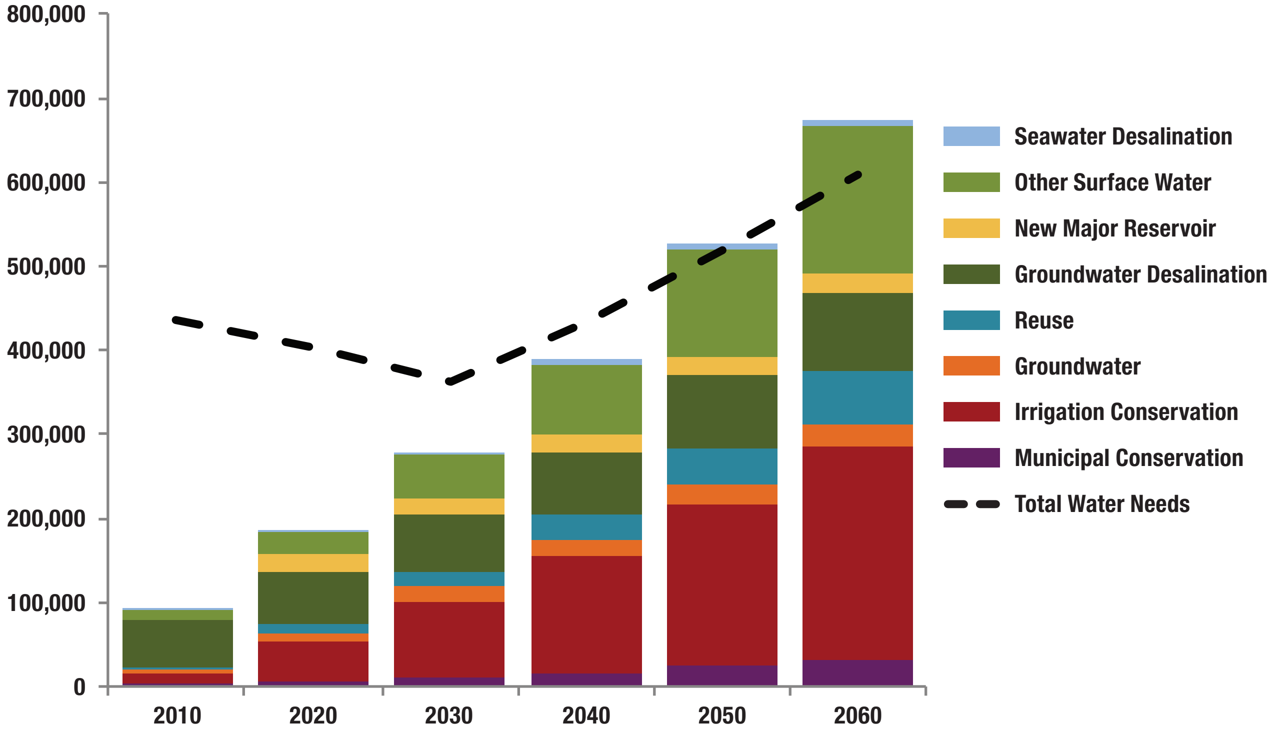
*Voting members during adoption of the 2011 Regional Water Plan:*

Glenn Jarvis (Chair), other; Jorge Barrera, municipalities; John Bruciak, municipalities; Mary Lou Campbell, public; James (Jim) Darling, river authorities; Ella de la Rosa, electric generating utilities; Robert E. Fulbright, agriculture; Carlos Garza, small business; Dennis Goldsberry, water utilities; Joe Guerra, electric generating utilities; Sonny Hinojosa, water districts; Sonia Lambert, water districts; Donald K. McGhee, small business/industries; Sonia Najera, environmental; Ray Prewett, agriculture; Tomas Rodriguez, Jr., municipalities; Gary Whittington, industries/other; John Wood, counties

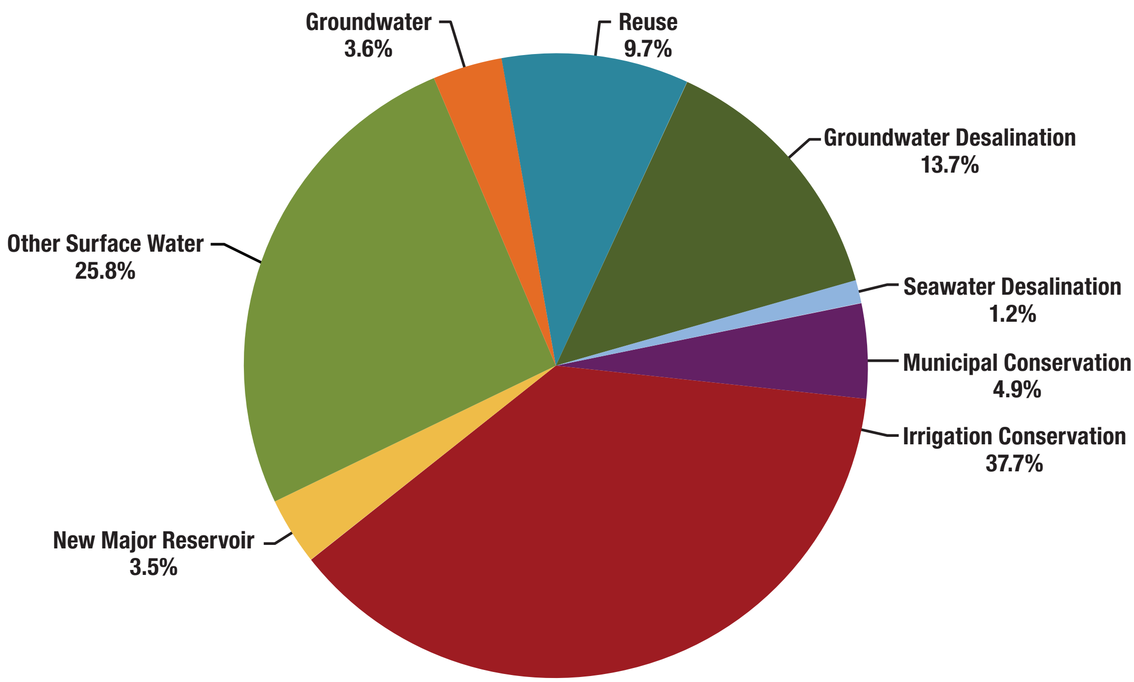
*Former voting members during the 2006 – 2011 planning cycle:*

Jose Aranda, counties; Charles (Chuck) Browning, water utilities; Karen Chapman, environmental; Kathleen Garrett, electric generating utilities; Robert Gonzales, municipalities; James R. Matz, other; Adrian Montemayor, municipalities; Xavier Villarreal, small business

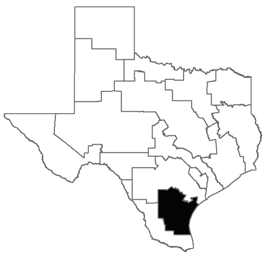
## FIGURE M.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE M.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Coastal Bend (N) Region



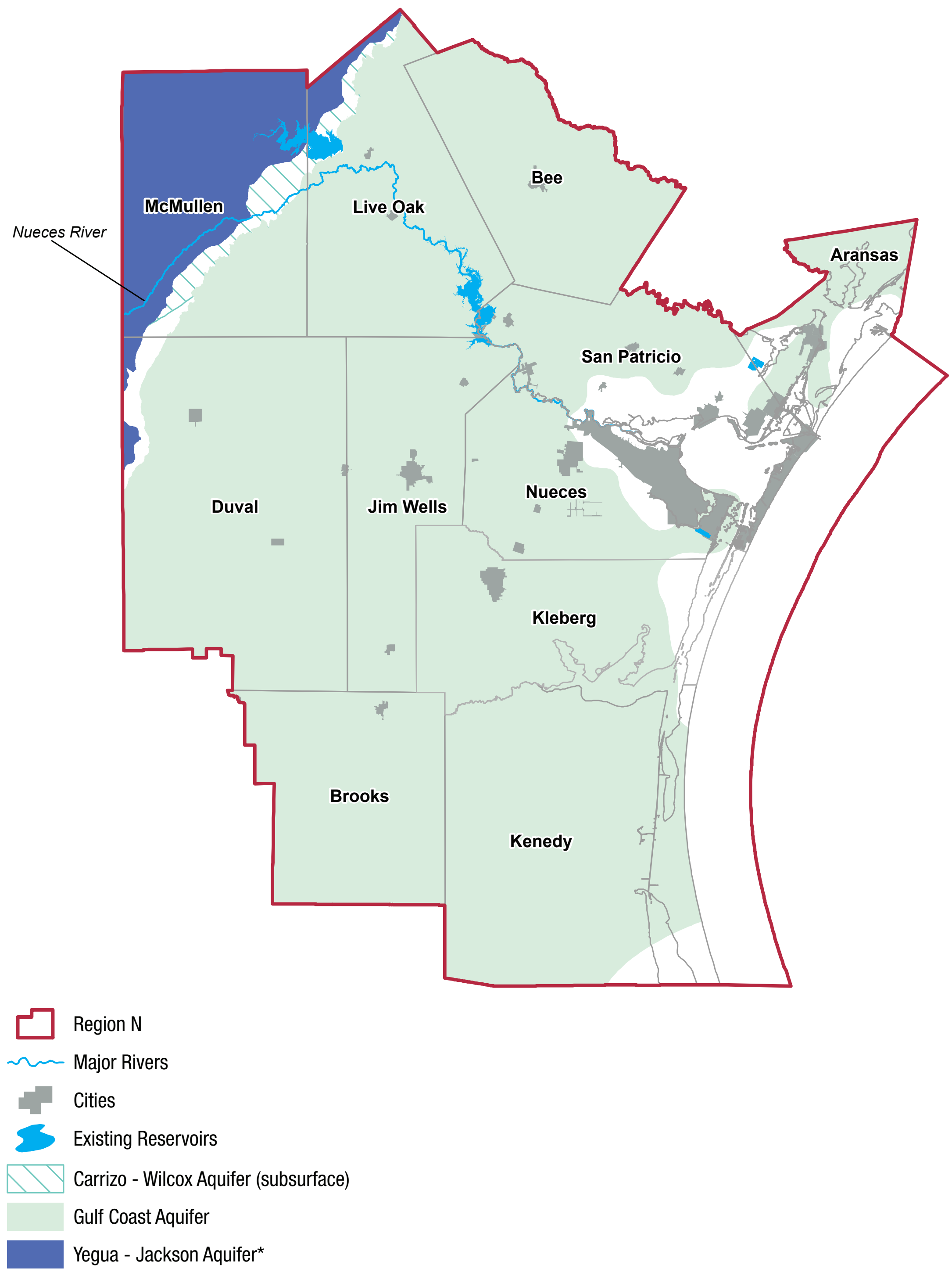
## The Coastal Bend Regional Water Planning Area includes 11 counties, portions of the Nueces River Basin, and its adjoining coastal basins, including the Nueces Estuary.

The Coastal Bend Regional Water Planning Area includes 11 counties, portions of the Nueces River Basin, and its adjoining coastal basins, including the Nueces Estuary (Figure N.1). The region's largest economic sectors are service industries, retail trade, government, construction, manufacturing, and the petrochemical industry. Corpus Christi is the region's largest metropolitan area. The 2011 Coastal Bend (N) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionN/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—75,744 acre-feet per year
- Recommended water management strategy volume in 2060—156,326 acre-feet per year
- Total capital cost—$656 million
- Conservation accounts for 5 percent of 2060 strategy volumes
- Two new major reservoirs (Lavaca Off-Channel, Nueces Off-Channel)
- Limited unmet mining needs

## FIGURE N.1. COASTAL BEND (N) REGIONAL WATER PLANNING AREA.




* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 3 percent of the state's total 2010 population resided in the Coastal Bend Region, and between 2010 and 2060 population is projected to increase by 44 percent to 885,665 (Table N.1). Ninety-three percent of this population growth is projected to occur in Nueces and San Patricio counties. By 2060, the total water demands for the region are projected to increase by 40 percent (Table N.1, Figure N.2). Municipal water use makes up the largest share of these demands in all decades and is projected to increase about 40 percent over the planning period. Rural municipal demand projections, represented by county-other, reflect a slight decrease as municipalities are anticipated to annex some of these rural areas. Manufacturing demands are also expected to grow significantly, increasing 38 percent. Though not the largest volumetric increase in the region, steam-electric demands are projected to increase 278 percent. Projected steam-electric demand increases are attributed to increased generating capacity in Nueces County.

## EXISTING WATER SUPPLIES

Over three-fourths of the region's existing water supply is associated with surface water resources (Table N.1, Figure N.2). The majority of those supplies are provided by Nueces River Basin streamflows together with reservoirs in the Nueces River Basin and interbasin transfers from the Lavaca Region. The region relies on significant amounts of surface water transferred from the Lavaca River Basin. The two major (Gulf Coast and Carrizo-Wilcox) and two minor (Queen City and Sparta) aquifers provide groundwater to numerous areas within the region. As the primary groundwater source, the Gulf Coast Aquifer underlies at least a portion of every county in the region. Existing surface water supply is projected to increase as a result of future increases in existing water supply contracts from the Lake Corpus Christi-Choke Canyon Reservoir System.

## NEEDS

The Coastal Bend Region faces water supply needs as early as 2010 in the event of drought (Table N.1, Figure N.2). Mining use accounts for approximately half of the 2010 needs (about 1,800 acre-feet). By the year 2060, the needs are dominated by manufacturing needs.

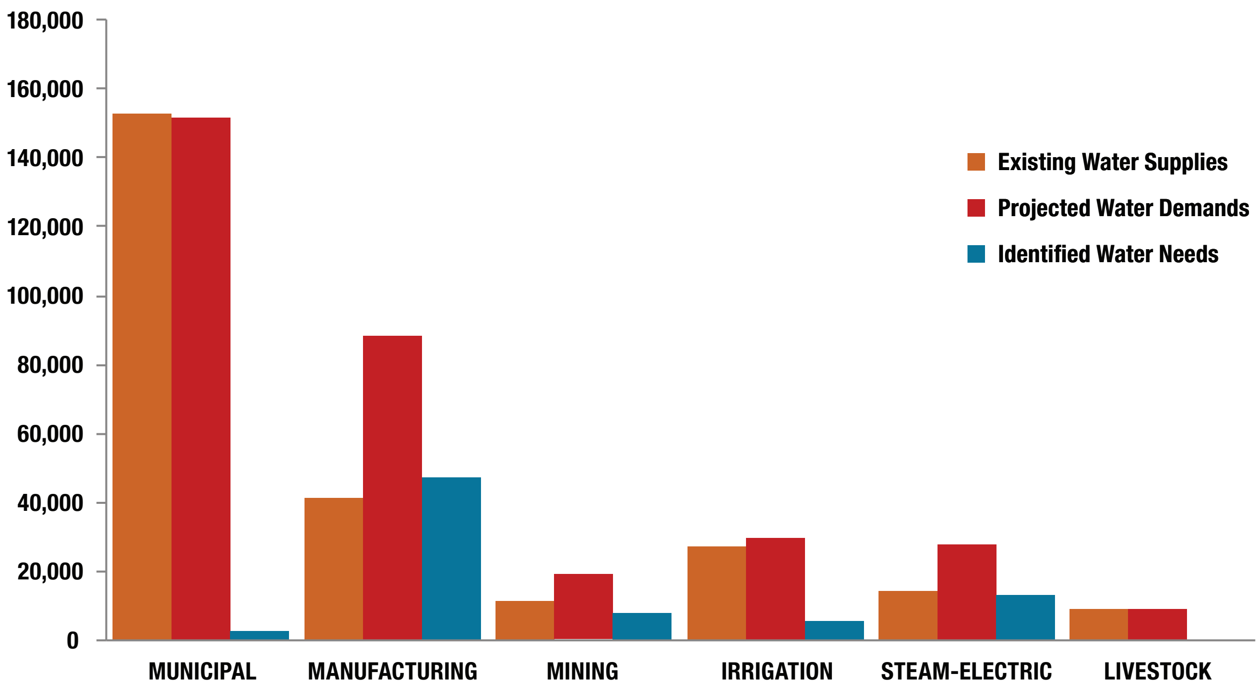
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Coastal Bend Regional Water Planning Group recommended a variety of water management strategies to meet future needs including two proposed off-channel reservoirs, groundwater development, interbasin transfers of surface water from the Colorado River Basin, and conservation. Implementing all recommended strategies in the Coastal Bend plan would result in 156,326 acre-feet of additional water supplies in 2060 (Figures N.3 and N.4) at a total capital cost of $656.1 million (Appendix A). Implementation of these strategies would meet all projected water needs in the region except for 3,876 acre-feet of mining needs in 2060 that would be unmet because no feasible strategies were identified.

## TABLE N.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 617,143 | 693,940 | 758,427 | 810,650 | 853,964 | 885,665 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 186,866 | 191,078 | 195,658 | 197,472 | 197,994 | 198,814 |
| Groundwater | 57,580 | 58,951 | 58,442 | 58,522 | 58,237 | 57,624 |
| **Total Water Supplies** | **244,446** | **250,029** | **254,100** | **255,994** | **256,231** | **256,438** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 100,231 | 111,366 | 120,543 | 128,115 | 134,959 | 140,636 |
| County-other | 11,264 | 11,495 | 11,520 | 11,310 | 11,077 | 10,838 |
| Manufacturing | 63,820 | 69,255 | 73,861 | 78,371 | 82,283 | 88,122 |
| Mining | 15,150 | 16,524 | 16,640 | 17,490 | 18,347 | 19,114 |
| Irrigation | 25,884 | 26,152 | 26,671 | 27,433 | 28,450 | 29,726 |
| Steam-electric | 7,316 | 14,312 | 16,733 | 19,683 | 23,280 | 27,664 |
| Livestock | 8,838 | 8,838 | 8,838 | 8,838 | 8,838 | 8,838 |
| **Total Water Demands** | **232,503** | **257,942** | **274,806** | **291,240** | **307,234** | **324,938** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 138 | 256 | 366 | 464 | 550 | 627 |
| County-other | 428 | 301 | 387 | 363 | 1,890 | 1,768 |
| Manufacturing | 409 | 7,980 | 15,859 | 25,181 | 34,686 | 46,905 |
| Mining | 1,802 | 2,996 | 4,471 | 6,166 | 6,897 | 7,584 |
| Irrigation | 627 | 569 | 1,264 | 2,316 | 3,784 | 5,677 |
| Steam-electric | 0 | 1,982 | 4,755 | 7,459 | 10,187 | 13,183 |
| **Total Water Needs** | **3,404** | **14,084** | **27,102** | **41,949** | **57,994** | **75,744** |

## FIGURE N.2. 2060 COASTAL BEND (N) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

Conservation strategies represent approximately 5 percent of the total amount of water that would be provided by all recommended water management strategies in 2060. Conservation strategies were recommended for municipal, irrigation, manufacturing, and mining water users. The Coastal Bend Region recommended that water user groups with and without shortages that exceed 165 gallons per capita per day should reduce consumption by 15 percent by 2060.

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- O.N. Stevens Water Treatment Plant Improvements would provide up to 42,329 acre-feet per year of surface water starting in 2010 with a capital cost of $31 million.
- Garwood Pipeline would provide 35,000 acre-feet per year of surface water starting in 2020 with a capital cost of $113 million.
- Off–Channel Reservoir near Lake Corpus Christi would provide 30,340 acre-feet per year of water starting in the year 2030 with a capital cost of $301 million
- Construction of Lavaca River Off-Channel Diversion and Off-Channel Reservoir Project would provide 16,242 acre-feet per year of water to Region N in 2060 with a capital cost of $139 million for Region N's portion of total project costs.

## REGION-SPECIFIC STUDIES

The Regional Water Planning Group developed five region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web-site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#n.

- Evaluation of Additional Potential Regional Water Supplies for Delivery through the Mary Rhodes Pipeline, Including Gulf Coast Groundwater and Garwood Project
- Optimization and Implementation Studies for Off-Channel Reservoir
- Implementation Analyses for Pipeline from Choke Canyon Reservoir to Lake Corpus Christi, Including Channel Loss Study Downstream of Choke Canyon Reservoir
- Water Quality Modeling of Regional Water Supply System to Enhance Water Quality and Improve Industrial Water Conservation
- Region-Specific Water Conservation Best Management Practices

## COASTAL BEND PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

*Voting members during adoption of the 2011 Regional Water Plan:*

Carola Serrato (Co-Chair) water utilities; Scott Bledsoe, III (Co-Chair), water districts; Tom Ballou, industries; Chuck Burns, agriculture; Teresa Carrillo, environmental; Billy Dick, municipalities; Lavoyger Durham, counties; Gary Eddins, electric generating utilities; Pancho Hubert, small business; Pearson Knolle, small business; Robert Kunkel, industries; Bernard Paulson, other; Thomas Reding, Jr., river authorities; Charles Ring, agriculture; Mark Scott, municipalities; Kimberly Stockseth, public ; Bill Stockton, counties

*Former voting members during the 2006 – 2011 planning cycle:*

Bill Beck, electric generating utilities; Patrick Hubert, small business; Josephine Miller, counties; Bobby Nedbalek, agriculture

FIGURE N.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).

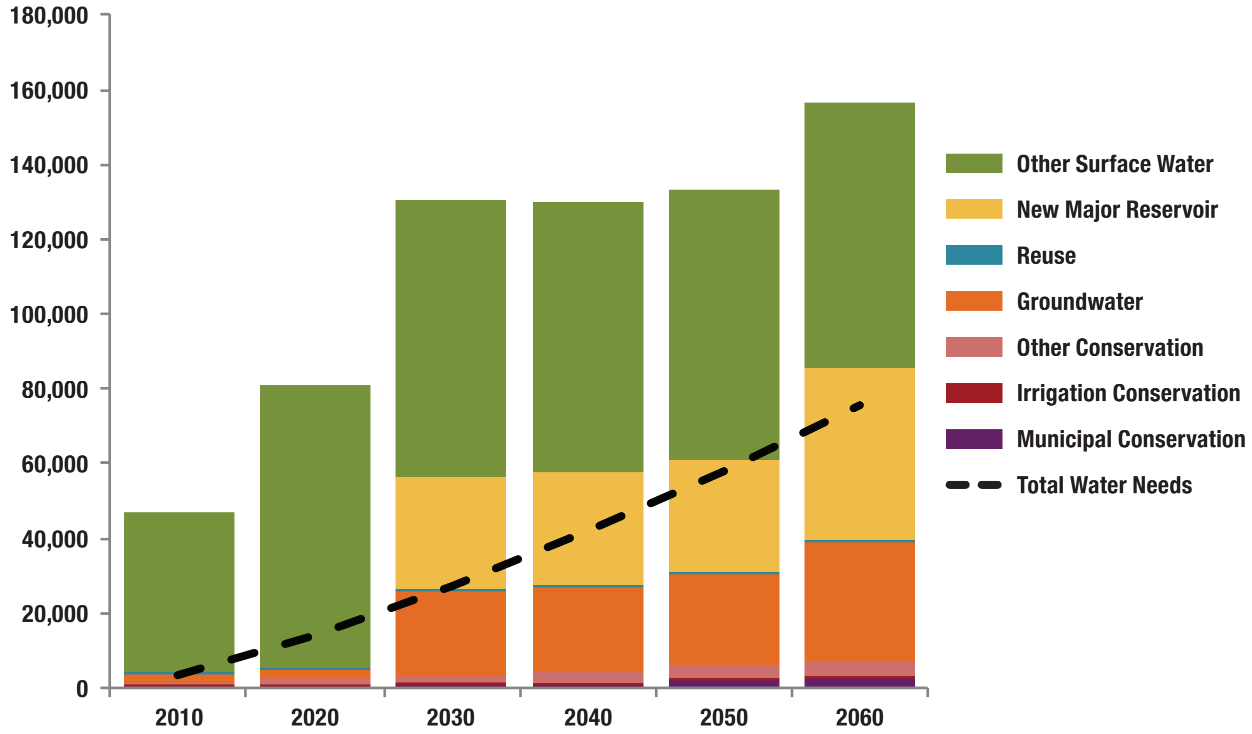
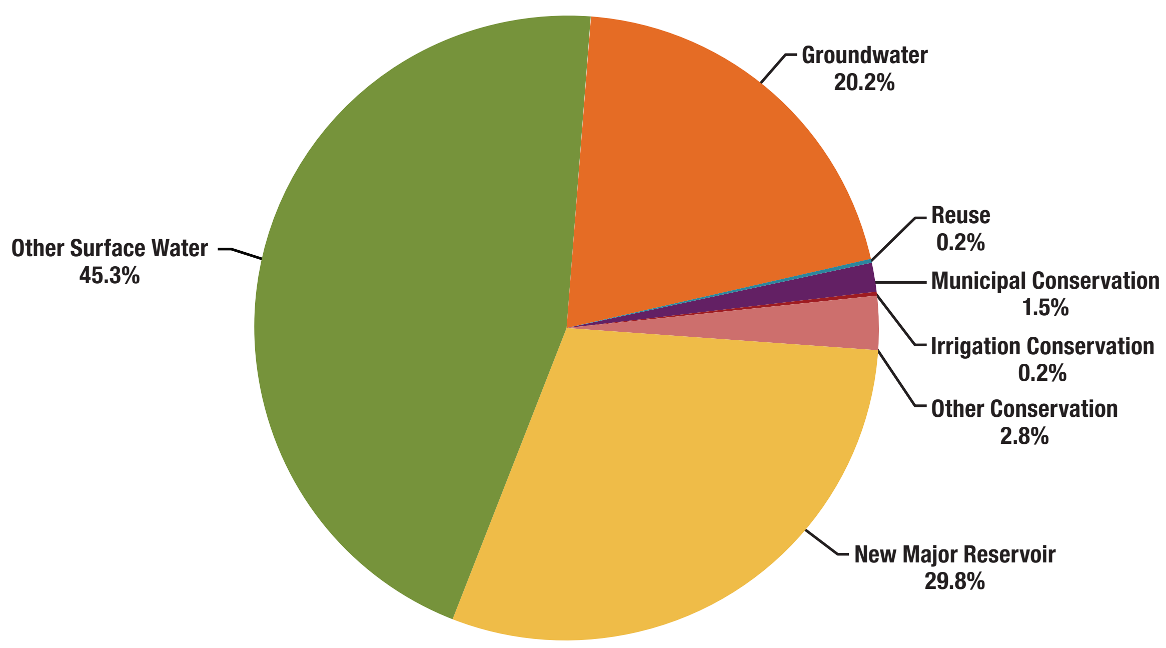
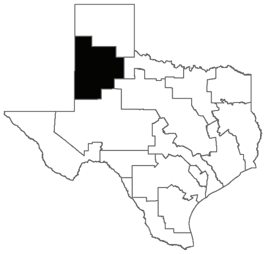



FIGURE N.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Llano Estacado (O) Region



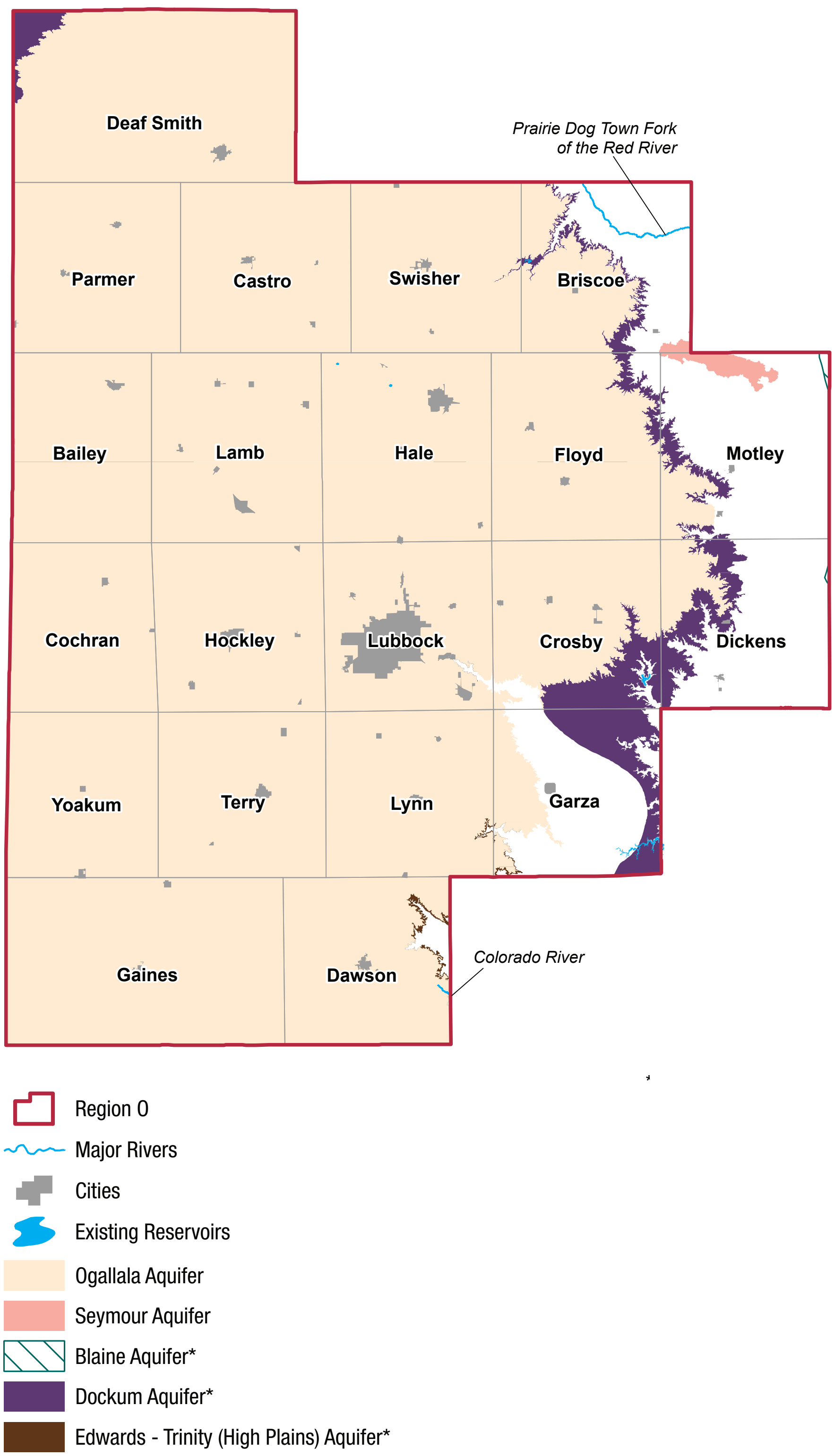
**The Llano Estacado Regional Water Planning Area encompasses 21 counties in the southern High Plains of Texas.**

The Llano Estacado Regional Water Planning Area encompasses 21 counties in the southern High Plains of Texas (Figure O.1). The region lies within the upstream parts of four major river basins (Canadian, Red, Brazos, and Colorado). Groundwater from the Ogallala Aquifer is the region's primary source of water and is used at a rate that exceeds recharge. The largest economic sectors in the region are livestock and crop operations, producing about 60 percent of the state's total cotton crop. Major cities in the region include Lubbock, Plainview, Levelland, Lamesa, Hereford, and Brownfield. The 2011 Region O Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionO/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—2,366,036 acre-feet per year
- Recommended water management strategy volume in 2060—395,957 acre-feet per year
- Total capital cost—$1.1 billion
- Conservation accounts for 74 percent of 2060 strategy volumes
- Two new major reservoirs (Jim Bertram Lake 07, Post)
- Significant unmet irrigation and livestock needs

## FIGURE O.1. LLANO ESTACADO (O) REGIONAL WATER PLANNING AREA.




* Minor aquifer (only shown where there is no major aquifer)

## POPULATION AND WATER DEMANDS

Approximately 2 percent of the state's total population resided in the Llano Estacado Region in 2010, and by the year 2060 is projected to increase 12 percent (Table O.1). The region's water demands, however, will decrease. By 2060, the total water demands for the region are projected to decrease 15 percent because of declining irrigation water demands (Table O.1). Irrigation demand is projected to decline 17 percent by 2060 due to declining well yields and increased irrigation efficiencies. Municipal water use, however, increases 7 percent by 2060 (Table O.1, Figure O.2).

## EXISTING WATER SUPPLIES

The Llano Estacado Planning Region depends primarily upon groundwater from the Ogallala Aquifer, with 97 percent of the region's supply in 2010 coming from this source. Approximately 94 percent of the water obtained from the aquifer is used for irrigation purposes. Other aquifers in the region (Seymour, Dockum, and Edwards-Trinity [High Plains]) constitute less than 1 percent of the supply. Surface water is supplied by White River Lake and Lake Meredith. Of these reservoirs, Lake Meredith, operated by the Canadian River Municipal Water Authority in the Panhandle Region, is the largest contributor. By 2060, the total surface water and groundwater supply is projected to decline 56 percent (Table O.1, Figure O.2). This projected decline in water supply is due to the managed depletion of the Ogallala Aquifer.

## NEEDS

During times of drought, increased demands require pumping that exceeds the capacity of the Ogallala Aquifer, resulting in water needs occurring across the region as early as 2010. The needs for the Llano Estacado Region are projected to increase 86 percent by 2060 (Table O.1, Figure O.2). The plan identifies needs for irrigation of 1,264,707 acre-feet in 2010 and 2,318,004 acre-feet in 2060. Municipal needs also increase significantly, to 30,458 acre-feet in 2060.

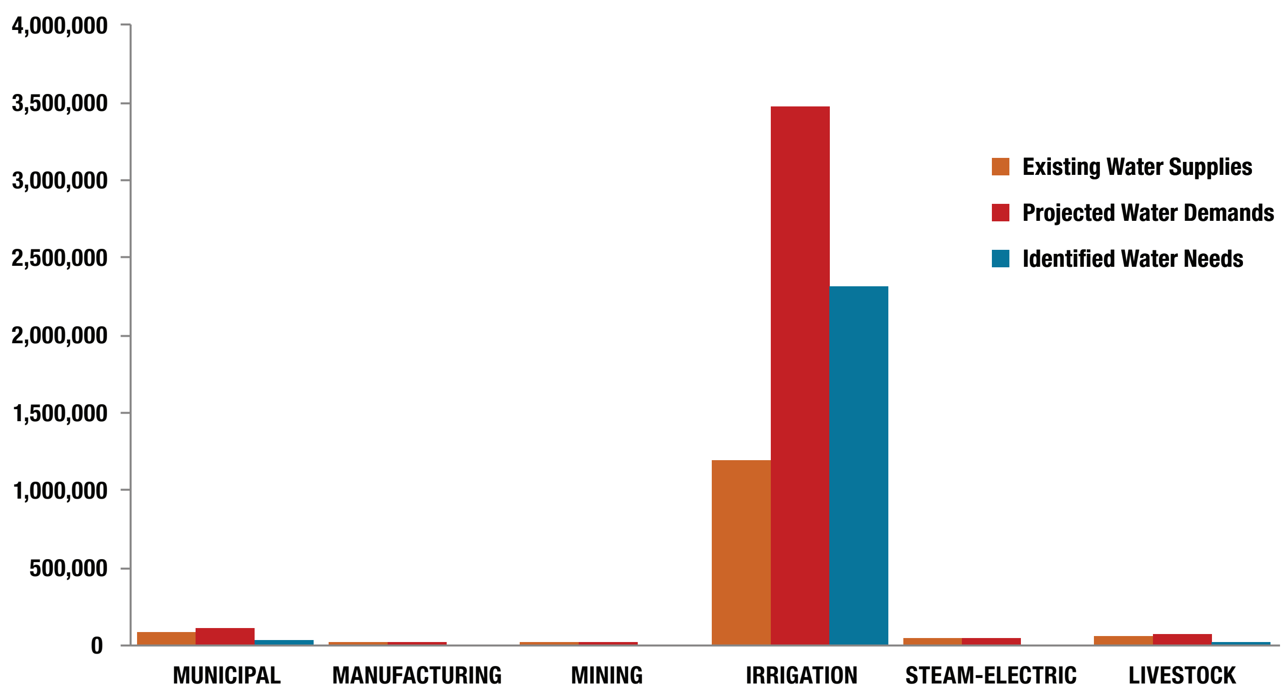
## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Llano Estacado Planning Group recommended a variety of water management strategies, providing 395,957 acre-feet of additional water supply by the year 2060 (Figures O.3 and O.4) at a total capital cost of $1.1 billion (Appendix A). The primary recommended water management strategy for the region is irrigation water conservation, which generates 72 percent of the volume of water from strategies in 2060, based on approximately 786,000 acres of irrigated crop land that did not have efficient irrigation systems. Unmet irrigation needs (2,043,247 acre-feet) remain in 21 counties in the region in 2060, because there were no economically feasible strategies identified to meet their needs.

## TABLE O.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| **Projected Population** | 492,627 | 521,930 | 540,908 | 552,188 | 553,691 | 551,758 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 28,261 | 33,707 | 33,590 | 33,490 | 32,096 | 32,042 |
| Groundwater | 3,076,297 | 2,454,665 | 1,966,463 | 1,577,083 | 1,412,889 | 1,337,017 |
| Reuse | 51,514 | 35,071 | 35,822 | 36,737 | 37,853 | 39,213 |
| **Total Water Supplies** | **3,156,072** | **2,523,443** | **2,035,875** | **1,647,310** | **1,482,838** | **1,408,272** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 87,488 | 91,053 | 92,823 | 93,459 | 93,458 | 93,935 |
| County-other | 11,949 | 12,420 | 12,652 | 12,583 | 12,399 | 12,005 |
| Manufacturing | 15,698 | 16,669 | 17,460 | 18,216 | 18,865 | 19,919 |
| Mining | 16,324 | 10,280 | 6,359 | 2,852 | 728 | 258 |
| Irrigation | 4,186,018 | 4,024,942 | 3,882,780 | 3,740,678 | 3,604,568 | 3,474,163 |
| Steam-electric | 25,645 | 25,821 | 30,188 | 35,511 | 42,000 | 49,910 |
| Livestock | 51,296 | 57,740 | 61,372 | 65,277 | 69,466 | 73,965 |
| **Total Water Demands** | **4,394,418** | **4,238,925** | **4,103,634** | **3,968,576** | **3,841,484** | **3,724,155** |
| **Needs (acre-feet per year)** | | | | | | |
| Municipal | 10,349 | 14,247 | 20,116 | 23,771 | 28,489 | 30,458 |
| Irrigation | 1,264,707 | 1,735,399 | 2,084,569 | 2,331,719 | 2,361,813 | 2,318,004 |
| Livestock | 1 | 763 | 3,191 | 9,506 | 14,708 | 17,574 |
| **Total Water Needs** | **1,275,057** | **1,750,409** | **2,107,876** | **2,364,996** | **2,405,010** | **2,366,036** |

## FIGURE O.2. 2060 LLANO ESTACADO (O) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## CONSERVATION RECOMMENDATIONS

Conservation strategies represent 74 percent of the total volume of water associated with all recommended water management strategies in 2060. Water conservation was recommended for every municipal water user group that had both a need and a water use greater than 172 gallons per capita per day (the regional average).

## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Irrigation Water Conservation would provide up to 479,466 acre-feet per year of water in 2010 with a capital cost of $346 million.
- Lake Alan Henry Pipeline for the City of Lubbock would provide 21,880 acre-feet per year of water starting in 2010 with a capital cost of $294 million.
- Post Reservoir would provide 25,720 acre-feet per year of water starting in 2030 with a capital cost of $110 million.

## REGION-SPECIFIC STUDIES

The Llano Estacado Regional Water Planning Group developed three region-specific studies during the initial phase of the third planning cycle. The final reports documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#o.

- Estimates of Population and Water Demands for New Ethanol and Expanding Dairies
- Evaluation of Water Supplies and Desalination Costs of Dockum Aquifer Water
- Video Conferencing Facilities Available for Coordination between Region A and O

## LLANO ESTACADO PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

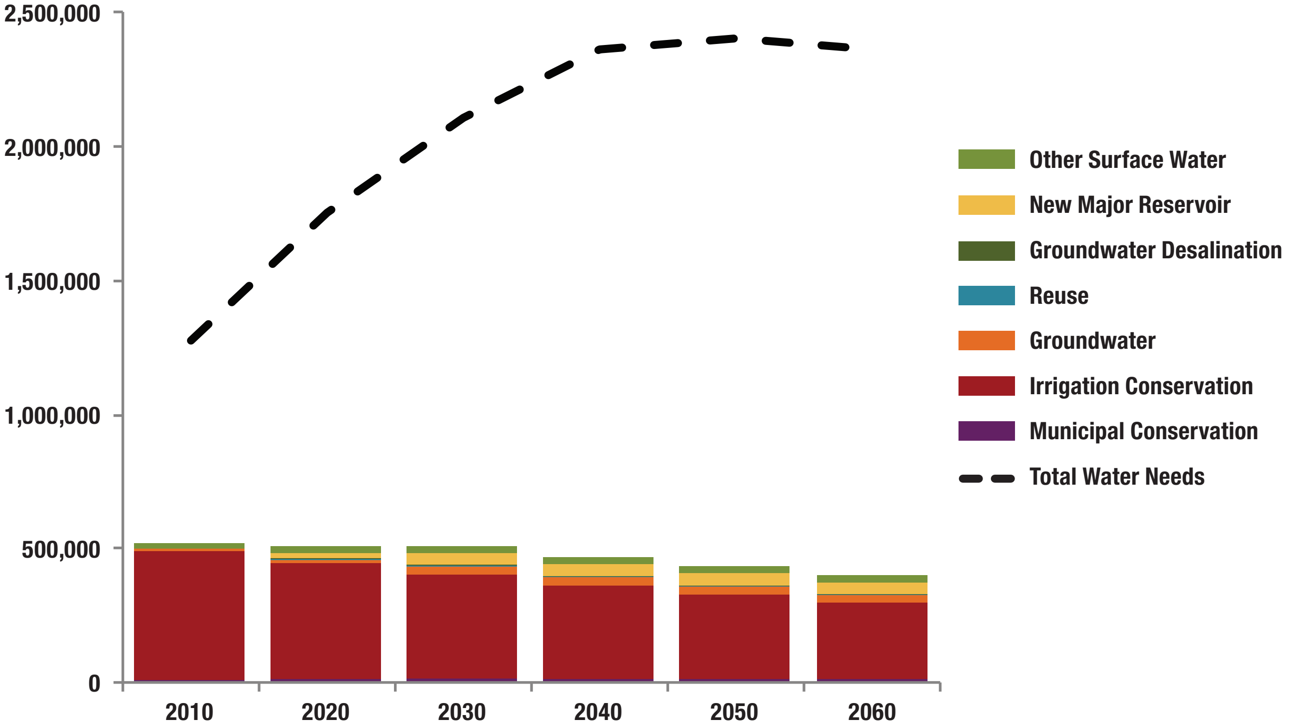
*Voting members during adoption of the 2011 Regional Water Plan:*

Harold P. “Bo” Brown, (Chair), agriculture; Melanie Barnes, public; Delaine Baucum, agriculture; Alan Bayer, counties; Bruce Blalack, municipalities; Jim Conkwright, water districts; Delmon Ellison, Jr., agriculture; Harvey Everheart, water districts; Bill Harbin, electric generating utilities; Doug Hutcheson, water utilities ; Bob Josserand, municipalities; Mark Kirkpatrick, agriculture; Richard Leonard, agriculture; Michael McClendon, river authorities; Don McElroy, small business; E.W. (Gene) Montgomery, industries; Ken Rainwater, public; Kent Satterwhite, river authorities; Aubrey Spear, municipalities; Jim Steiert, environmental; John Taylor, municipalities

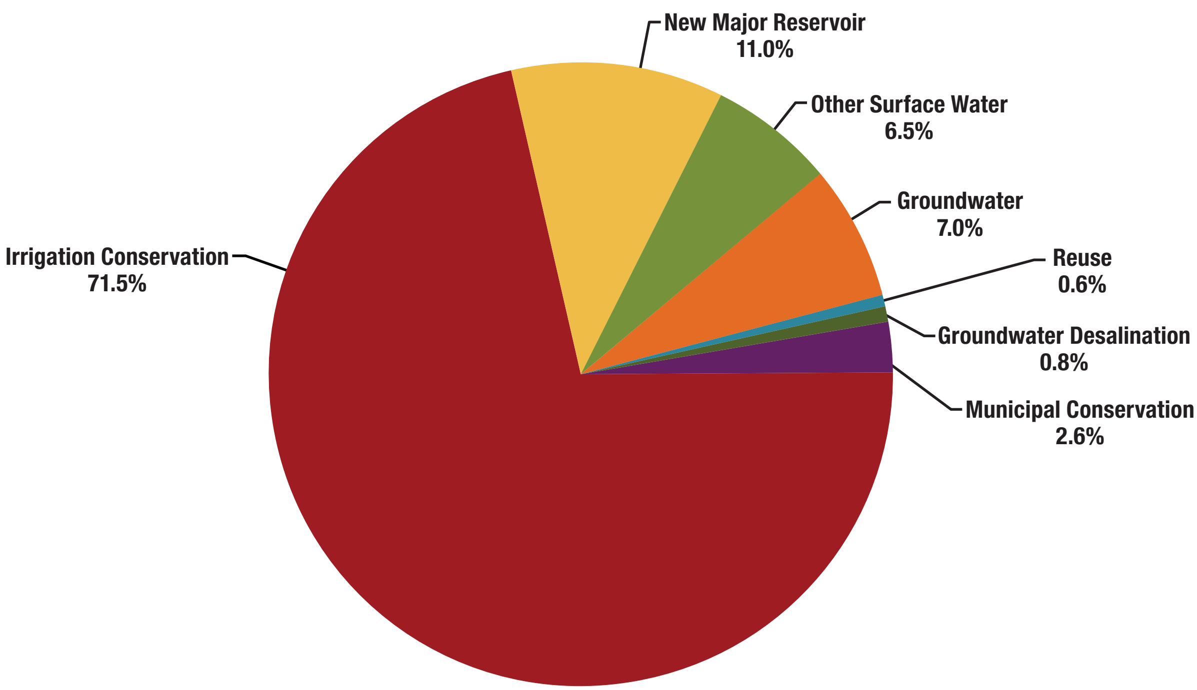
*Former voting members during the 2006 – 2011 planning cycle:*

Tom Adams, municipalities; Jim Barron, counties; Don Ethridge, agriculture; Wayne Collins, municipalities; Terry Lopas, river authorities; Jared Miller, municipalities

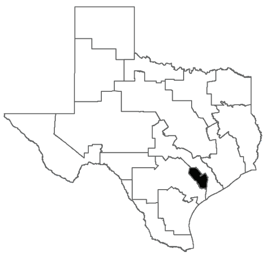
## FIGURE O.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




## FIGURE O.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# 2 Summary of Lavaca (P) Region



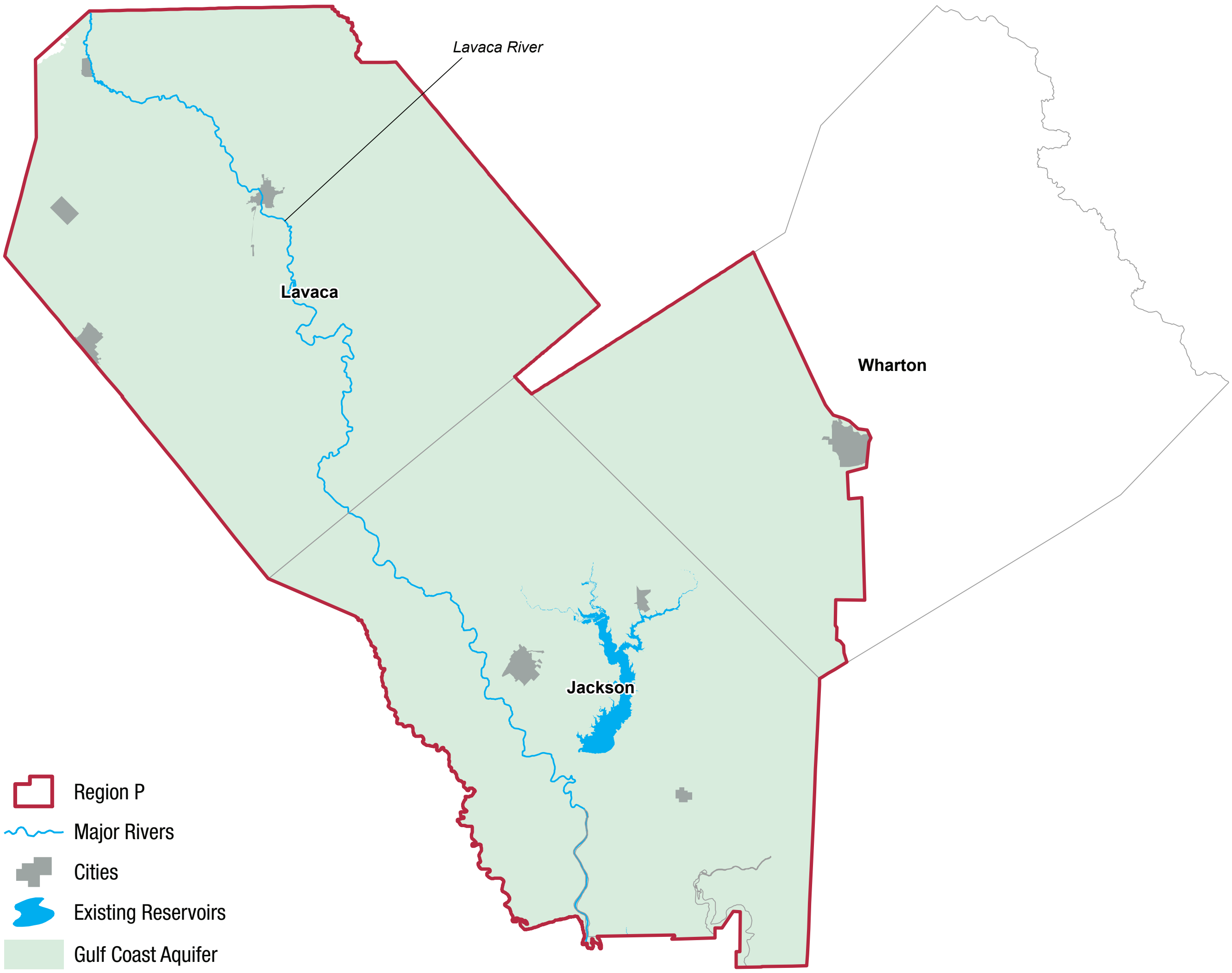
**The Lavaca Regional Water Planning Area is composed of Jackson and Lavaca counties and Precinct Three of Wharton County, including the entire City of El Campo.**

The Lavaca Regional Water Planning Area is composed of Jackson and Lavaca counties and Precinct Three of Wharton County, including the entire City of El Campo (Figure P.1). Other cities in the region include Edna, Yoakum, and Hallettsville. Most of the region lies in the Lavaca River Basin, with the Lavaca and Navidad Rivers being its primary source of surface water. Groundwater from the Gulf Coast Aquifer supplies most of the water for the planning area. The largest economic sector in the region is agribusiness, while manufacturing, oil and gas production, and mineral production also contribute to the region's economy. The 2011 Lavaca (P) Regional Water Plan can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/3rdRound/2011_RWP/RegionP/.

## PLAN HIGHLIGHTS

- Additional supply needed in 2060—67,739 acre-feet per year
- Recommended water management strategy volume in 2060—67,739 acre-feet per year
- Total capital cost—none

## FIGURE P.1. LAVACA REGIONAL WATER PLANNING AREA.



## POPULATION AND WATER DEMANDS

In 2010, less than 1 percent of the state's total population resided in the Lavaca Region, and between 2010 and 2060, population is projected to increase by less than 1 percent (Table P.1). The region's total water demand is projected to increase by less than 1 percent, and agricultural irrigation demand will remain constant (Table P.1). By the year 2060, municipal demand is expected to increase by 5 percent and manufacturing demand is expected to increase by 31 percent, while county-other demands are expected to decrease by 24 percent (Table P.1, Figure P.2).

## EXISTING WATER SUPPLIES

The region relies on the Gulf Coast Aquifer for groundwater supply, which is 99 percent of the total water supply in 2010. The principal surface water supply is Lake Texana, the only reservoir in the region. The total surface water and groundwater supply is projected to remain constant from 2010 to 2060 at 164,148 acre-feet (Table P.1, Figure P.2).

## NEEDS

Irrigation is the only water use sector in the Lavaca Region anticipated to need additional water over the planning horizon (Table P.1, Figure P.2.). In each decade, 67,739 acre-feet of additional water is expected to be needed, when surface water supplies become unavailable due to drought conditions.

## RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST

The Lavaca Planning Group analyzed various strategies to meet needs, but the only one determined to be economically feasible was temporarily overdrafting the Gulf Coast Aquifer to provide additional irrigation water during drought. This strategy produces 67,739 acre-feet of water which is sufficient to meet the region's needs (Figures P.3 and P.4). There is no capital cost associated with this strategy because all necessary infrastructure is assumed to already be in place (Appendix A).

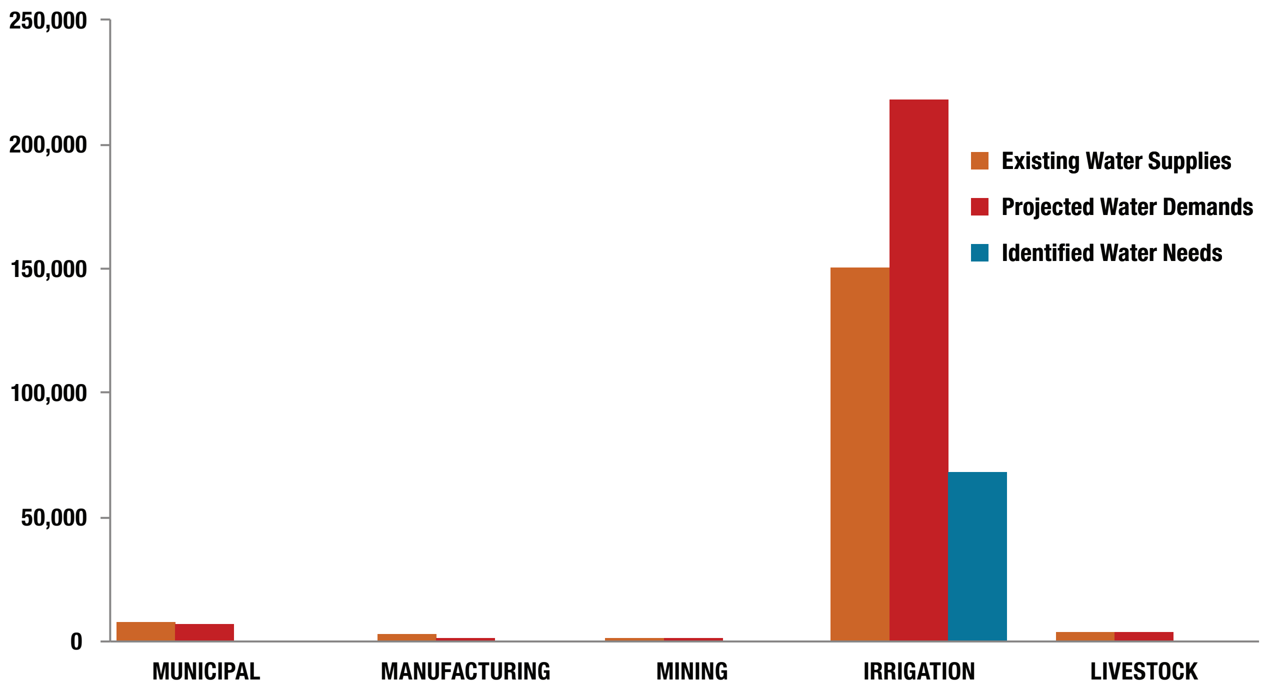
## CONSERVATION RECOMMENDATIONS

Water conservation was not recommended as a strategy because it was not the most cost-effective method to meet irrigation needs, which are the only needs in the region. Since there were no municipal needs, no municipal conservation was recommended. However, the planning group did recommend that all municipal water user groups implement water conservation measures. The Lavaca Planning Group also recommended continued agricultural water conservation practices as one of its policy recommendations. The region supports state and federal programs that provide financial and technical assistance to agricultural producers and result in increased irrigation efficiency and overall water conservation.

## TABLE P.1. POPULATION, WATER SUPPLY, DEMAND, AND NEEDS 2010–2060

| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Projected Population | 49,491 | 51,419 | 52,138 | 51,940 | 51,044 | 49,663 |
| **Existing Supplies (acre-feet per year)** | | | | | | |
| Surface water | 1,832 | 1,832 | 1,832 | 1,832 | 1,832 | 1,832 |
| Groundwater | 162,316 | 162,316 | 162,316 | 162,316 | 162,316 | 162,316 |
| **Total Water Supplies** | **164,148** | **164,148** | **164,148** | **164,148** | **164,148** | **164,148** |
| **Demands (acre-feet per year)** | | | | | | |
| Municipal | 4,841 | 4,927 | 4,975 | 4,996 | 5,032 | 5,092 |
| County-other | 2,374 | 2,378 | 2,283 | 2,119 | 1,957 | 1,800 |
| Manufacturing | 1,089 | 1,162 | 1,223 | 1,281 | 1,331 | 1,425 |
| Mining | 164 | 172 | 177 | 182 | 188 | 192 |
| Irrigation | 217,846 | 217,846 | 217,846 | 217,846 | 217,846 | 217,846 |
| Livestock | 3,499 | 3,499 | 3,499 | 3,499 | 3,499 | 3,499 |
| **Total Water Demands** | **229,813** | **229,984** | **230,003** | **229,923** | **229,853** | **229,854** |
| **Needs (acre-feet per year)** | | | | | | |
| Irrigation | 67,739 | 67,739 | 67,739 | 67,739 | 67,739 | 67,739 |
| **Total Water Needs** | **67,739** | **67,739** | **67,739** | **67,739** | **67,739** | **67,739** |

## FIGURE P.2. 2060 LAVACA (P) EXISTING SUPPLIES, PROJECTED DEMANDS, AND IDENTIFIED WATER NEEDS BY WATER USE CATEGORY (ACRE-FEET PER YEAR).



## SELECT MAJOR WATER MANAGEMENT STRATEGIES

- Conjunctive Use of Groundwater (temporary overdraft) will provide 67,739 acre-feet of water starting in the year 2010 with no capital cost determined since it was assumed that all infrastructure was already in place.

## REGION-SPECIFIC STUDY

The Lavaca Regional Water Planning Group developed a region-specific study during the initial phase of the third planning cycle. The final report documenting the findings can be found on the TWDB Web site at https://www.twdb.state.tx.us/wrpi/rwp/rwp_study.asp#p.

- Agricultural Water Demands Analysis

## LAVACA PLANNING GROUP MEMBERS AND INTERESTS REPRESENTED

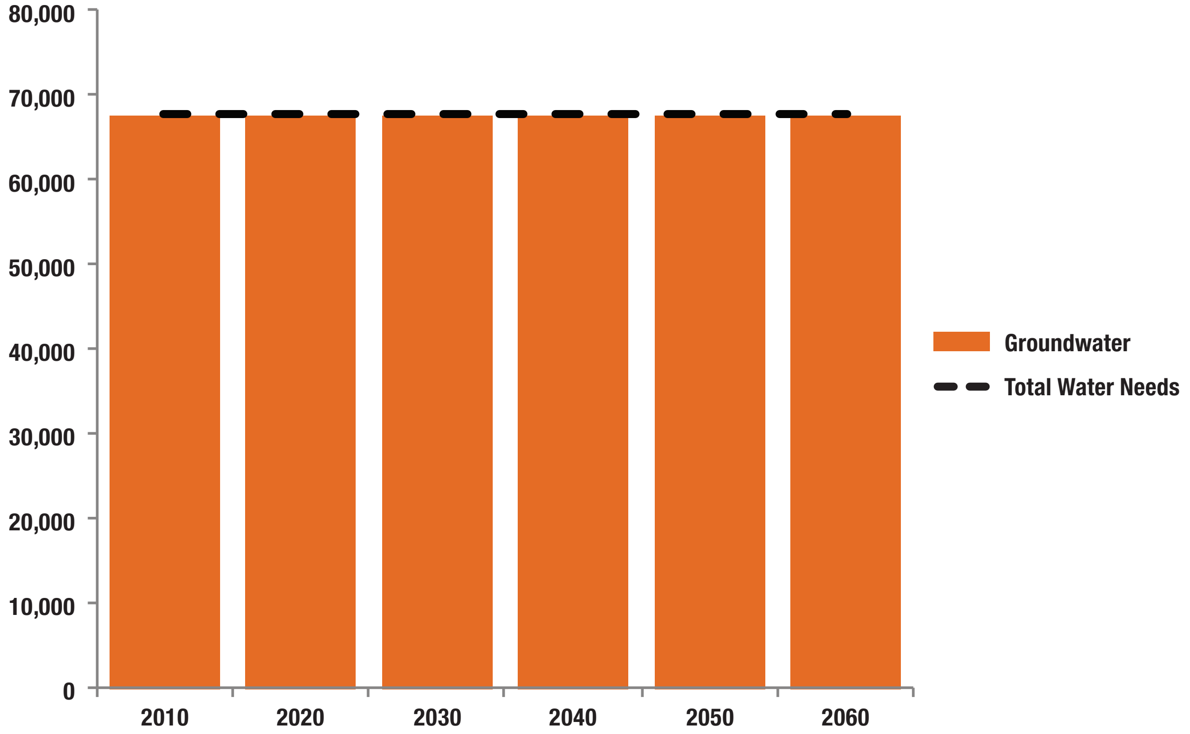
***Voting members during adoption of the 2011 Regional Water Plan:***

Harrison Stafford, II (Chair), counties; Calvin Bonzer, small business; Tommy Brandenberger, industries; Patrick Brzozowski, river authorities; John Butschek, municipalities; Gerald Clark, agriculture; Roy Griffin, electric generating utilities; Lester Little, agriculture; Jack Maloney, municipalities; Phillip Miller, counties; Richard Otis, industries; Edward Pustka, public; L.G. Raun, agriculture; Dean Schmidt, agriculture; Robert Shoemate, environmental; Michael Skalicky, water districts; David Wagner, counties; Larry Waits, agriculture; Ed Weinheimer, small business

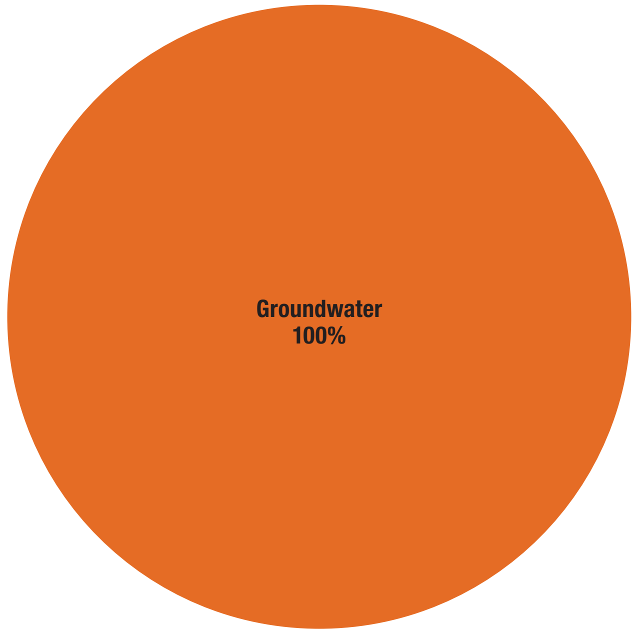
***Former voting members during the 2006 – 2011 planning cycle:***

Pat Hertz, water utilities; Judge Ronald Leck, counties; Paul Morkovsky, industries; Wayne Popp, water districts; Dean Schmidt, agriculture; Bob Weiss, public

### FIGURE P.3. RECOMMENDED WATER MANAGEMENT STRATEGY WATER SUPPLY VOLUMES FOR 2010–2060 (ACRE-FEET PER YEAR).




### FIGURE P.4. 2060 RECOMMENDED WATER MANAGEMENT STRATEGIES–RELATIVE SHARE OF SUPPLY.



# Quick Facts

**Even with significant population increase, water demand in Texas is projected to increase by only 22 percent, from about 18 million acre-feet per year in 2010 to about 22 million acre-feet per year in 2060. This smaller increase is primarily due to declining demand for irrigation water and increased emphasis on municipal conservation.**

# 3 Population and Water Demand Projections

**The population in Texas is expected to increase 82 percent between the years 2010 and 2060, growing from 25.4 million to 46.3 million people. Growth rates vary considerably across the state, with some planning areas more than doubling over the planning horizon and others growing only slightly or not at all.**

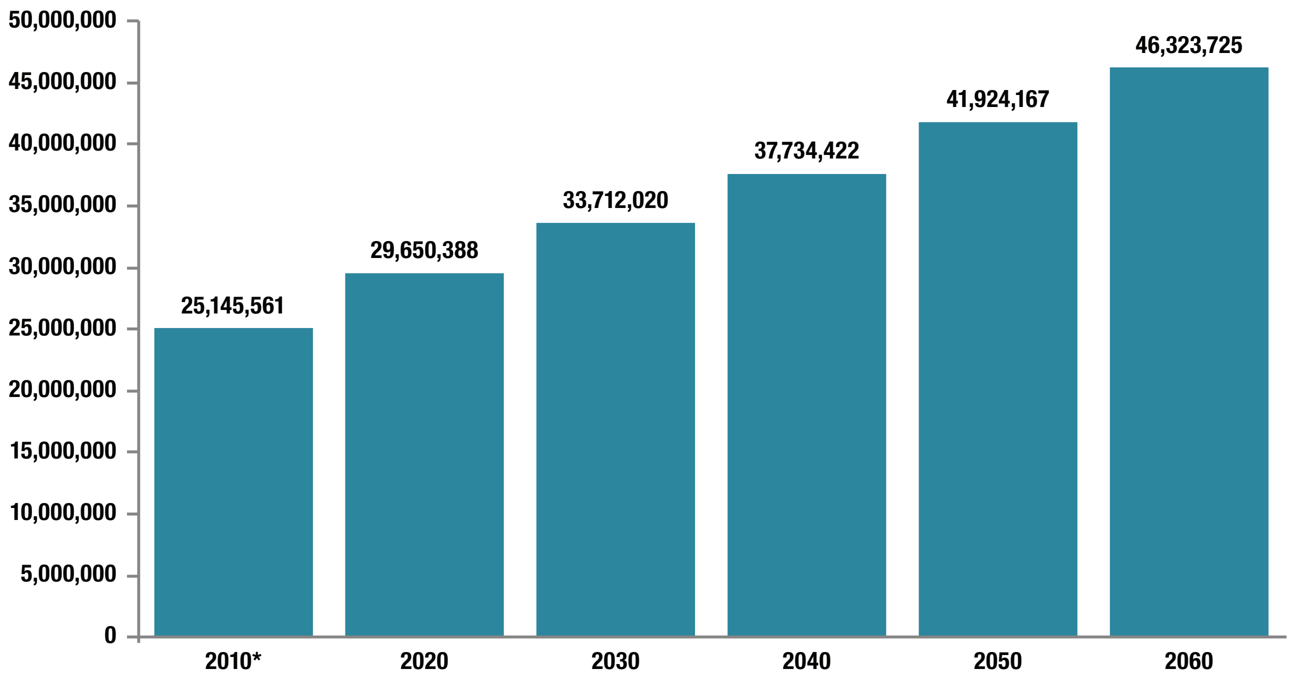
The first step in the regional water planning process is to quantify current and projected population and water demand over the 50-year planning horizon. Both the state and regional water plans incorporate projected population and water demand for cities, water utilities, and rural areas throughout the state. Water demand projections for wholesale water providers and for manufacturing, mining, steam-electric, livestock, and irrigation water use categories are also used in the planning process. TWDB developed projections in coordination with the Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, Texas Department of Agriculture, and the regional water planning groups for inclusion in the regional water plans and the state water plan. The final population and water demand projections are approved by TWDB's governing board.

## 3.1 POPULATION PROJECTIONS

As noted in every state water plan since the 1968 State Water Plan, Texas is a fast-growing state, and every new Texan requires water to use in the house, on the landscape, and in the food they consume and materials they buy.

Texas is not only the second most populated state in the nation, but also the state that grew the most between 2000 and 2010, increasing from 20.8 million residents to 25.1 million (Figure 3.1). However, such dramatic growth has not occurred evenly across the

## FIGURE 3.1. TEXAS STATE POPULATION PROJECTED TO 2060.




*2010 population is the official population count from the U.S. Census Bureau; 2020–2060 represent projected population used in the 2012 State Water Plan.

state. Of 254 counties, 175 gained population and 79 lost population between the 2000 and 2010 censuses. The majority of the growing counties were located in the eastern portion of the state or along the Interstate Highway-35 corridor.

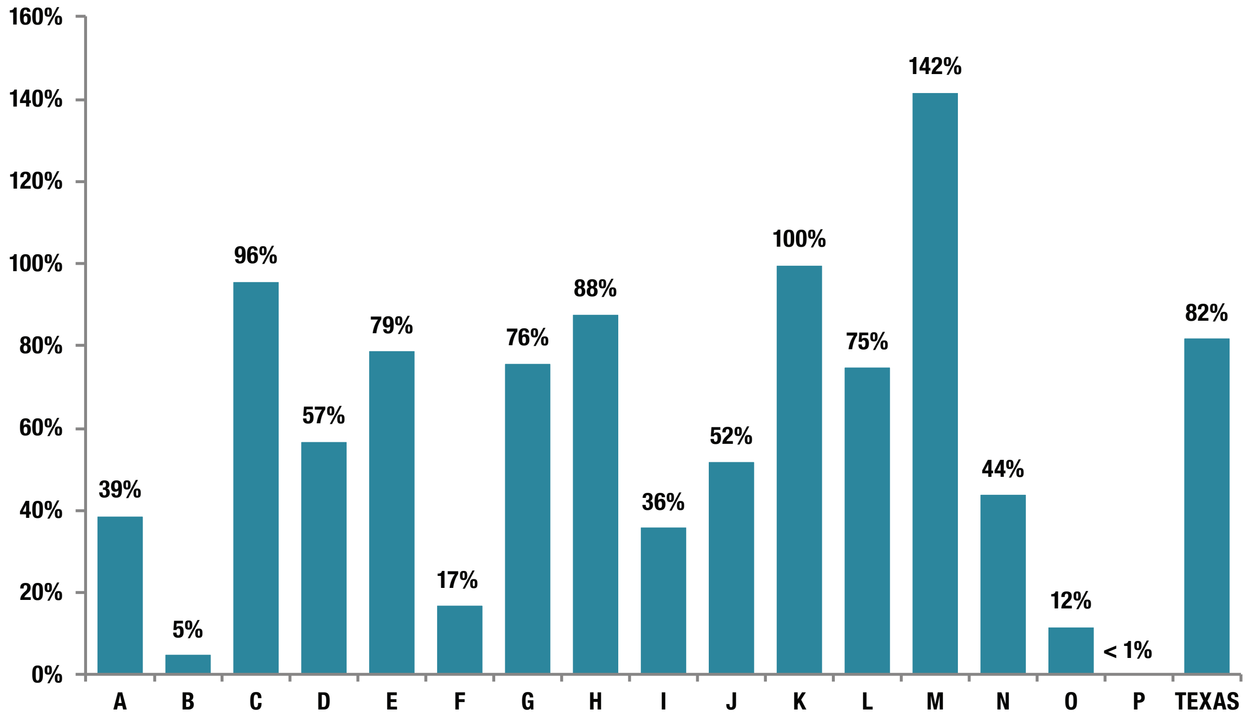
### 3.1.1 PROJECTION METHODOLOGY

As required in the water planning process, the population of counties, cities, and large non-city water utilities were projected for 50 years, from 2010 to 2060. During the development of the 2011 regional water plans, due to the lack of new census data, the population projections from the 2007 State Water Plan were used as a baseline and adjusted where more recent data was available from the Texas State Data Center.

The population projections for the 2006 regional water plans and the 2007 State Water Plan were created by a two-step process. The initial step used county projections from the Office of the State Demographer and the Texas State Data Center, the agencies charged with disseminating demographic and related socioeconomic data to the state of Texas. These projections were calculated using the cohort-component method: the county's population is projected one year at a time by applying historical growth rates, survival rates, and net migration rates to individual cohorts (age, sex, race, and ethnic groups). The Texas State Data Center projections are only done at the county level, requiring further analysis to develop projections for the sub-county areas.

Sub-county population projections were calculated for cities with a population greater than 500, non-city water utilities with an average daily use greater than 250,000 gallons, and "county-other." County-other is an aggregation of residential, commercial, and institutional water users in cities with less than 500 people or non-city utilities that provide less than an average of 250,000 gallons per day, as well as

## FIGURE 3.2. PROJECTED POPULATION GROWTH FOR PLANNING REGIONS FOR 2010–2060.




unincorporated rural areas in a given county. With the county projections as a guide, projections for the municipal water user groups (cities and utilities) within each county were calculated. In general, the projections for these water user groups were based upon the individual city or utility's share of the county growth between 1990 and 2000. TWDB staff developed draft population projections with input from staff of the Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, and Texas Department of Agriculture. Following consultations with the regional water planning groups, these projections were then adopted by TWDB's governing board for use in the 2006 regional water plans.

For the 2011 regional water plans, the planning groups were able to request revisions to population projections for specific municipal water user groups, including cities and large non-city utilities. In certain regions, population estimates suggested that growth was taking place faster in some of the counties and cities than what was previously projected in the 2006 regional water plans. The planning groups could propose revisions, with the amount of upward population projection revision roughly limited to the amount of under-projections, as suggested by the Texas State Data Center's most recent population estimates. Population projections were revised, at least partially, for all changes requested by the planning groups: 352 municipal water user groups in 64 counties and 9 regions. This input from the cities and utilities through the regional water planning groups, combined with the long-range, demographically-driven methods, increases the accuracy of the population projections. The statewide total of the projections for 2010 that resulted from this process were slightly higher than the 2010 Census population.

## TABLE 3.1. TEXAS STATE POPULATION PROJECTIONS FOR 2010–2060

| Region | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| A | 388,104 | 423,380 | 453,354 | 484,954 | 516,729 | 541,035 |
| B | 210,642 | 218,918 | 223,251 | 224,165 | 223,215 | 221,734 |
| C | 6,670,493 | 7,971,728 | 9,171,650 | 10,399,038 | 11,645,686 | 13,045,592 |
| D | 772,163 | 843,027 | 908,748 | 978,298 | 1,073,570 | 1,213,095 |
| E | 863,190 | 1,032,970 | 1,175,743 | 1,298,436 | 1,420,877 | 1,542,824 |
| F | 618,889 | 656,480 | 682,132 | 700,806 | 714,045 | 724,094 |
| G | 1,957,767 | 2,278,243 | 2,576,783 | 2,873,382 | 3,164,776 | 3,448,879 |
| H | 6,020,078 | 6,995,442 | 7,986,480 | 8,998,002 | 10,132,237 | 11,346,082 |
| I | 1,090,382 | 1,166,057 | 1,232,138 | 1,294,976 | 1,377,760 | 1,482,448 |
| J | 135,723 | 158,645 | 178,342 | 190,551 | 198,594 | 205,910 |
| K | 1,412,834 | 1,714,282 | 2,008,142 | 2,295,627 | 2,580,533 | 2,831,937 |
| L | 2,460,599 | 2,892,933 | 3,292,970 | 3,644,661 | 3,984,258 | 4,297,786 |
| M | 1,628,278 | 2,030,994 | 2,470,814 | 2,936,748 | 3,433,188 | 3,935,223 |
| N | 617,143 | 693,940 | 758,427 | 810,650 | 853,964 | 885,665 |
| O | 492,627 | 521,930 | 540,908 | 552,188 | 553,691 | 551,758 |
| P | 49,491 | 51,419 | 52,138 | 51,940 | 51,044 | 49,663 |
| **Texas** | **25,388,403** | **29,650,388** | **33,712,020** | **37,734,422** | **41,924,167** | **46,323,725** |

### 3.1.2 PROJECTIONS

Due to natural increase and a net in-migration, it is projected that Texas will continue to have robust growth. The state is projected to grow approximately 82 percent, from 25.4 million in 2010 to 46.3 million, by 2060 (Figure 3.2). As illustrated in the growth over the last decade, regional water planning areas that include the major metropolitan areas of Houston (Region H), the Dallas-Fort Worth area (C), Austin (K), San Antonio (L), and the Lower Rio Grande Valley (M) are anticipated to capture 82 percent of the state's growth by 2060 (Table 3.1).

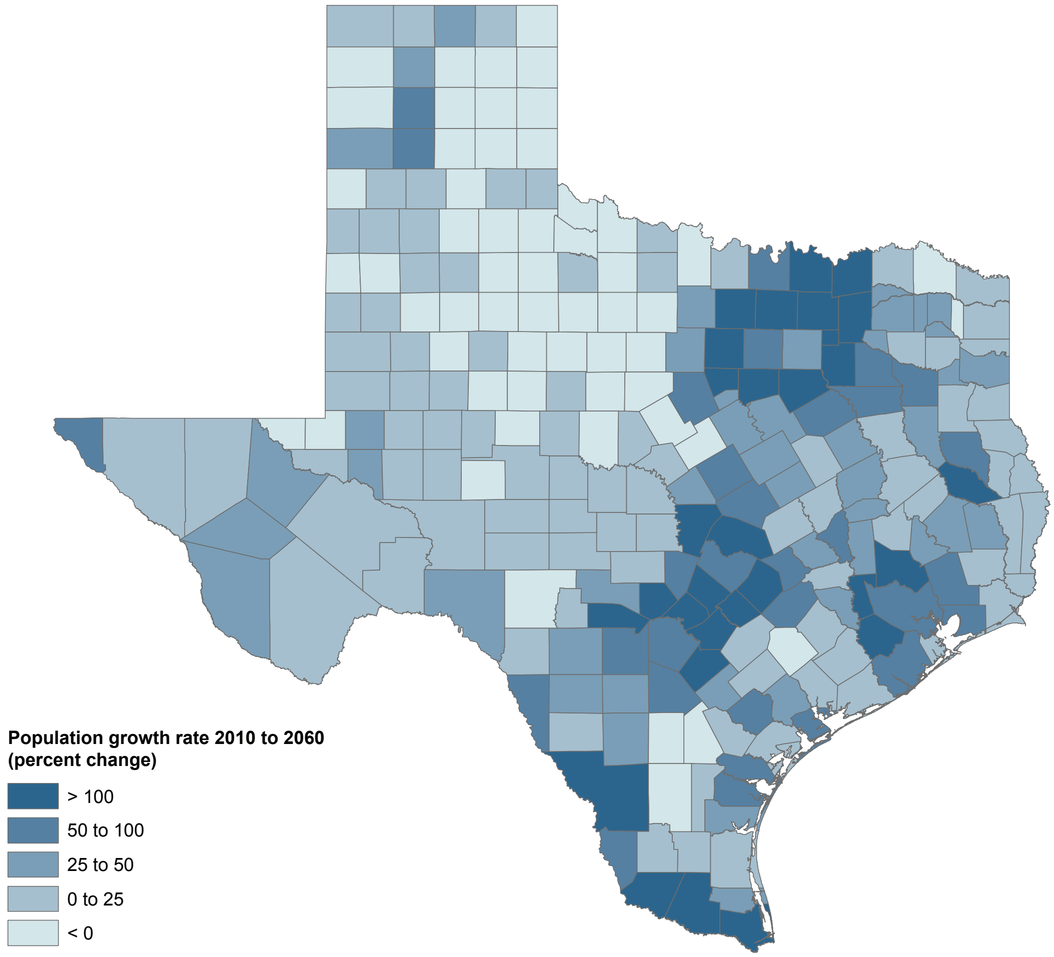
Regions C, G, H, L, and M are expected to grow the most by 2060, while regions B, F, and P are expected to grow at the lowest rates. Individual counties are expected to grow at varying rates (Figure 3.3).

### 3.1.3 ACCURACY OF PROJECTIONS

At the state level, the 2010 population projections for the 2011 regional water plans were 1 percent greater than the 2010 census results: 25.39 million versus 25.15 million residents (Figure 3.4). Comparisons of 2010 projections and the 2010 census for the previous seven state water plans range from an over-projection of 7.4 percent in the 1968 State Water Plan to an under-projection by 11.3 percent in the "Low" series of the 1984 State Water Plan. The prior two state water plans developed through regional water planning, the 2002 State Water Plan and the 2007 State Water Plan, under-projected the 2010 population by only 2.6 and 1.0 percent, respectively. The 2060 population projection is projected to be slightly higher than what was projected in the 2007 State Water Plan: 46.3 million compared to 45.5 million. While shorter-range projections will always tend to be more accurate, the regional water planning process increases overall projection accuracy because of the use of better local information.

For geographic areas with smaller populations (regions, counties, and water user groups), the relative difference between projected population and actual growth can increase. At the regional water planning area level, 12 regions had populations that were over-projected, most notably Region N at 9.3 percent, Region J at 6.1 percent, and Region B at 5.7 percent

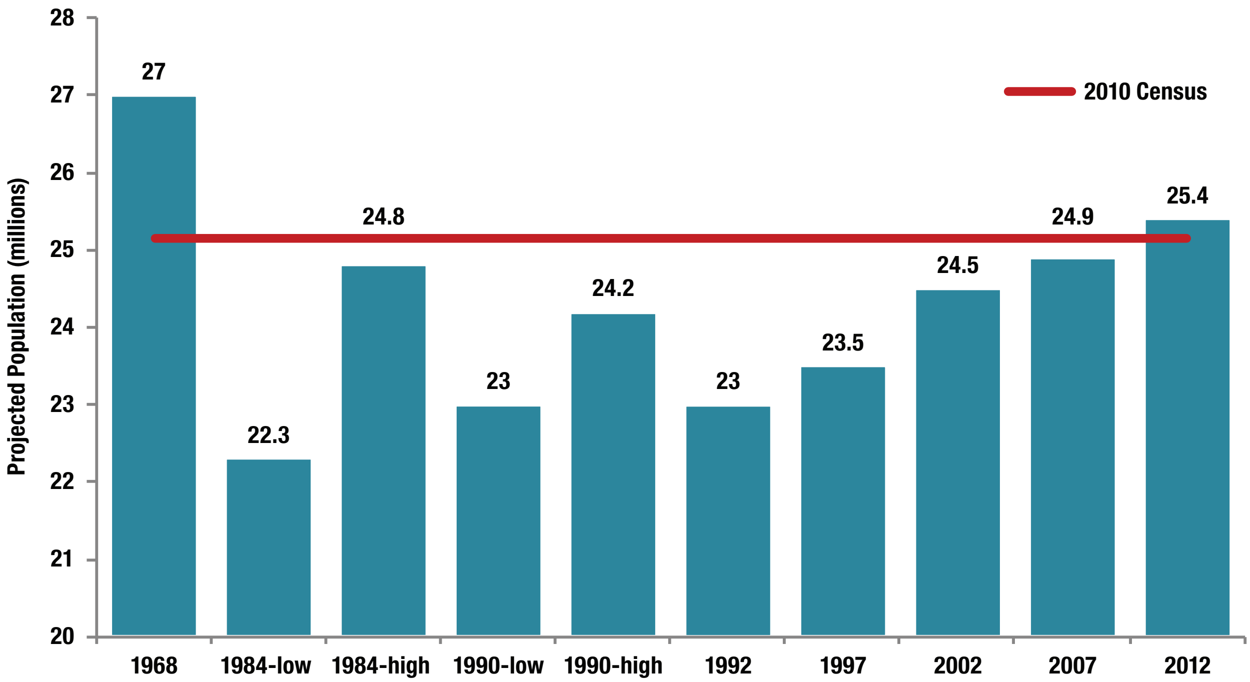
## FIGURE 3.3. PROJECTED POPULATION GROWTH IN TEXAS COUNTIES.




## TABLE 3.2. COMPARISON BETWEEN 2010 POPULATION PROJECTIONS AND ACTUAL 2010 CENSUS POPULATION DATA

| Region | 2000 Census | 2010 Census | 2010 Projected Population, 2012 SWP | Projection Difference |
|---|---|---|---|---|
| A | 355,832 | 380,733 | 388,104 | 1.9% |
| B | 201,970 | 199,307 | 210,642 | 5.7% |
| C | 5,254,748 | 6,455,167 | 6,670,493 | 3.3% |
| D | 704,171 | 762,423 | 772,163 | 1.3% |
| E | 705,399 | 826,897 | 863,190 | 4.4% |
| F | 578,814 | 623,354 | 618,889 | -0.7% |
| G | 1,621,965 | 1,975,174 | 1,957,767 | -0.9% |
| H | 4,848,918 | 6,093,920 | 6,020,078 | -1.2% |
| I | 1,011,317 | 1,071,582 | 1,090,382 | 1.8% |
| J | 114,742 | 127,898 | 135,723 | 6.1% |
| K | 1,132,228 | 1,411,097 | 1,412,834 | 0.1% |
| L | 2,042,221 | 2,526,374 | 2,460,599 | -2.6% |
| M | 1,236,246 | 1,587,971 | 1,628,278 | 2.5% |
| N | 541,184 | 564,604 | 617,143 | 9.3% |
| O | 453,997 | 489,926 | 492,627 | 0.6% |
| P | 48,068 | 49,134 | 49,491 | 0.7% |
| **Total** | **20,851,820** | **25,145,561** | **25,388,403** | **1.0%** |

## FIGURE 3.4. COMPARISON OF STATE WATER PLAN POPULATION PROJECTIONS AND ACTUAL 2010 CENSUS POPULATION DATA.*




*In some of the past water plans, both a high and low projection series was analyzed.

(Table 3.2). Some of the larger and faster growing regions were under-projected, including Region L at 2.6 percent, Region H at 1.2 percent, and Region G at 0.9 percent.

At the county level, 23 counties were under-projected by 5 percent or more, the largest of which were Fort Bend, Bell, Smith, Galveston, Brazos, Midland, and Guadalupe (Figure 3.5). One hundred twenty-two counties were over-projected by at least 5 percent, the largest of which were Dallas, Hays, Johnson, Potter, Nueces, and Ellis. Apart from the larger counties in the state, many of the over-projected counties are in west Texas. A complete listing of all county population projections can be found in Appendix B (Projected Population of Texas Counties).

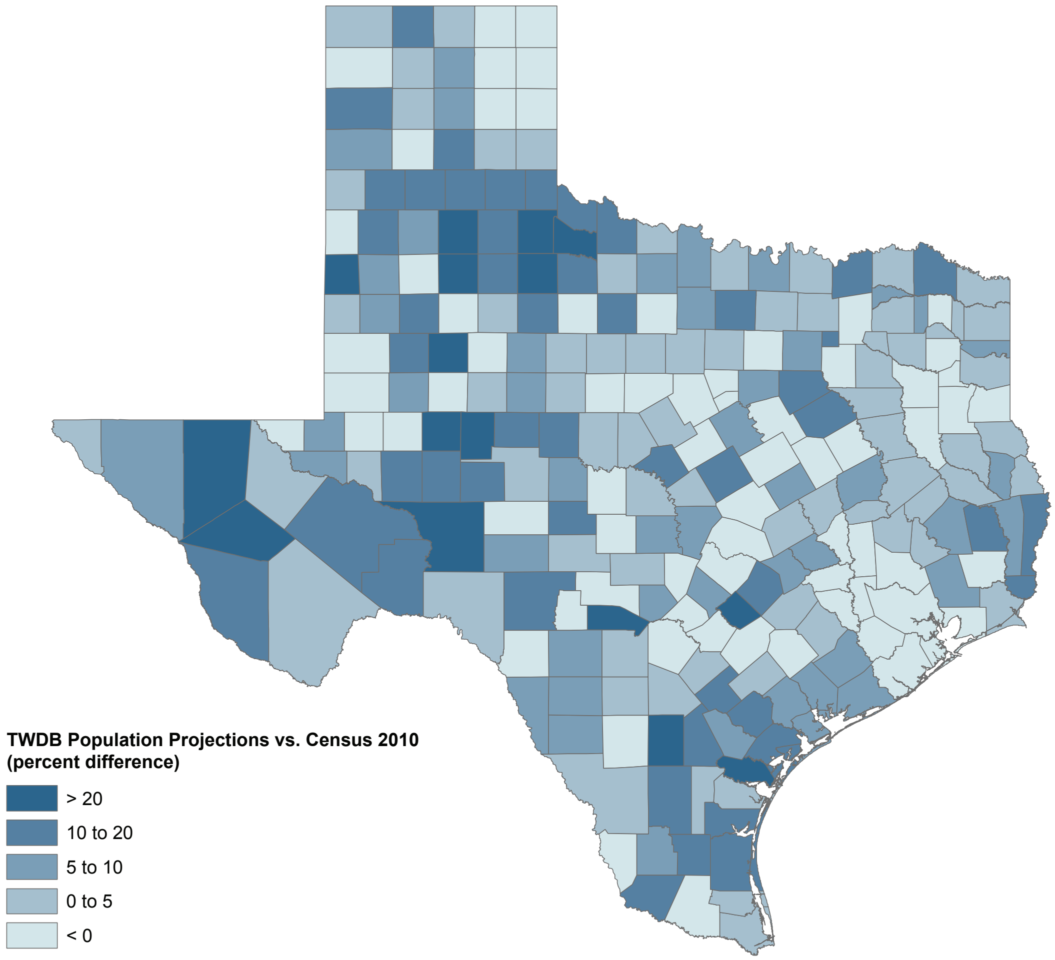
As part of the process for the 2016 regional water plans and the 2017 State Water Plan, population projections for cities, utilities, and counties will be developed anew with the methodology described above, with population and information derived from the 2010 census. As indicated by Figure 3.5, some counties are expected to have their population projections increase while others are expected to have more modest growth than in previous projections.

## 3.2 WATER DEMAND PROJECTIONS

Determining the amount of water needed in the future is one of the key building blocks of the regional and state water planning process. Projections of water demands are created for six categories, including

- **Municipal:** residential, commercial, and institutional water users in (a) cities with more than 500 residents, (b) non-city utilities that provide more than 280 acre-feet a year (equivalent to 250,000 gallons per day), and (c) a combined

## FIGURE 3.5. PERCENT DIFFERENCE BETWEEN 2010 POPULATION PROJECTIONS AND 2010 CENSUS POPULATION DATA.




water user grouping of each county's remaining rural areas, referred to as county-other

- **Manufacturing:** industrial firms, such as food processors, paper mills, electronics manufacturers, aircraft assemblers, and petrochemical refineries
- **Mining:** key mining sectors in the state, such as coal, oil and gas, and aggregate producers
- **Steam-electric:** coal and natural gas-fired and nuclear power generation plants
- **Livestock:** feedlots, dairies, poultry farms, and other commercial animal operations
- **Irrigation:** commercial field crop production

Similar to population projections, the 2011 regional water plans generally used demand projections from the 2007 State Water Plan; revisions were made for the steam-electric water use category and other specific water user groups due to changed conditions or the results of region-specific studies. Water demand projections are based upon "dry-year" conditions and water usage under those conditions. For the 2007 State Water Plan, the year 2000 was selected to represent the statewide dry-year conditions for several reasons:

- For 7 of the 10 climatic regions in the state, the year 2000 included the most months of moderate or worse drought between 1990 and 2000. For the remaining three regions, the year 2000 had the second-most months of moderate or worse drought in that period.

- During the summer months (May to September), when landscape and field crop irrigation is at its peak, the majority of the state was in moderate or worse drought during that entire period.

These water demand projections were developed to determine how much water would be needed during a drought. The regional water planning groups were able to request revisions to the designated dry-year for an area or for the resulting water demand projections if a different year was more representative of dry-year conditions for that particular area.

While the state's population is projected to grow 82 percent between 2010 and 2060, the amount of water needed is anticipated to grow by only 22 percent. (Table 3.3, Figure 3.6). This moderate total increase is due to the anticipated decline in irrigation water use as well as a slight decrease in the per capita water use in the municipal category (though the total municipal category increases significantly due to population growth).

### 3.2.1 MUNICIPAL WATER DEMAND

Municipal water demand consists of water to be used for residential (single family and multi-family), commercial (including some manufacturing firms that do not use water in their production process), and institutional purposes (establishments dedicated to public service). The water user groups included in this category include cities, large non-city water utilities, and rural county-other. Large-scale industrial facilities, whether supplied by a utility or self-supplied, that use significant amounts of water are included in the manufacturing, mining, or steam-electric power categories. Correlated with a slightly higher 2060 population projection than in the 2007 State Water Plan, the 2060 municipal water demands for the state are projected to be 8.4 million acre-feet compared to 8.2 million acre-feet in the 2007 State Water Plan.

Municipal water demand projections are calculated using the projected populations for cities, non-city water utilities, and county-other and multiplying the projected population by the total per capita water use. Per capita water use, measured in "gallons per capita per day," is intended to capture all residential, commercial, and institutional uses, including systems loss. Gallons per capita per day is calculated for each water user group by dividing total water use (intake minus sales to industry and other systems) by the population served. Total water use is derived from responses to TWDB's Water Use Survey, an annual survey of ground and surface water use by municipal and industrial entities within the state of Texas.

In general, total per capita water use was assumed to decrease over the planning horizon due to the installation of water-efficient plumbing fixtures (shower heads, toilets, and faucets) as required in the Texas Water Saving Performance Standards for Plumbing Fixtures Act of 1991. These fixtures are assumed to be installed as older ones require replacement. Although developed too late to be incorporated into the 2011 regional water plans, additional water-saving requirements have been mandated for dishwashers and clothes washing machines. Such savings will be included in the next regional water plan demand projections.

### 3.2.2 MANUFACTURING WATER DEMANDS

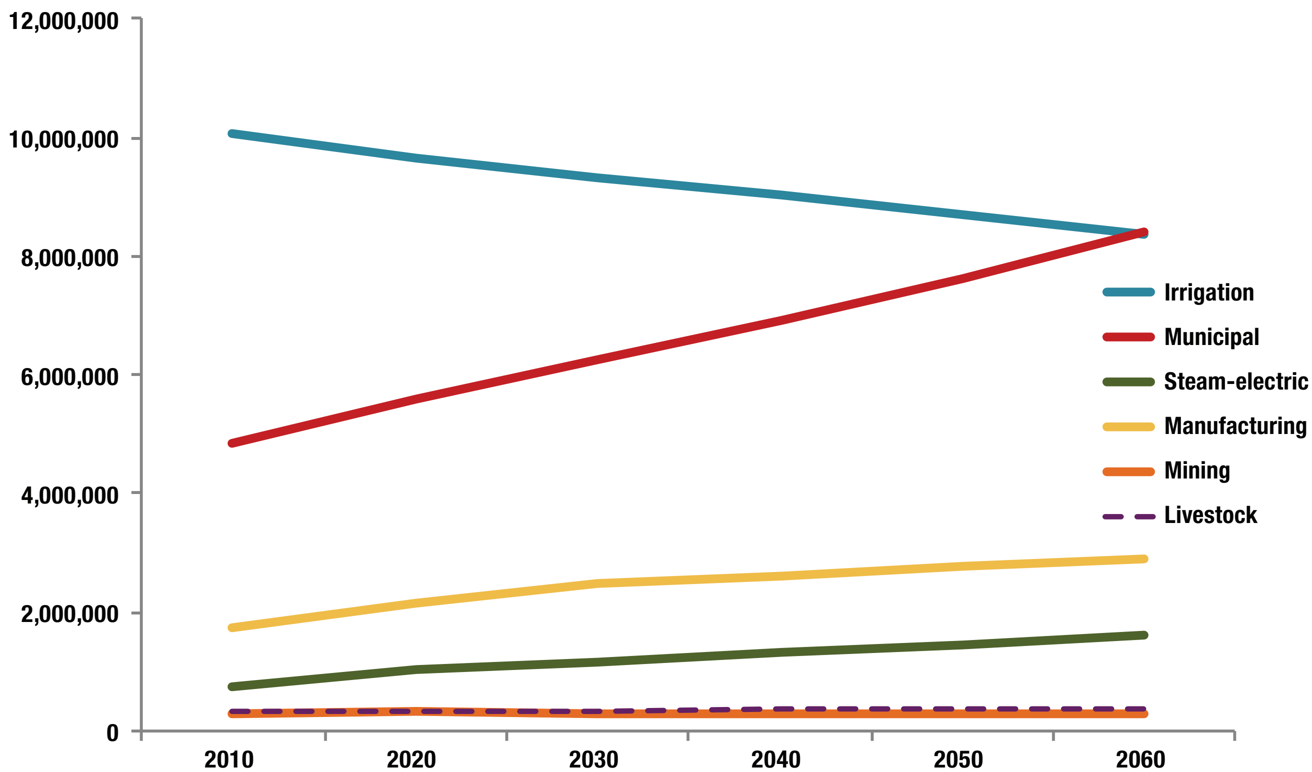
Manufacturing water demands consist of the future water necessary for large facilities, including those that process chemicals, oil and gas refining, food,

## PROJECTED WATER DEMAND CALCULATION, 2010–2060


## TABLE 3.3. SUMMARY OF WATER DEMAND PROJECTIONS BY USE CATEGORY FOR 2010–2060 (ACRE-FEET PER YEAR)

| Category | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Percent of 2060 Demand |
|---|---|---|---|---|---|---|---|
| Municipal | 4,851,201 | 5,580,979 | 6,254,784 | 6,917,722 | 7,630,808 | 8,414,492 | 38.3% |
| Manufacturing | 1,727,808 | 2,153,551 | 2,465,789 | 2,621,183 | 2,755,335 | 2,882,524 | 13.1% |
| Mining | 296,230 | 313,327 | 296,472 | 285,002 | 284,640 | 292,294 | 1.3% |
| Steam-electric | 733,179 | 1,010,555 | 1,160,401 | 1,316,577 | 1,460,483 | 1,620,411 | 7.4% |
| Livestock | 322,966 | 336,634 | 344,242 | 352,536 | 361,701 | 371,923 | 1.7% |
| Irrigation | 10,079,215 | 9,643,908 | 9,299,464 | 9,024,866 | 8,697,560 | 8,370,554 | 38.1% |
| **Texas** | **18,010,599** | **19,038,954** | **19,821,152** | **20,517,886** | **21,190,527** | **21,952,198** | |

## FIGURE 3.6. WATER DEMAND PROJECTIONS BY USE CATEGORY (ACRE-FEET PER YEAR).*




*Water demand projections for the livestock and mining water use categories are similar enough to be indistinguishable at this scale.

## TABLE 3.4. PER CAPITA WATER USE FOR THE 40 LARGEST CITIES IN TEXAS FOR 2008–2060 (GALLONS PER CAPITA PER DAY)

| City or Place Name | 2008 Per Capita Use | 2008 Residential Per Capita Use | 2020 Per Capita Use | 2040 Per Capita Use | 2060 Per Capita Use |
|---|---|---|---|---|---|
| Frisco | 254 | 158 | 289 | 289 | 283 |
| Midland | 235 | 159 | 254 | 248 | 247 |
| Plano | 223 | 113 | 253 | 250 | 249 |
| Richardson | 216 | 128 | 278 | 274 | 272 |
| Dallas | 213 | 95 | 252 | 247 | 246 |
| Beaumont | 206 | 140 | 209 | 203 | 201 |
| McAllen | 202 | 114 | 197 | 193 | 193 |
| College Station | 193 | 92 | 217 | 213 | 212 |
| Irving | 193 | 104 | 249 | 246 | 246 |
| Waco | 193 | 72 | 183 | 183 | 183 |
| Fort Worth | 192 | 75 | 207 | 203 | 202 |
| Longview | 190 | 75 | 120 | 115 | 115 |
| Amarillo | 188 | 108 | 201 | 201 | 201 |
| McKinney | 183 | 122 | 240 | 240 | 240 |
| Tyler | 177 | 103 | 255 | 249 | 248 |
| Austin | 171 | 102 | 173 | 171 | 169 |
| Carrollton | 162 | 102 | 188 | 184 | 183 |
| Odessa | 160 | 108 | 202 | 195 | 194 |
| Arlington | 157 | 100 | 179 | 175 | 174 |
| Sugar Land | 155 | 94 | 214 | 211 | 211 |
| Corpus Christi | 154 | 80 | 171 | 166 | 165 |
| Laredo | 154 | 88 | 192 | 189 | 188 |
| Round Rock | 154 | 96 | 194 | 191 | 191 |
| Grand Prairie | 152 | 89 | 152 | 148 | 148 |
| Denton | 150 | 60 | 179 | 176 | 176 |
| Garland | 150 | 90 | 160 | 156 | 155 |
| San Antonio | 149 | 92 | 139 | 135 | 134 |
| Lewisville | 143 | 75 | 173 | 171 | 170 |
| Lubbock | 141 | 93 | 202 | 196 | 195 |
| Abilene | 139 | 73 | 161 | 155 | 154 |
| Wichita Falls | 138 | 88 | 172 | 170 | 168 |
| El Paso | 137 | 98 | 130 | 130 | 130 |
| Brownsville | 134 | 63 | 221 | 217 | 217 |
| Houston | 134 | 65 | 152 | 147 | 146 |
| Mesquite | 134 | 90 | 164 | 168 | 168 |
| San Angelo | 131 | 91 | 193 | 187 | 186 |
| Killeen | 127 | 82 | 179 | 174 | 167 |
| Pearland | 112 | 105 | 127 | 124 | 124 |
| Pasadena | 109 | 67 | 110 | 105 | 104 |
| Missouri City | 86 | 68 | 167 | 167 | 169 |

## TABLE 3.5. COMPARISON OF 2009 WATER USE ESTIMATES WITH PROJECTED 2010 WATER USE (ACRE-FEET PER YEAR)

| Category | 2009 Estimated Water Use[1] | 2010 Projected Water Use | Estimated Difference from Projection |
|---|---|---|---|
| Municipal | 4,261,585 | 4,851,201 | -12.2% |
| Manufacturing | 1,793,911 | 1,727,808 | 3.8% |
| Mining[2] | 168,273 | 296,230 | -43.2% |
| Steam-Electric Power | 454,122 | 733,179 | -38.1% |
| Livestock | 297,047 | 322,966 | -8.0% |
| Irrigation | 9,256,426 | 10,079,215 | -8.2% |
| **Total** | **16,231,364** | **18,010,599** | **-9.9%** |

[1] Annual water use estimates are based upon returned water use surveys and other estimation techniques. These estimates may be updated when more accurate information becomes available.

[2] The 2009 mining use estimates represent an interpolation of estimated 2008 and 2010 volumes (UT Bureau of Economic Geology, 2011)

### COMPARING PER CAPITA WATER USE

Since the 2007 State Water Plan, there has been an increasing amount of interest in comparing how much water is used by various cities (Table 3.4). Unfortunately, this measure can often be inappropriate and misleading. There are a number of valid reasons that cities would have differing per capita water use values, including

- climatic conditions;
- amount of commercial and institutional customers;
- construction activities;
- price of water;
- income of the customers;
- number of daily or seasonal residents; and
- age of infrastructure.

Per capita water use tends to be higher in cities with more arid climates; more non-residential businesses; high-growth areas requiring more new building construction; lower cost of water; higher-income residents; more commuters or other part-time residents who are not counted in the official population estimates; and with more aging infrastructure, which can result in greater rates of water loss.

Because of the variations between water providers, the total municipal per capita water use as described earlier is not a valid tool for comparison. As a start to providing more detailed and useful information, the annual residential per capita water use of cities in the state water plan has been calculated since 2007, in addition to the more comprehensive total municipal per capita use. Residential per capita use is calculated using the volume sold directly to single- and multi-family residences. As more water utilities are encouraged to track their sales volumes by these categories, a more complete picture of residential per capita water use across the state will be available in the years to come. Two bills passed in the recent 82nd Texas Legislature in 2011 address this type of water use information: Senate Bill 181 and Senate Bill 660, both of which require standardization of water use and conservation calculations for specific sectors of water use.

paper, and other materials. Demands in the 2012 State Water Plan were based on those from the 2007 State Water Plan. Demand projections were drafted as part of a contracted study (Waterstone Environmental Hydrology and Engineering, Inc. and The Perryman Group, 2003) that analyzed historical water use and trends and projected industrial activity. The projections incorporated economic projections for the various manufacturing sectors, general economic output-water use coefficients, and efficiency improvements of new technology. Future growth in water demand was assumed to be located in the same counties in which such facilities currently exist unless input from the regional water planning group identified new or decommissioned facilities.

Some regions requested increases to the 2007 State Water Plan projections due to changed conditions. Manufacturing demands are projected to grow 67 percent from 1.7 million acre-feet to 2.9 million acre feet. This 2060 projection of 2.9 million acre-feet is an increase of roughly 12 percent over the 2.6 million acre-feet projected in the 2007 State Water Plan.

### 3.2.3 MINING WATER DEMANDS

Mining water demands consist of water used in the exploration, development, and extraction processes of oil, gas, coal, aggregates, and other materials. The mining category is the smallest of the water user categories and is expected to decline 1 percent from 296,230 acre-feet to 292,294 acre-feet between 2010 and 2060. In comparison, the 2007 State Water Plan mining water demands ranged from 270,845 acre-feet to 285,573 acre-feet from 2010 and 2060. Mining demands increased in a number of counties reflecting initial estimates of increased water use in hydraulic fracturing operations in the Barnett Shale area.

Similar to manufacturing demand projections, the current projections were generated as part of the 2007 State Water Plan and used a similar methodology: analyzing known water use estimates and economic projections. The mining category has been particularly difficult to analyze and project due to the isolated and dispersed nature of oil and gas facilities, the transient and temporary nature of water used, and the lack of reported data for the oil and gas industry.

Due to the increased activity that had occurred in oil and gas production by hydraulic fracturing, in 2009 TWDB contracted with the University of Texas Bureau of Economic Geology (2011) to conduct an extensive study to re-evaluate the water used in mining operations and to project such uses for the next round of water planning. Initial results from the study indicate that, while fracturing and total mining water use continues to represent a small portion (less than 1 percent) of statewide water use, percentages can be significantly larger in some localized areas. In particular, the use of water for hydraulic fracturing operations is expected to increase significantly through 2020. The results of this study will form the basis for mining water demand projections for the 2016 regional water plans. Future trends in these types of water use will be monitored closely in the upcoming planning process.

### 3.2.4 STEAM-ELECTRIC POWER GENERATION WATER DEMANDS

The steam-electric power generation category consists of water used for the purposes of producing power. Where a generation facility diverts surface water, uses it for cooling purposes, and then returns a large portion of the water to the water body, the water use for the facility is only the volume consumed in the cooling process and not returned. For the 2011 regional water plans, the University of Texas Bureau of Economic

Geology (2008) completed a TWDB-funded study of steam-electric power generation water use and projected water demands. Regional water planning groups reviewed the projections developed in this study and were encouraged to request revisions where better local information was available.

A challenge for the projection of such water use is the very mobile nature of electricity across the state grid. While the demand may occur where Texans build houses, the power and water use for its production can be in nearly any part of the state. Beyond the specific future generation facilities on file with the Public Utility Commission of Texas, the increased demand for power generation and the accompanying use of water was assumed to be located in the counties that currently have power generation capabilities. Steam-electric water use is expected to increase by 121 percent over the planning horizon, from 0.7 million acre-feet in 2010 to 1.6 million acre-feet in 2060. This 2060 projection remains consistent with the projection of 1.5 million acre-feet in the 2007 State Water Plan.

### 3.2.5 IRRIGATION WATER DEMANDS

Irrigated agriculture uses over half of the water in Texas, much of the irrigation taking place in Regions A, O, and M and in the rice producing areas along the coast. Projections in the current regional water plans were based on those from the 2006 regional plans, with revisions to select counties based upon better information. Region A conducted a study to develop revised projections on a region-wide basis. Irrigation projections have been continually adjusted at the beginning of each planning cycle, with the previous projections being used as a base to be adjusted by factors and trends including

- changes in the amount of acreage under irrigation;
- increases in irrigation application efficiency;
- changes in canal losses for surface water diversions; and
- changes in cropping patterns.

Irrigation demand is expected to decline over the planning horizon by 17 percent, from 10 million acre-feet in 2010 to 8.3 million acre-feet in 2060, largely due to anticipated natural improvements in irrigation efficiency, the loss of irrigated farm land to urban development in some regions, and the economics of pumping water from increasingly greater depths. The projections are slightly reduced from the 2007 State Water Plan, which included a statewide 2010 projection of 10.3 million acre-feet and 8.6 million acre-feet in 2060.

### 3.2.6 LIVESTOCK WATER DEMANDS

Livestock water demand includes water used in the production of various types of livestock including cattle (beef and dairy), hogs, poultry, horses, sheep, and goats. Projections for livestock water demand are based upon the water use estimates for the base "dry year" and then generally held constant into the future. Some adjustments have been made to account for shifts of confined animal feeding operations into or out of a county. The volume of water needed for livestock is projected to remain fairly constant over the planning period, increasing only by 15 percent over 50 years, from 322,966 acre-feet in 2010 to 371,923 acre-feet in 2060. The livestock use projections from the 2007 State Water Plan ranged from 344,495 acre-feet in 2010 to 404,397 acre-feet in 2060.

### 3.2.7 COMPARISON OF WATER DEMAND PROJECTIONS AND WATER USE ESTIMATES

Water demand projections for the 2012 State Water Plan and 2011 regional water plans were developed early in the five-year planning cycle and for this reason include projected water demands for the year 2010. To provide a benchmark of the relative accuracy of the projections, the projected 2010 volumes are compared with preliminary TWDB water use estimates from the most recent year available, 2009, an appropriate year for comparison as it was generally considered the second driest year of the last decade statewide, and the projected water demands are intended to be in dry-year conditions.

Overall, the statewide 2009 water use estimates are 10 percent less than the 2010 projections (Table 3.5). Projected water use can in general be expected to represent an upper bound to actual water use. One reason is that, even when a relatively dry year is experienced, not all parts of the state will experience the most severe drought, while the projections are calculated under the assumption that all water users are in drought conditions. Projections also are intended to reflect the water use that would take place if there were no supply restrictions. In practice, especially for municipal water users, water conservation and drought management measures to reduce water demand are implemented. In the context of water planning, such reductions are not automatically assumed to occur and thus reduce projected water use, but are more properly accounted for as water management strategies expected to be implemented in times of drought.

In each of the agricultural categories, estimated water use was 8 percent less than projected. Large differences occurred in the industrial categories of mining and steam-electric power. More recent research has indicated that the mining use projected for 2010 in this plan is overstated, and will be adjusted for the next planning cycle. Some of the difference in electric generation may be explained by increased efficiencies, but incomplete data returns for the 2009 estimates may also be a factor. The 2009 water use estimate for the municipal category is 12 percent less than the projected volume.

While 2009 was a relatively dry year, it did not approach the severity of drought conditions being experienced by most of Texas in the current year, 2011. Water use estimates for 2011 will provide a more representative comparison with 2010 projections, and will be incorporated into water demand projections for the next planning cycle, when they become available.

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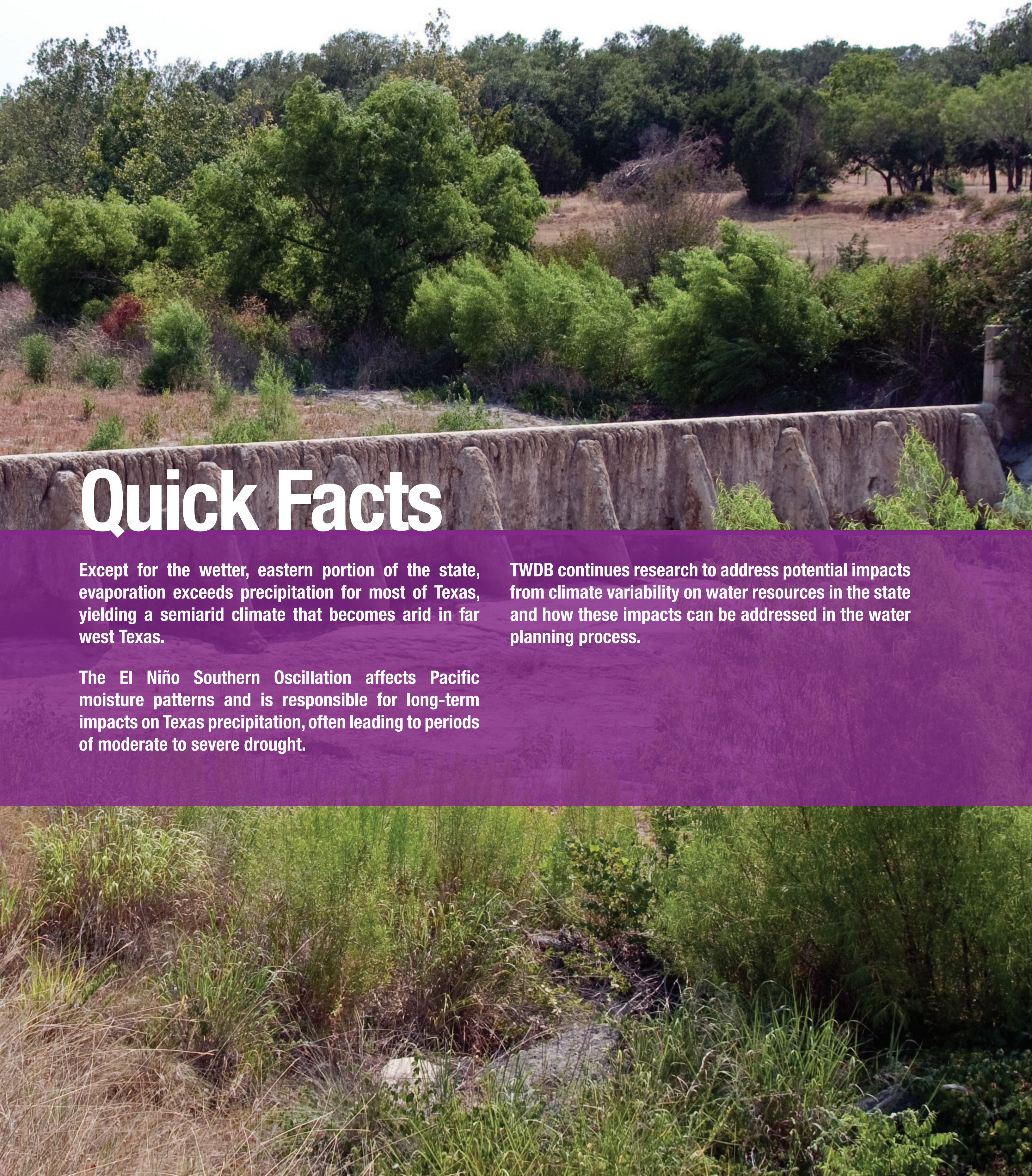


# Quick Facts

Except for the wetter, eastern portion of the state, evaporation exceeds precipitation for most of Texas, yielding a semiarid climate that becomes arid in far west Texas.

The El Niño Southern Oscillation affects Pacific moisture patterns and is responsible for long-term impacts on Texas precipitation, often leading to periods of moderate to severe drought.

TWDB continues research to address potential impacts from climate variability on water resources in the state and how these impacts can be addressed in the water planning process.

# 4 Climate of Texas

**Average annual temperature gradually increases from about 52°F in the northern Panhandle of Texas to about 68°F in the Lower Rio Grande Valley. Average annual precipitation decreases from over 55 inches in Beaumont to less than 10 inches in El Paso.**

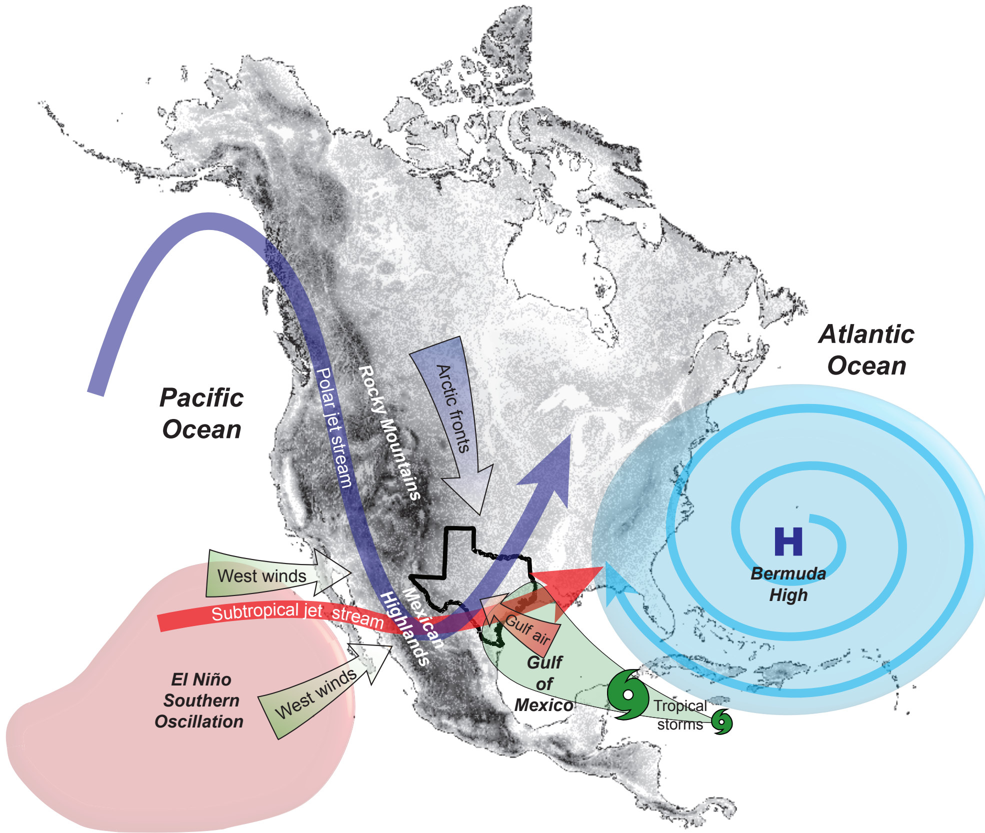
Because of its size—spanning over 800 miles both north to south and east to west—Texas has a wide range of climatic conditions over several diverse geographic regions. Climate is an important consideration in water supply planning because it ultimately determines the state's weather and, consequently, the probability of drought and the availability of water for various uses. The variability of the state's climate also represents both a risk and an uncertainty that must be considered by the regional water planning groups when developing their regional water plans (Chapter 10, Risk and Uncertainty).

## 4.1 OVERVIEW OF THE STATE'S CLIMATE

The variability of Texas' climate is a consequence of interactions between the state's unique geographic location on the North American continent and several factors that result because of the state's location (Figure 4.1):

- the movements of seasonal air masses such as arctic fronts from Canada
- subtropical west winds from the Pacific Ocean and northern Mexico
- tropical cyclones or hurricanes from the Gulf of Mexico
- a high pressure system in the Atlantic Ocean known as the Bermuda High
- the movement of the jet streams

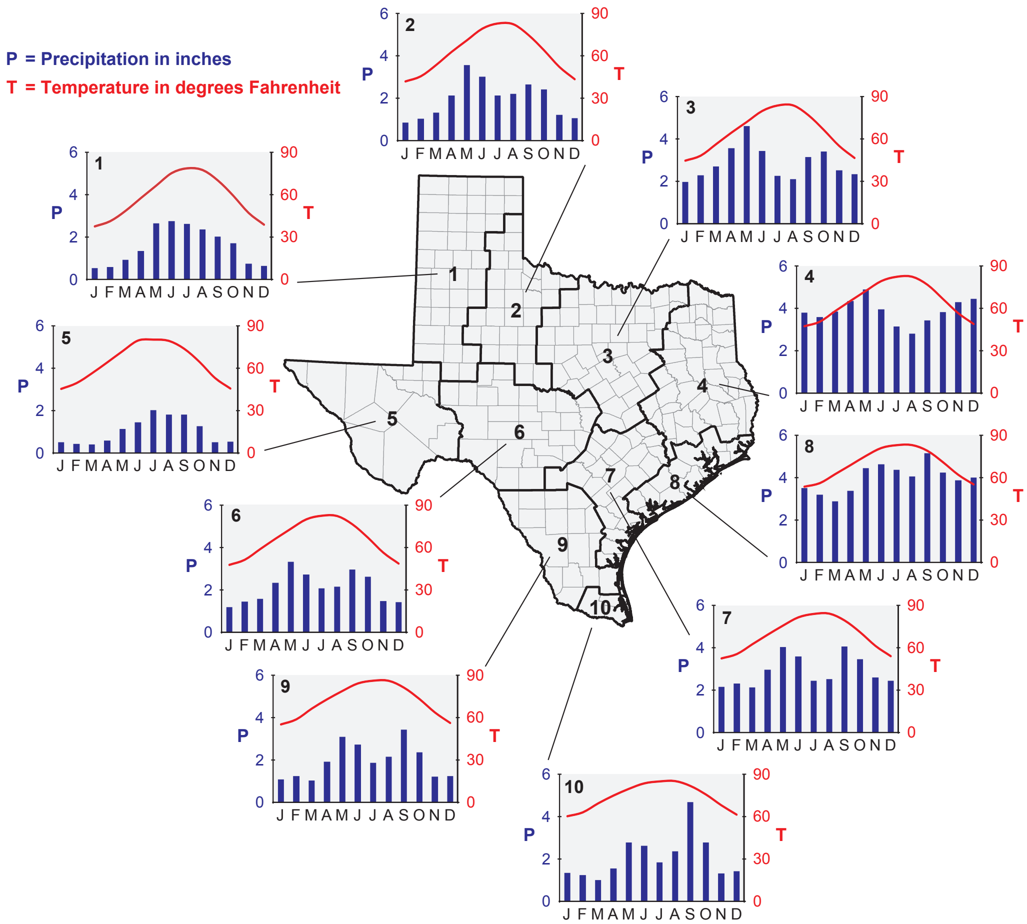
**FIGURE 4.1. THE GEOGRAPHIC LOCATION OF TEXAS WITHIN NORTH AMERICA AND ITS INTERACTION WITH SEASONAL AIR MASSES AFFECTS THE STATE'S UNIQUE CLIMATE VARIABILITY (SOURCE DIGITAL ELEVATION DATA FOR BASE MAP FROM USGS, 2000).**




The Gulf of Mexico is the predominant geographical feature affecting the state's climate, moderating seasonal temperatures along the Gulf Coast and more importantly, providing the major source of precipitation for most of the state (TWDB, 1967; Larkin and Bomar, 1983). However, precipitation in the Trans-Pecos and the Panhandle regions of Texas originates mostly from the eastern Pacific Ocean and from land-recycled moisture (TWDB, 1967; Slade and Patton, 2003). The 370 miles of Texas Gulf Coast creates a significant target for tropical cyclones that make their way into the Gulf of Mexico during the hurricane season. The Rocky Mountains guide polar fronts of cold arctic air southward into the state during the fall, winter, and spring.

During the summer, the dominant weather feature in extreme west Texas is the North American (or Southwest) Monsoon, as the warm desert southwest draws moist air northward from the Gulf of California and the Gulf of Mexico to produce summertime thunderstorms. In the rest of Texas, summertime thunderstorms form along the sea breeze or in response to tropical or subtropical disturbances. Warm dry air masses from the high plains of northern Mexico are pulled into the state by the jet stream during the spring and fall seasons, colliding with humid air from

## FIGURE 4.2. CLIMATE DIVISIONS OF TEXAS WITH CORRESPONDING CLIMOGRAPHS (SOURCE DATA FROM NCDC, 2011).




the Gulf of Mexico, funneled by the western limb of the Bermuda High system—producing destabilized inversions between the dry and humid air masses and generating severe thunderstorms and tornadoes.

## 4.2 CLIMATE DIVISIONS

The National Climatic Data Center divides Texas into 10 climate divisions (Figure 4.2). Climate divisions represent regions with similar characteristics such as vegetation, temperature, humidity, rainfall, and seasonal weather changes. Climate data collected at locations throughout the state are averaged within each of the divisions. These divisions are commonly used to assess climate characteristics across the state:

- Division 1 (High Plains): Continental steppe or semi-arid savanna
- Division 2 (Low Rolling Plains): Sub-tropical steppe or semi-arid savanna
- Division 3 (Cross Timbers): Sub-tropical sub-humid mixed savanna and woodlands
- Division 4 (Piney Woods): Sub-tropical humid mixed evergreen-deciduous forestland
- Division 5 (Trans-Pecos): Except for the slightly wetter high desert mountainous areas, sub-tropical arid desert
- Division 6 (Edwards Plateau): Sub-tropical steppe or semi-arid brushland and savanna

- Division 7 (Post Oak Savanna): Sub-tropical sub-humid mixed prairie, savanna, and woodlands
- Division 8 (Gulf Coastal Plains): Sub-tropical humid marine prairies and marshes
- Division 9 (South Texas Plains): Sub-tropical steppe or semi-arid brushland
- Division 10 (Lower Rio Grande Valley): Sub-tropical sub-humid marine

## 4.3 TEMPERATURE, PRECIPITATION, AND EVAPORATION

Average annual temperature gradually increases from about 52°F in the northern Panhandle of Texas to about 68°F in the Lower Rio Grande Valley, except for isolated mountainous areas of far west Texas, where temperatures are cooler than the surrounding arid valleys and basins (Figure 4.3). In Far West Texas, the average annual temperature sharply increases from about 56°F in the Davis and Guadalupe mountains to about 64°F in the Presidio and Big Bend areas. Average annual precipitation decreases from over 55 inches in Beaumont to less than 10 inches in El Paso (Figure 4.4). Correspondingly, average annual gross lake evaporation is less than 50 inches in east Texas and more than 75 inches in far west Texas (Figure 4.5).

Although most of the state's precipitation occurs in the form of rainfall, small amounts of ice and snow can occur toward the north and west, away from the moderating effects of the Gulf of Mexico. The variability of both daily temperature and precipitation generally increases inland across the state and away from the Gulf, while relative humidity generally decreases from east to west and inland away from the coast. The range between summer and winter average monthly temperatures increases with increased distance from the Gulf of Mexico. Except for climatic divisions 1 and 5 in far west Texas, the state climate divisions show two pronounced rainy seasons in the spring and fall. Both rainy seasons are impacted by polar fronts interacting with moist Gulf air during those seasons, with the fall rainy season also impacted by hurricanes and tropical depressions.

Most of the annual rainfall in Texas occurs during rain storms, when a large amount of precipitation falls over a short period of time. Except for the subtropical humid climate of the eastern quarter of the state, evaporation exceeds precipitation—yielding a semi-arid or steppe climate that becomes arid in far west Texas.

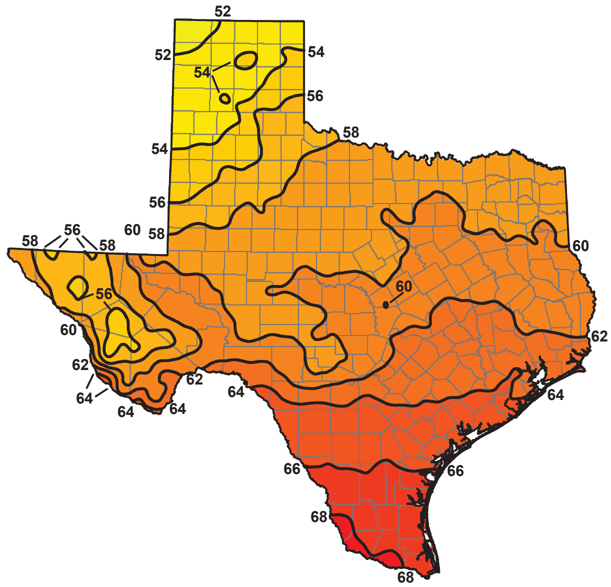
## 4.4 CLIMATE INFLUENCES

Texas climate is directly influenced by prominent weather features such as the Bermuda High and the jet streams. These weather features are in turn influenced by cyclical changes in sea surface temperature patterns associated with the El Niño Southern Oscillation, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, and the atmospheric pressure patterns of the North Atlantic Oscillation.

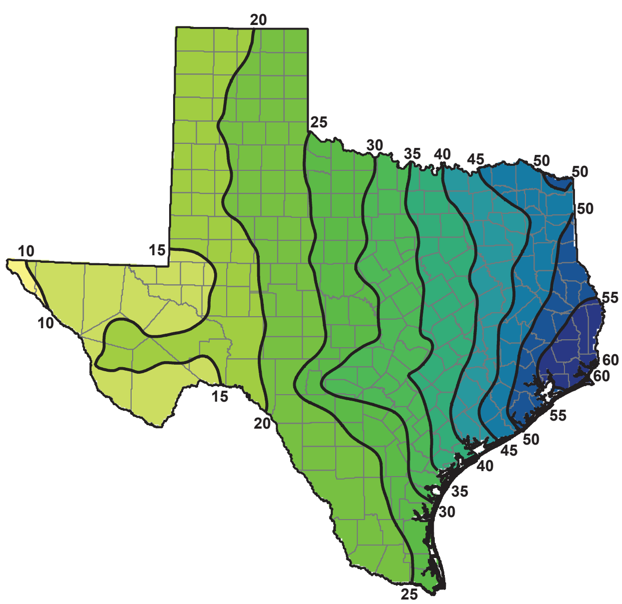
The Bermuda High, a dominant high pressure system of the North Atlantic Oscillation, influences the formation and path of tropical cyclones as well as climate patterns across Texas and the eastern United States. During periods of increased intensity of the Bermuda High system, precipitation extremes also tend to increase. The jet streams are narrow, high altitude, and fast-moving air currents with meandering paths from west to east. They steer large air masses across the earth's surface and their paths and locations generally determine the climatic state between drought and unusually wet conditions.

The El Niño Southern Oscillation, a cyclical fluctuation of ocean surface temperature and air pressure in the tropical Pacific Ocean, affects Pacific moisture patterns

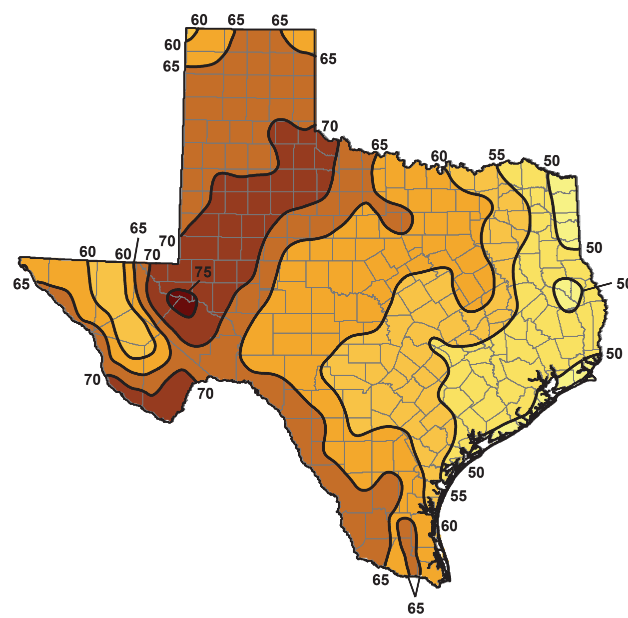
### FIGURE 4.3. AVERAGE ANNUAL TEMPERATURE FOR 1981 TO 2010 (DEGREES FAHRENHEIT) (SOURCE DATA FROM TWDB, 2005 AND PRISM CLIMATE GROUP, 2011).




### FIGURE 4.4. AVERAGE ANNUAL PRECIPITATION FOR 1981 TO 2010 (INCHES) (SOURCE DATA FROM TWDB, 2005 AND PRISM CLIMATE GROUP, 2011).




### FIGURE 4.5. AVERAGE ANNUAL GROSS LAKE EVAPORATION FOR 1971 TO 2000 (INCHES) (SOURCE DATA FROM TWDB, 2005).



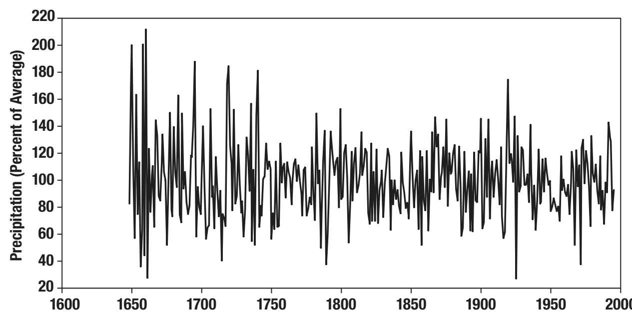
## TABLE 4.1. RANKINGS OF PALMER DROUGHT SEVERITY INDICES BASED ON DROUGHT DURATION AND DROUGHT INTENSITY FOR CLIMATE DIVISIONS OF TEXAS

| Climate Division | Duration Ranking | | | Intensity Ranking | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 |
| **1** | 1950 to 1956 | 1962 to 1967 | 1933 to 1936 | 1950 to 1956 | 1909 to 1911 | 1933 to 1936 |
| **2** | 1950 to 1956 | 1909 to 1913 | 1963 to 1967 | 1950 to 1956 | 1909 to 1913 | 1916 to 1918 |
| **3** | 1951 to 1956 | 1909 to 1913 | 1916 to 1918 | 1951 to 1956 | 1916 to 1918 | 2005 to 2006 |
| **4** | 1962 to 1967 | 1915 to 1918 | 1936 to 1939 | 1915 to 1918 | 1954 to 1956 | 1951 to 1952 |
| **5** | 1950 to 1957 | 1998 to 2003 | 1962 to 1967 | 1950 to 1957 | 1933 to 1937 | 1998 to 2003 |
| **6** | 1950 to 1956 | 1909 to 1913 | 1993 to 1996 | 1950 to 1956 | 1916 to 1918 | 1962 to 1964 |
| **7** | 1948 to 1956 | 1909 to 1912 | 1896 to 1899 | 1948 to 1956 | 1916 to 1918 | 1962 to 1964 |
| **8** | 1950 to 1956 | 1915 to 1918 | 1962 to 1965 | 1950 to 1956 | 1915 to 1918 | 1962 to 1965 |
| **9** | 1950 to 1956 | 1909 to 1913 | 1962 to 1965 | 1950 to 1956 | 1916 to 1918 | 1988 to 1990 |
| **10** | 1945 to 1957 | 1960 to 1965 | 1988 to 1991 | 1945 to 1957 | 1999 to 2002 | 1988 to 1991 |

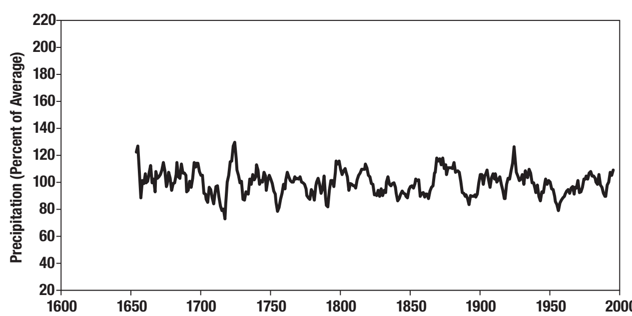
and is responsible for long-term impacts on Texas precipitation, often leading to periods of moderate to severe drought. During a weak or negative oscillation, known as a La Niña phase, precipitation will generally be below average in Texas and some degree of drought will occur. (The State Climatologist and the National Atmospheric and Oceanic Administration both attribute drought conditions experienced in Texas in 2010 and 2011 to La Niña conditions in the Pacific.) During a strong positive oscillation or El Niño phase, Texas will usually experience above average precipitation.

The Pacific Decadal Oscillation affects sea surface temperatures in the northern Pacific Ocean, while the Atlantic Multidecadal Oscillation affects the sea surface temperature gradient from the equator poleward (Nielson-Gammon, 2011a). These two long-term oscillations can enhance or dampen the effects of the El Niño Southern Oscillation phases and therefore long-term patterns of wet and dry cycles of the climate. Generally, drought conditions are enhanced by cool sea surface temperatures of the Pacific Decadal Oscillation and also warm sea surface temperatures of the Atlantic Multidecadal Oscillation.

### FIGURE 4.6. ANNUAL PRECIPITATION BASED ON POST OAK TREE RINGS FOR THE SAN ANTONIO AREA (DATA FROM CLEAVELAND, 2006).




### FIGURE 4.7. SEVEN-YEAR RUNNING AVERAGE OF PRECIPITATION BASED ON POST OAK TREE RINGS FOR THE SAN ANTONIO AREA (DATA FROM CLEAVELAND, 2006).



## 4.5 DROUGHT SEVERITY IN TEXAS

Droughts are periods of less than average precipitation over a period of time. The Palmer Drought Severity Index is often used to quantify long-term drought conditions and is commonly used by the U.S. Department of Agriculture to help make policy decisions such as when to grant emergency drought assistance. The severity of drought depends upon several factors, though duration and intensity are the two primary components. The drought of record during the 1950s ranks the highest in terms of both duration and intensity (Table 4.1). However, it should be noted that drought rankings can be misleading since a single year of above average rainfall can interrupt a prolonged drought, reducing its ranking. Nonetheless, on a statewide basis, the drought of the 1950s still remains the most severe drought the state has ever experienced based on recorded measurements of precipitation. Other significant droughts in Texas occurred in the late 1800s and the 1910s, 1930s, and 1960s. At the end of 2011, the 2011 drought may rank among the most intense one-year droughts on record in many climatic divisions.

## 4.6 CLIMATE VARIABILITY

The climate of Texas is, has been, and will continue to be variable. Since variability affects the availability of the state's water resources, it is recognized by the regional water planning groups when addressing needs for water during a repeat of the drought of record. More discussion on how planning groups address climate variability and other uncertainties can be found in Chapter 10, Challenges and Uncertainty.

Climate data are generally available in Texas from the late 19th century to the present, but this is a relatively short record that can limit our understanding of long-term climate variability. Besides the variability measured in the record, historic variability can be estimated through environmental proxies by the study of tree rings, while future variability can be projected through the analysis of global climate models. Annual tree growth, expressed in a tree growth ring, is strongly influenced by water availability. A dry year results in a thin growth ring, and a wet year results in a thick growth ring. By correlating tree growth ring thickness with precipitation measured during the period of record, scientists can extend the climatic record back hundreds of years.

In Texas, scientists have completed precipitation data reconstructions using post oak and bald cypress trees. In the San Antonio area (Cleaveland, 2006), reconstruction of precipitation using post oak trees from 1648 to 1995 (Figure 4.6) indicates that the highest annual precipitation was in 1660 (about 212 percent of average) and the lowest annual precipitation was in 1925 (about 27 percent of average).

Drought periods in this dataset can also be evaluated with seven-year running averages (Figure 4.7). The drought of record that ended in 1956 can be seen in this reconstruction, with the seven-year precipitation during this period about 79 percent of average. This record shows two seven-year periods that were drier than the drought of record: the seven-year period that ended in 1717 had precipitation of about 73 percent of average, and the seven-year period that ended in 1755 had a seven-year average precipitation of about 78 percent. There have been about 15 seven-year periods where precipitation was below 90 percent of average, indicating an extended drought.

## 4.7 FUTURE VARIABILITY

Climate scientists have developed models to project what the Earth's climate may be like in the future under certain assumptions, including the composition of the atmosphere. In simple terms, the models simulate incoming solar energy and the outgoing energy in the form of long-wave radiation. The models also simulate interactions between the atmosphere, oceans, land, and ice using well-established physical principles. The models are capable of estimating future climate based on assumed changes in the atmosphere that change the balance between incoming and outgoing energy. These models can provide quantitative estimates of future climate variability, particularly at continental and larger scales (IPCC, 2007). Confidence in these estimates is higher for some climate variables, such as temperature, than for others, such as precipitation.

While the climate models provide a framework for understanding future changes on a global or continental scale, scientists have noted that local temperature changes, even over decades to centuries, may also be strongly influenced by changes in regional climate patterns and sea surface temperature variations, making such changes inherently more complex. According to John W. Nielsen-Gammon, "If temperatures rise and precipitation decreases as projected by climate models, droughts as severe as those in the beginning or middle of the 20th Century would become increasingly likely" (2011b). However, the temperature increase began during a period of unusually cold temperatures. It is only during the last 10 to 15 years that temperatures have become as warm as during earlier parts of the 20th century, such as the Dust Bowl of the 1930s and the drought of the 1950s.

Climate scientists have also reported results of model projections specific to Texas, with the projected temperature trends computed relative to a simulated 1980 to 1999 average. The projections indicate an increase of about 1°F for the 2000 to 2019 period, 2°F for the 2020 to 2039 period, and close to 4°F for the 2040 to 2059 period (Nielsen-Gammon, 2011c).

Precipitation trends over the 20th century are not always consistent with climate model projections. The model results for precipitation indicate a decline in precipitation toward the middle of the 21st century. However, the median rate of decline (about 10 percent per century) is smaller than the observed rate of increase over the past century. Furthermore, there is considerable disagreement among models whether there will be an increase or a decrease in precipitation prior to the middle of the 21st century. While the climate models tend to agree on the overall global patterns of precipitation changes, they produce a wide range of precipitation patterns on the scale of Texas itself, so that there is no portion of the state that is more susceptible to declining precipitation in the model projections than any other.

Climate scientists have reported that drought is expected to increase in general worldwide because of the increase of temperatures and the trend toward concentration of rainfall into events of shorter duration (Nielsen-Gammon, 2011c). In Texas, temperatures are likely to rise; however, future precipitation trends are difficult to project. If temperatures rise and precipitation decreases, as projected by climate models, Texas would begin seeing droughts in the middle of the 21st century that are as bad or worse as those in the beginning or middle of the 20th century.

While the study of climate models can certainly be informative during the regional water planning process, there is a considerable degree of uncertainty associated with use of the results at a local or regional scale. The large-scale spatial resolution of most climate models (typically at a resolution of 100 to

200 miles by 100 to 200 miles) are of limited use for planning regions since most hydrological applications require information at a 30-mile scale or less. Recent research, including some funded by TWDB, has been focused in the area of "downscaling" climate models, or converting the global-scale output to regional-scale conditions. The process to produce a finer-scale climate model can be resource-intensive and can only be done one region at a time, thus making it difficult to incorporate the impacts of climate variability in local or region-specific water supply projections.

## 4.8 TWDB ONGOING RESEARCH

TWDB has undertaken several efforts to address potential impacts from climate variability to water resources in the state and how these impacts can be addressed in the water planning process. In response to state legislation, TWDB co-hosted a conference in El Paso on June 17, 2008, to address the possible impact of climate change on surface water supplies from the Rio Grande (Sidebar: The Far West Texas Climate Change Conference). The agency also hosted two Water Planning and Climate Change Workshops

### THE FAR WEST TEXAS CLIMATE CHANGE CONFERENCE

As a result of legislation passed during the 80th Texas Legislative Session, TWDB, in coordination with the Far West Texas Regional Water Planning Group, conducted a study regarding the possible impact of climate change on surface water supplies from the portion of the Rio Grande in Texas subject to the Rio Grande Compact. In conducting the study, TWDB was directed to a convene a conference within the Far West Texas regional water planning area to review

- any analysis conducted by a state located west of Texas regarding the impact of climate change on surface water supplies in that state;
- any other current analysis of potential impacts of climate change on surface water resources; and
- recommendations for incorporating potential impacts of climate change into the Far West Texas Regional Water Plan, including potential impacts to the Rio Grande in Texas subject to the Rio Grande Compact, and identifying feasible water management strategies to offset any potential impacts.

The Far West Texas Climate Change Conference was held June 17, 2008, in El Paso. Over 100 participants attended, including members of the Far West Texas Regional Water Planning Group and representatives from state and federal agencies, environmental organizations, water providers, universities, and other entities. TWDB published a report on the results of the conference in December 2008. General policy recommendations from the conference included

- continuing a regional approach to considering climate change in regional water planning;
- establishing a consortium to provide a framework for further research and discussion;
- reconsidering the drought of record as the benchmark scenario for regional water planning; and
- providing more funding for research, data collection, and investments in water infrastructure.

in 2008 and 2009 to address the issue of climate on a state level. The workshops convened experts in the fields of climate variability and water resources planning to discuss possible approaches to estimating the impact of climate variability on water demand and availability and how to incorporate these approaches into regional water planning efforts.

In response to recommendations from these experts, TWDB initiated two research studies. The *Uncertainty and Risk in the Management of Water Resources* (INTERA Incorporated and others, 2010) study developed a generalized methodology that allows various sources of uncertainty to be incorporated into the regional water planning framework. Using estimates of the probability of specific events, planners will be able to use this model to analyze a range of scenarios and potential future outcomes. A second, on-going research study assessing global climate models for water resource planning applications is comparing global climate models to determine which are most suitable for use in Texas. The study is also comparing regionalization techniques used in downscaling of global climate models and will provide recommendations on the best methodology for a given region.

The agency also formed a staff workgroup that leads the agency's efforts to

- monitor the status of climate science, including studies for different regions of Texas;
- assess changes predicted by climate models;
- analyze and report data regarding natural climate variability; and
- evaluate how resilient water management strategies are in adapting to climate variability and how regional water planning groups might address the impacts.

Until better information is available to determine the impacts of climate variability on water supplies and water management strategies evaluated during the planning process, regional water planning groups can continue to use safe yield (the annual amount of water that can be withdrawn from a reservoir for a period of time longer than the drought of record) and to plan for more water than required to meet needs, as methods to address uncertainty and reduce risks. TWDB will continue to monitor climate policy and science and incorporate new developments into the cyclical planning process when appropriate. TWDB will also continue stakeholder and multi-disciplinary involvement on a regular basis to review and assess the progress of the agency's efforts.

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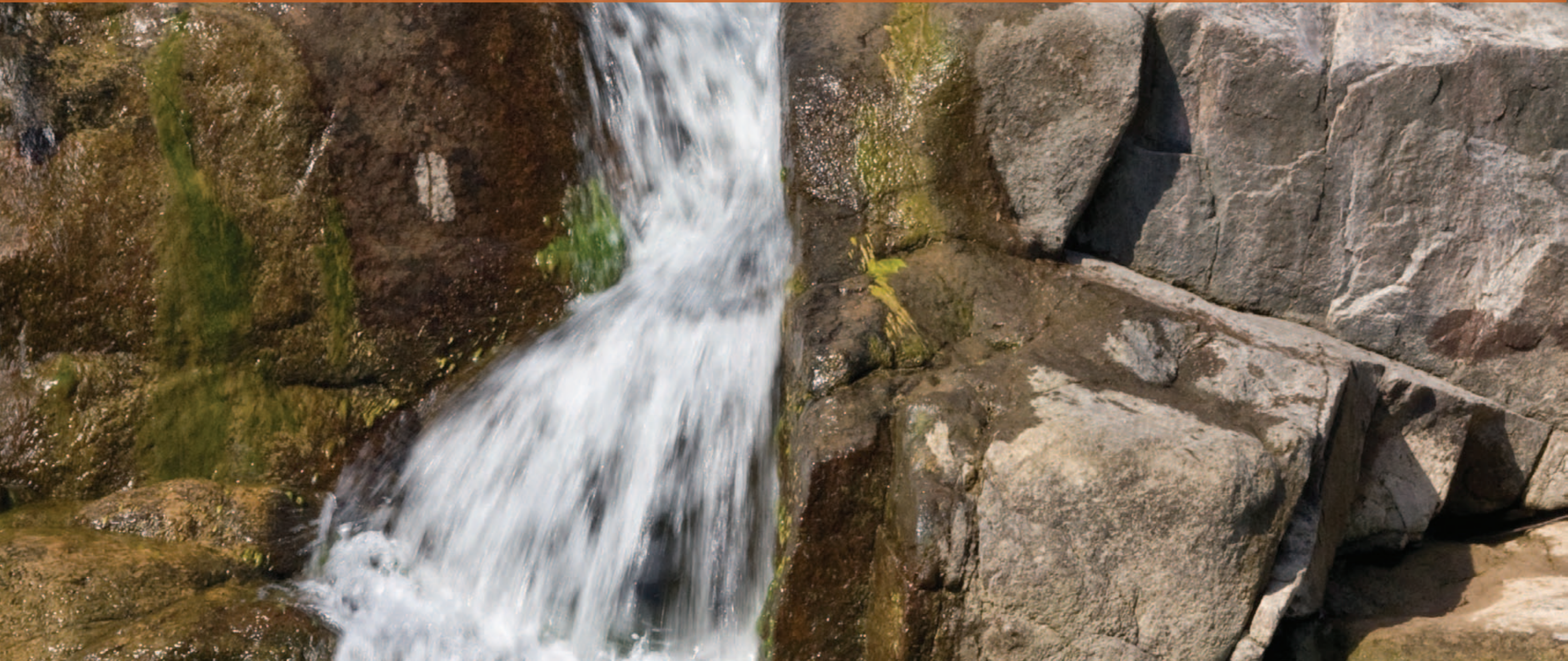
# Quick Facts

Groundwater supplies are projected to decrease 30 percent, from about 8 million acre-feet in 2010 to about 5.7 million acre-feet in 2060, primarily due to reduced supply from the Ogallala Aquifer as a result of its depletion over time, and reduced supply from the Gulf Coast Aquifer due to mandatory reductions in pumping to prevent land subsidence.

Surface water supplies are projected to increase by about 6 percent, from about 8.4 million acre-feet in 2010 to about 9.0 million acre-feet in 2060, based on a new methodology of adding contract expansions to existing supply only when those supplies are needed, and offsetting losses due to sedimentation of reservoirs.



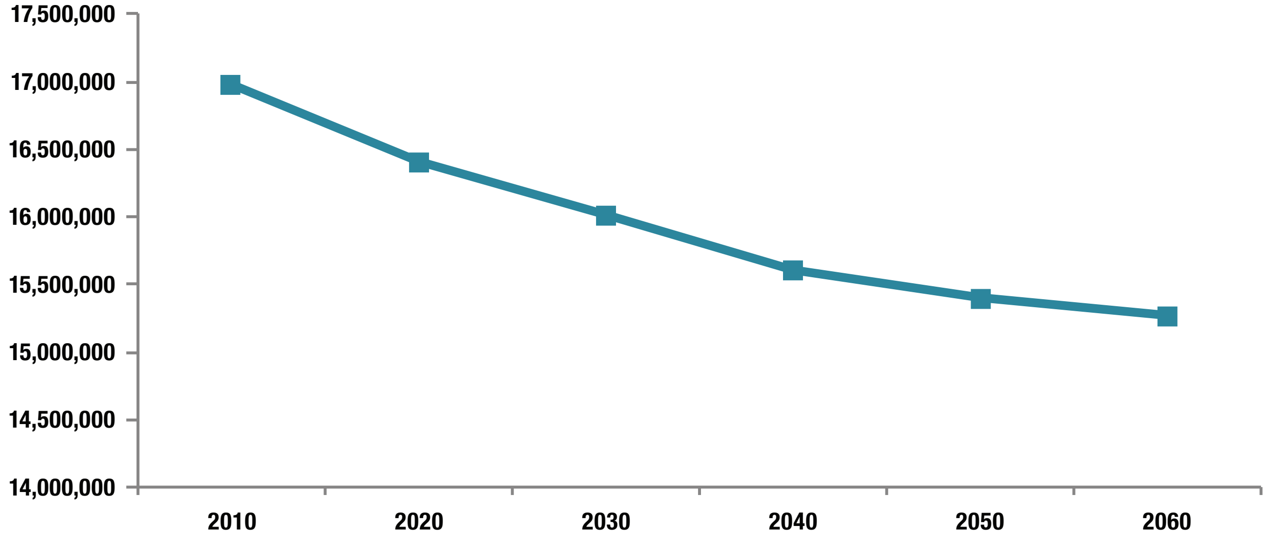
# 5 Water Supplies

**Existing water supplies — the amount of water that can be produced with current permits, current contracts, and existing infrastructure during drought — are projected to decrease about 10 percent, from about 17.0 million acre-feet in 2010 to about 15.3 million acre-feet in 2060.**

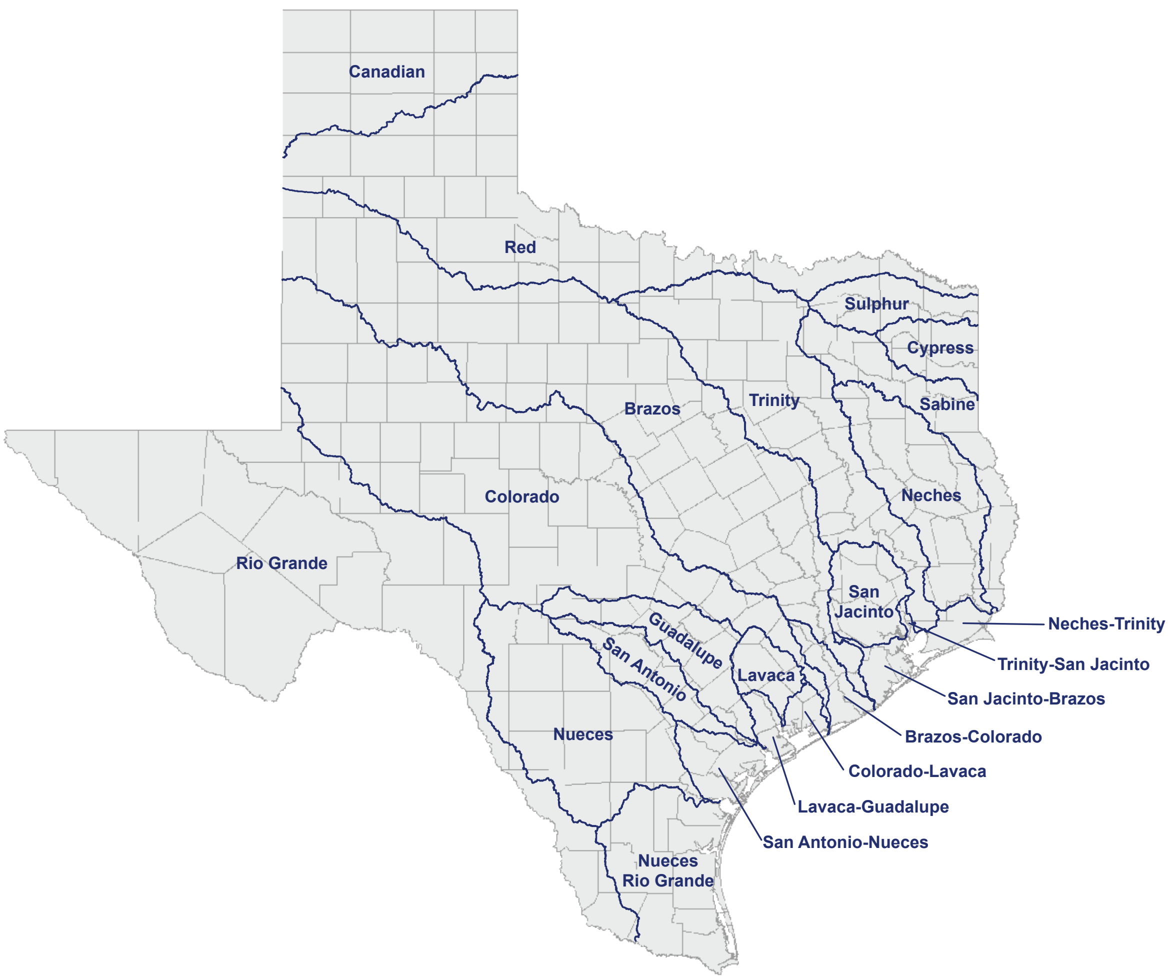
When planning to address water needs during a drought, it is important to know how much water is available now and how much water will be available in the future. Water supplies are traditionally from surface water and groundwater sources; however, water reuse and seawater desalination are expected to become a growing source of water over the next 50 years. Existing water supplies are those supplies that are physically and legally available now. In other words, existing supplies include water that providers have permits or contracts for now and are able to provide to water users with existing infrastructure such as reservoirs, pipelines, and well fields. Water availability, on the other hand, refers to how much water would be available if there were no legal or infrastructure limitations.

During their evaluation of existing water supplies, regional water planning groups determine how much water would be physically and legally available from existing sources under drought conditions with consideration of all existing permits, agreements, and infrastructure. To estimate existing water supplies, the planning groups use the state's surface water and groundwater availability models, when available. The state's existing water supplies—mainly from surface water, groundwater, and reuse water—are projected to decrease about 10 percent over the planning horizon, from about 17.0 million acre-feet in 2010 to about 15.3 million acre-feet in 2060 (Figure 5.1). Estimates of existing supplies compared to projected water demands are used by the planning groups to determine water supply needs or surpluses for individual water user groups.

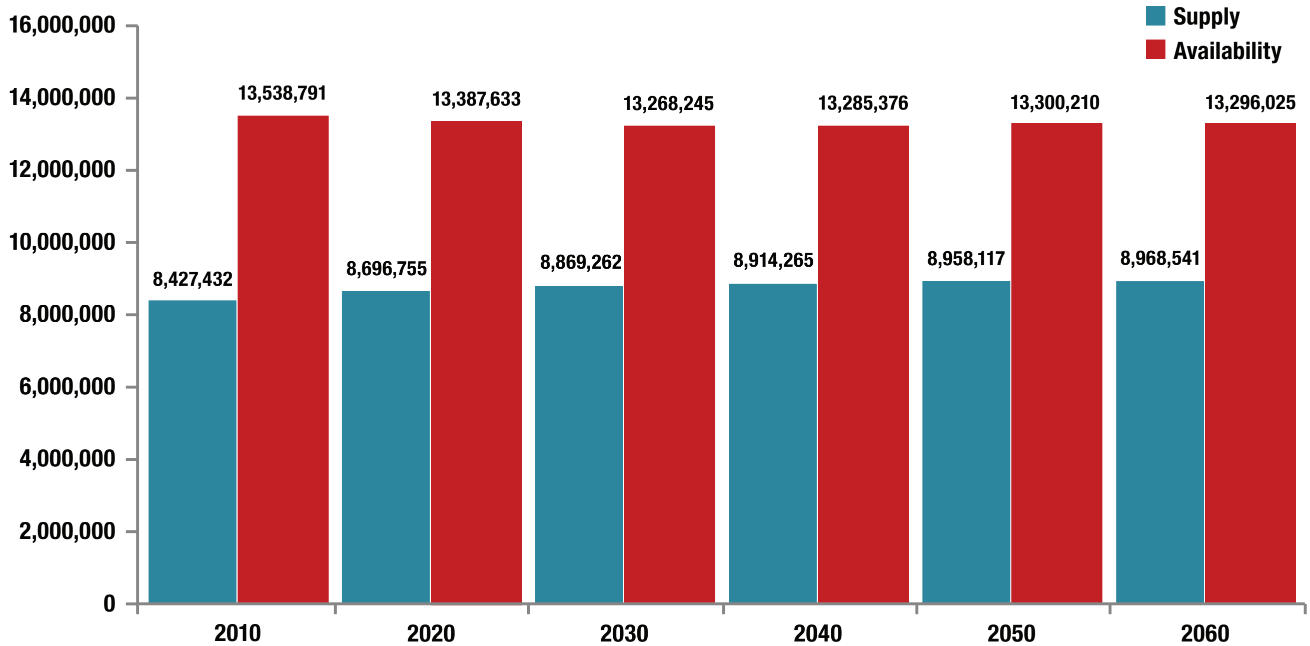
## FIGURE 5.1. PROJECTED EXISTING WATER SUPPLIES (ACRE-FEET PER YEAR).




## FIGURE 5.2. MAJOR RIVER BASINS OF TEXAS.



## FIGURE 5.3. PROJECTED EXISTING SURFACE WATER SUPPLIES AND SURFACE WATER AVAILABILITY THROUGH 2060 (ACRE-FEET PER YEAR).




## 5.1 SURFACE WATER SUPPLIES

Surface water accounted for nearly 40 percent of the total 16.1 million acre-feet of water used in Texas in 2008, according to the latest TWDB Water Use Survey information available. The state has a vast array of surface waters, including rivers and streams, lakes and reservoirs, springs and wetlands, bays and estuaries, and the Gulf of Mexico. Texas' surface water resources include

- 15 major river basins and 8 coastal basins (Figure 5.2)
- 191,000 miles of streams and rivers
- 7 major and 5 minor estuaries

The 2007 State Water Plan included summaries of each of the 15 major river basins in Texas; these summaries are still current and are incorporated by reference in the 2012 State Water Plan. The river basin summaries included location maps; a description of the basin; and information on reservoir capacity and yield, surface water rights, and approximate surface water supply with implementation of water management strategies recommended in the 2007 State Water Plan.

Surface water is captured in 188 major water supply reservoirs (Appendix C)—those with a storage capacity of 5,000 acre-feet or more—and in over 2,000 smaller impoundments throughout the state. Nine of Texas' 16 planning regions rely primarily on surface water for their existing supplies and will continue to rely on this important resource through 2060. Surface water abundance generally matches precipitation patterns in Texas; annual yield from Texas' river basins, the average annual flow volume per unit of drainage area, varies from about 11.8 inches in the Sabine River Basin in east Texas to 0.1 inch in the Rio Grande Basin in west Texas.

### 5.1.1 EXISTING SURFACE WATER SUPPLIES

Existing surface water supplies represent the maximum amount of water legally and physically available from existing sources for use during drought

## TABLE 5.1. EXISTING SURFACE WATER SUPPLIES BY RIVER BASIN (ACRE-FEET PER YEAR)

| River Basin | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Percent Change* |
|---|---|---|---|---|---|---|---|
| Brazos | 1,273,273 | 1,271,586 | 1,275,209 | 1,277,160 | 1,277,876 | 1,278,589 | 0 |
| Brazos-Colorado | 21,433 | 21,485 | 21,536 | 21,591 | 21,654 | 21,662 | 1 |
| Canadian | 44,174 | 55,816 | 55,779 | 55,729 | 54,332 | 54,264 | 22 |
| Colorado | 994,305 | 989,650 | 990,151 | 991,147 | 992,524 | 991,281 | -0 |
| Colorado-Lavaca | 4,298 | 4,298 | 4,298 | 4,298 | 4,298 | 4,298 | 0 |
| Cypress | 274,271 | 273,979 | 273,618 | 273,247 | 273,915 | 274,029 | -0 |
| Guadalupe | 205,990 | 206,626 | 205,197 | 201,260 | 201,329 | 201,408 | -2 |
| Lavaca | 79,354 | 79,354 | 79,354 | 79,354 | 79,354 | 79,354 | 0 |
| Lavaca-Guadalupe | 434 | 434 | 434 | 434 | 434 | 434 | 0 |
| Neches | 524,063 | 802,883 | 985,391 | 1,013,133 | 1,034,174 | 1,060,852 | 102 |
| Neches-Trinity | 79,066 | 79,066 | 79,066 | 79,066 | 79,066 | 79,067 | 0 |
| Nueces | 148,874 | 153,069 | 157,631 | 159,427 | 159,934 | 160,746 | 8 |
| Nueces-Rio Grande | 8,908 | 8,908 | 8,908 | 8,908 | 8,908 | 8,908 | 0 |
| Red | 342,559 | 328,060 | 323,901 | 319,524 | 314,769 | 309,339 | -9 |
| Rio Grande | 1,150,631 | 1,144,214 | 1,138,329 | 1,132,278 | 1,125,801 | 1,119,901 | -2 |
| Sabine | 691,243 | 670,275 | 650,091 | 649,761 | 649,841 | 648,341 | -6 |
| Sabine-Louisiana | 235 | 235 | 235 | 235 | 235 | 235 | 0 |
| San Antonio | 61,259 | 61,259 | 61,258 | 61,258 | 61,257 | 61,256 | 0 |
| San Antonio-Nueces | 1,794 | 1,794 | 1,794 | 1,794 | 1,794 | 1,794 | 0 |
| San Jacinto | 202,592 | 202,952 | 203,117 | 203,113 | 203,126 | 203,133 | 0 |
| San Jacinto-Brazos | 27,450 | 27,434 | 27,501 | 27,545 | 27,597 | 27,645 | 0 |
| Sulphur | 308,788 | 311,559 | 316,552 | 321,336 | 325,577 | 333,513 | 8 |
| Trinity | 1,943,370 | 1,962,750 | 1,970,841 | 1,993,645 | 2,021,370 | 2,009,621 | 3 |
| Trinity-San Jacinto | 39,068 | 39,069 | 39,071 | 39,022 | 38,952 | 38,871 | 0 |
| **Total** | **8,427,432** | **8,696,755** | **8,869,262** | **8,914,265** | **8,958,117** | **8,968,541** | **6** |

*Percent represents the percent change from 2010 through 2060.

conditions. Most planning regions base their estimates of existing surface water supplies on firm yield, the maximum volume of water a reservoir can provide each year under a repeat of the drought of record. Some regions, however, base their plans and estimates of existing supply on safe yield, the annual amount of water that can be withdrawn from a reservoir for a period of time longer than the drought of record, often one to two years. Use of safe yield in planning allows a buffer to account for climate variability, including the possibility of a drought that might be worse than the drought of record.

Total existing surface water supplies in Texas were 8.4 million acre-feet in 2010; these supplies are projected to increase to 9.0 million acre-feet by 2060 (Figure 5.3). The amount of existing supplies was determined by the planning groups based on a combination of firm yields and safe yields.

Existing surface water supplies are greatest in the Trinity, Brazos, and Rio Grande river basins (Table 5.1). Existing supplies increase the most from 2010 to 2060 for the Neches River Basin as additional surface water is made available through existing contracts. The increase in contracted water through 2060 is greater than the loss of existing surface water supply that occurs due to reservoir sedimentation. Decreases in the amount of existing surface water supplies can occur due to loss of reservoir capacity to sedimentation. The 2007 State Water Plan also showed a decreasing trend in surface water supply due to sedimentation.

## TABLE 5.2. SURFACE WATER AVAILABILITY BY RIVER BASIN (ACRE-FEET PER YEAR)

| River Basin | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Percent Change* |
|---|---|---|---|---|---|---|---|
| Brazos | 1,641,169 | 1,653,791 | 1,594,374 | 1,586,831 | 1,579,328 | 1,571,832 | -4 |
| Brazos-Colorado | 21,433 | 21,485 | 21,536 | 21,591 | 21,654 | 21,662 | 1 |
| Canadian | 48,136 | 68,105 | 68,064 | 68,024 | 67,984 | 67,947 | 41 |
| Colorado | 1,170,052 | 1,149,068 | 1,154,169 | 1,183,249 | 1,189,432 | 1,225,451 | 5 |
| Colorado-Lavaca | 4,298 | 4,298 | 4,298 | 4,298 | 4,298 | 4,298 | 0 |
| Cypress | 378,087 | 377,847 | 377,607 | 377,367 | 377,127 | 376,887 | 0 |
| Guadalupe | 273,961 | 273,890 | 273,820 | 273,749 | 273,678 | 273,607 | 0 |
| Lavaca | 79,374 | 79,374 | 79,374 | 79,374 | 79,374 | 79,374 | 0 |
| Lavaca-Guadalupe | 434 | 434 | 434 | 434 | 434 | 434 | 0 |
| Neches | 2,328,154 | 2,324,792 | 2,321,431 | 2,318,067 | 2,314,705 | 2,311,367 | -1 |
| Neches-Trinity | 79,070 | 79,070 | 79,070 | 79,070 | 79,070 | 79,071 | 0 |
| Nueces | 185,920 | 184,902 | 183,884 | 182,866 | 181,851 | 180,843 | -3 |
| Nueces-Rio Grande | 8,922 | 8,922 | 8,922 | 8,922 | 8,922 | 8,922 | 0 |
| Red | 578,732 | 574,363 | 569,966 | 565,463 | 560,798 | 556,427 | -4 |
| Rio Grande | 1,184,415 | 1,176,889 | 1,169,864 | 1,162,838 | 1,155,812 | 1,149,286 | -3 |
| Sabine | 1,837,834 | 1,834,362 | 1,830,796 | 1,827,234 | 1,823,675 | 1,820,110 | -1 |
| Sabine-Louisiana | 235 | 235 | 235 | 235 | 235 | 235 | 0 |
| San Antonio | 61,259 | 61,259 | 61,258 | 61,258 | 61,257 | 61,256 | 0 |
| San Antonio-Nueces | 1,794 | 1,794 | 1,794 | 1,794 | 1,794 | 1,794 | 0 |
| San Jacinto | 324,110 | 320,570 | 316,835 | 312,931 | 309,044 | 305,151 | -6 |
| San Jacinto-Brazos | 58,791 | 58,775 | 51,026 | 51,070 | 51,122 | 51,170 | -13 |
| Sulphur | 524,561 | 522,307 | 519,889 | 517,755 | 515,332 | 513,224 | -2 |
| Trinity | 2,708,894 | 2,571,944 | 2,540,440 | 2,561,796 | 2,604,123 | 2,596,498 | -4 |
| Trinity-San Jacinto | 39,156 | 39,157 | 39,159 | 39,160 | 39,161 | 39,179 | 0 |
| **Total** | **13,538,791** | **13,387,633** | **13,268,245** | **13,285,376** | **13,300,210** | **13,296,025** | **-2** |

*Percent represents the percent change from 2010 through 2060.

### 5.1.2 SURFACE WATER AVAILABILITY

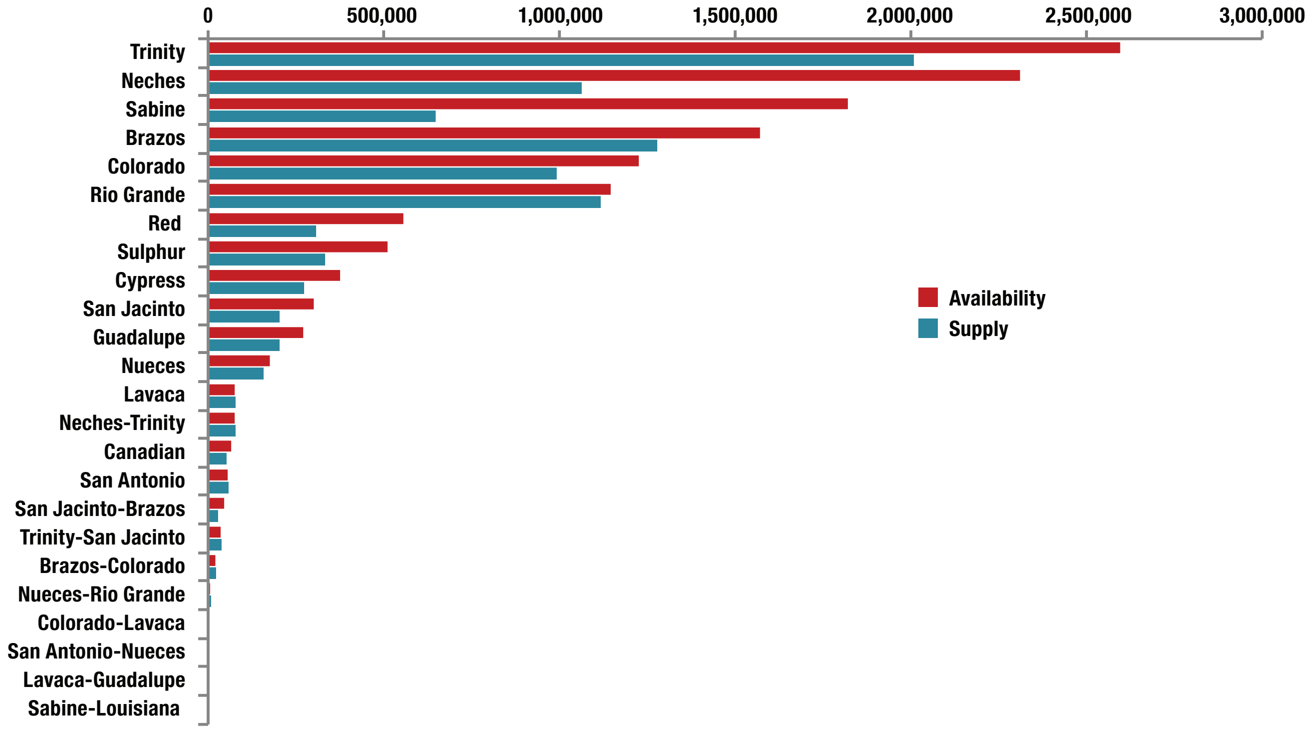
Surface water availability is derived from water availability models, computer-based simulations developed by the Texas Commission on Environmental Quality that predict the amount of water that would be available for diversion under a specified set of conditions. Surface water availability represents the maximum amount of water available each year during the drought of record regardless of legal or physical availability. Total surface water availability in Texas in 2010 is estimated at 13.5 million acre-feet per year and decreases to 13.3 million acre-feet per year (Figure 5.3) by 2060. Water availability is the greatest in the Trinity, Neches, and Sabine river basins for the 2010 to 2060 period (Table 5.2). Loss of some surface water availability is due to reservoir sedimentation.

Surface water availability projections equal or exceed existing supplies in all river basins in the state (Figure 5.4). The Neches and Sabine river basins, where availability exceeds supply by 2 million acre-feet in 2060, show the greatest potential to increase surface water supplies in the future.

### 5.1.3 FUTURE IMPACTS TO AVAILABILITY: ENVIRONMENTAL FLOWS

The concept of environmental flows refers to the water required to maintain healthy and productive rivers and estuaries—bays or inlets, often at the mouth of a river, in which large quantities of freshwater and seawater mix together. State law requires consideration of environmental flows in Texas' regional water planning and surface water permitting processes.

## FIGURE 5.4. EXISTING SURFACE WATER SUPPLIES AND SURFACE WATER AVAILABILITY IN 2060 BY RIVER BASIN (ACRE-FEET PER YEAR).




Early studies of the effect of freshwater inflow upon the bays and estuaries of Texas led to a series of publications for all of Texas' major estuaries in the 1980s, with subsequent updates in the 1990s and 2000s. Instream flow needs—the amount of water needed in a stream to adequately provide for downstream uses occurring within the stream channel—were first developed for Texas' rivers using the "Lyon's method," and later the Consensus Criteria for Environmental Flow Needs for water supply planning. Senate Bill 2, passed by the 77th Texas Legislature in 2001, directed TWDB, the Texas Commission on Environmental Quality, and the Texas Parks and Wildlife Department to work together to maintain data collection programs and conduct studies to develop appropriate methodologies for determining environmental flows needed to protect rivers and streams.

Although methodologies had been established for developing environmental flow needs prior to 2007, there was a desire among stakeholders for more certainty in how the methodologies would be applied in the evaluation and permitting of new water supply projects. Senate Bill 3, passed by the 80th Texas Legislature in 2007, addressed these issues and led to a new approach in developing environmental flow needs for the state's major rivers and estuaries in an accelerated, science-based process with stakeholder input.

Environmental flow recommendations resulting from the Senate Bill 3 process are scheduled to be completed for the Sabine-Neches, Trinity-San Jacinto, Brazos, Colorado-Lavaca, Guadalupe-San Antonio, Nueces, and Rio Grande river basins and their associated bays by 2012. Standards and rules for these systems are scheduled to be set by the Texas Commission on Environmental Quality in 2013 and to be available for use in developing the 2017 State Water Plan. No schedule has been set for the remaining river basins in Texas.

Planning groups consider the impacts of recommended water management strategies on a number of resources, including instream flows and bay and estuary freshwater inflows. Senate Bill 3 rules for environmental flows for Texas' rivers and estuaries had not been adopted while the 2011 regional water plans were being developed; therefore, they were not considered in development of the 2012 State Water Plan. The regional water planning groups must meet all state laws when developing regional water plans and must therefore consider Senate Bill 3 environmental flow standards that are in place when developing future plans.

Beginning with the 2011 to 2016 planning cycle, regional water plans will consider environmental flow standards as they are developed and adopted by the Texas Commission on Environmental Quality as a result of the Senate Bill 3 environmental flow process. These new standards will be incorporated, as appropriate, within the surface water availability models that planning groups use to assess current surface water supplies and to evaluate and recommend water management strategies. In basins that do not have environmental flow standards in place, other site-specific studies or the Consensus Criteria for Environmental Flow Needs will continue to be considered, as in previous planning cycles.

## 5.2 GROUNDWATER SUPPLIES

Groundwater is and will continue to be an important source of water for Texas. Before 1940, groundwater provided less than 1 million acre-feet of water per year to Texans. Since the drought of record in the 1950s, groundwater production has been about 10 million acre-feet per year. In 2008, according to the latest TWDB Water Use Survey information available, groundwater provided 60 percent of the 16.1 million acre-feet of water used in the state. Farmers used about 80 percent of this groundwater to irrigate crops. Municipalities used about 15 percent of all the groundwater in 2008, meeting about 35 percent of their total water demands.

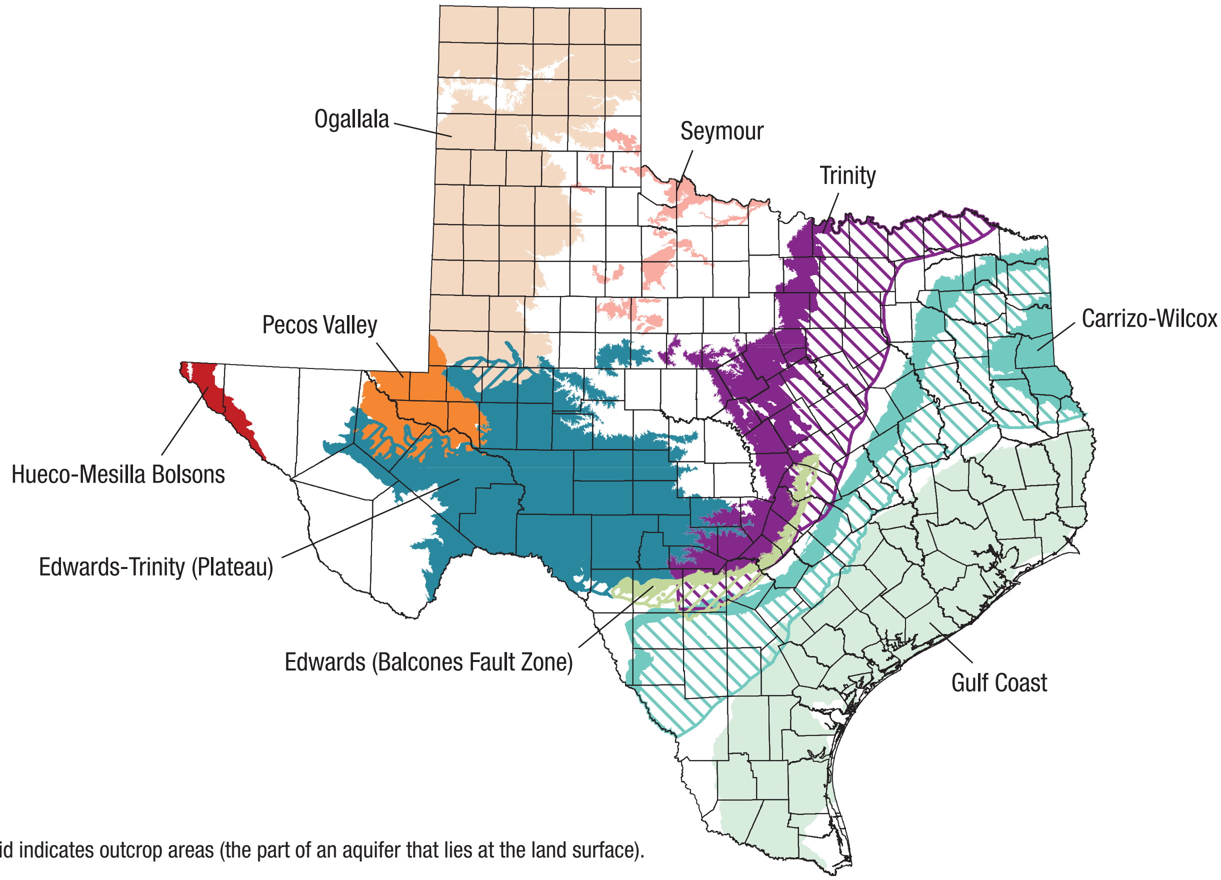
TWDB recognizes 30 major and minor aquifers, each with their own characteristics and ability to produce water. Along with a number of other local, state, and federal agencies, TWDB monitors the water quality and water levels of these aquifers. This information assists groundwater managers and regional water planning groups in estimating groundwater supplies and availability. It is also used in groundwater availability models, developed by TWDB to aid groundwater managers and water planners in better understanding and using this vital natural resource in Texas.

Texas has a number of aquifers that are capable of producing groundwater for municipal, industrial, and agricultural uses. TWDB recognizes 9 major aquifers that produce large amounts of water over large areas (Figure 5.5), and 21 minor aquifers that produce minor amounts of water over large areas or large amounts of water over small areas (Figure 5.6). The 2007 State Water Plan included summaries of each of the 30 major and minor aquifers in Texas; these summaries are still current and are incorporated by reference in the 2012 State Water Plan. The aquifer summaries include location maps; a discussion and list of aquifer properties and characteristics; and projections of groundwater supplies, including supplies to be obtained from implementing water management strategies from the 2007 State Water Plan.

### 5.2.1 EXISTING GROUNDWATER SUPPLIES

Existing groundwater supplies represent the amount of groundwater that can be produced with current

## FIGURE 5.5. THE MAJOR AQUIFERS OF TEXAS.



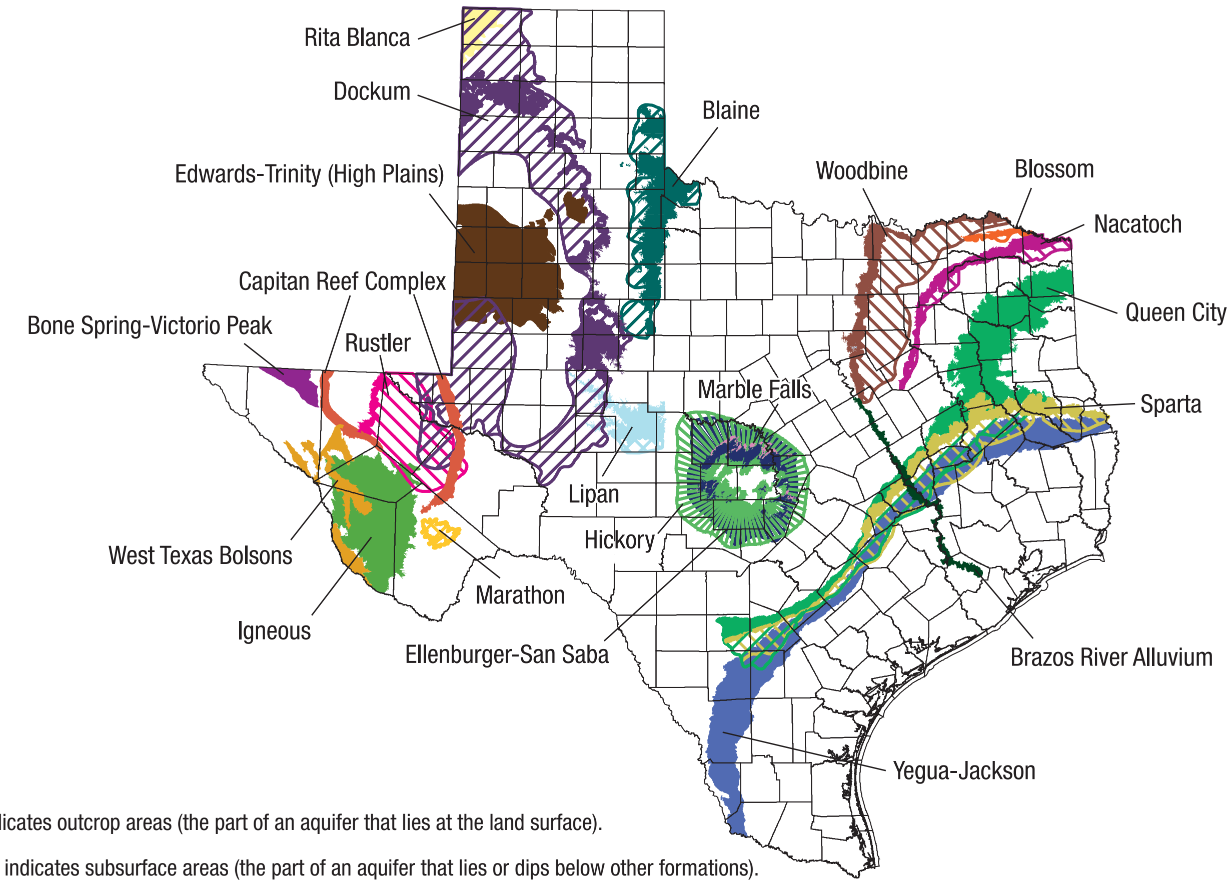

Solid indicates outcrop areas (the part of an aquifer that lies at the land surface).

Hatched indicates subsurface areas (the part of an aquifer that lies or dips below other formations).

permits and existing infrastructure. Because permits and existing infrastructure limit how much groundwater can be produced, existing groundwater supply can be—and often is—less than the total amount that can be physically produced from an aquifer. A permit represents a legal limit on how much water can be produced. Therefore, even though a group of wells may be able to pump 2,000 acre-feet per year, the supply is limited to 1,000 acre-feet per year if the permit is for 1,000 acre-feet per year. On the other hand, if the permit is for 2,000 acre-feet per year but existing infrastructure—that is, current wells—can only pump 1,000 acre-feet per year, then the groundwater supply is 1,000 acre-feet per year. By calculating groundwater supply, water planners know how much groundwater can be used with current infrastructure and what needs to be done to meet needs in the future (for example, larger pumps, new wells, or pipelines).

Existing groundwater supplies were about 8.1 million acre-feet per year in 2010 and will decline 30 percent over the planning horizon, to about 5.7 million acre-feet per year by 2060 (Figure 5.7, Table 5.3). This decline is due primarily to reduced supplies from the Ogallala and Gulf Coast aquifers: annual Ogallala Aquifer supplies are projected to decline by about 2 million acre-feet per year by 2060 as a result of depletion, while annual Gulf Coast Aquifer supplies are projected to decline by about 210,000 acre-feet per year by 2060 due to mandatory reductions in pumping to prevent land surface subsidence (Figure 5.8). In

## FIGURE 5.6. THE MINOR AQUIFERS OF TEXAS.




Solid indicates outcrop areas (the part of an aquifer that lies at the land surface).

Hatched indicates subsurface areas (the part of an aquifer that lies or dips below other formations).

The Edwards-Trinity (High Plains) and Rita Blanca aquifers are both entirely subsurface.

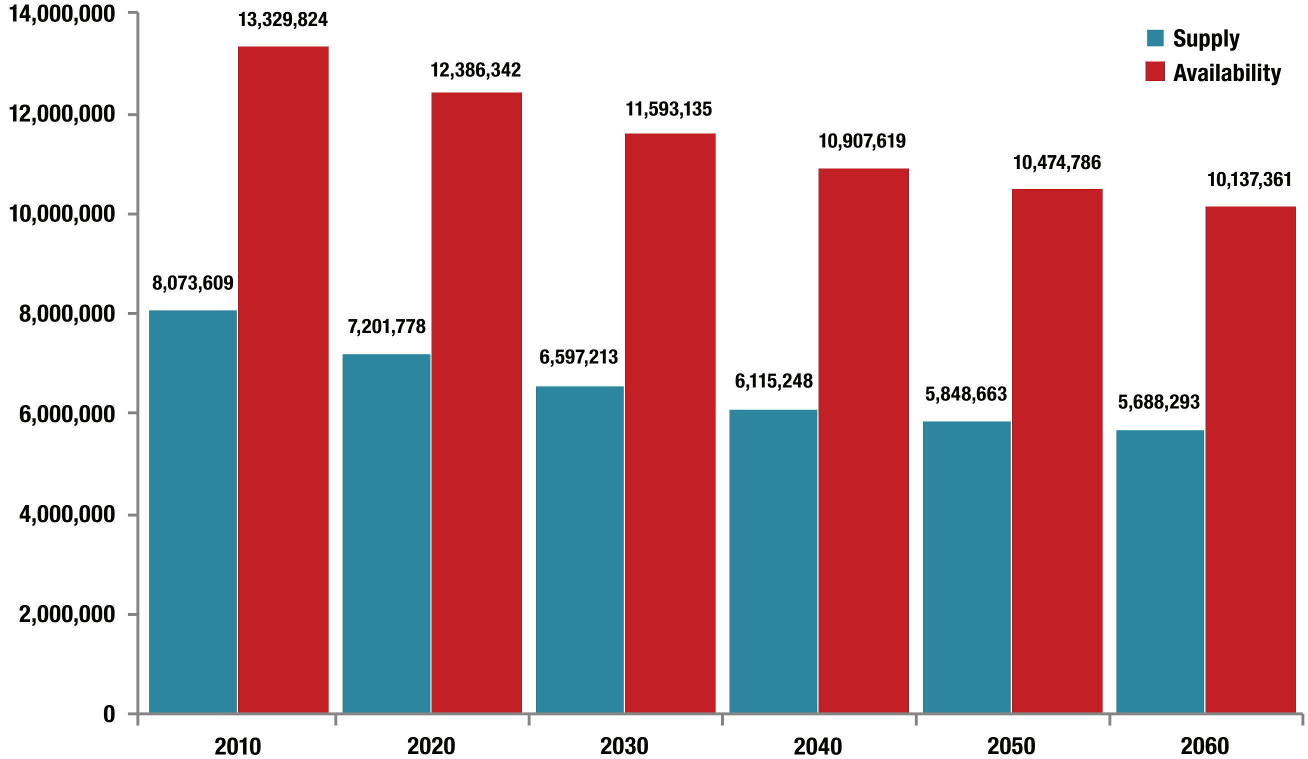
most cases, existing groundwater supplies either remain constant over the planning horizon or decrease by 2060.

### 5.2.2 GROUNDWATER AVAILABILITY

Groundwater availability is the amount of water from an aquifer that is available for use regardless of legal or physical availability. One might think that the amount of groundwater available for use is all of the water in the aquifer; however, that may not—and probably is not—the case. Groundwater availability is limited by existing infrastructure, as well as by law, groundwater management district goals, and state rules. For example, the Texas Legislature directed the subsidence districts in Fort Bend, Galveston, and Harris counties to decrease and limit groundwater production to prevent land subsidence, the sinking of the land's surface. Another example is the Edwards (Balcones Fault Zone) Aquifer, most of which is regulated by the Edwards Aquifer Authority, which was created by the Texas Legislature to manage and protect the aquifer system by limiting groundwater production.

To determine groundwater availability, planning groups used one of two policies: sustainability, in which an aquifer can be pumped indefinitely; or planned depletion, in which an aquifer is drained over a period of time. Total groundwater availability in 2010 is about 13.3 million acre-feet per year (Table 5.4). Because of projected declines in the Dockum, Edwards-Trinity (High Plains), Gulf Coast, Ogallala,

## FIGURE 5.7. PROJECTED EXISTING GROUNDWATER SUPPLIES AND GROUNDWATER AVAILABILITY THOUGH 2060 (ACRE-FEET PER YEAR).




Rita Blanca, and Seymour aquifers, availability decreases to 10.1 million acre-feet per year by 2060.

### 5.2.3 GROUNDWATER SUPPLY TRENDS

The groundwater availability numbers established by the regional water planning groups for the 2011 regional water plans vary from those established by the regional planning groups in the 2007 State Water Plan. In some counties, planning groups increased their estimates of groundwater availability, and in other counties, planning groups decreased their estimates of groundwater availability. Table 5.5 summarizes these changes in terms of volume (acre-feet per year) by decade, with "no significant change" defined as an increase or decrease of less than 1,000 acre-feet per year. Table 5.6 summarizes these changes in terms of percent change from the 2007 State Water Plan, with "no significant change" defined as an increase or decrease of less than 10 percent of the 2007 State Water Plan groundwater availability.

### 5.2.4 POTENTIAL FUTURE IMPACTS RELATING TO GROUNDWATER AVAILABILITY

Future regional water plans may be impacted by the amount of groundwater that will be considered as available to meet water demands as determined through the state's desired future conditions planning process. They may also be impacted by groundwater permitting processes that limit the term of the permit or allow for reductions in originally permitted amounts.

In 2005, the 79th Legislature passed House Bill 1763, which modified the Texas Water Code regarding how groundwater availability is determined in Texas. Among the changes, House Bill 1763 regionalized decisions on groundwater availability and required

## TABLE 5.3. EXISTING GROUNDWATER SUPPLIES FOR THE MAJOR AND MINOR AQUIFERS (ACRE-FEET PER YEAR)

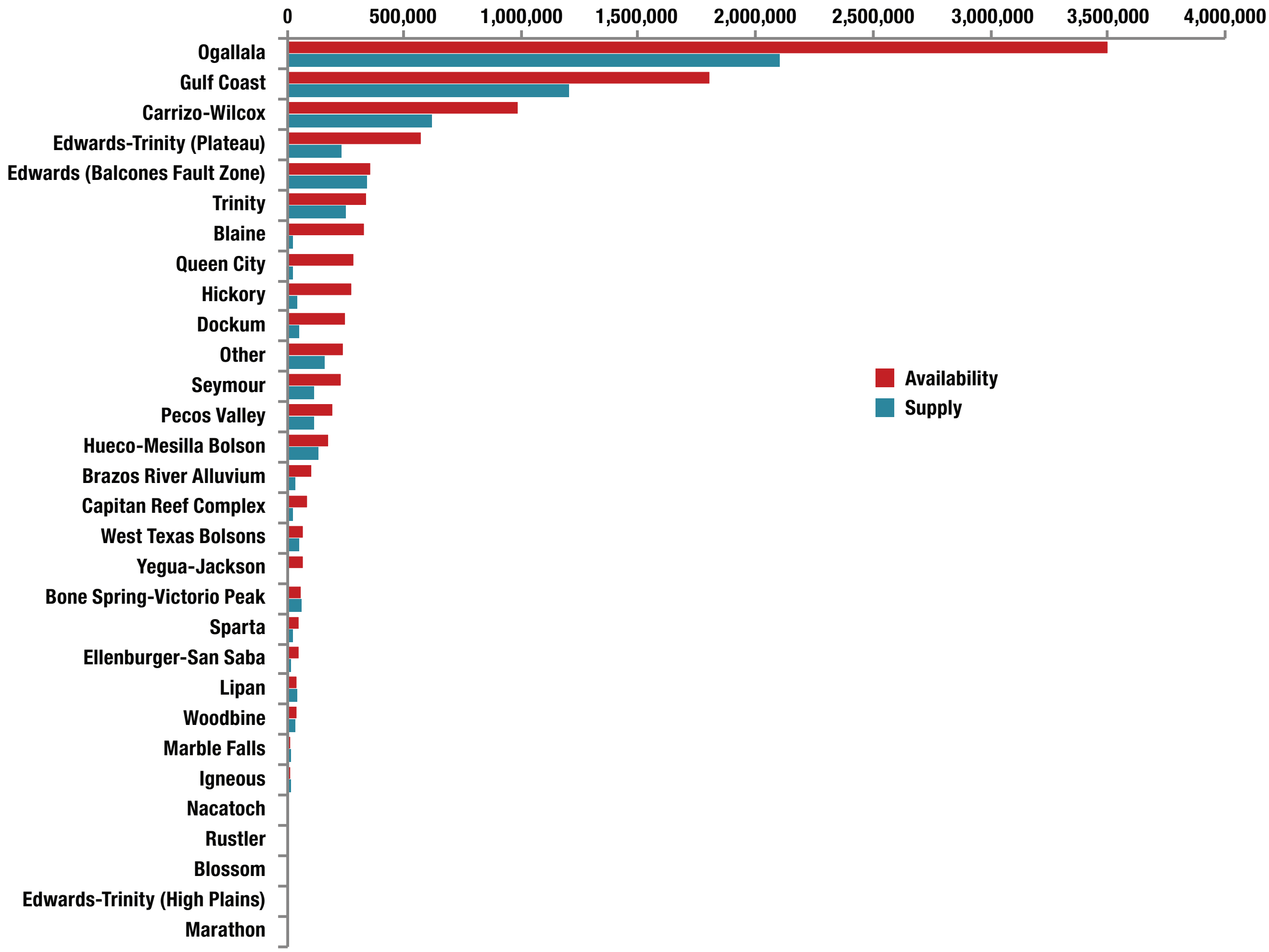
| Aquifer | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Percent Change* |
|---|---|---|---|---|---|---|---|
| Blaine | 32,267 | 28,170 | 27,702 | 27,122 | 25,759 | 24,496 | -24 |
| Blossom | 815 | 815 | 815 | 815 | 815 | 815 | 0 |
| Bone Spring-Victorio Peak | 63,000 | 63,000 | 63,000 | 63,000 | 63,000 | 63,000 | 0 |
| Brazos River Alluvium | 39,198 | 38,991 | 38,783 | 38,783 | 38,783 | 38,783 | -1 |
| Capitan Reef Complex | 23,144 | 24,669 | 25,743 | 26,522 | 27,017 | 27,327 | 18 |
| Carrizo-Wilcox | 622,443 | 627,813 | 628,534 | 619,586 | 614,425 | 616,855 | -1 |
| Dockum | 55,585 | 55,423 | 61,510 | 59,837 | 58,429 | 57,086 | 3 |
| Edwards (Balcones Fault Zone) | 338,778 | 338,702 | 338,828 | 338,794 | 338,775 | 338,763 | 0 |
| Edwards-Trinity (High Plains) | 4,160 | 3,580 | 2,802 | 2,335 | 2,065 | 2,065 | -50 |
| Edwards-Trinity (Plateau) | 225,409 | 225,450 | 225,468 | 225,467 | 225,467 | 225,472 | 0 |
| Ellenburger-San Saba | 21,786 | 21,778 | 21,776 | 21,776 | 21,831 | 21,886 | 0 |
| Gulf Coast | 1,378,663 | 1,242,949 | 1,191,798 | 1,186,142 | 1,176,918 | 1,166,310 | -15 |
| Hickory | 49,037 | 49,126 | 49,205 | 49,279 | 49,344 | 49,443 | 1 |
| Hueco-Mesilla Bolson | 131,826 | 131,826 | 131,826 | 131,826 | 131,826 | 131,826 | 0 |
| Igneous | 13,946 | 13,946 | 13,946 | 13,946 | 13,946 | 13,946 | 0 |
| Lipan | 42,523 | 42,523 | 42,523 | 42,523 | 42,523 | 42,523 | 0 |
| Marathon | 148 | 148 | 148 | 148 | 148 | 148 | 0 |
| Marble Falls | 13,498 | 13,498 | 13,498 | 13,498 | 13,498 | 13,522 | 0 |
| Nacatoch | 3,733 | 3,822 | 3,854 | 3,847 | 3,808 | 3,776 | 1 |
| Ogallala and Rita Blanca | 4,187,892 | 3,468,454 | 2,911,789 | 2,448,437 | 2,202,499 | 2,055,245 | -51 |
| Other | 159,688 | 159,789 | 159,820 | 159,822 | 159,827 | 159,896 | 0 |
| Pecos Valley | 120,029 | 114,937 | 114,991 | 115,025 | 115,071 | 115,125 | -4 |
| Queen City | 26,441 | 26,507 | 26,574 | 26,438 | 26,507 | 26,556 | 0 |
| Rustler | 2,469 | 2,469 | 2,469 | 2,469 | 2,469 | 2,469 | 0 |
| Seymour | 142,021 | 132,045 | 128,882 | 127,530 | 124,863 | 122,205 | -14 |
| Sparta | 25,395 | 25,373 | 25,359 | 24,919 | 24,924 | 24,933 | -2 |
| Trinity | 254,384 | 250,837 | 250,544 | 250,392 | 249,291 | 249,040 | -2 |
| West Texas Bolsons | 52,804 | 52,804 | 52,804 | 52,804 | 52,804 | 52,804 | 0 |
| Woodbine | 34,173 | 34,036 | 33,932 | 33,876 | 33,741 | 33,688 | -1 |
| Yegua-Jackson | 8,354 | 8,298 | 8,290 | 8,290 | 8,290 | 8,290 | -1 |
| **Total** | **8,073,609** | **7,201,778** | **6,597,213** | **6,115,248** | **5,848,663** | **5,688,293** | **-30** |

*Percent represents the percent change from 2010 through 2060.

regional water planning groups to use groundwater availability figures from the groundwater conservation districts. In 2011, the 82nd Texas Legislature replaced the term "managed available groundwater" with "modeled available groundwater," effective September 1, 2011. Modeled available groundwater represents the total amount of groundwater, including both permitted and exempt uses, that can be produced from the aquifer in an average year, that achieves a "desired future condition," a description of how the aquifer will look in the future. Managed available groundwater was the amount of groundwater production not including uses that were exempt from permitting that would achieve the desired future condition. From a regional water planning and state water planning perspective, the use of modeled available groundwater considers all uses—those permitted by groundwater conservation districts as well as those uses that are exempt from permitting.

Before House Bill 1763, each groundwater conservation district defined groundwater availability for its jurisdiction and included it in their groundwater management plans under the name "total usable amount of groundwater." As a result of the passage of House Bill 1763, districts are now working together in each designated groundwater management area (Figure 5.9) to develop and adopt desired future

## FIGURE 5.8. GROUNDWATER SUPPLY AND GROUNDWATER AVAILABILITY IN 2060 BY AQUIFER (ACRE-FEET PER YEAR).




conditions for their groundwater resources. The districts then submit these desired future conditions to TWDB. TWDB, in turn, provides estimates of "modeled available groundwater"—the new term in statute for groundwater availability—to the districts for inclusion in their groundwater management plans and to the regional water planning groups for inclusion in their regional water plans.

Statute required that groundwater conservation districts in groundwater management areas submit their desired future conditions to TWDB by September 1, 2010. However, for the regional water planning groups to be required to include managed available groundwater values in their 2011 regional water plans, desired future conditions had to be submitted to TWDB before January 1, 2008, allowing TWDB to estimate managed available groundwater values. The inclusion of managed available groundwater values in the regional water plans for desired future conditions submitted to TWDB after that date was at the discretion of the regional water planning groups.

Because most of the desired future conditions were adopted after 2008, regional water planning groups generally had to use their own estimates of groundwater availability to meet their statutory deadlines for adoption of their regional water

## TABLE 5.4. GROUNDWATER AVAILABILITY FOR THE MAJOR AND MINOR AQUIFERS (ACRE-FEET PER YEAR)

| Aquifer | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Percent Change* |
|---|---|---|---|---|---|---|---|
| Blaine | 326,950 | 325,700 | 325,700 | 325,700 | 325,700 | 325,700 | 0 |
| Blossom | 2,273 | 2,273 | 2,273 | 2,273 | 2,273 | 2,273 | 0 |
| Bone Spring-Victorio Peak | 63,000 | 63,000 | 63,000 | 63,000 | 63,000 | 63,000 | 0 |
| Brazos River Alluvium | 108,183 | 108,183 | 108,183 | 108,183 | 108,183 | 108,183 | 0 |
| Capitan Reef Complex | 86,150 | 86,150 | 86,150 | 86,150 | 86,150 | 86,150 | 0 |
| Carrizo-Wilcox | 1,002,648 | 1,002,073 | 994,513 | 994,391 | 994,367 | 994,367 | -1 |
| Dockum | 382,188 | 342,266 | 337,070 | 305,244 | 277,270 | 252,570 | -34 |
| Edwards (Balcones Fault Zone) | 350,682 | 350,932 | 353,432 | 353,532 | 356,182 | 357,782 | 2 |
| Edwards-Trinity (High Plains) | 4,160 | 3,580 | 2,802 | 2,335 | 2,065 | 2,065 | -50 |
| Edwards-Trinity (Plateau) | 572,598 | 572,598 | 572,598 | 572,598 | 572,598 | 572,598 | 0 |
| Ellenburger-San Saba | 50,339 | 50,339 | 50,339 | 50,339 | 50,339 | 50,339 | 0 |
| Gulf Coast | 1,898,091 | 1,816,285 | 1,776,213 | 1,775,997 | 1,776,384 | 1,775,991 | -6 |
| Hickory | 275,089 | 275,089 | 275,089 | 275,089 | 275,089 | 275,089 | 0 |
| Hueco-Mesilla Bolson | 178,000 | 178,000 | 178,000 | 178,000 | 178,000 | 178,000 | 0 |
| Igneous | 15,100 | 15,100 | 15,100 | 15,100 | 15,100 | 15,100 | 0 |
| Lipan | 48,535 | 48,535 | 48,535 | 48,535 | 48,535 | 48,535 | 0 |
| Marathon | 200 | 200 | 200 | 200 | 200 | 200 | 0 |
| Marble Falls | 17,679 | 17,679 | 17,679 | 17,679 | 17,679 | 17,679 | 0 |
| Nacatoch | 10,494 | 10,494 | 10,494 | 10,494 | 10,494 | 10,494 | 0 |
| Ogallala and Rita Blanca | 6,379,999 | 5,561,382 | 4,832,936 | 4,179,979 | 3,773,018 | 3,459,076 | -46 |
| Other | 238,192 | 238,209 | 238,202 | 238,174 | 238,144 | 238,154 | 0 |
| Pecos Valley | 200,451 | 200,451 | 200,451 | 200,451 | 200,451 | 200,451 | 0 |
| Queen City | 291,336 | 291,336 | 291,336 | 291,336 | 291,336 | 291,336 | 0 |
| Rustler | 2,492 | 2,492 | 2,492 | 2,492 | 2,492 | 2,492 | 0 |
| Seymour | 243,173 | 242,173 | 228,527 | 228,527 | 228,527 | 228,527 | -6 |
| Sparta | 54,747 | 54,747 | 54,747 | 54,747 | 54,747 | 54,747 | 0 |
| Trinity | 342,192 | 342,193 | 342,191 | 342,191 | 341,580 | 341,580 | 0 |
| West Texas Bolsons | 70,746 | 70,746 | 70,746 | 70,746 | 70,746 | 70,746 | 0 |
| Woodbine | 44,905 | 44,905 | 44,905 | 44,905 | 44,905 | 44,905 | 0 |
| Yegua-Jackson | 69,232 | 69,232 | 69,232 | 69,232 | 69,232 | 69,232 | 0 |
| **Total** | **13,329,824** | **12,386,342** | **11,593,135** | **10,907,619** | **10,474,786** | **10,137,361** | **-24** |

*Percent represents the percent change from 2010 through 2060.

plans. The groundwater conservation districts in groundwater management areas 8 and 9 were the only ones to submit desired future conditions for some of its aquifers by that deadline (Table 5.7). By the fourth round of regional water planning (2011 to 2016), managed available groundwater numbers that are based on the districts' desired future conditions will be available for use in all regional water plans.

In the next round of regional water planning (2011 to 2016), planning groups will be required to use modeled available groundwater volumes to determine water supply needs in their regions. As a result, there will be some groundwater availability estimates that are lower than the regional water planning group's groundwater availability estimates in prior regional plans. This situation may impact the amount of water supply needs and strategies in the plan. If needs are greater or strategies cannot be implemented due to unavailable supplies, regional water planning groups and those looking to implement water management strategies will have to consider other sources of water. It is also important to note that despite what is shown in this plan for groundwater availability, the managed available groundwater and a groundwater conservation district's associated permitting process will ultimately dictate whether or not a particular strategy can be implemented.

## TABLE 5.5. NUMBER OF COUNTIES WHERE THERE IS A DECREASE, NO SIGNIFICANT CHANGE, OR INCREASE IN GROUNDWATER AVAILABILITY BETWEEN 2007 STATE WATER PLAN AND 2011 REGIONAL WATER PLANS (ACRE-FEET PER YEAR)

| Decade | Decrease of more than 1,000 acre-feet per year | Decrease of less than 1,000 acre-feet per year or increase of less than 1,000 acre-feet per year | Increase of more than 1,000 acre-feet per year |
|---|---|---|---|
| 2010 | 20 | 170 | 64 |
| 2020 | 22 | 169 | 63 |
| 2030 | 22 | 169 | 63 |
| 2040 | 23 | 170 | 61 |
| 2050 | 26 | 169 | 59 |
| 2060 | 29 | 170 | 55 |

Groundwater permitting processes that provide for limited term-permits or that allow for reductions in a permit holder's allocations over a short period of time could also impact the certainty and feasibility of water management strategies and may require looking at strategies that use other sources of water than groundwater.

## 5.3 REUSE SUPPLIES

Reuse refers to the use of groundwater or surface water that has already been beneficially used. The terms "reclaimed water," "reused water," and "recycled water" are used interchangeably in the water industry. As defined in the Texas Water Code, reclaimed water is domestic or municipal wastewater that has been treated to a quality suitable for beneficial use. Reuse or reclaimed water is not the same as graywater, that is, untreated household water from sinks, showers, and baths.

There are two types of water reuse: direct reuse and indirect reuse. Direct reuse refers to the introduction of reclaimed water via pipelines, storage tanks, and other necessary infrastructure directly from a water reclamation plant to a distribution system. For example, treating wastewater and then piping it to an industrial center or a golf course would be considered direct reuse. Indirect reuse is the use of water, usually treated effluent, which is placed back into a water supply source such as a lake, river, or aquifer, and then retrieved to be used again. Indirect reuse projects that involve a watercourse require a "bed and banks" permit from the state, which authorizes the permit holder to convey and subsequently divert water in a watercourse or stream. Both direct and indirect reuse can be applied for potable—suitable for drinking—and non-potable—suitable for uses other than drinking—purposes.

Water reuse has been growing steadily in Texas over the past two decades. A recent survey of Texas water producers revealed that in 2010 approximately 62,000 acre-feet per year of water was used as direct reuse and 76,000 acre-feet per year of water was used as bed and banks permitted indirect reuse. The number of entities receiving permits from the Texas Commission on Environmental Quality for direct non-potable water reuse rose from 1 in 1990 to 187 by June 2010. Evidence of the increasing interest and application of indirect reuse is also illustrated by several large and successful projects that have been implemented by the Tarrant Regional Water District and the Trinity River Authority in the Dallas-Fort Worth area.

Like surface water and groundwater, the amount of existing water reuse supplies is based on the amount of water that can be produced with current permits and existing infrastructure. The planning groups estimated that the existing supplies in 2010 were approximately 482,000 acre-feet per year. Reuse supplies will increase to about 614,000 acre-feet per year by 2060 (Figure 5.10, Table 5.8). Existing water supplies from direct and indirect reuse by 2060 for 16 regional water planning areas are shown in Figure 5.11 and Figure 5.12. The amount of existing supply from direct reuse was about 279,000 acre-feet per year in 2010, and indirect reuse was approximately 203,000

## TABLE 5.6. NUMBER OF COUNTIES WHERE THERE IS A DECREASE, NO SIGNIFICANT CHANGE, OR INCREASE IN GROUNDWATER AVAILABILITY BETWEEN 2007 STATE WATER PLAN AND 2011 REGIONAL WATER PLANS (EXPRESSED AS A PERCENT)

| Decade | Decrease of more than 10 percent | Decrease of less than 10 percent or increase of less than 10 percent | Increase of more than 10 percent |
|---|---|---|---|
| 2010 | 19 | 183 | 52 |
| 2020 | 19 | 182 | 51 |
| 2030 | 18 | 183 | 53 |
| 2040 | 20 | 182 | 52 |
| 2050 | 21 | 182 | 51 |
| 2060 | 22 | 182 | 50 |

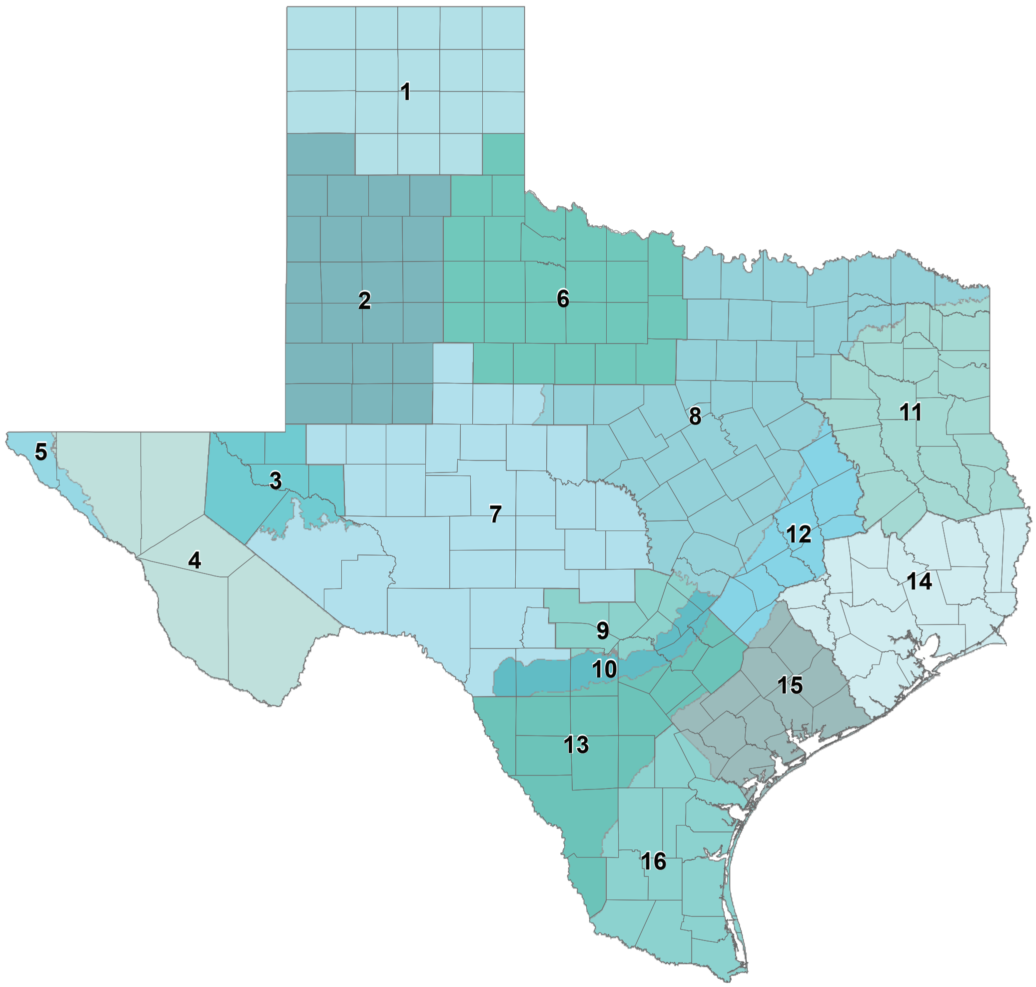
## TABLE 5.7. SUMMARY OF MANAGED AVAILABLE GROUNDWATER VALUES INCLUDED IN THE 2011 REGIONAL WATER PLANS

| Regional water planning area | Groundwater management area | Aquifer |
|---|---|---|
| B | 8 | Trinity (Montague County) |
| C | 8 | Trinity, Woodbine |
| D | 8 | Woodbine |
| F | 8 | Trinity (Brown County) |
| G | 8 | Brazos River Alluvium, Woodbine, and Edwards (Balcones Fault Zone) |
| K | 8 | Edwards (Balcones Fault Zone), Hickory, Ellenburger-San Saba, Marble Falls |
| L | 9 | Edwards Group of the Edwards-Trinity (Plateau) |

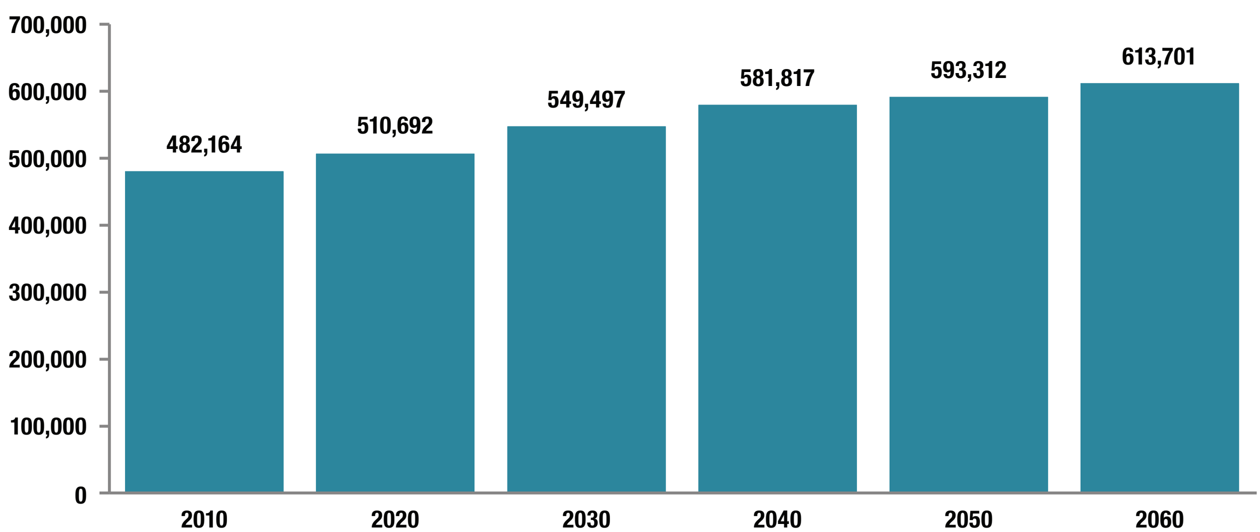
## TABLE 5.8. PROJECTED EXISTING SUPPLY OF WATER FROM WATER REUSE (ACRE-FEET PER YEAR)

| Region | Reuse type | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| A | Direct reuse | 25,129 | 28,928 | 30,620 | 32,528 | 34,598 | 37,577 |
| C | Direct reuse | 34,552 | 33,887 | 32,413 | 31,465 | 30,731 | 30,340 |
| C | Indirect reuse | 148,134 | 197,929 | 240,590 | 261,827 | 269,412 | 276,789 |
| D | Direct reuse | 83,642 | 78,247 | 72,821 | 67,505 | 68,761 | 77,635 |
| E | Direct reuse | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 |
| E | Indirect reuse | 38,031 | 38,031 | 38,031 | 38,031 | 38,031 | 38,031 |
| F | Direct reuse | 19,015 | 19,309 | 19,459 | 19,609 | 19,759 | 19,909 |
| G | Direct reuse | 17,344 | 17,344 | 17,344 | 17,344 | 17,344 | 17,344 |
| H | Indirect reuse | 0 | 0 | 438 | 14,799 | 14,840 | 14,866 |
| I | Direct reuse | 1,518 | 1,533 | 1,546 | 1,559 | 1,570 | 1,584 |
| I | Indirect reuse | 16,559 | 13,687 | 13,687 | 13,687 | 13,687 | 13,687 |
| L | Direct reuse | 16,049 | 16,049 | 16,049 | 16,049 | 16,049 | 16,049 |
| M | Direct reuse | 24,677 | 24,677 | 24,677 | 24,677 | 24,677 | 24,677 |
| O | Direct reuse | 51,514 | 35,071 | 35,822 | 36,737 | 37,853 | 39,213 |
| | **Total direct** | **279,440** | **261,045** | **256,751** | **253,473** | **257,342** | **270,328** |
| | **Total indirect** | **202,724** | **249,647** | **292,746** | **328,344** | **335,970** | **343,373** |
| | **Total reuse** | **482,164** | **510,692** | **549,497** | **581,817** | **593,312** | **613,701** |

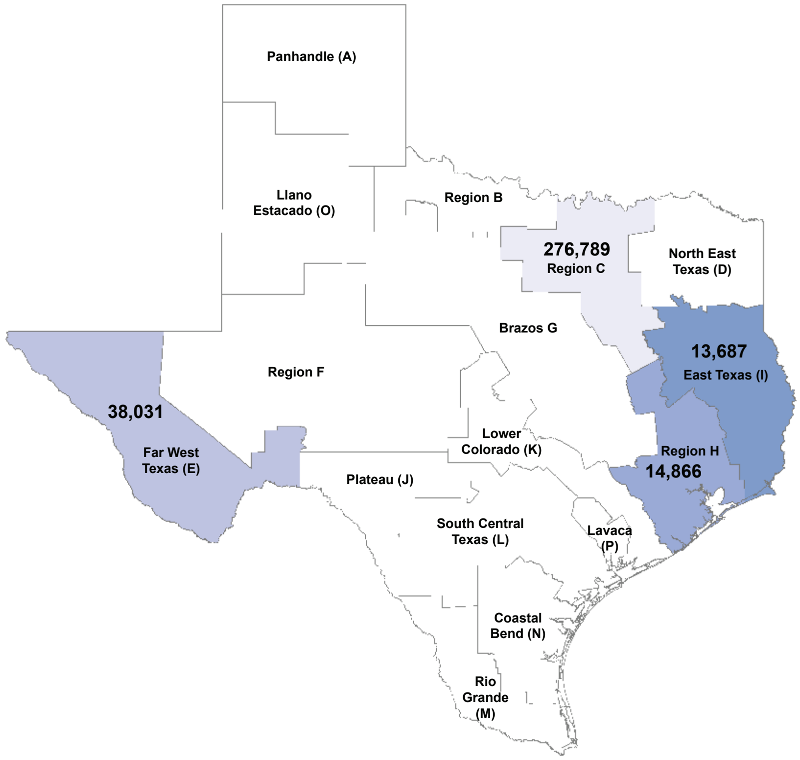
## FIGURE 5.9. GROUNDWATER MANAGEMENT AREAS IN TEXAS.



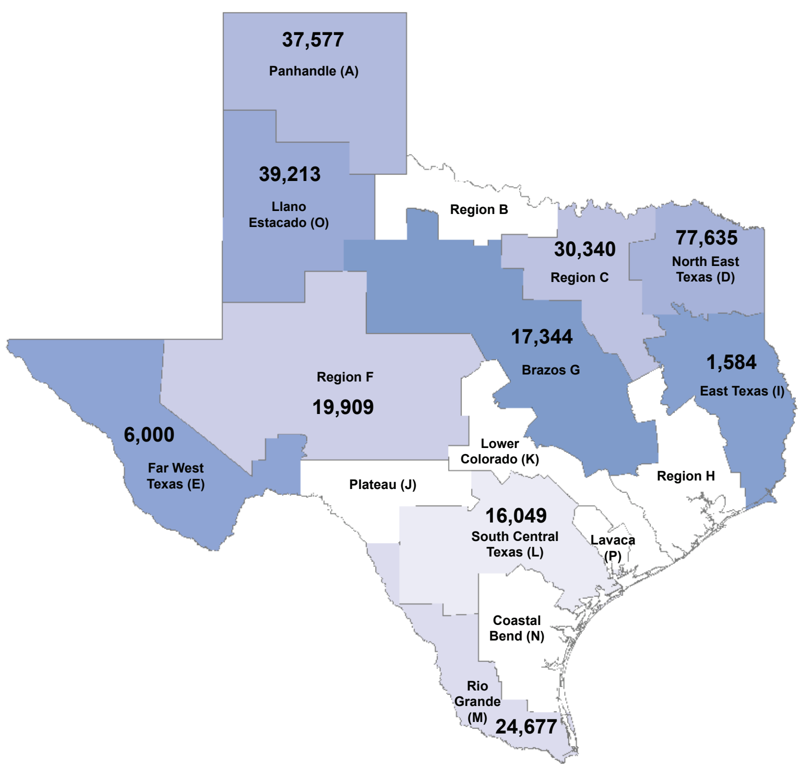

## FIGURE 5.10. PROJECTED EXISTING WATER REUSE SUPPLIES THROUGH 2060 (ACRE-FEET PER YEAR).



## FIGURE 5.11. EXISTING INDIRECT REUSE SUPPLIES THROUGH 2060 BY REGION (ACRE-FEET PER YEAR).




## FIGURE 5.12. EXISTING DIRECT REUSE SUPPLIES THROUGH 2060 BY REGION (ACRE-FEET PER YEAR).



# Quick Facts

In the event of severe drought conditions, the state faces an immediate need for additional water supplies of 3.6 million acre-feet per year.

If Texas does not implement new water supply projects or management strategies, then homes, businesses, and agricultural enterprises throughout the state are projected to need 8.3 million acre-feet of additional water supply by 2060.

Planning groups were unable to find economically feasible strategies to meet over 2 million acre-feet of annual needs, with the vast majority of the unmet needs in irrigation.

Annual economic losses from not meeting water supply needs could result in a reduction in income of approximately $11.9 billion annually if current drought conditions approach the drought of record, and as much as $115.7 billion annually by 2060, with over a million lost jobs.

# 6 Water Supply Needs

## Needs are projected water demands in excess of existing supplies that would be legally and physically available during a drought of record.

Growing at a rate of approximately 1,100 people per day over the last decade, Texas is one of the fastest growing states in the nation. By 2060, the population of the state is projected to increase to over 46 million people. Rapid growth, combined with Texas' robust economy and susceptibility to drought, makes water supply a crucial issue. If water infrastructure and water management strategies are not implemented, Texas could face serious social, economic, and environmental consequences in both the large metropolitan areas as well as the vast rural areas of the state.

Unreliable water supplies could have overwhelming negative implications for Texas. For example, water shortages brought on by drought conditions would more than likely curtail economic activity in industries heavily reliant on water, which could result in not only job loss but a monetary loss to local economies as well as the state economy. Also, a lack of reliable water supply may bias corporate decision-makers against expanding or locating their businesses in Texas.

## TABLE 6.1. WATER NEEDS BY REGION (ACRE-FEET PER YEAR)

| Region | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| A | 454,876 | 454,118 | 487,316 | 501,830 | 462,230 | 418,414 |
| B | 23,559 | 28,347 | 34,074 | 35,802 | 37,485 | 40,397 |
| C | 69,087 | 399,917 | 686,836 | 953,949 | 1,244,618 | 1,588,236 |
| D | 10,252 | 14,724 | 18,696 | 31,954 | 60,005 | 96,142 |
| E | 209,591 | 213,091 | 215,624 | 210,794 | 216,113 | 226,569 |
| F | 191,057 | 200,868 | 204,186 | 211,018 | 214,792 | 219,995 |
| G | 131,489 | 196,761 | 228,978 | 272,584 | 334,773 | 390,732 |
| H | 290,890 | 524,137 | 698,776 | 833,518 | 1,004,872 | 1,236,335 |
| I | 28,856 | 83,032 | 83,153 | 106,900 | 141,866 | 182,145 |
| J | 1,494 | 1,878 | 2,044 | 2,057 | 2,275 | 2,389 |
| K | 255,709 | 303,240 | 294,534 | 309,813 | 340,898 | 367,671 |
| L | 174,235 | 265,567 | 308,444 | 350,063 | 390,297 | 436,751 |
| M | 435,922 | 401,858 | 362,249 | 434,329 | 519,622 | 609,906 |
| N | 3,404 | 14,084 | 27,102 | 41,949 | 57,994 | 75,744 |
| O | 1,275,057 | 1,750,409 | 2,107,876 | 2,364,996 | 2,405,010 | 2,366,036 |
| P | 67,739 | 67,739 | 67,739 | 67,739 | 67,739 | 67,739 |
| **Total** | **3,623,217** | **4,919,770** | **5,827,627** | **6,729,295** | **7,500,589** | **8,325,201** |

For all these reasons as well as others, it is important to identify potential future water supply needs to analyze and understand how the needs for water could affect communities throughout the state during a severe drought and to plan for meeting those needs. When developing regional water plans, regional water planning groups compare existing water supplies with current and projected water demands to identify when and where additional water supplies are needed for each identified water user group and wholesale water provider. TWDB provides assistance in conducting this task by performing a socioeconomic impact analysis for each region at their request.

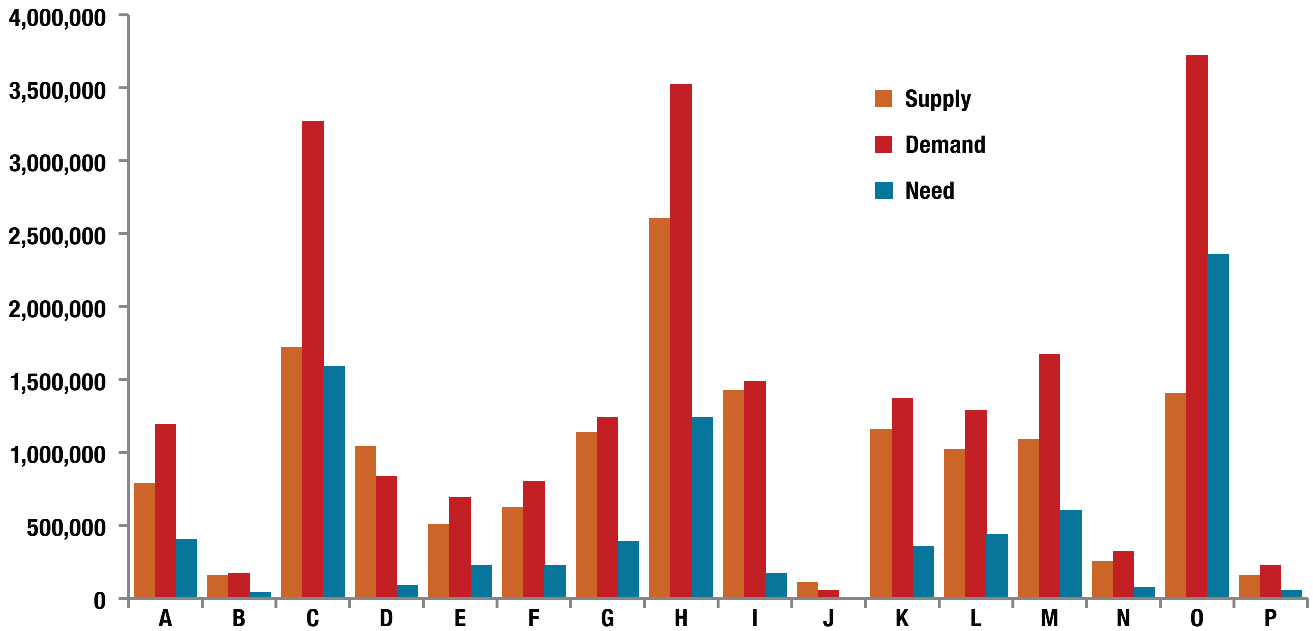
## 6.1 IDENTIFICATION OF NEEDS

When existing water supplies available to a specific water user group are less than projected demands, there is a need for water. In other words, once there is an identified water demand projection for a given water user group, this estimate is then deducted from identified existing supplies for that water user group, resulting in either a water supply surplus or a need. Planning groups have identified a statewide water supply need of 3.6 million acre-feet in 2010 and 8.3 million acre-feet by 2060, which is a slight reduction from the 2007 State Water Plan in which planning groups identified estimated needs of 3.7 million acre-feet in 2010 and 8.9 million acre-feet in 2060. Table 6.1 shows the total water supply needs identified for each region by the regional water planning groups for the current planning cycle.

Although in some regions it appears that there are sufficient existing water supplies region-wide to meet demands under drought conditions in the early planning decades, local existing water supplies are not always available to all users throughout the region. Therefore, water needs were identified as a result of this geographic “mismatch” of existing supplies and anticipated shortages (Figure 6.1).

The regional water planning groups were tasked with identifying needs for water user groups—municipal, county-other, manufacturing, steam-electric, livestock,

**FIGURE 6.1. EXISTING WATER SUPPLIES, PROJECTED DEMANDS, AND NEEDS BY REGION IN 2060 (ACRE-FEET PER YEAR).**




irrigation, and mining—and wholesale water providers. Water uses for the following categories were estimated at the county level: county-other, manufacturing, mining, steam-electric, livestock, and irrigation.

The planning groups identified 982 total non-municipal water user groups; 174 (18 percent) of these would currently have inadequate water supply in drought of record conditions, with that number increasing to 260 (26 percent) by 2060. The planning groups also identified 1,587 total municipal water user groups and 173 total wholesale water providers. Of the municipal water user groups, 470 (30 percent) would currently have water supply needs if the state were facing drought conditions, increasing to 825 (52 percent of the total) in 2060. Of the wholesale water providers, the planning groups identified 83 (48 percent) that would currently face shortages; those with needs are projected to increase to 109 (63 percent) by 2060 (Table 6.2). If no action is taken to implement water management strategies, over 50 percent of the state's population in 2060 would face a water need of at least 45 percent of their projected demand during a repeat of drought conditions.

### 6.1.1 MUNICIPAL NEEDS

Municipal water use accounts for about 9 percent of total identified needs or roughly 315,000 acre-feet in 2010, increasing to 41 percent or 3.4 million acre-feet by 2060. These estimates are down from projections in the 2007 State Water Plan, where municipal water supply needs were projected to be about 610,000 and 3.8 million acre-feet in 2010 and 2060, respectively. This reduction is a result of implementing projects from the past plan.

If the state were to experience drought conditions like those in the 1950s, Region L would currently experience the largest identified municipal needs at

## TABLE 6.2. NUMBER OF WATER USER GROUPS WITH NEEDS BY REGION

| Region | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| A | 8 | 14 | 20 | 22 | 22 | 23 |
| B | 7 | 8 | 8 | 8 | 7 | 7 |
| C | 172 | 246 | 262 | 267 | 269 | 270 |
| D | 17 | 20 | 28 | 32 | 36 | 39 |
| E | 2 | 10 | 10 | 11 | 12 | 12 |
| F | 53 | 54 | 50 | 52 | 54 | 54 |
| G | 66 | 72 | 84 | 89 | 96 | 97 |
| H | 132 | 229 | 234 | 237 | 237 | 241 |
| I | 31 | 41 | 45 | 51 | 56 | 60 |
| J | 2 | 2 | 2 | 2 | 2 | 2 |
| K | 36 | 46 | 53 | 59 | 63 | 67 |
| L | 47 | 58 | 65 | 69 | 72 | 77 |
| M | 35 | 44 | 50 | 54 | 63 | 64 |
| N | 8 | 12 | 14 | 15 | 16 | 16 |
| O | 26 | 37 | 45 | 48 | 53 | 54 |
| P | 2 | 2 | 2 | 2 | 2 | 2 |
| **Total water user groups with needs** | **644** | **895** | **972** | **1,018** | **1,060** | **1,085** |
| **Total water user groups** | **2,569** | **2,569** | **2,569** | **2,569** | **2,569** | **2,569** |
| **Percent of water user groups with needs** | **25** | **35** | **38** | **40** | **41** | **42** |

about 96,000 acre-feet. However, by 2060, Regions C, H, and M account for the majority of these needs, with the Dallas-Fort Worth area responsible for a large portion of those needs. In fact, with the exception of Region P, every region in the state would be affected by future municipal water shortages.

### 6.1.2 WHOLESALE WATER PROVIDERS

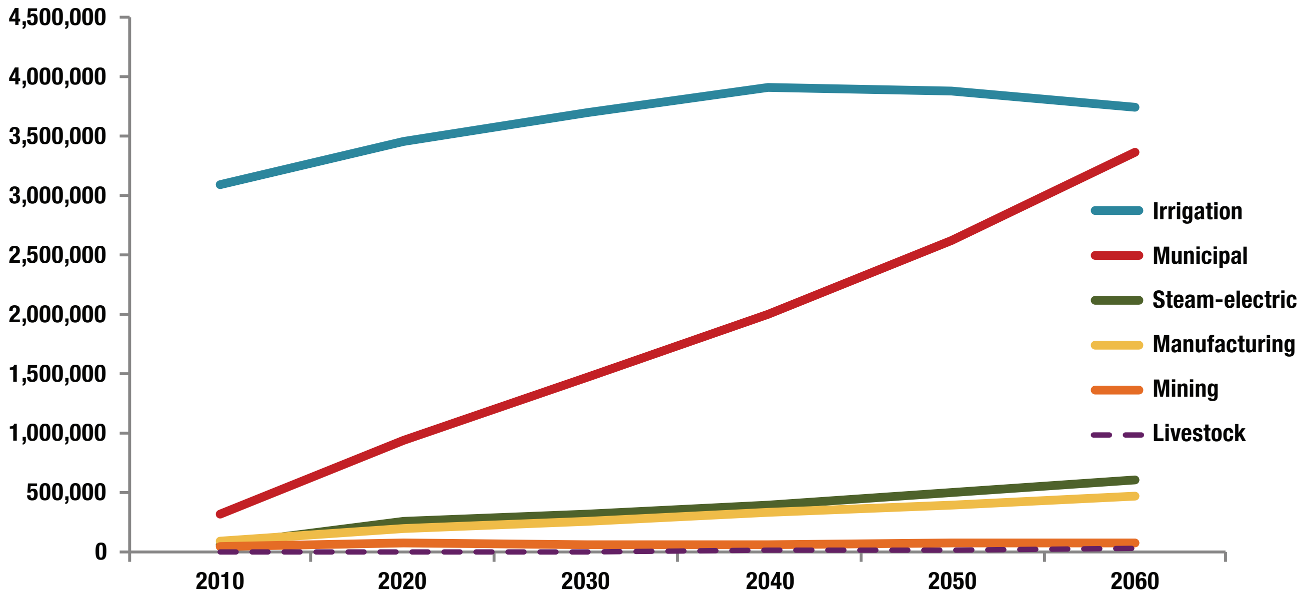
Wholesale water providers—entities such as some river authorities, municipal utility districts, and water supply corporations—deliver and sell large amounts of raw (untreated) or treated water for municipal and manufacturing use on a wholesale or retail basis. In many instances, the burden of their water needs is shared by both the water user group facing the projected shortage and the entity that provides water to them, since the needs for wholesale water providers are not additional to those of water user groups but made up of needs from several of those entities.

Wholesale water providers are projected to have total water supply needs under drought conditions of about 835,000 acre-feet in 2010 and 4.4 million acre-feet in 2060. Tarrant Regional Water District, the City of Dallas, North Texas Municipal Water District, and the City of Fort Worth are the wholesale water providers with the largest projected needs by 2060.

### 6.1.3 NON-MUNICIPAL NEEDS

*Irrigation:* Irrigation accounts for the largest share of the state's total current water demand, roughly 60 percent. It is projected to remain the state's largest water use category through 2050, although by 2060, TWDB projects its share of the total demand will decline to approximately 38 percent of total water demand. As expected, irrigation also accounts for the largest percentage of projected water supply needs under drought conditions at 3.1 million acre-feet, or 86 percent of the total in 2010; irrigation needs are projected to increase to 3.8 million acre-feet by 2060. However, this will only account for about 45 percent of the state's total water needs in 2060, due to the large increase in volume of municipal needs from 2010 to

## FIGURE 6.2. PROJECTED WATER NEEDS BY USE CATEGORY (ACRE-FEET PER YEAR).




2060 (Figure 6.2). The vast majority of irrigation needs occur in the most heavily irrigated parts of the state.

Irrigation needs represent an increase from those projected in the 2007 State Water Plan, which were 2.8 million acre-feet in 2010 and 3.7 million acre-feet by 2060. This increase is largely due to the transfer of water rights from irrigation to municipal and groundwater depletion in the more heavily irrigated parts of the state.

*Livestock:* Although livestock water use is quite small in comparison to other water uses, the inability to meet demands could prove costly for some parts of the state. Under drought conditions, Region I would account for almost all of the projected livestock needs for 2010, which are slightly over 1,000 acre-feet. By 2060, the state total is projected to increase to approximately 30,000 acre-feet, with Region O accounting for the majority of the total needs followed by Region I. This represents a decline from the projected livestock needs of about 11,000 acre-feet in 2010 and 39,000 acre-feet in 2060, identified in the 2007 State Water Plan. Region A accounted for a large percentage of livestock needs during the last round of planning; however, based on reduced livestock water use demands that resulted from a detailed study performed for this round of planning, no projected needs for livestock have been identified in Region A in the 2012 State Water Plan.

*Mining:* Planning groups identified 47,000 acre-feet of water needs for the mining industry statewide under drought conditions for 2010, with that total increasing to almost 85,000 acre-feet by 2060. This is an increase from needs identified in the 2007 State Water Plan, which were approximately 38,000 and 79,000 acre-feet in 2010 and 2060, respectively. In 2010, Regions I and K will have the largest percentage of mining needs, whereas by 2060 Regions C and H have the largest portion of identified mining needs. However, these projections were developed before the boom in natural gas extraction extended to some eastern and southern areas of the state late in the last decade.

## TABLE 6.3. PROJECTED WATER NEEDS BY USE CATEGORY BY REGION (ACRE-FEET PER YEAR)

| Region | Category | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| A | Irrigation | 454,628 | 452,144 | 477,338 | 482,226 | 433,155 | 381,180 |
| | Manufacturing | 173 | 800 | 1,317 | 2,845 | 4,212 | 5,866 |
| | Municipal | 0 | 1,075 | 8,544 | 16,631 | 24,727 | 31,214 |
| | Steam-electric | 75 | 99 | 117 | 128 | 136 | 154 |
| B | Irrigation | 22,945 | 23,926 | 24,909 | 25,893 | 26,876 | 29,058 |
| | Mining | 177 | 153 | 145 | 149 | 162 | 162 |
| | Municipal | 437 | 468 | 491 | 502 | 460 | 462 |
| | Steam-electric | 0 | 3,800 | 8,529 | 9,258 | 9,987 | 10,715 |
| C | Irrigation | 510 | 2,588 | 3,412 | 4,007 | 4,492 | 4,913 |
| | Manufacturing | 557 | 11,946 | 21,151 | 30,369 | 39,640 | 48,894 |
| | Mining | 414 | 4,909 | 10,036 | 14,782 | 19,445 | 23,779 |
| | Municipal | 67,606 | 367,257 | 622,541 | 869,956 | 1,140,044 | 1,459,327 |
| | Steam-electric | 0 | 13,217 | 29,696 | 34,835 | 40,997 | 51,323 |
| D | Irrigation | 56 | 0 | 14 | 115 | 238 | 388 |
| | Municipal | 1,557 | 2,358 | 3,245 | 4,443 | 8,938 | 18,285 |
| | Steam-electric | 8,639 | 12,366 | 15,437 | 27,396 | 50,829 | 77,469 |
| E | Irrigation | 209,591 | 201,491 | 195,833 | 183,734 | 176,377 | 169,156 |
| | Manufacturing | 0 | 813 | 1,511 | 2,186 | 2,760 | 3,674 |
| | Municipal | 0 | 6,981 | 13,300 | 18,464 | 28,823 | 43,460 |
| | Steam-electric | 0 | 3,806 | 4,980 | 6,410 | 8,153 | 10,279 |
| F | Irrigation | 157,884 | 154,955 | 152,930 | 149,472 | 146,995 | 144,276 |
| | Manufacturing | 3,537 | 4,138 | 3,747 | 4,403 | 4,707 | 5,152 |
| | Mining | 503 | 660 | 29 | 143 | 232 | 375 |
| | Municipal | 22,038 | 31,275 | 36,100 | 43,706 | 46,511 | 49,619 |
| | Steam-electric | 7,095 | 9,840 | 11,380 | 13,294 | 16,347 | 20,573 |
| G | Irrigation | 59,571 | 56,961 | 54,422 | 51,942 | 49,527 | 47,181 |
| | Manufacturing | 2,762 | 3,441 | 4,108 | 4,783 | 5,393 | 6,054 |
| | Mining | 9,670 | 10,544 | 10,963 | 11,301 | 11,704 | 12,158 |
| | Municipal | 20,944 | 54,332 | 76,594 | 110,959 | 150,533 | 192,467 |
| | Steam-electric | 38,542 | 71,483 | 82,891 | 93,599 | 117,616 | 132,872 |
| H | Irrigation | 151,366 | 141,232 | 137,995 | 137,113 | 140,733 | 144,802 |
| | Manufacturing | 75,164 | 131,531 | 168,597 | 202,219 | 231,118 | 255,604 |
| | Mining | 5,992 | 10,595 | 13,850 | 16,278 | 18,736 | 20,984 |
| | Municipal | 55,151 | 228,106 | 360,236 | 453,142 | 579,269 | 758,934 |
| | Steam-electric | 3,203 | 12,609 | 18,058 | 24,726 | 34,976 | 55,972 |
| | Livestock | 14 | 64 | 40 | 40 | 40 | 39 |
| I | Irrigation | 1,675 | 1,805 | 2,156 | 2,536 | 2,955 | 3,416 |
| | Manufacturing | 3,392 | 16,014 | 24,580 | 33,256 | 40,999 | 49,588 |
| | Mining | 14,812 | 29,744 | 9,395 | 10,075 | 10,748 | 11,276 |
| | Municipal | 4,412 | 7,351 | 9,314 | 11,633 | 15,366 | 20,509 |
| | Steam-electric | 3,588 | 25,922 | 33,615 | 43,053 | 62,778 | 85,212 |
| | Livestock | 977 | 2,196 | 4,093 | 6,347 | 9,020 | 12,144 |
| J | Municipal | 1,494 | 1,878 | 2,044 | 2,057 | 2,275 | 2,389 |
| K | Irrigation | 234,738 | 217,011 | 198,717 | 181,070 | 164,084 | 135,822 |
| | Manufacturing | 146 | 298 | 452 | 605 | 741 | 934 |
| | Mining | 13,550 | 13,146 | 12,366 | 6,972 | 5,574 | 5,794 |
| | Municipal | 6,894 | 19,592 | 29,636 | 44,548 | 88,381 | 135,891 |
| | Steam-electric | 193 | 53,005 | 53,175 | 76,430 | 81,930 | 89,042 |
| | Livestock | 188 | 188 | 188 | 188 | 188 | 188 |
| L | Irrigation | 68,465 | 62,376 | 56,519 | 50,894 | 45,502 | 41,782 |
| | Manufacturing | 6,539 | 13,888 | 20,946 | 27,911 | 34,068 | 43,072 |
| | Mining | 521 | 726 | 1,771 | 1,992 | 2,293 | 2,493 |
| | Municipal | 96,653 | 137,614 | 178,217 | 218,245 | 256,777 | 297,386 |
| | Steam-electric | 2,054 | 50,962 | 50,991 | 51,021 | 51,657 | 52,018 |
| | Livestock | 3 | 1 | 0 | 0 | 0 | 0 |
| M | Irrigation | 407,522 | 333,246 | 239,408 | 245,896 | 252,386 | 258,375 |
| | Manufacturing | 1,921 | 2,355 | 2,748 | 3,137 | 3,729 | 4,524 |
| | Municipal | 26,479 | 64,277 | 115,719 | 178,005 | 252,293 | 330,625 |
| | Steam-electric | 0 | 1,980 | 4,374 | 7,291 | 11,214 | 16,382 |
| N | Irrigation | 627 | 569 | 1,264 | 2,316 | 3,784 | 5,677 |
| | Manufacturing | 409 | 7,980 | 15,859 | 25,181 | 34,686 | 46,905 |
| | Mining | 1,802 | 2,996 | 4,471 | 6,166 | 6,897 | 7,584 |
| | Municipal | 566 | 557 | 753 | 827 | 2,440 | 2,395 |
| | Steam-electric | 0 | 1,982 | 4,755 | 7,459 | 10,187 | 13,183 |
| O | Irrigation | 1,264,707 | 1,735,399 | 2,084,569 | 2,331,719 | 2,361,813 | 2,318,004 |
| | Municipal | 10,349 | 14,247 | 20,116 | 23,771 | 28,489 | 30,458 |
| | Livestock | 1 | 763 | 3,191 | 9,506 | 14,708 | 17,574 |
| P | Irrigation | 67,739 | 67,739 | 67,739 | 67,739 | 67,739 | 67,739 |

## TABLE 6.4. UNMET NEEDS 2010–2060 (ACRE-FEET PER YEAR)

| Region | Category | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| A | Irrigation | 454,628 | 254,900 | 127,413 | 97,003 | 60,375 | 30,307 |
| B | Irrigation | 9,911 | 0 | 0 | 0 | 0 | 0 |
| C | Irrigation | 87 | 0 | 0 | 0 | 0 | 0 |
| D | Irrigation | 56 | 0 | 14 | 115 | 238 | 388 |
| E | Irrigation | 209,591 | 168,904 | 163,246 | 158,209 | 159,914 | 161,775 |
| F | Irrigation | 153,159 | 125,967 | 100,485 | 97,453 | 96,177 | 94,108 |
| F | Steam-electric | 1,219 | 3,969 | 5,512 | 7,441 | 10,608 | 14,935 |
| G | Irrigation | 49,973 | 45,234 | 40,664 | 38,358 | 36,113 | 33,932 |
| G | Mining | 1,800 | 2,001 | 2,116 | 2,281 | 2,446 | 2,567 |
| G | Municipal | 2,196 | 0 | 0 | 0 | 0 | 0 |
| G | Steam-electric | 36,086 | 0 | 0 | 0 | 0 | 0 |
| I | Mining | 7,772 | 8,620 | 9,191 | 9,760 | 10,333 | 10,772 |
| I | Steam-electric | 2,588 | 0 | 0 | 0 | 0 | 0 |
| L | Irrigation | 48,378 | 44,815 | 42,090 | 39,473 | 36,959 | 34,544 |
| M | Irrigation | 394,896 | 285,316 | 149,547 | 107,676 | 59,571 | 4,739 |
| N | Mining | 1,591 | 2,448 | 3,023 | 3,374 | 3,660 | 3,876 |
| O | Irrigation | 862,586 | 1,348,515 | 1,728,725 | 2,000,555 | 2,057,677 | 2,043,247 |
| O | Livestock | 1 | 763 | 3,191 | 9,506 | 14,708 | 17,574 |
| **Total** | | **2,236,518** | **2,291,452** | **2,375,217** | **2,571,204** | **2,548,779** | **2,452,764** |

*Steam-electric:* Planning groups identified 63,000 acre-feet of potential water shortages for the steam-electric category in 2010, increasing dramatically to over 615,000 acre-feet by 2060. Region G accounts for the largest share of these needs for both 2010 and 2060.

Regions K, I, and D, however, are also projected to have significant water supply needs by 2060 under drought conditions. This is a reduction from the steam-electric needs identified in the 2007 State Water Plan, which were approximately 76,000 acre-feet in 2010 and 675,000 acre-feet in 2060, statewide.

*Manufacturing*: Planning groups identified a potential shortage of 95,000 acre-feet for the manufacturing water use category in 2010, increasing to about 470,000 acre-feet by 2060. This represents a decline from those needs identified in the last round of planning, where planning groups estimated projected needs of 132,000 and 500,000 acre-feet in 2010 and 2060, respectively. The decline is due to a reduction in Region H's water supply needs in 2010 and reductions for Regions A, C, and K in 2060, which was a result of an increase in allocated supplies in these regions. The majority of potential manufacturing needs in the 2012 State Water Plan occur in Region H, most notably in Brazoria and Harris counties, in both 2010 and 2060.

## 6.2 UNMET NEEDS

During the current round of planning, planning groups identified some water needs that could not be met because no feasible water management strategy could be implemented in the identified decades of needs. The majority of unmet needs fall under the irrigation water use category, especially in Regions A, E, F, M, and O. For irrigation water needs, it is likely that under drought conditions, the return on the investment is not sufficient to support implementation of costly water management strategies.

The remainder of unmet needs are relatively small, with many of them occurring only in the 2010 decade when timing issues precluded strategy implementation. In the remaining decades, there are unmet steam-electric needs in Region F, unmet mining needs in Regions G, I, and N, and unmet livestock needs in Region O. Identified unmet needs can be seen in Table 6.4.

## 6.3 SOCIOECONOMIC IMPACT OF NOT MEETING WATER NEEDS

As part of the regional planning process, planning groups are tasked with evaluating the social and economic impacts of not meeting identified water supply needs. TWDB provided assistance in conducting this task by performing a socioeconomic impact analysis for each region at their request. The impact analysis is based on the assumption of a physical shortage of raw surface or groundwater due to drought conditions. Under this scenario, impacts are estimates for a single year (2010, 2020, 2030, 2040, 2050, and 2060), and shortages are assumed to be temporary events resulting from drought conditions.

There are two major components to TWDB's socioeconomic analysis: (1) an economic impact component and (2) a social impact component. The economic component analyzes the impacts of water shortages on residential water consumers and losses to regional economies from reduced economic output in agriculture, industry, and commerce. The social component focuses on demographic effects, including changes in population and school enrollment, by incorporating results from the economic impact element and assessing how changes in a region's economy due to water shortages could affect patterns of migration.

Variables impacted by projected water shortages identified in this analysis include the following:

- **Regional income:** Total payroll costs, including wages and salaries plus benefits paid by industries; corporate income; rental income; and interest payments to corporations and individuals in a given region.
- **State and local business taxes:** Sales, excise, fees, licenses, and other taxes paid during normal operation of an industry.
- **Number of full- and part-time jobs:** Number of full and part-time jobs including self-employment.
- **Population losses:** Unrecognized gains in population due to water shortages.
- **Declines in school enrollment:** Potential losses to future enrollment due to population losses.

There are a variety of tools available for use in estimating economic impacts; however, the most widely used methods are input-output models combined with social accounting matrices. Impacts in this study were estimated using proprietary software known as IMPLAN PRO™. IMPLAN is a modeling system originally developed by the U.S. Forest Service in the late 1970s. Today, MIG Inc. (formerly Minnesota IMPLAN Group Inc.) owns the copyright and distributes data and software. IMPLAN is also utilized by the U.S. Army Corps of Engineers as well as many other federal and state agencies.

Once potential output reductions due to water shortages were estimated, direct impacts to total sales, employment, regional income, and business taxes were derived using regional level economic multipliers. Secondary impacts were derived using a similar methodology; however, indirect multiplier coefficients are used.

As with any attempt to measure human social activities, assumptions are necessary. Assumptions are needed to maintain a level of generality and simplicity so that models can be applied on several geographic levels and across different economic sectors. Some of the assumptions made in this analysis include the following:

- Water supply needs as reported by regional planning groups are the starting point for socioeconomic analysis.
- Since plans are developed for drought conditions on a decadal basis, estimated socioeconomic impacts are point estimates for years in which water needs are reported (2010, 2020, 2030, 2040, 2050, and 2060). Given that the resulting impacts are not cumulative in nature, it is inappropriate to sum these impacts over the planning horizon; doing so would imply that the drought conditions will occur every 10 years in the future.
- Indirect impacts measure only linkages to supporting industries (those who sell inputs to an affected sector), not the impacts on businesses that purchase the sector's final product. Thus, the measured impacts of a given water shortage likely represent an underestimate of the losses to a region's economy.
- The analysis assumes the general structure of the economy remains the same over the planning horizon.
- Monetary figures are reported in constant year 2006 U.S. dollars.

### 6.3.1 SOCIOECONOMIC ANALYSIS RESULTS

Assuming drought conditions were experienced statewide and water management strategies identified in the 2012 State Water Plan were not implemented, planning areas could suffer significant economic losses (Table 6.5). Models show that Texas businesses and workers could lose approximately $11.9 billion in income in 2010, with that total increasing to an estimated $115.7 billion by 2060. Losses to state and local business taxes associated with commerce could reach $1.1 billion in 2010 and escalate to roughly $9.8 billion in 2060. If water management strategies identified in the 2012 State Water Plan are not implemented to meet these needs, Texans could face an estimated 115,000 lost jobs in 2010 and 1.1 million in 2060. The state could also fail to meet its true growth potential, losing an estimated 1.4 million in potential population growth and 403,000 fewer students by 2060. The 1950s drought of record was estimated to cost the Texas economy about $3.5 billion (adjusted to 2008 dollars) annually (TBWE, 1959).

In short, TWDB estimates of socioeconomic impacts show if the state were to experience drought conditions in any year in the planning horizon and strategies were not put in place, there would be severe social and economic consequences. Furthermore, if drought conditions were to recur, the duration would likely exceed a single year and possibly cause actual impacts to the state that would exceed the estimates included in the 2012 State Water Plan.

## REFERENCES

TBWE (Texas Board of Water Engineers), 1959, A Study of Droughts in Texas: Texas Board of Water Engineers Bulletin 5914, 76 p.

## TABLE 6.5. ANNUAL ECONOMIC LOSSES FROM NOT MEETING WATER SUPPLY NEEDS FOR 2010–2060 (MILLIONS OF 2006 DOLLARS)

| Region | Category | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| A | Regional income ($) | 183 | 309 | 472 | 509 | 538 | 906 |
| | State and local business taxes ($) | 11 | 30 | 53 | 57 | 62 | 116 |
| | Number of full- and part-time jobs | 2,970 | 3,417 | 4,067 | 4,459 | 4,806 | 4,879 |
| | Population losses | 3,693 | 4,234 | 4,670 | 5,548 | 6,338 | 6,864 |
| | Declines in school enrollment | 1,042 | 1,201 | 1,237 | 1,025 | 1,171 | 1,270 |
| B | Regional income ($) | 5 | 5 | 5 | 5 | 5 | 6 |
| | State and local business taxes ($) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| | Number of full- and part-time jobs | 85 | 88 | 92 | 96 | 100 | 108 |
| | Population losses | 13 | 522 | 1,156 | 1,254 | 1,354 | 1,451 |
| | Declines in school enrollment | 4 | 148 | 328 | 356 | 384 | 412 |
| C | Regional income ($) | 2,336 | 5,176 | 12,883 | 19,246 | 24,741 | 49,721 |
| | State and local business taxes ($) | 130 | 341 | 848 | 1,288 | 1,672 | 3,060 |
| | Number of full- and part-time jobs | 23,808 | 52,165 | 131,257 | 206,836 | 270,935 | 546,676 |
| | Population losses | 33,019 | 74,375 | 190,664 | 301,075 | 394,560 | 796,606 |
| | Declines in school enrollment | 10,348 | 24,340 | 64,415 | 102,345 | 134,283 | 271,468 |
| D | Regional income ($) | 357 | 515 | 620 | 871 | 1,341 | 1,960 |
| | State and local business taxes ($) | 51 | 73 | 88 | 123 | 189 | 267 |
| | Number of full- and part-time jobs | 1,224 | 1,780 | 2,150 | 2,998 | 4,639 | 6,784 |
| | Population losses | 1,472 | 2,144 | 2,590 | 3,611 | 5,588 | 8,171 |
| | Declines in school enrollment | 415 | 608 | 735 | 1,024 | 1,585 | 2,318 |
| E | Regional income ($) | 41 | 749 | 1,212 | 1,690 | 2,144 | 2,810 |
| | State and local business taxes ($) | 2 | 51 | 78 | 107 | 137 | 179 |
| | Number of full- and part-time jobs | 340 | 2,447 | 3,944 | 5,669 | 7,380 | 9,843 |
| | Population losses | 409 | 2,947 | 4,745 | 6,787 | 8,814 | 11,750 |
| | Declines in school enrollment | 115 | 836 | 1,257 | 1,254 | 1,628 | 2,173 |
| F | Regional income ($) | 1,444 | 1,715 | 2,195 | 2,729 | 3,061 | 3,470 |
| | State and local business taxes ($) | 145 | 176 | 236 | 288 | 330 | 380 |
| | Number of full- and part-time jobs | 19,225 | 21,784 | 26,293 | 34,853 | 37,661 | 40,877 |
| | Population losses | 25,050 | 26,239 | 31,670 | 41,980 | 45,362 | 49,236 |
| | Declines in school enrollment | 7,065 | 7,444 | 8,389 | 7,759 | 8,378 | 9,106 |
| G | Regional income ($) | 1,890 | 4,375 | 5,621 | 6,297 | 7,183 | 8,204 |
| | State and local business taxes ($) | 214 | 530 | 693 | 778 | 893 | 1,027 |
| | Number of full- and part-time jobs | 14,699 | 33,660 | 39,733 | 48,896 | 58,432 | 73,117 |
| | Population losses | 15,801 | 35,645 | 41,465 | 51,910 | 61,309 | 71,604 |
| | Declines in school enrollment | 4,457 | 10,112 | 11,764 | 14,727 | 17,393 | 20,314 |
| H | Regional income ($) | 3,195 | 5,189 | 10,012 | 12,910 | 15,759 | 18,637 |
| | State and local business taxes ($) | 326 | 536 | 1,024 | 1,375 | 1,689 | 2,036 |
| | Number of full- and part-time jobs | 20,176 | 37,849 | 82,478 | 100,622 | 126,412 | 149,380 |
| | Population losses | 24,433 | 45,514 | 99,071 | 122,686 | 152,028 | 175,839 |
| | Declines in school enrollment | 6,891 | 12,913 | 26,242 | 22,674 | 28,078 | 32,522 |
| I | Regional income ($) | 1,264 | 3,279 | 2,087 | 3,609 | 5,027 | 5,957 |
| | State and local business taxes ($) | 116 | 334 | 213 | 358 | 528 | 627 |
| | Number of full- and part-time jobs | 8,739 | 20,661 | 11,018 | 16,886 | 24,091 | 28,872 |
| | Population losses | 10,511 | 24,754 | 13,269 | 20,337 | 29,015 | 34,773 |
| | Declines in school enrollment | 2,965 | 7,023 | 3,764 | 5,770 | 8,232 | 9,865 |

## TABLE 6.5. ANNUAL ECONOMIC LOSSES FROM NOT MEETING WATER SUPPLY NEEDS FOR 2010–2060 (MILLIONS OF 2006 DOLLARS) - CONTINUED

| Region | Category | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| J | Regional income ($) | 2 | 2 | 2 | 2 | 2 | 2 |
| | State and local business taxes ($) | 0.3 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Number of full- and part-time jobs | 63 | 63 | 61 | 59 | 60 | 61 |
| | Population losses | 80 | 80 | 80 | 80 | 80 | 80 |
| | Declines in school enrollment | 20 | 20 | 20 | 20 | 20 | 20 |
| K | Regional income ($) | 138 | 1,326 | 1,396 | 2,246 | 2,407 | 2,933 |
| | State and local business taxes ($) | 15 | 179 | 186 | 305 | 326 | 393 |
| | Number of full- and part-time jobs | 1,989 | 8,447 | 9,860 | 14,651 | 16,273 | 21,576 |
| | Population losses | 2,393 | 10,174 | 11,876 | 17,647 | 19,601 | 25,988 |
| | Declines in school enrollment | 675 | 2,886 | 3,146 | 3,261 | 3,620 | 4,807 |
| L | Regional income ($) | 299 | 5,279 | 5,943 | 7,034 | 8,192 | 8,944 |
| | State and local business taxes ($) | 39 | 564 | 668 | 775 | 885 | 965 |
| | Number of full- and part-time jobs | 10,128 | 19,948 | 39,716 | 53,848 | 67,085 | 78,736 |
| | Population losses | 12,886 | 43,823 | 58,402 | 74,857 | 86,896 | 54,411 |
| | Declines in school enrollment | 3,635 | 12,433 | 15,470 | 13,835 | 16,049 | 10,064 |
| M | Regional income ($) | 324 | 325 | 382 | 909 | 1,568 | 2,935 |
| | State and local business taxes ($) | 27 | 34 | 43 | 104 | 179 | 337 |
| | Number of full- and part-time jobs | 5,081 | 5,609 | 6,664 | 17,658 | 32,124 | 62,574 |
| | Population losses | 6,112 | 6,756 | 8,027 | 21,269 | 38,597 | 75,252 |
| | Declines in school enrollment | 1,724 | 1,917 | 2,277 | 6,034 | 10,950 | 21,349 |
| N | Regional income ($) | 56 | 427 | 1,612 | 2,484 | 5,999 | 7,796 |
| | State and local business taxes ($) | 3 | 22 | 74 | 123 | 274 | 352 |
| | Number of full- and part-time jobs | 430 | 3,125 | 11,275 | 16,375 | 42,420 | 55,025 |
| | Population losses | 520 | 3,770 | 13,590 | 19,730 | 51,100 | 66,280 |
| | Declines in school enrollment | 130 | 890 | 2,990 | 3,030 | 7,840 | 10,180 |
| O | Regional income ($) | 356 | 714 | 949 | 1,214 | 1,415 | 1,437 |
| | State and local business taxes ($) | 18 | 38 | 53 | 71 | 83 | 86 |
| | Number of full- and part-time jobs | 5,546 | 10,843 | 14,760 | 19,532 | 23,761 | 23,966 |
| | Population losses | 7,160 | 13,910 | 18,670 | 24,590 | 29,830 | 30,030 |
| | Declines in school enrollment | 1,680 | 3,270 | 4,380 | 5,770 | 7,000 | 7,040 |
| P | Regional income ($) | 16 | 16 | 16 | 16 | 16 | 16 |
| | State and local business taxes ($) | 2 | 2 | 2 | 2 | 2 | 2 |
| | Number of full- and part-time jobs | 215 | 215 | 215 | 215 | 215 | 215 |
| | Population losses | 258 | 259 | 259 | 259 | 259 | 259 |
| | Declines in school enrollment | 73 | 73 | 73 | 73 | 73 | 73 |
| **Total** | **Regional income losses ($)** | **11,905** | **29,400** | **45,409** | **61,771** | **79,398** | **115,734** |
| | **State and local business taxes losses ($)** | **1,100** | **2,909** | **4,261** | **5,755** | **7,249** | **9,828** |
| | **Number of full- and part-time jobs losses** | **114,718** | **222,101** | **383,583** | **543,653** | **716,394** | **1,102,689** |
| | **Population losses** | **143,810** | **295,146** | **500,204** | **713,620** | **930,731** | **1,408,594** |
| | **Declines in school enrollment** | **41,239** | **86,114** | **146,487** | **188,957** | **246,684** | **402,981** |

# Quick Facts

Municipal conservation strategies are expected to result in about 650,000 acre-feet of supply by 2060, with irrigation and other conservation strategies totaling another 1.5 million acre-feet per year.

The planning groups recommended 26 new major reservoirs projected to generate approximately 1.5 million acre-feet per year by 2060. Other surface water strategies would result in about 3 million acre-feet per year.

Recommended strategies relying on groundwater are projected to result in about 800,000 additional acre-feet per year by 2060.

# 7 Water Management Strategies

**The regional planning groups recommended 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought, resulting in a total, if implemented, of 9.0 million acre-feet per year in additional water supplies by 2060. Some recommended strategies are associated with demand reduction or making supplies physically or legally available to users.**

After identifying surpluses and needs for water in their regions, regional water planning groups evaluate and recommend water management strategies to meet the needs for water during a severe drought. Planning groups must address the needs of all water users, if feasible. If existing supplies do not meet future demand, they recommend specific water management strategies to meet water supply needs, such as conservation of existing water supplies, new surface water and groundwater development, conveyance facilities to move available or newly developed water supplies to areas of need, water reuse, and others.

TWDB may provide financial assistance for water supply projects only if the needs to be addressed by the project will be addressed in a manner that is consistent with the regional water plans and the state water plan. This same provision applies to the granting of water right permits by the Texas Commission on Environmental Quality, although the governing bodies of these agencies may grant a waiver to the consistency requirement. TWDB funding programs that are targeted at the implementation of state water plan projects, such as the Water Infrastructure Fund, further require that projects must be recommended water management strategies in the regional water plans and the state water plan to be eligible for financial assistance.

## TABLE 7.1. RECOMMENDED WATER MANAGEMENT STRATEGY SUPPLY VOLUMES BY REGION (ACRE-FEET PER YEAR)

| Region | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| A | 2,718 | 332,468 | 545,207 | 617,843 | 631,629 | 648,221 |
| B | 15,373 | 40,312 | 40,289 | 49,294 | 76,252 | 77,003 |
| C | 79,898 | 674,664 | 1,131,057 | 1,303,003 | 2,045,260 | 2,360,302 |
| D | 11,330 | 16,160 | 20,180 | 33,977 | 62,092 | 98,466 |
| E | 3,376 | 66,225 | 79,866 | 98,816 | 112,382 | 130,526 |
| F | 90,944 | 157,243 | 218,705 | 236,087 | 235,400 | 235,198 |
| G | 137,858 | 405,581 | 436,895 | 496,528 | 562,803 | 587,084 |
| H | 378,759 | 622,426 | 863,980 | 1,040,504 | 1,202,010 | 1,501,180 |
| I | 53,418 | 363,106 | 399,517 | 427,199 | 607,272 | 638,076 |
| J | 13,713 | 16,501 | 20,360 | 20,862 | 20,888 | 23,010 |
| K | 350,583 | 576,795 | 554,504 | 571,085 | 565,296 | 646,167 |
| L | 188,297 | 376,003 | 542,606 | 571,553 | 631,476 | 765,738 |
| M | 90,934 | 182,911 | 275,692 | 389,319 | 526,225 | 673,846 |
| N | 46,954 | 81,020 | 130,539 | 130,017 | 133,430 | 156,326 |
| O | 517,459 | 503,886 | 504,643 | 464,588 | 429,136 | 395,957 |
| P | 67,739 | 67,739 | 67,739 | 67,740 | 67,739 | 67,739 |
| **Total** | **2,049,353** | **4,483,040** | **5,831,779** | **6,518,415** | **7,909,290** | **9,004,839** |

## 7.1 EVALUATION AND SELECTION OF WATER MANAGEMENT STRATEGIES

After the water demand and supply comparisons and needs analyses were completed, planning groups evaluated potentially feasible water management strategies to meet the needs for water within their regions. A water management strategy is a plan or a specific project to meet a need for additional water by a discrete user group, which can mean increasing the total water supply or maximizing an existing supply. Strategies can include development of new groundwater or surface water supplies; conservation; reuse; demand management; expansion of the use of existing supplies such as improved operations or conveying water from one location to another; or less conventional methods like weather modification, brush control, and desalination.

Factors used in the water management strategy assessment process include

- the quantity of water the strategy could produce;
- capital and annual costs;
- potential impacts the strategy could have on the state's water quality, water supply, and agricultural and natural resources (Chapter 8, Impacts of Plans); and
- reliability of the strategy during time of drought.

Calculating the costs of water management strategies is done using uniform procedures to compare costs between regions and over time, since some strategies are recommended for immediate implementation, while others are needed decades into the future. Cost assumptions include expressing costs in 2008 dollars, using a 20-year debt service schedule, using capital costs of construction as well as annual operation and maintenance costs, and providing unit costs per acre-foot of water produced.

Reliability is an evaluation of the continued availability of an amount of water to the users over time, but particularly during drought. A water management strategy's reliability is considered high if water is determined to be available to the user all the time, but

## TABLE 7.2. RECOMMENDED WATER MANAGEMENT STRATEGY SUPPLY VOLUMES BY TYPE OF STRATEGY (ACRE-FEET PER YEAR)

| Type of Water Management Strategy | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Municipal Conservation | 137,847 | 264,885 | 353,620 | 436,632 | 538,997 | 647,361 |
| Irrigation Conservation | 624,151 | 1,125,494 | 1,351,175 | 1,415,814 | 1,463,846 | 1,505,465 |
| Other Conservation * | 4,660 | 9,242 | 15,977 | 18,469 | 21,371 | 23,432 |
| New Major Reservoir | 19,672 | 432,291 | 918,391 | 948,355 | 1,230,573 | 1,499,671 |
| Other Surface Water | 742,447 | 1,510,997 | 1,815,624 | 2,031,532 | 2,700,690 | 3,050,049 |
| Groundwater | 254,057 | 443,614 | 599,151 | 668,690 | 738,484 | 800,795 |
| Reuse | 100,592 | 428,263 | 487,795 | 637,089 | 766,402 | 915,589 |
| Groundwater Desalination | 56,553 | 81,156 | 103,435 | 133,278 | 163,083 | 181,568 |
| Conjunctive Use | 26,505 | 88,001 | 87,496 | 113,035 | 136,351 | 135,846 |
| Aquifer Storage and Recovery | 22,181 | 61,743 | 61,743 | 72,243 | 72,243 | 80,869 |
| Weather Modification | 0 | 15,206 | 15,206 | 15,206 | 15,206 | 15,206 |
| Drought Management | 41,701 | 461 | 461 | 461 | 461 | 1,912 |
| Brush Control | 18,862 | 18,862 | 18,862 | 18,862 | 18,862 | 18,862 |
| Seawater Desalination | 125 | 125 | 143 | 6,049 | 40,021 | 125,514 |
| Surface Water Desalination | 0 | 2,700 | 2,700 | 2,700 | 2,700 | 2,700 |
| **Total Supply Volumes** | **2,049,353** | **4,483,040** | **5,831,779** | **6,518,415** | **7,909,290** | **9,004,839** |

*Other conservation is associated with manufacturing, mining, and steam-electric power industries.

it is considered low or moderate if the availability is contingent on other factors.

The water management strategy evaluation process also considered other factors applicable to individual regions including difficulty of implementation, regulatory issues, regional or local political issues, impacts to recreation, and socioeconomic benefits or impacts.

Upon conclusion of a thorough evaluation process, planning groups recommended a combination of water management strategies to meet specific needs in their regions during a repeat of the drought of record. In this planning cycle, planning groups could also include alternative water management strategies in their plans. An alternative strategy may be substituted for a strategy that is no longer recommended, under certain conditions and with the approval of the TWDB executive administrator. All recommended and alternative water management strategies included in the 2011 regional water plans are presented in Appendix A.

## 7.2 SUMMARY OF RECOMMENDED WATER MANAGEMENT STRATEGIES

To meet the needs for water during a repeat of the drought of record, regional water planning groups evaluated and recommended water management strategies that would account for an additional 9.0 million acre-feet per year of water by 2060 if all are implemented (Tables 7.1 and 7.2). These strategies included 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought (this figure is lower than presented in previous plans because it does not separately count each entity participating in a given project).

### 7.2.1 WATER CONSERVATION

Conservation focuses on efficiency of use and the reduction of demands on existing water supplies. In 2010, almost 767,000 acre-feet per year of water conservation savings is recommended, increasing to nearly 2.2 million acre-feet per year by 2060 from all forms of conservation strategies (Table 7.3). Some of the savings from water conservation practices are achieved

## TABLE 7.3. SUPPLY VOLUMES FROM RECOMMENDED CONSERVATION STRATEGIES BY REGION (ACRE-FEET PER YEAR)

| Region | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| A | 0 | 299,077 | 488,721 | 544,840 | 553,661 | 556,914 |
| B | 13,231 | 13,798 | 13,833 | 13,875 | 13,891 | 14,702 |
| C | 46,780 | 107,975 | 154,950 | 197,288 | 240,912 | 290,709 |
| D | 0 | 0 | 0 | 0 | 0 | 0 |
| E | 0 | 33,275 | 37,275 | 41,275 | 46,275 | 52,275 |
| F | 3,197 | 43,113 | 80,551 | 81,141 | 81,769 | 82,423 |
| G | 10,857 | 24,873 | 31,473 | 33,757 | 38,011 | 41,758 |
| H | 116,880 | 137,151 | 147,529 | 156,336 | 172,831 | 183,933 |
| I | 20,111 | 30,480 | 33,811 | 36,085 | 41,381 | 41,701 |
| J | 579 | 622 | 641 | 643 | 669 | 681 |
| K | 18,498 | 169,207 | 179,630 | 192,541 | 221,622 | 241,544 |
| L | 33,843 | 41,032 | 47,818 | 53,944 | 64,761 | 82,297 |
| M | 15,743 | 54,469 | 102,047 | 154,932 | 217,882 | 286,629 |
| N | 1,664 | 2,449 | 3,398 | 4,466 | 5,766 | 7,150 |
| O | 485,275 | 442,100 | 399,095 | 359,792 | 324,783 | 293,542 |
| P | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **766,658** | **1,399,621** | **1,720,772** | **1,870,915** | **2,024,214** | **2,176,258** |

passively in the normal course of daily activities, such as flushing a low-flow toilet or showering with a low-flow showerhead. Other savings are achieved through education and programs designed specifically to reduce water usage. Conservation includes water savings from municipal, irrigation, and "other" (mining, manufacturing, and power generation) water users. Water conservation is being recommended in greater quantities over time. Comparing the 2007 State Water Plan with the 2012 plan, there is an additional 129,400 acre-feet of water conservation recommended in the current plan.

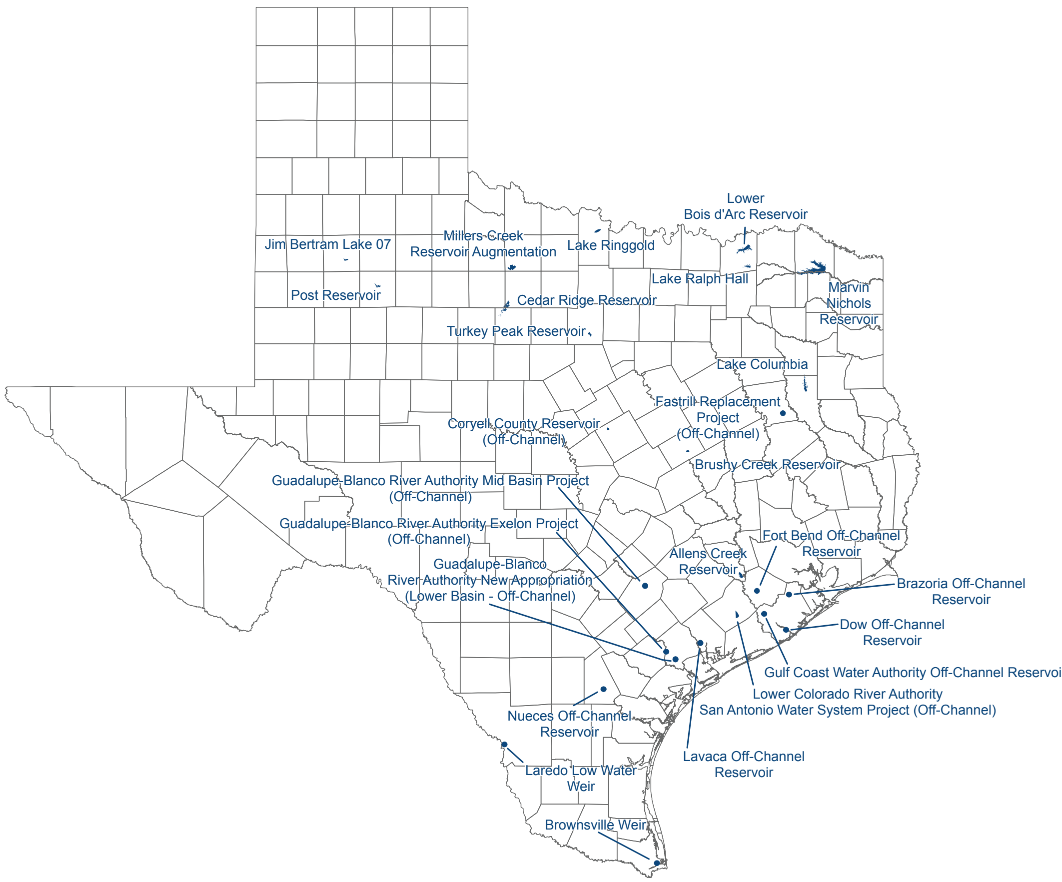
### 7.2.2 SURFACE WATER STRATEGIES

Surface water strategies include stream diversions, new reservoirs, other surface water strategies such as new or expanded contracts or connection of developed supplies, and operational changes.

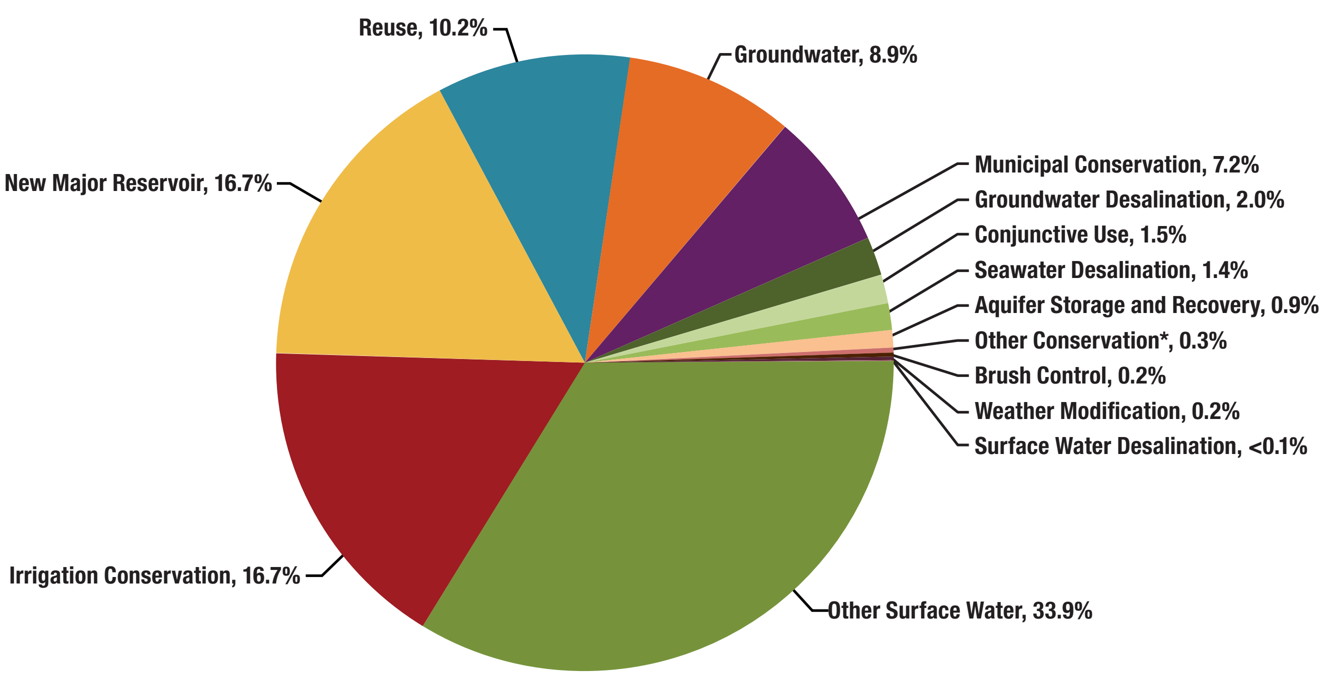
One long-term trend in Texas is the relative shift from reliance on groundwater to surface water. The volume of water produced by surface water strategies recommended in 2060 is five times greater than that produced by recommended groundwater strategies. Surface water strategies, excluding desalination and non-traditional strategies, compose about 51 percent of the recommended volume of new water, compared to 9 percent from groundwater strategies in the 2012 State Water Plan. Surface water management strategies recommended by the regional planning groups total in excess of 4.5 million acre-feet per year by 2060.

In the 2012 State Water Plan, 26 new major reservoirs are recommended to meet water needs in several regions (Figure 7.1). A major reservoir is defined as one having 5,000 or more acre-feet of conservation storage. These new reservoirs would produce 1.5 million acre-feet per year in 2060 if all are built, representing 16.7 percent of the total volume of all recommended strategies for 2060 combined (Figure 7.2). Not surprisingly, the majority of these projects would be located east of the Interstate Highway-35 corridor where rainfall and resulting runoff are more plentiful than in the western portion of the state.

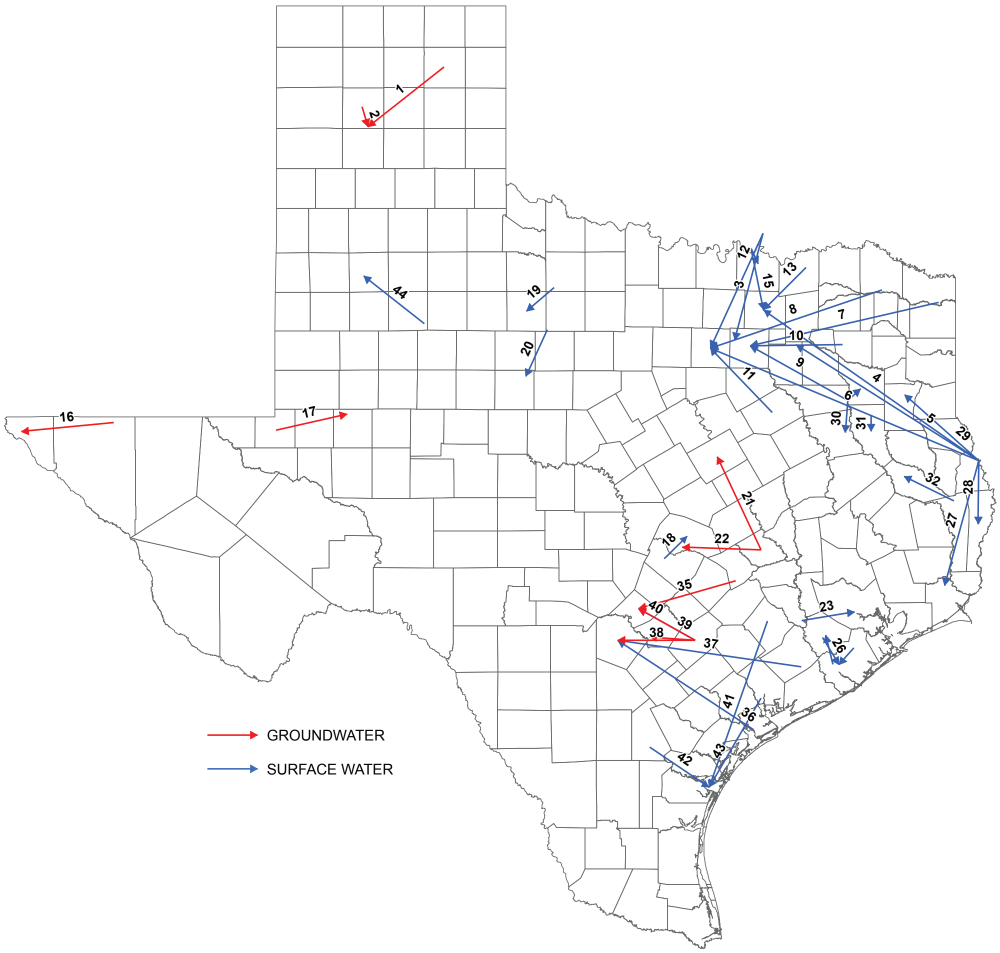
## FIGURE 7.1. RECOMMENDED NEW MAJOR RESERVOIRS.




## FIGURE 7.2. RELATIVE VOLUMES OF RECOMMENDED WATER MANAGEMENT STRATEGIES IN 2060.



## FIGURE 7.3. RECOMMENDED GROUND AND SURFACE WATER CONVEYANCE AND TRANSFER PROJECTS.




"Other surface water" strategies include existing supplies that are not physically or legally available at the present time. Examples include an existing reservoir that has no pipeline to convey water to some or all users, a water user that does not have a water supply contract with the appropriate water supplier, or an entity that has no "run-of-river" water right to divert water for use.

Other surface water strategies are recommended to provide in excess of 742,400 acre-feet per year of supply in 2010, and about 3 million acre-feet per year by 2060. Other surface water is the largest water management strategy category recommended, and usually requires additional infrastructure such as new pipelines to divert and convey water from an existing source to a new point of use. Transporting water from existing, developed sources such as reservoirs, to a new point of use many miles away, is very common in Texas and will become more prevalent in the future. An example is the current project to construct a joint pipeline from Lake Palestine to transport water to Dallas and water from Tarrant Regional Water District's lakes to Fort Worth. Figure 7.3 and Table 7.4 depict recommended major groundwater and surface water conveyance and transfer projects.

## TABLE 7.4. RECOMMENDED GROUND AND SURFACE WATER CONVEYANCE AND TRANSFER PROJECTS

| ID | Project | Conveyance From | To |
|---|---|---|---|
| 1 | Roberts County Well Field | Roberts County | Amarillo |
| 2 | Potter County Well Field | Potter County | Amarillo |
| 3 | Oklahoma Water to Irving | Oklahoma Lake/Reservoir | Irving |
| 4 | Toledo Bend Project | Toledo Bend Reservoir | Collin County |
| 5 | Toledo Bend Project | Toledo Bend Reservoir | Kaufman County |
| 6 | Toledo Bend Project | Toledo Bend Reservoir | Tarrant County |
| 7 | Wright Patman - Reallocation of Flood Pool | Wright Patman Lake | Dallas |
| 8 | Marvin Nichols Reservoir | Marvin Nichols Reservoir | Colin, Denton, Tarrant Counties |
| 9 | Lake Palestine Connection (Integrated Pipeline with Tarrant Regional Water District) | Lake Palestine | Dallas |
| 10 | Additional Pipeline From Lake Tawakoni (More Lake Fork Supply) | Lake Fork | Dallas |
| 11 | Tarrant Regional Water District Third Pipeline and Reuse | Navarro County | Tarrant County |
| 12 | Oklahoma Water to North Texas Municipal Water District, Tarrant Regional Water District, Upper Trinity Regional Water District | Oklahoma Lake/Reservoir | Colin, Denton, Tarrant Counties |
| 13 | Lower Bois D'Arc Creek Reservoir | Lower Bois D'Arc Reservoir | Collin County |
| 14 | Grayson County Project | Lake Texoma Non-System Portion | Collin, Grayson Counties |
| 15 | Lake Texoma - Authorized (Blend) | Lake Texoma North Texas Municipal Water District System | Collin County |
| 16 | Integrated Water Management Strategy - Import From Dell Valley | Dell City | El Paso |
| 17 | Develop Cenozoic Aquifer Supplies | Winkler County | Midland |
| 18 | Regional Surface Water Supply | Lake Travis | Williamson County |
| 19 | Millers Creek Augmentation | Millers Creek Reservoir | Haskell County |
| 20 | Cedar Ridge Reservoir | Cedar Ridge Reservoir | Abilene |
| 21 | Conjunctive Use (Lake Granger Augmentation) | Burleson County | Mclennan |
| 22 | Conjunctive Use (Lake Granger Augmentation) | Burleson County | Round Rock |
| 23 | Allens Creek Reservoir | Allens Creek Lake/Reservoir | Houston |
| 24 | Gulf Coast Water Authority Off-Channel Reservoir | Gulf Coast Water Authority Off-Channel Reservoir | Fort Bend County |
| 25 | Brazoria Off-Channel Reservoir | Brazoria Off-Channel Reservoir | Brazoria County |
| 26 | Fort Bend Off-Channel Reservoir | Fort Bend Off-Channel Lake/Reservoir | Brazoria County |
| 27 | Purchased Water | Toledo Bend Reservoir | Jefferson County |
| 28 | Purchased Water | Toledo Bend Reservoir | Newton County |
| 29 | Purchased Water | Toledo Bend Reservoir | Rusk County |
| 30 | Purchased Water | Lake Palestine | Anderson County |
| 31 | Lake Columbia | Lake Columbia | Cherokee County |
| 32 | Angelina County Regional Project | Sam Rayburn-Steinhagen Reservoir System | Lufkin |
| 33 | Lake Palestine Infrastructure | Lake Palestine | Tyler |
| 34 | Regional Carrizo For Schertz-Seguin Local Government Corporation Project Expansion | Gonzales County | Guadalupe County |
| 35 | Guadalupe-Blanco River Authority Simsboro Project | Lee County | Comal County |
| 36 | Seawater Desalination | Gulf Of Mexico Sea Water | Bexar County |
| 37 | Off-Channel Reservoir - Lower Colorado River Authority/ San Antonio Water System Project (Region L Component) | Colorado, Matagorda, Wharton Counties | Bexar County |
| 38 | Regional Carrizo For Saws (Including Gonzales County) | Gonzales County | Bexar County |
| 39 | Guadalupe-Blanco River Authority Mid-Basin (Surface Water) | Gonzales County | Comal County |
| 40 | Texas Water Alliance Regional Carrizo (Including Gonzales County) | Carrizo-Wilcox Aquifer | Comal County |
| 41 | Garwood Pipeline And Off-Channel Reservoir Storage | Colorado River | Corpus Christi |
| 42 | Off-Channel Reservoir Near Lake Corpus Christi | Nueces Off-Channel Reservoir | Corpus Christi |
| 43 | Lavaca River Off-Channel Reservoir Diversion Project | Lavaca Off-Channel Reservoir | Corpus Christi |
| 44 | Lake Alan Henry Pipeline | Lake Alan Henry | Lubbock |

Some regions recommended operational improvement strategies for existing reservoirs to increase their efficiency by working in tandem with one or more other reservoirs as a system. "System operations" involves operating multiple reservoirs as a system to gain the maximum amount of water supply from them.

Reallocation of reservoir storage from one approved purpose to another is a strategy that was recommended by some regions to meet needs from existing reservoirs. This reallocation requires formal changes in the way reservoirs are operated and shifts more of the storage space from flood control or hydro-electric power generation to water supply. If the operational change involves a federal agency such as the U.S. Army Corps of Engineers, congressional approval is required if the reallocation involves more than 50,000 acre-feet. These operational changes may come at a cost, however. Compensation for lost electrical generation will likely be required for hydro-electric storage reallocation, and additional property damages from flooding are possible if flood storage capacity is reduced.

### 7.2.3 GROUNDWATER STRATEGIES

Groundwater management strategies recommended in the regional water plans total 254,057 acre-feet in 2010 and increasing to 800,795 acre-feet in 2060. Additional recommendations for groundwater desalination of 56,553 acre-feet in 2010 and 181,568 acre-feet in 2060 result in a total of 310,610 acre-feet of groundwater in 2010 and 982,363 acre-feet in 2060. Desalination of brackish groundwater and other groundwater management strategies compose about 11 percent of the total volume of water from recommended strategies in 2060. Not including desalination, the recommended groundwater strategies involve some combination of the following: 1) installing new wells; 2) increasing production from existing wells; 3) installing supplemental wells; 4) temporarily over-drafting aquifers to supplement supplies; 5) building, expanding, or replacing treatment plants to make groundwater meet water quality standards; and 6) reallocating or transferring groundwater supplies from areas where projections indicate that surplus groundwater will exist to areas with needs.

### 7.2.4 WATER REUSE STRATEGIES

Water management strategies involving reuse are recommended to provide roughly 100,600 acre-feet per year of water in 2010, increasing to approximately 915,600 acre-feet per year in 2060. This represents slightly more than 10 percent of the volume of water produced by all strategies in 2060. Reuse projects in the 2012 State Water Plan produce approximately 348,000 acre-feet less water than those recommended in 2007. This is directly related to several recommended wastewater effluent reuse projects that were funded through TWDB's Water Infrastructure Fund and have been implemented in the intervening five-year period.

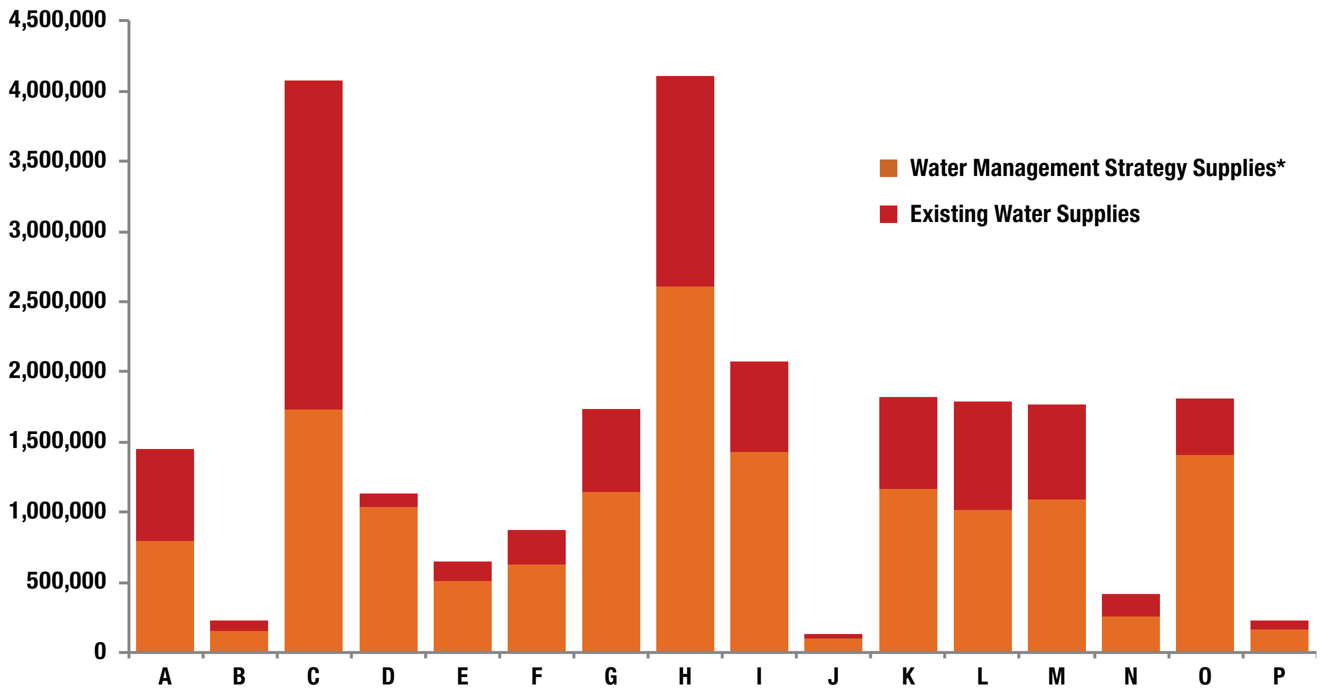
Direct reuse projects in which the wastewater never leaves the treatment system until it is conveyed through a pipeline to the point of use do not require an additional conveyance permit. These projects are commonly used to provide water for landscapes, parks, and other irrigation in many Texas communities.

Indirect reuse involves discharge of wastewater into a stream and later routing or diverting it for treatment as water supply. Since the wastewater is discharged into state water for conveyance downstream, it requires authorization known as a "bed and banks permit" from the Texas Commission on Environmental Quality.

## TABLE 7.5. RECOMMENDED WATER MANAGEMENT STRATEGY CAPITAL COSTS BY REGION (MILLIONS OF DOLLARS)

| Region | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Total |
|---|---|---|---|---|---|---|---|
| A | $187 | $129 | $137 | $287 | — | — | $739 |
| B | $110 | — | — | $7 | $383 | — | $499 |
| C | $9,922 | $3,976 | $3,891 | $928 | $17 | $2,747 | $21,482 |
| D | $39 | — | — | — | — | — | $39 |
| E | — | $382 | — | $246 | $214 | — | $842 |
| F | $223 | $439 | $252 | — | — | — | $915 |
| G | $2,064 | $745 | $94 | $273 | $10 | — | $3,186 |
| H | $4,710 | $4,922 | $287 | $1,135 | $458 | $506 | $12,019 |
| I | $363 | $350 | $79 | $80 | — | $12 | $885 |
| J | $11 | $44 | — | — | — | — | $55 |
| K | $663 | $67 | $4 | $169 | — | $4 | $907 |
| L | $1,022 | $2,973 | $2,321 | $2 | $12 | $1,294 | $7,623 |
| M | $2,070 | $124 | — | — | — | — | $2,195 |
| N | $45 | $113 | $360 | — | — | $139 | $656 |
| O | $669 | $273 | $167 | — | — | — | $1,108 |
| P | — | — | — | — | — | — | — |
| **Total** | **$22,097** | **$14,537** | **$7,592** | **$3,127** | **$1,095** | **$4,702** | **$53,150** |

## FIGURE 7.4. EXISTING SUPPLIES AND RECOMMENDED WATER MANAGEMENT STRATEGY SUPPLIES BY REGION (ACRE-FEET PER YEAR).




* Some water management strategies include demand reduction or shifts of existing supplies to other users.

Using artificially created wetlands to provide biological treatment such as nutrient uptake, the Tarrant Regional Water District was the first wholesale water provider in Texas to discharge treated wastewater through a natural filtering system before returning the water to its water supply lakes. This provides an additional source of water, which then can be diverted to water treatment plants for potable use. Similar indirect reuse projects are being implemented by other water suppliers in north Texas, and additional projects are in the planning stages.

### 7.2.5 OTHER STRATEGIES

**Conjunctive use** is the combined use of multiple sources that optimizes the beneficial characteristics of each source. Approximately 136,000 acre-feet of water per year is recommended by 2060 from this strategy.

**Weather modification**, sometimes referred to as cloud seeding, is the application of scientific technology that can enhance a cloud's ability to produce precipitation. More than 15,000 acre-feet per year of new supply is recommended from this strategy for all decades between 2020 and 2060 in Region A.

**Drought management** is a temporary demand reduction technique based on groundwater or surface water supply levels of a particular utility. Unlike conservation, which can be practiced most or all of the time, drought management is temporary and is usually associated with summer weather conditions. Drought management is recommended to supply nearly 2,000 acre-feet per year by 2060.

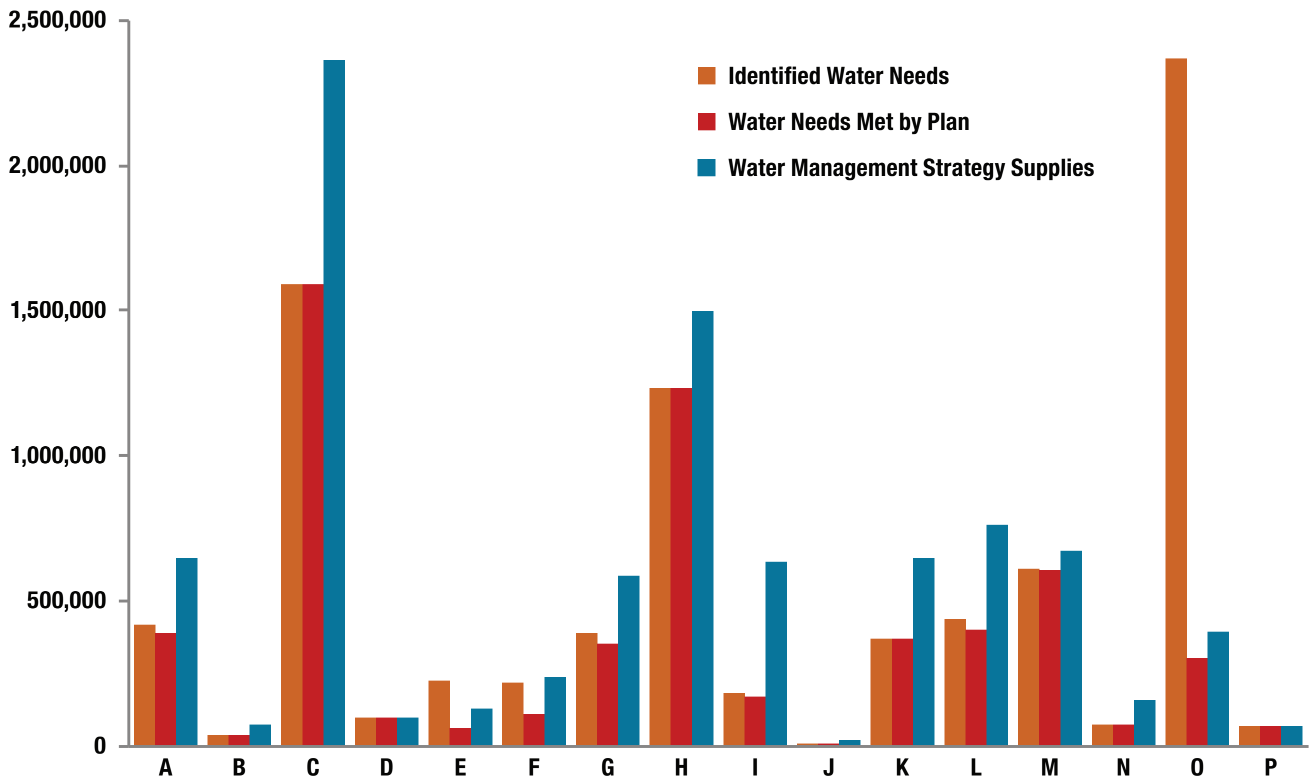
**Aquifer storage and recovery** refers to the practice of injecting potable water into an aquifer where it is stored for later use, often to meet summer peak usage demands. This strategy is feasible only in certain formations and in areas where only the utility owning the water can access it. It is recommended to provide almost 81,000 acre-feet per year by 2060.

**Brush control** and other land stewardship techniques have been recommended for many areas in the western half of the state. Removing ash juniper and other water consuming species has been shown in studies to restore springflow and improve surface water runoff in some cases. However, since water produced by this strategy during a drought when little rainfall occurs is difficult to quantify, it is not often recommended as a strategy to meet municipal needs. Brush control is recommended to supply approximately 19,000 acre-feet per year in all decades between 2010 and 2060.

**Desalination**, the process of removing salt from seawater or brackish water, is expected to produce nearly 310,000 acre-feet of potable water by 2060. Improvements in membrane technology, new variations on evaporative-condensation techniques, and other more recent changes have made desalination more cost-competitive than before. However, it is a very energy-intensive process and power costs have a significant effect on the price of produced water.

**Rainwater harvesting** is the capture, diversion, and storage of rainwater for landscape irrigation, drinking and domestic use, aquifer recharge, and stormwater abatement. Rainwater harvesting helps reduce outdoor irrigation demands on potable water systems. While it is often a component of municipal water conservation programs, rainwater harvesting was not recommended as a water management strategy to meet needs since, like brush control, the volume of water may not be available during drought conditions.

## FIGURE 7.5. WATER NEEDS, NEEDS MET BY PLANS, AND STRATEGY SUPPLY BY REGION (ACRE-FEET PER YEAR).




### DROUGHT MANAGEMENT

On April Fool's Day in 1911, legendary Texas cattleman and oil pioneer, W.T. "Tom" Waggoner, discovered oil on his family's ranch near Electra. In the midst of one of the worst droughts on record, he exclaimed, "Damn the oil, I need water for my cattle." (Time Magazine US, 2011).

Though his perspective may have changed with the expansion of the Waggoner ranching and oil empire, water has remained scarce in the region, particularly during times of drought. Nearly a century later, the town of Electra—named after Tom Waggoner's daughter—faced a desperate situation during the drought of 2000. With a mere 45-day water supply, the town imposed severe water restrictions. Residents were limited to 1,000 gallons of water per person per month, about a third of an average American's typical water use. All outdoor watering was banned and people were asked to use their toilets five times before flushing (CNN, 2000).

Drought management strategies, such as those used in Electra in 2000, are temporary measures that are used to reduce water demand during a drought. All wholesale and retail public water suppliers and irrigation districts in Texas must include these measures in drought contingency plans as required by the Texas Water Code. In Region B and many areas of Texas, water conservation and drought management are a way of life.

## 7.3 WATER MANAGEMENT STRATEGY TOTALS AND COSTS

As discussed further in Chapter 9 (Financing Needs), the total capital costs of the 2012 State Water Plan—representing all of the water management strategies recommended by the regional water planning groups—is $53 billion. The estimated capital costs of strategy implementation has increased significantly from the 2007 estimate of $31 billion, and it does not include annual costs such as operational and maintenance costs (Table 7.5). The increase in costs is attributable to several factors, including an increased volume of strategies in areas of high population growth, increased construction costs, increased costs of purchasing water rights, increased land and mitigation costs, and the addition of new projects to address uncertainty and other considerations.

In general, recommended water management strategy supply volumes increased significantly over the 50-year planning period due to the anticipated increase in population and water demands, coupled with a reduction of current supplies over time. In Figure 7.4, the total water supply volume from all recommended water management strategies for each region is shown in addition to the current water supplies. The total in this figure is not the total water available to the region because water management strategies include redistribution of existing supplies and water conservation, which are reductions in demands.

Some regions recommended water management strategies that would provide water in excess of their identified needs. This was done for various reasons including uncertainty in the ability of a strategy to be implemented; recommending the ultimate capacity of the strategy such as a reservoir in a decade before the entire firm yield is needed; potential acceleration of population and demand growth; and uncertainty related to demand and supply projections, due to various factors such as climate variability or the possibility of a drought worse than the drought of record (Figure 7.5).

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Time Magazine US, 2011, Milestones December 23, 1934: Time Magazine, http://www.time.com/time/magazine/article/0,9171,711640,00.html#ixzz1LUcDQnR.

# Quick Facts

**Recommended water management strategies to improve source water quality, through saltwater barriers or removal of contaminants, are expected to provide over 400,000 acre-feet of water per year by 2060.**

# 8 Impacts of Plans

**Regional water plans take into account potential impacts on water quality and consistency with long-term protection of the state's water, agricultural, and natural resources.**

During preparation of their plans, regional water planning groups evaluate how the implementation of recommended and alternative water management strategies could affect water quality in Texas. Each regional water plan includes a description of the potential major impacts of recommended strategies on key parameters of water quality, as identified by the planning group as important to the use of the water resource within their regions. The plans compare current conditions to future conditions with the recommended water management strategies in place.

Each regional water plan must also describe how it is consistent with long-term protection of the state's water, agricultural, and natural resources. To accomplish this task, planning groups estimate the environmental impacts of water management strategies and identify specific resources important to their planning areas, along with how these resources are protected through the regional water planning process.

## 8.1 WATER QUALITY

Water quality is an important consideration in water supply planning. Water quality affects the suitability of water for drinking, agriculture, industry, or other uses. Water quality concerns may determine how much water can be withdrawn from a river or stream without causing significant damage to the environment. These issues are important to planners and water providers because of the impact existing water quality can have on the cost of treating water to drinking water standards. The quality of surface water and groundwater is affected by its natural environment as well as by contamination through human activity.

The implementation of recommended water management strategies can potentially improve or degrade water quality. In their evaluation and choices of water management strategies, each planning group must consider water quality in the region. This includes identifying current water quality concerns, as well as the impacts that recommended water management strategies may have on water quality parameters or criteria.

### 8.1.1 SURFACE WATER QUALITY

Water quality is an integral component of the overall health of surface water bodies and impacts the treatment requirements for the state's water supply. The state surface water quality programs are based on the federal Clean Water Act and the Texas Water Code, with the Texas Commission on Environmental Quality having jurisdiction over the state's surface water quality programs, as delegated by the U.S. Environmental Protection Agency.

The Texas Commission on Environmental Quality sets surface water quality standards as goals to maintain the quality of water in the state. A water quality standard is composed of two parts: a designated use and the criteria necessary to attain and maintain that use. The three basic designated water uses for site-specific water quality standards are

- domestic water supply (including fish consumption),
- recreation, and
- aquatic life.

#### *Surface Water Quality Parameters*

The regional water planning groups use parameters from the Texas Surface Water Quality Standards to evaluate water quality impacts of the recommended water management strategies. These standards include general criteria for pollutants that apply to all surface waters in the state, site-specific standards, and additional protection for classified water bodies that are defined in the standards as being of intermediate, high, or exceptional quality. The following parameters are used for evaluating the support of designated uses:

- **Total Dissolved Solids (Salinity):** For most purposes, salinity is considered equivalent to total dissolved solids content. Salinity concentration determines whether water is acceptable for drinking water, livestock, or irrigation. Low salinity is considered 'fresh' water and is generally usable for all applications. Slightly saline water may be used to irrigate crops, as well as to water livestock, depending on the type of crop and the levels of solids in the water. Several river segments in the state have relatively moderate concentrations of salts including the upper portions of the Red and Wichita rivers in Region B; the Colorado River in Region F; and the Brazos River in Regions G and O. These regions have recommended water management strategies to address salinity issues.
- **Nutrients:** A nutrient is classified as a chemical constituent, most commonly a form of nitrogen or phosphorus, that can contribute to the overgrowth of aquatic vegetation and impact water uses in high

concentrations. Nutrients from permitted point source discharges must not impair an existing, designated, presumed, or attainable use. Site-specific numeric criteria for nutrients are related to the concentration of chlorophyll *a* in water and are a measure of the density of phytoplankton.

- **Dissolved Oxygen:** Dissolved oxygen concentrations must be sufficient to support existing, designated, presumed, and attainable aquatic life uses in classified water body segments. For intermittent streams with seasonal aquatic life uses, dissolved oxygen concentrations proportional to the aquatic life uses must be maintained during the seasons when the aquatic life uses occur. Unclassified intermittent streams with perennial pools are presumed to have a limited aquatic life use and correspondingly lower dissolved oxygen criteria.
- **Bacteria:** Some bacteria, although not generally harmful themselves, are indicative of potential contamination by feces of warm-blooded animals. Water quality criteria are based on these indicator bacteria rather than direct measurements of pathogens primarily because of cost, convenience, and safety. An applicable surface water use designation is not a guarantee that the water so designated is completely free of disease-causing organisms. Even where the concentration of indicator bacteria is less than the criteria for primary or secondary contact recreation, there is still some risk of contracting waterborne diseases from the source water without treatment.
- **Toxicity:** Toxicity is the occurrence of adverse effects to living organisms due to exposure to a wide range of toxic materials. Concentrations of chemicals in Texas surface waters must be maintained at sufficiently low levels to preclude adverse toxic effects on aquatic life, terrestrial life, livestock/domestic animals, and human health resulting from contact recreation, consumption of aquatic organisms, consumption of drinking water, or any combination of the three. Surface waters with sustainable fisheries or public drinking water supply uses must not exceed applicable human health toxic criteria, and those waters used for domestic water supply must not exceed toxic material concentrations that prevent them from being treated by conventional methods to meet federal and state drinking water standards.

### *Surface Water Quality Monitoring and Restoration Programs*

The Texas Commission on Environmental Quality coordinates the cooperative multi-stakeholder monitoring of surface water quality throughout the state, regulates and permits wastewater discharges, and works to improve the quality of water body segments that do not meet state standards.

To manage the more than 11,000 named surface water bodies in the state, the Texas Commission on Environmental Quality has subdivided the most significant rivers, lakes, wetlands, and estuaries into classified segments. A segment is that portion of a water body that has been identified as having homogenous physical, chemical, and hydrological characteristics. As displayed in the *Atlas of Texas Surface Waters* (TCEQ, 2004) classified segments are water bodies (or a portion of a water body) that are individually defined in the state surface water quality standards.

Water body segments that exceed one or more water quality standards are considered to be impaired. A list of these impaired segments is submitted to the U.S. Environmental Protection Agency, as required under Section 303(d) of the Clean Water Act. The *2008 Texas Water Quality Inventory and 303(d) List* (TCEQ, 2011) identifies 386 impaired water body segments in Texas (Figure 8.1).

Several state programs have been developed by the Texas Commission on Environmental Quality in partnership with stakeholders to determine whether water quality standards have been attained in individual water bodies and to plan and implement best management practices in an effort to restore impaired water resources. These include the Surface Water Quality Monitoring program, the Clean Rivers program, the Total Maximum Daily Load program, and the Nonpoint Source Pollution program. The regional water planning groups use information and data from these programs during their water management strategy evaluation processes.

### 8.1.2 GROUNDWATER QUALITY

Groundwater accounts for almost 60 percent of the water used in Texas. In its natural environment, groundwater slowly dissolves minerals as it recharges and flows through an aquifer. In many cases, these dissolved minerals are harmless at the levels in which they are naturally present in the groundwater. However, in some cases, groundwater may dissolve excessive amounts of certain minerals, making it unsuitable for some uses.

Other groundwater contamination may also result from human activities, such as leakage from petroleum storage tank systems, salt water disposal pits, pipelines, landfills, and abandoned wells, as well as infiltration of pesticides and fertilizers. These types of contamination are often localized but can also be widespread, covering large areas that are used for agriculture or oil and gas production.

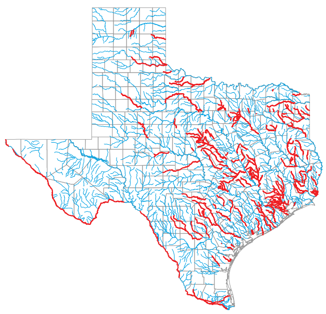
Although there are no equivalent water quality standards for groundwater as exists for surface water, the Texas Water Code provides general powers to groundwater conservation districts to make and enforce rules to prevent degradation of water quality.

#### *Common Groundwater Quality Parameters*

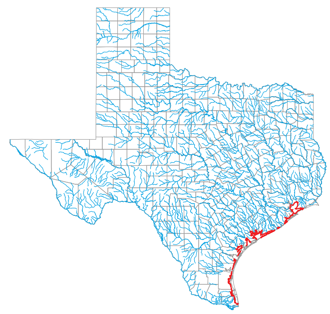
Below are a few of the more common drinking water parameters used in assessment of public water supplies that are applicable to groundwater quality:

- **Total Dissolved Solids (Salinity):** As was noted with surface water, total dissolved solids are a measure of the salinity of water and represent the amount of minerals dissolved in water. Moderately saline groundwater is defined as 'brackish' and is a viable potential water source for desalination treatment to make it suitable for public consumption. Much of the groundwater in the state's aquifers is fresh; however, brackish groundwater is more common than fresh in the southern Gulf Coast Aquifer and in aquifers in many parts of west Texas.
- **Nitrates:** Although nitrates exist naturally in groundwater, elevated levels generally result from human activities, such as overuse of fertilizer and improper disposal of human and animal waste. High levels of nitrates in groundwater often coexist with other contaminants. Human and animal waste sources of nitrates will often contain bacteria, viruses, and protozoa; fertilizer sources of nitrates usually contain herbicides and pesticides. Groundwater in Texas that exceeds this drinking water standard for nitrates is located mostly in the Ogallala and Seymour aquifers, although parts of the Edwards-Trinity (High Plains), Dockum, and Trinity aquifers are also affected.
- **Arsenic:** Although arsenic can occur both naturally and through human contamination, most of the arsenic in Texas groundwater is naturally occurring. Most of the groundwater supplies in Texas that exceed standards occur in the southern half of the Ogallala Aquifer, the Hueco-Mesilla

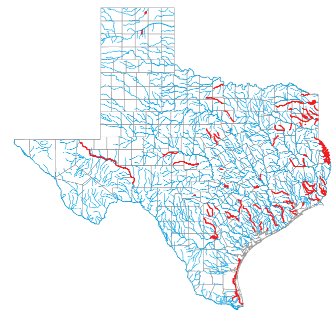
BACTERIA IMPAIRMENT



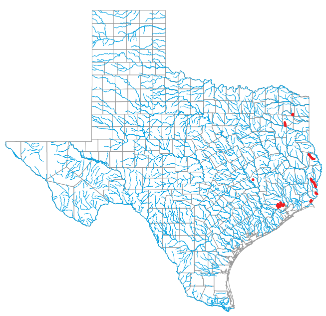
BACTERIA IMPAIRMENT FOR OYSTERS



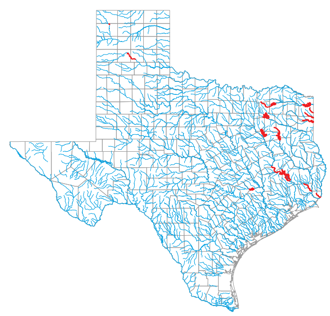
DISSOLVED OXYGEN IMPAIRMENT



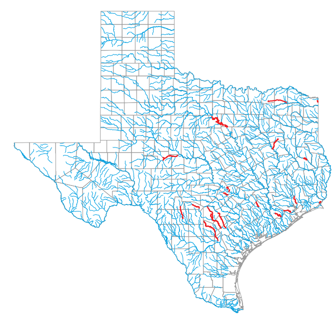
TOXICITY IMPAIRMENT



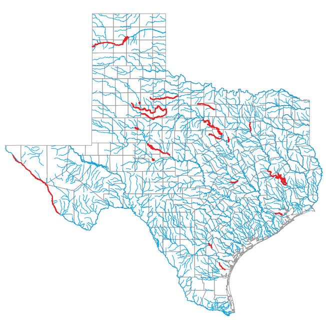
PH IMPAIRMENT



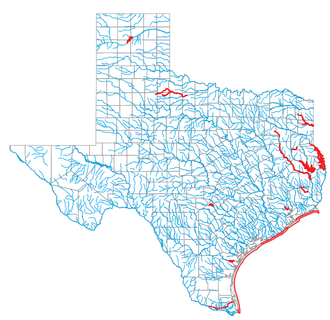
BIOLOGICAL INTEGRITY IMPAIRMENT



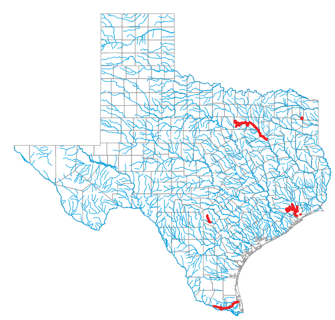
DISSOLVED SOLIDS IMPAIRMENT



METALS IMPAIRMENT



ORGANICS IMPAIRMENT



NITRATE AND NITRITE IMPAIRMENT

**FIGURE 8.1. IMPAIRED RIVER SEGMENTS AS DEFINED BY SECTION 303(D) OF THE CLEAN WATER ACT (TCEQ, 2008).**

Bolsons, and the West Texas Bolsons located in the western portions of Texas,  as well as in the Gulf Coast Aquifer in southeast Texas (Figure 8.2).

- **Radionuclides:** A radionuclide is an atom with an unstable nucleus that emits radiation. Most groundwater in Texas with gross alpha radiation greater than the maximum acceptable level is found in the Hickory Aquifer in central Texas and the Dockum Aquifer of west Texas (Figure 8.3). The Edwards-Trinity (Plateau), Gulf Coast, and Ogallala aquifers also have significant numbers of wells with high levels of gross alpha radiation. Although contamination from human activity can be a source of radionuclides, most of the radionuclides in Texas groundwater occur naturally. Where radionuclides are found in drinking water supplies, communities and water providers must provide additional levels of water treatment to remove the radionuclides, blend the groundwater with surface water to dilute the radionuclide concentration, or find an alternative source of drinking water.

### *Groundwater Quality Monitoring and Restoration Programs*

The Texas Groundwater Protection program, administered by the Texas Commission on Environmental Quality, supports and coordinates the groundwater monitoring, assessment, and research activities of the interagency Texas Groundwater Protection Committee, made up of nine state agencies as well as the Texas Alliance of Groundwater Districts. The Texas Groundwater Protection Committee publishes an annual report describing the status of current groundwater monitoring programs to assess ambient groundwater quality and also contains current documented regulatory groundwater contamination cases within the state and the enforcement status of each case. As part of its efforts to monitor groundwater quality, TWDB is currently funding research on the effects of natural and human influences on groundwater quantity.

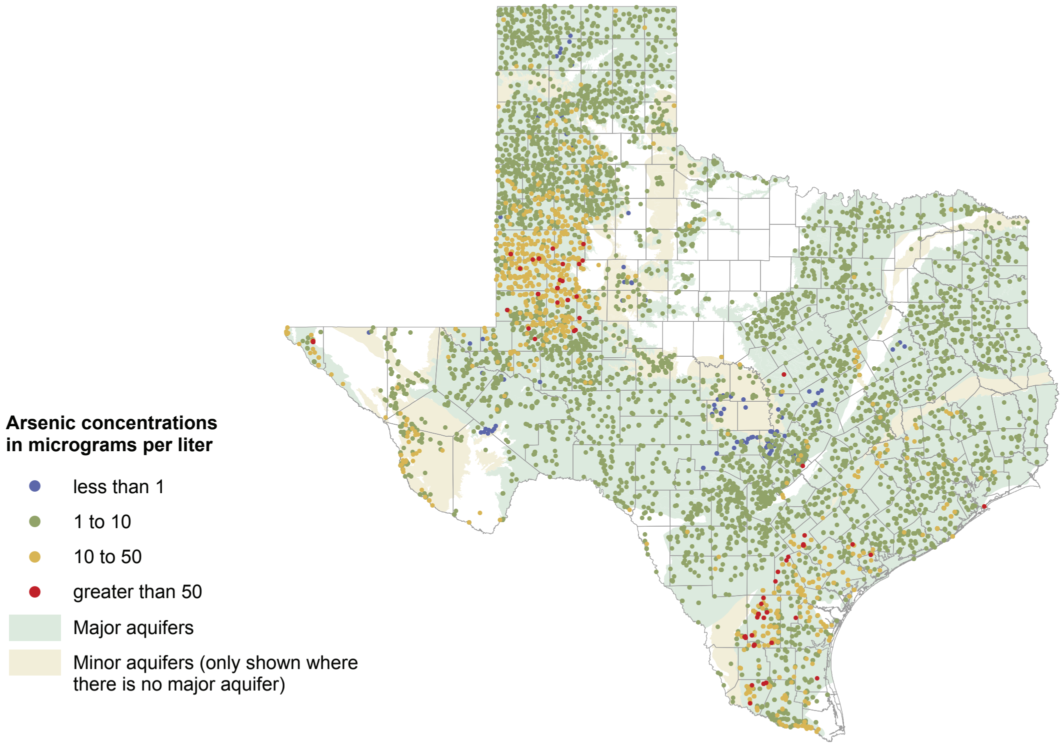
## 8.1.3 POTENTIAL IMPACTS OF RECOMMENDED WATER MANAGEMENT STRATEGIES ON WATER QUALITY

To assess how the implementation of water management strategies could potentially affect water quality, planning groups identified key water quality parameters within their regions. These parameters were generally based on surface and groundwater quality standards, the list of impaired waters developed by the Texas Commission on Environmental Quality, and input from local and regional water management entities and the public.

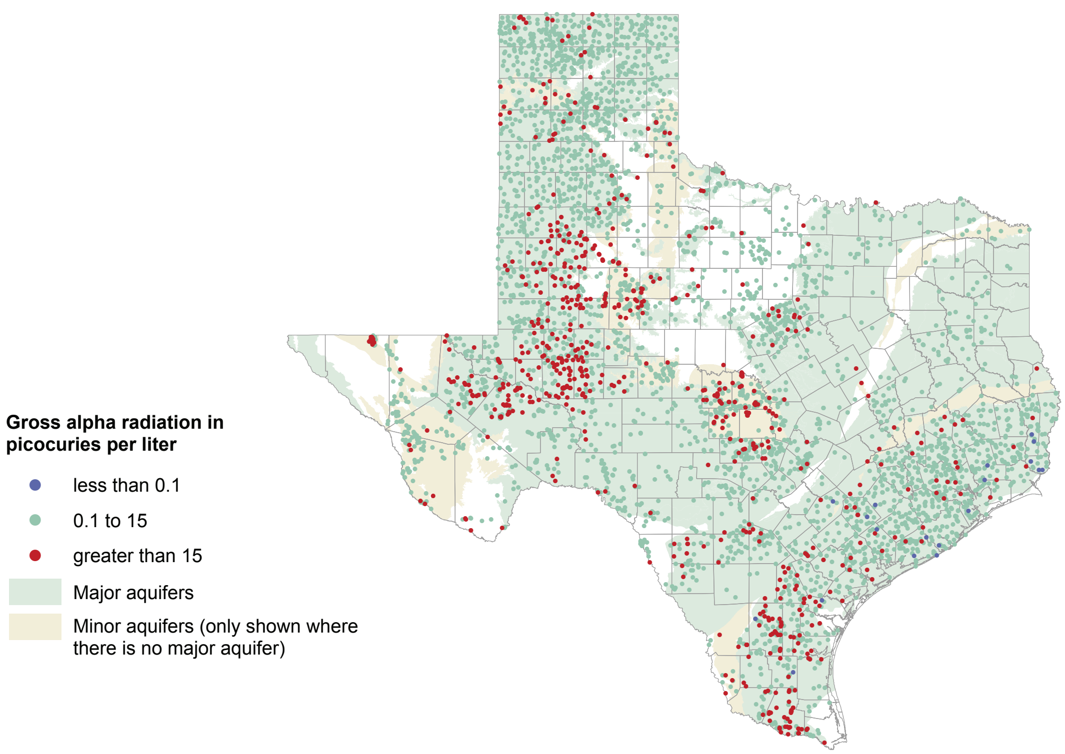
Regional water planning groups presented high-level assessments of how the implementation of strategies could potentially affect the water quality of surface water and groundwater sources. Regions used different approaches, including categorical assessments (such as “low” “moderate,” or “high”), or numerical impact classifications such as “1-5.” Statewide, about a third of the recommended water management strategies were designated by the regional water planning groups to have no adverse impacts, while more than half were estimated to only have low or minimum impacts. Approximately 10 percent were classified as having medium or moderate impacts to water quality. No water management strategies recommended by the regional water planning groups were expected to have a high impact on water quality.

Although many recommended water management strategies include water treatment as part of the project implementation, seven regional water planning areas recommended water management strategies whose primary goal is to improve the quality of the source water. These include saltwater barriers to reduce

## FIGURE 8.2. IMPAIRED GROUNDWATER WELLS/AQUIFERS FOR ARSENIC.




## FIGURE 8.3. IMPAIRED GROUNDWATER WELLS/AQUIFERS FOR RADIONUCLIDES.



inflow of saline waters into receiving streams as well as removal of contaminants such as nitrates, arsenic, and radionuclides from surface water and groundwater. Statewide, these strategies will improve over 400,000 acre-feet of water per year by 2060 (Table 8.1).

Several other recommended water management strategies are anticipated to have a secondary benefit of improving the quality of the source water, primarily by reducing the volume of high total dissolved solids effluent flows and contaminants into receiving waters. Examples of these strategies include on-farm reuse, irrigation scheduling, and direct and indirect reuse.

## 8.2 POTENTIAL IMPACTS TO THE STATE'S WATER, AGRICULTURAL, AND NATURAL RESOURCES

In addition to considering the potential impact of strategies on water quality, planning groups also evaluated the potential impacts of each water management strategy on the state's water, agricultural, and natural resources. In analyzing the impact of water management strategies on the state's water resources, the planning groups honored all existing water rights and contracts and considered conservation strategies for all municipal water user groups with a water supply need. They also based their analyses of environmental flow needs for specific water management strategies on Consensus Criteria for Environmental Flow Needs or site-specific studies (Chapter 5, Water Supplies). In addition, planning groups were required to consider water management strategies to meet the water supply needs of irrigated agriculture and livestock production.

Planning groups determined mitigation costs and quantified the potential of impacts for all water management strategies considered. Some used categorical assessments describing impacts as "high," "moderate," and "low." These ratings were based on existing data and the potential to avoid or mitigate impacts to agricultural and natural resources. For example, a "low" rating implied that impacts could be avoided or mitigated relatively easily. In contrast, a "high" rating implied that impacts would be significant and mitigation requirements would be substantial. Other planning groups used a numerical rating that indicated the level of impact. Many planning groups based their ratings on factors such as the volume of discharges a strategy would produce or the number of irrigated acres lost. Another approach relied on identifying the number of endangered or threatened species listed in a county with a proposed water source.

In general, most planning groups relied on existing information for evaluating the impacts of water management strategies on agricultural and natural resources. However, some regions performed region-wide impact analyses to evaluate potential cumulative impacts. For example, because of the close connection between the Edwards Aquifer, spring and river flows, and bay and estuary inflows, Region L developed an overall impact analysis that took into account many factors including draw-down of aquifers, impacts on spring flows, ecologically significant stream segments, bay and estuary inflows, vegetation and habitat, cultural resources, as well as endangered and threatened species.

## REFERENCES

TCEQ (Texas Commission on Environmental Quality), 2004, Atlas of Texas Surface Waters: Texas Commission on Environmental Quality Publication Number GI-316, http://www.tceq.texas.gov/publications/gi/gi-316/gi-316_intro.html/at_download/file.

## TABLE 8.1. WATER MANAGEMENT STRATEGIES DESIGNED TO IMPROVE SOURCE WATER QUALITY

| Region | Water Management Strategy Name | Description | Annual Volume in 2060 (acre-feet) |
|---|---|---|---|
| B | Nitrate removal plant | Removal of moderate to high levels of nitrate from the Seymour Aquifer | 50 |
| B | Wichita Basin chloride control project | Designed to reduce the amount of salt contamination from eight of the Red River Basin's natural salt sources; three of which lie within the Wichita River Basin. | 26,500 |
| C | Lake Texoma - authorized (blend) | Blending groundwater with surface water to decrease total dissolved solids concentration. | 113,000 |
| C | Tarrant Regional Water District Wetlands Project | Additional tertiary treatment via wetlands for conventionally treated wastewater prior to release into receiving reservoir (Richland-Chambers and Cedar Creek Reservoir) | 105,500 |
| E | Arsenic removal facility | Removes naturally occurring arsenic from groundwater that exceeds newly revised drinking water standards | 276 |
| E | Integrated water management strategy for the City and County of El Paso - desalination of agricultural drain water | Surface water quality improvement (new this planning cycle): will treat agricultural drain water at the end of the irrigation season, when the level of dissolved salts becomes too high for conventional treatment | 2,700 |
| F | Bottled water program | Water quality improvement - no cost effective resolution for current poor quality groundwater source | 1 |
| F | Develop Ellenburger Aquifer supplies | Blending groundwater with surface water to decrease concentration of naturally occurring radionuclides | 200 |
| F | Develop Hickory Aquifer supplies | Blending groundwater with surface water to decrease concentration of naturally occurring radionuclides | 12,160 |
| G | Groundwater-Surface Water Conjunctive Use (Lake Granger Augmentation) | Blending groundwater with surface water to decrease concentration of contaminants | 70,246 |
| G | Stonewall, Kent, and Garza Chloride Control Project | Improve surface water quality by using brine recovery wellfields for saline aquifers; this will decrease amount of salt leaching into tributaries to the Brazos River; market brine products to cover annual costs; volume of water with improved water quality undetermined at this time | n/a |
| H | Brazos Saltwater Barrier | Improve surface water quality in the lower Brazos Basin during low flow periods, by preventing seawater intrusion at raw water intake structures; volume of water with improved water quality undetermined at this time | n/a |
| I | Saltwater Barrier Conjunctive Operation with Rayburn/Steinhagen | Improve surface water quality by impeding salt water intrusion into the Neches River downstream of reservoirs so released water remains salt free for downstream diversion. | 111,000 |
| | **Total** | | **441,663** |

TCEQ (Texas Commission on Environmental Quality), 2011, 2008 Texas Water Quality Inventory and 303(d) List; Texas Commission on Environmental Quality, http://www.tceq.texas.gov/waterquality/assessment/08twqi/twqi08.html.

# Quick Facts

The capital cost of the 2012 State Water Plan is about 23 percent of the $231 billion in the total costs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years.

The 80th and 81st Texas Legislatures provided funding to implement recommended water management strategies to meet the needs for additional water supply needs during times of drought, enabling the issuance of over $1.47 billion in bonds to finance state water plan projects at below market rates. This funding is expected to have an economic impact resulting in the generation of $2.6 billion in additional sales revenue and over 19 thousand jobs.

In addition to dedicated appropriations for State Water Plan financial assistance, TWDB has provided over $530 million in additional funding to implement strategies recommended in the 2007 State Water Plan through Economically Distressed Areas Program, Texas Water Development Fund, Water Assistance Fund, Rural Water Assistance Fund, and the Drinking Water State Revolving Fund.

# 9 Financing Needs

**The capital cost to design, construct, or implement the strategies and projects is $53 billion and represents about only about a quarter of the total needs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years.**

During the regional water planning process, planning groups estimated the costs of potentially feasible water management strategies. The total estimated capital cost of the 2012 State Water Plan, representing all of the strategies recommended by the regional water planning groups, is $53 billion. This amount is about 23 percent of the $231 billion in the total costs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years. Water providers reported an anticipated need of $26.9 billion from state financial assistance programs to help implement recommended strategies for municipal water user groups in the 2012 State Water Plan. A number of state and federal financial assistance programs are available to aid in implementation of water supply projects; however, there is still a need for a long-term, affordable, and sustainable method to provide financial assistance for the implementation of state water plan projects.

## 9.1 COSTS OF IMPLEMENTING THE STATE WATER PLAN

As part of their evaluations, regional water planning groups estimate the costs of potentially feasible water management strategies that are under consideration during the planning process. These include the costs to develop a new source of water needed during times of drought, the costs of infrastructure needed to convey the water from the source to treatment facilities, and the costs to treat the water for end users. Water management strategies in the regional water plans do not include costs associated with internal system distribution facilities or aging infrastructure needs, unless the strategy increases available supply through water conservation or reduction of water loss in a system.

Water management strategy cost estimates include direct and indirect capital costs, debt service, and annual operating and maintenance expenses each decade over the planning horizon, as follows:

**Capital Costs:** Capital costs include engineering and feasibility studies, including those for permitting and mitigation, construction, legal assistance, financing, bond counsel, land and easements costs, and purchases of water rights. Construction costs include expenses for infrastructure such as pump stations, pipelines, water intakes, water treatment and storage facilities, well fields, and relocation of existing infrastructure such as roads and utilities. All costs are reported in constant September 2008 U.S. dollars per the Engineering News-Record Construction Cost Index, which is used throughout the U.S. construction industry to calculate building material prices and construction labor costs.

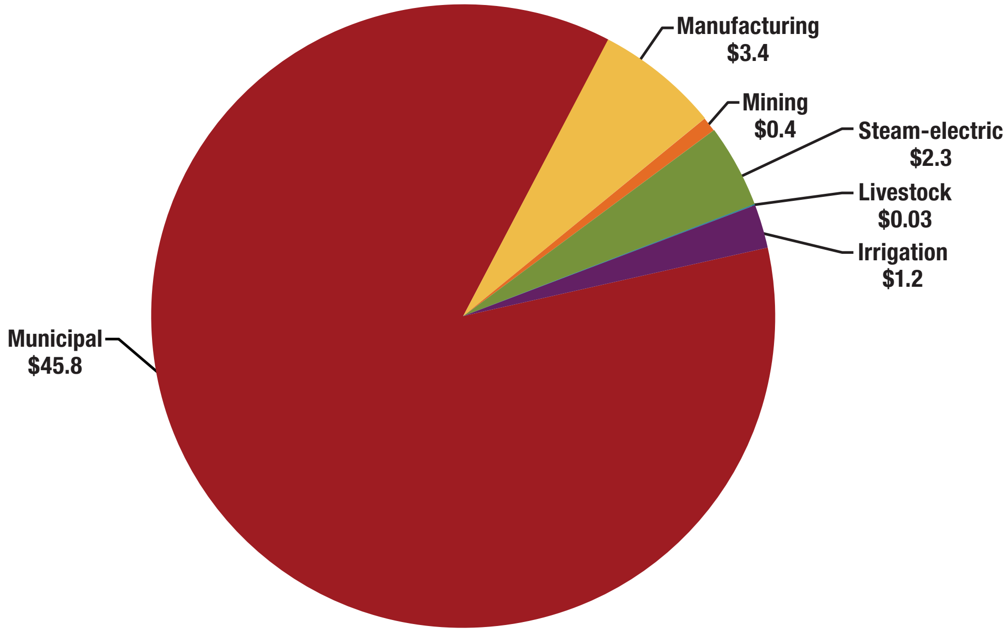
**Interest and Debt Service:** Interest during construction is based on total project costs drawn down at a constant rate per month during the construction period. Planning groups assume level debt service and an annual interest rate of 6.0 percent for project financing. The length of debt service is based on an estimated 20 years for most water management strategies and 40 years for reservoirs.

**Annual Operating and Maintenance Costs:** Operations and maintenance costs are based on the quantity of water supplied. Planning groups calculate annual operating and maintenance costs as 1.0 percent of the total estimated construction costs for pipelines, 2.5 percent of the estimated construction costs for pump stations, and 1.5 percent of the estimated construction costs for dams. Costs include labor and materials required to maintain projects such as regular repair and replacement of equipment. Power costs are calculated on an annual basis using calculated horsepower input and a power purchase cost of $0.09 per kilowatt hour.

The majority of the $53 billion costs are for water management strategies recommended for municipal water user groups (Figure 9.1). While the identified water needs of 8.3 million acre-feet per year in 2060 are less than the 8.9 million acre-feet per year identified in the 2007 State Water Plan, the costs of implementing the strategies have increased significantly from the $31.0 billion estimated in the 2007 State Water Plan. The increase was due to several factors:

- an increased volume of strategies in areas of high population growth;
- increased construction costs;
- increased costs of purchasing water rights;
- increased land and mitigation costs;
- the addition of new infrastructure projects to deliver treated water from existing and new water sources;

## FIGURE 9.1. TOTAL CAPITAL COSTS OF RECOMMENDED WATER MANAGEMENT STRATEGIES BY WATER USE CATEGORY (BILLIONS OF DOLLARS).




- the addition of new projects to address uncertainty in the ability to implement projects;
- inclusion, at a greater level of detail, of additional infrastructure that will be required to deliver and treat water to water users; and
- the addition of new projects to address the uncertainty that could result from climate change or a drought worse than the drought of record.

The decrease in the amount of needs from the 2007 plan to the 2012 plan is attributed to the successful implementation of previously recommended water management strategies, including those funded by the 80th and 81st Texas Legislatures (see Implementation of State Water Plan Projects, 9.4.1).

Region C ($21.5 billion), Region H ($12.0 billion), and Region L ($7.6 billion) have the highest estimated capital costs for implementation of their 2011 regional water plans. The costs associated with these three planning areas account for approximately 77 percent of the total capital costs in the 2012 State Water Plan. Their combined populations represent over 62 percent of the total projected population for the state by 2060.

The total estimated costs for implementing the 2012 State Water Plan are consistent with a general trend of increasing costs. The total estimated capital cost of the 2007 State Water Plan, $31.0 billion, was substantially higher than the $17.9 billion estimated in the 2002 State Water Plan. The 1997 State Water Plan, developed by TWDB prior to regional water planning, estimated $4.7 billion in costs for recommended major water supply and conveyance systems through 2050. These trends indicate that delays in the implementation of projects will likely result in continued cost increases.

## 9.2 COSTS OF ALL WATER INFRASTRUCTURE NEEDS

While the capital costs to implement the state water plan may seem staggering, the amount of funding needed to implement all water-related infrastructure in Texas is far greater. The estimated costs to implement water management strategies in the regional water plans do not include costs associated with internal system distribution facilities or aging infrastructure needs, nor do the plans include needs for wastewater infrastructure or flood control projects. Since 1984, TWDB has estimated the costs for implementing various types of water infrastructure—including those that go above and beyond water supply strategies. These estimates demonstrate the need for federal revolving fund financial assistance programs and help put the costs of the state water plan in perspective.

Estimated costs for water supply facilities, major water conveyances, major raw water treatment, wells and facilities, reservoirs, chloride control, and wastewater treatment were first provided in the 1984 State Water Plan. The 1990 State Water Plan expanded these estimates to include flood protection. All subsequent plans have provided cost estimates for all water-related infrastructure in Texas, divided into four categories:

- Water supplies (water management strategies recommended in the regional water plans, including costs of major conveyances to points of distribution)
- Water treatment and distribution not included in the regional water plans and state water plan
- Wastewater treatment and collection
- Flood control

The estimated capital costs included in the 2012 State Water Plan for water supply infrastructure represent the total capital costs of the 16 regional water plans. Estimates of capital costs for other water treatment and distribution and for wastewater facilities were developed using information gathered by TWDB with federal infrastructure needs surveys mandated by the Safe Drinking Water Act and the Clean Water Act. Estimates of the capital costs for current and planned flood control projects were obtained from the "Flood Funding Needs Database Research Project" funded by TWDB (Halff Associates, Inc., 2011).

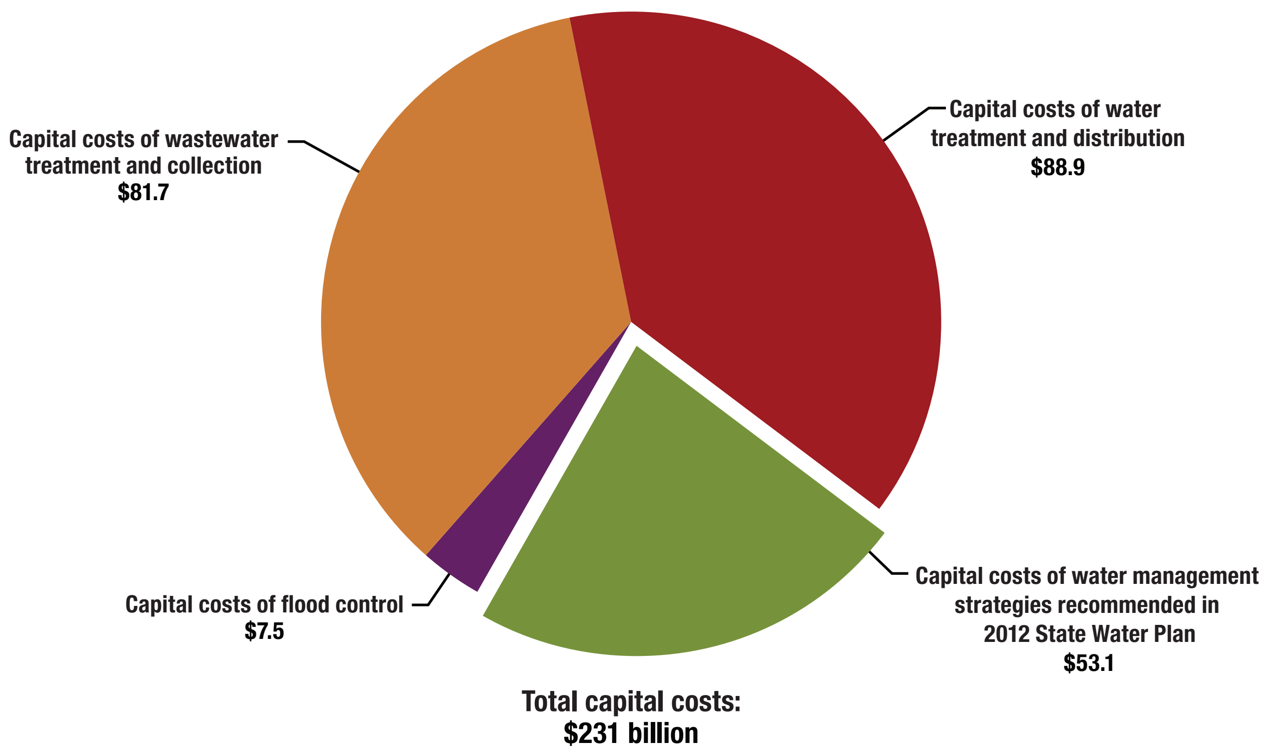
Current TWDB estimates indicate that Texas will need to invest about $231 billion by 2060 to meet the state's needs for water supply, water and wastewater infrastructure, and flood control. The 2012 State Water Plan recommends water management strategies that represent an estimated $53 billion, or 23 percent, of these total needs (Figure 9.2).

## 9.3 FUNDING NEEDED TO IMPLEMENT THE STATE WATER PLAN

Each planning cycle, regional water planning groups assess the amount of state financial support that local and regional water providers will need to implement municipal water management strategies recommended in their plans for times of drought. During development of the 2011 regional water plans, planning groups surveyed every water provider that had a municipal water management strategy with an associated capital cost to determine if they needed financial assistance from the state.

Of 694 water providers contacted, 269 responded to the survey and reported an anticipated need of $26.9 billion from state financial assistance programs to help implement recommended strategies. This amount represents about 58 percent of the total capital costs for water management strategies recommended for

## FIGURE 9.2. TOTAL CAPITAL COSTS FOR WATER SUPPLIES, WATER TREATMENT AND DISTRIBUTION, WASTEWATER TREATMENT AND COLLECTION, AND FLOOD CONTROL (BILLIONS OF DOLLARS).




municipal water user groups in the 2011 regional water plans (Table 9.1). Of the total reported need for state financial assistance, nearly $15.7 billion is expected to occur between the years 2010 and 2020; $4.2 billion will occur between 2020 and 2030; $4.1 billion between 2030 and 2040; and $1.9 billion between 2040 and 2050 (Figure 9.3).

Water providers reported that over $20 billion (75 percent) of the requested funds would target construction activities and land acquisition; $3.3 billion (12 percent) would finance project permitting, planning, and design activities; $3.1 billion would finance excess storage capacity; and approximately $440 million is needed for projects in rural and economically distressed areas of the state.

Not only are the costs to implement strategies significantly higher now than in previous state water plans, the needs for state assistance to help implement projects represent a much larger portion of the plan's total costs. Of the $31.0 billion total presented in the 2007 State Water Plan, only about $2.1 billion or 6.8 percent of the total was needed in the form of state assistance. However, later events indicated that the need for state assistance was underestimated, and a new financing survey was completed in 2008. At the request of the legislative Joint Committee on State Water Funding, TWDB surveyed 570 entities, with 212 water providers (37 percent) reporting an anticipated need for $17.1 billion in funds from TWDB financial assistance programs. The increases in requests for funding can be attributed in part to higher survey

## TABLE 9.1. 2060 WATER MANAGEMENT STRATEGY SUPPLIES (ACRE-FEET PER YEAR), CAPITAL COST, AND REPORTED FINANCIAL ASSISTANCE NEEDED

| Region | Water Management Strategy Supplies | Water Management Strategy Capital Cost (millions $) | Financial Assistance Needed (millions $) |
|---|---|---|---|
| A | 648,221 | $739 | $624 |
| B | 77,003 | $499 | $384 |
| C | 2,360,302 | $21,482 | $11,743 |
| D | 98,466 | $39 | $5 |
| E | 130,526 | $842 | $500 |
| F | 235,198 | $915 | $593 |
| G | 587,084 | $3,186 | $1,153 |
| H | 1,501,180 | $12,019 | $7,142 |
| I | 638,076 | $885 | $500 |
| J | 23,010 | $55 | $20 |
| K | 646,167 | $907 | $154 |
| L | 765,738 | $7,623 | $3,517 |
| M | 673,846 | $2,195 | $445 |
| N | 156,326 | $656 | $0 |
| O | 395,957 | $1,108 | $78 |
| P | 67,739 | $0 | $0 |
| **Total** | **9,004,839** | **$53,150** | **$26,857** |

response rates and to an increased awareness of the availability of attractive state financial assistance programs targeted at state water plan projects.

## 9.4 IMPLEMENTATION OF STATE WATER PLAN PROJECTS

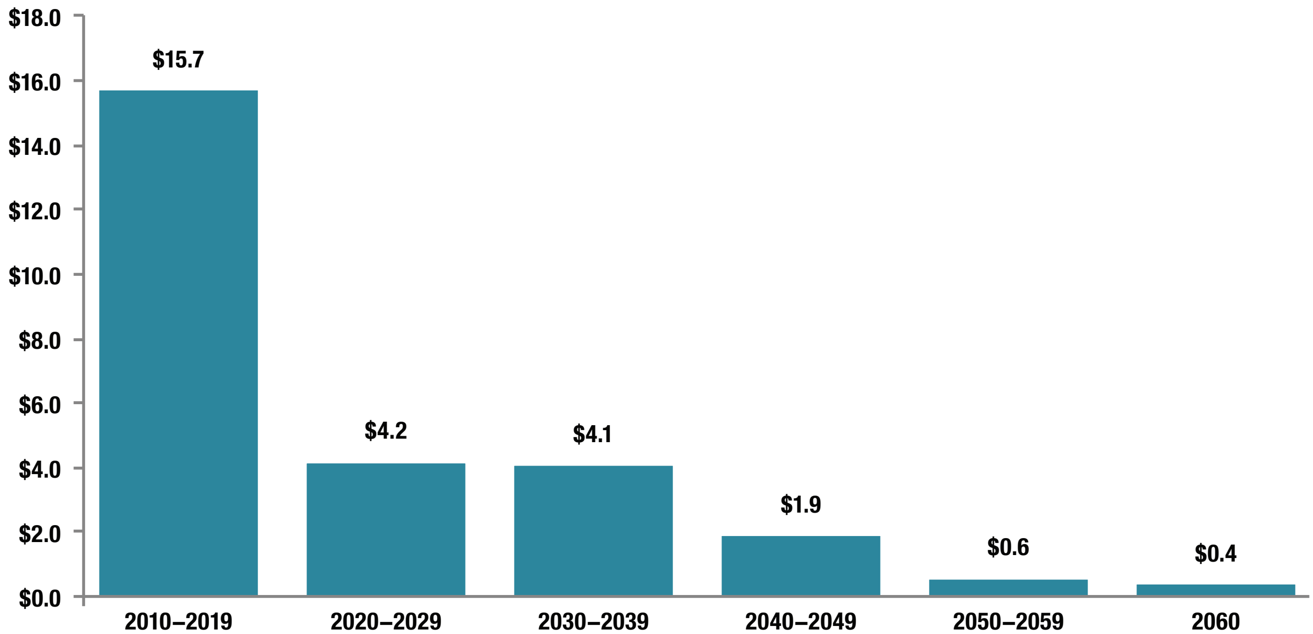
### 9.4.1 STATE WATER PLAN FUNDING

In response to the 2007 State Water Plan, the 80th and 81st Texas Legislatures provided funding to implement recommended water management strategies to meet the needs for additional water supply during times of drought. In 2007 and 2009, the Texas Legislature appropriated funds that enabled the issuance of over $1.47 billion in bonds to finance state water plan projects at below market rates. These projects were recommended water management strategies in the 2006 regional water plans and the 2007 State Water Plan. Funding was distributed through three TWDB programs: the Water Infrastructure Fund, the State Participation Program, and the Economically Distressed Areas Program.

As a result of these appropriations, TWDB has committed over $1 billion in financial assistance for 46 projects across the state, including projects in 11 of the 16 regional water planning areas (Figure 9.4). A variety of water management strategies have been funded, including groundwater desalination; new groundwater wells; wetlands that treat water for reuse; transmission and treatment facilities; and planning, design, and permitting of new reservoirs. Once implemented, these projects will generate over 1.5 million acre-feet of water that will help meet millions of Texans' needs for water during drought (Table 9.2).

The Water Infrastructure Fund, TWDB's financial assistance program designed specifically for state water plan projects, has been "oversubscribed," meaning that the demands for financial assistance have far exceeded what the program has been able to provide. Over $1.5 billion in requests was submitted for funding through the Water Infrastructure Fund, but

## FIGURE 9.3. DEMAND FOR TWDB FINANCIAL ASSISTANCE PROGRAMS BY DECADE OF ANTICIPATED NEED (BILLIONS OF DOLLARS).




there was not sufficient funding available to provide assistance to all projects that were eligible. In 2011, the 82nd Texas Legislature authorized additional funding to finance approximately $100 million in state water plan projects; these funds will be available during state fiscal years 2012 and 2013.

TWDB also funds recommended water management strategies through other loan programs. In addition to dedicated appropriations for state water plan financial assistance, TWDB has provided over $530 million in additional funding to implement strategies recommended in the 2007 State Water Plan through the Economically Distressed Areas Program, the Texas Water Development Fund, the Water Assistance Fund, the Rural Water Assistance Fund, and the Drinking Water State Revolving Fund.

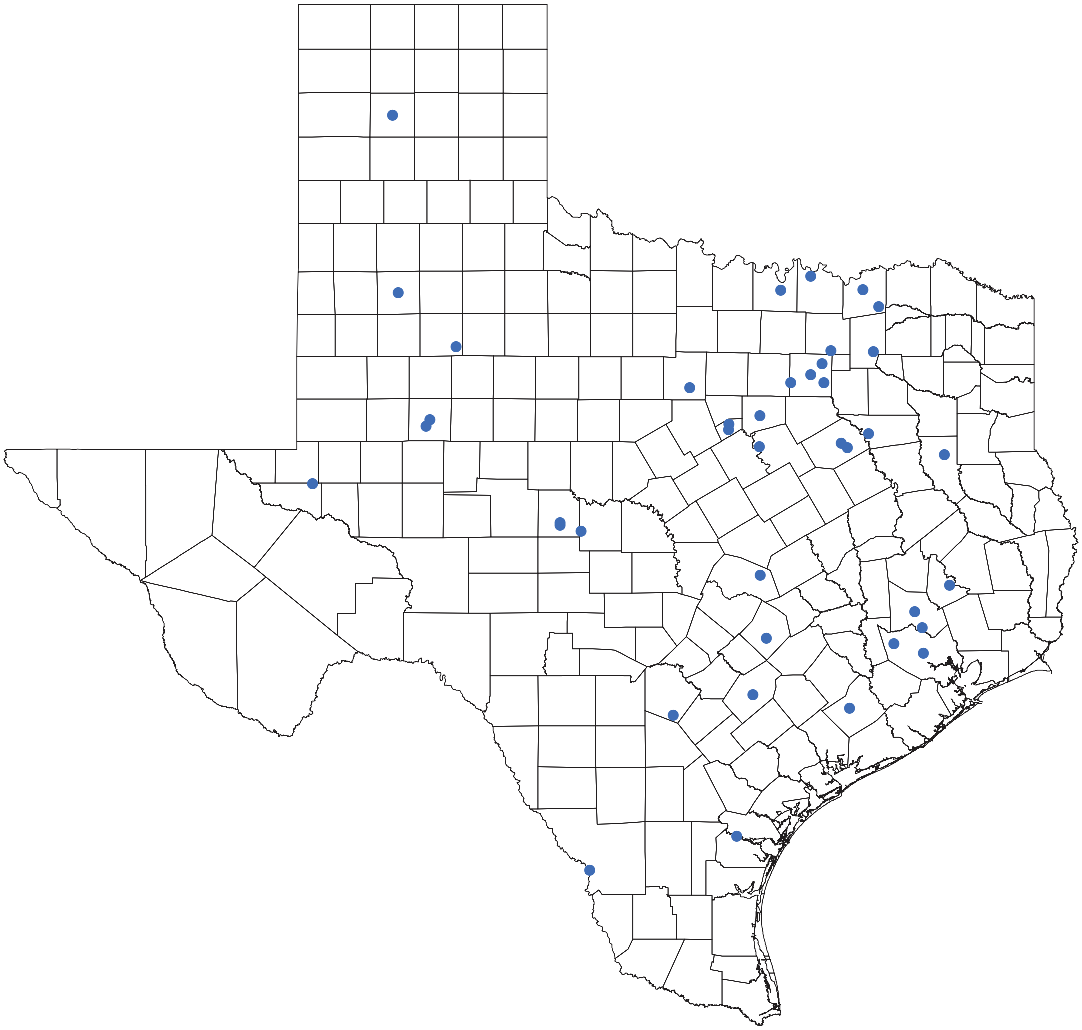
### 9.4.2 ECONOMIC BENEFITS OF IMPLEMENTATION

The implementation of water management strategies can often have a significant positive economic impact within a particular region and also on the state's economy as a whole. In the short term, construction projects provide a temporary boost to a local economy through employment and earnings. Expenditures on materials and labor as well as planning, design, and construction services result in increased local income. After construction is complete, permanent employment is supported by the operation and maintenance of water supply facilities.

It is estimated that every billion dollars in financial assistance provided for state water plan projects, over the course of project implementation, will

- generate $1.75 billion in sales revenues in the construction, engineering, and materials sectors and supporting businesses;
- create $888.8 million in state gross domestic product;
- add $43.9 million in state and local tax receipts; and
- create or support nearly 13,077 jobs in the state.

## FIGURE 9.4. LOCATIONS OF STATE WATER PLAN PROJECTS FUNDED BY TWDB.



### 9.4.3 IMPLEMENTATION SURVEY

Although TWDB does not have a formal mechanism in place to track implementation of all water management strategies, regardless of funding sources, the agency has undertaken efforts to assess the implementation progress of strategies from the 2007 State Water Plan. In the summer of 2011, TWDB contacted cities and water utilities with recommended water management strategies in the 2007 State Water Plan to evaluate implementation progress. Since water projects, particularly those that involve infrastructure, can require several years or more to put into place, progress was defined as any type of project construction or any form of pre-implementation activity, such as negotiating contracts, applying for and securing financing, state and federal permits, or conducting preliminary engineering studies.

Of the 497 projects for which the sponsoring entities responded, 139 of them (28 percent) reported some form of progress on strategy implementation. Of these, 65 (13 percent) reported that strategies had been

# TABLE 9.2. STATE WATER PLAN PROJECTS FUNDED BY TWDB PROGRAMS

| Entity | Funding Program | | | | | | Population Served | | Supply Generated | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water Infrastructure Fund Deferred | Water Infrastructure Fund Construction | Water Infrastructure Fund Rural | Economically Distressed Areas Program - State Water Plan Rural | Economically Distressed Areas Program - State Water Plan | State Participation | 2010 | 2060 | 2010 | 2060 |
| Central Harris Co. Regional Water Authority | | $22,050,000 | | | | | 29,950 | 41,550 | 2,375 | 4,806 |
| Coastal Water Authority | $28,000,000 | | | | | | 2,240,974 | 3,626,591 | - | 394,266 |
| Dallas, City of | | $15,100,000 | | | | | 2,050,026 | 3,208,230 | - | 20,458 |
| *Dallas, City of | $8,280,000 | | | | | | - | - | - | 29,924 |
| Lubbock, City of | | $22,615,000 | | | | | 216,974 | 248,622 | 21,880 | 21,880 |
| Tarrant Regional Water District | $3,135,000 | | | | | | 2,417,419 | 4,942,954 | - | 105,500 |
| *Tarrant Regional Water District | $6,755,000 | | | | | | - | - | - | - |
| Upper Trinity Regional Water District | $10,400,000 | | | | | | 131,129 | 576,237 | - | 34,050 |
| *Dallas, City of | | $94,723,000 | | | | | - | - | - | - |
| Brazos River Authority | | $22,000,000 | | | | | 151,729 | 524,852 | 26,505 | 70,246 |
| Corsicana, City of | $1,935,000 | | | | | | 29,940 | 37,894 | - | 2,268 |
| North Texas Municipal Water District | | $26,155,000 | | | | | 1,546,195 | 3,256,816 | 50,000 | 10,000 |
| *North Texas Municipal Water District | | $17,825,000 | | | | | - | - | - | - |
| San Jacinto River Authority | $21,500,000 | | | | | | - | - | - | 52,534 |
| Somervell County Water District | | $9,367,000 | $9,494,000 | $9,494,000 | $2,680,000 | | 7,542 | 9,804 | 840 | 840 |
| Amarillo, City of | | $38,885,000 | | | | | 223,607 | 336,060 | - | 10,831 |
| Cleburne, City of | $1,180,000 | | | | | | 30,572 | 52,812 | 680 | 680 |
| *Cleburne, City of | $4,750,000 | | | | | | - | - | 2,128 | 2,128 |
| *North Texas Municipal Water District | $9,930,000 | | | | | | - | - | - | 108,487 |
| Palo Pinto County Municipal Water District No. 1 | $3,200,000 | | | | $4,800,000 | | 37,026 | 48,513 | - | 7,600 |
| *Lubbock, City of | | $19,945,000 | | | | | - | - | - | - |
| Angelina and Neches River Authority | | | | | | $48,530,000 | 98,078 | 142,311 | - | 75,700 |
| *Coastal Water Authority | $5,115,000 | | | | | | - | - | - | - |
| San Antonio Water System | $35,000,000 | | | | | | 1,354,381 | 2,116,782 | - | 26,400 |
| Laredo, City of | | | | | $7,500,000 | | 234,423 | 650,317 | 1,425 | 49,863 |
| *Amarillo, City of | | $47,400,000 | | | | | - | - | - | - |
| Colorado River Municipal Water District | | $11,685,000 | | | | $45,315,000 | 121,434 | 148,673 | - | 6,000 |
| *Cleburne, City of | | $14,500,000 | | | | | - | - | - | - |
| Corpus Christi, City of | $8,000,000 | | | | | | - | - | - | 35,000 |
| Grand Prairie, City of | | $4,995,000 | | | | | - | - | - | 6,726 |
| Greater Texoma Utility Authority | | $21,230,000 | | | | | 2,000 | 18,000 | - | 113,000 |
| *Lubbock, City of | | $41,000,000 | | | | | - | - | - | - |
| *Tarrant Regional Water District | $17,835,000 | $83,785,000 | | | | | - | - | - | 107,347 |
| *Colorado River Municipal Water District | | $11,970,000 | | | | | - | - | - | 1,855 |
| Greater Texoma Utility Authority/ City of Gainesville | | $7,235,000 | | | | | 37,326 | 67,289 | - | 4,480 |
| *San Antonio Water System | | $24,550,000 | | | | | - | - | - | - |
| Corpus Christi, City of | $2,395,000 | | | | | | - | - | 42,329 | 32,996 |
| Guadalupe Blanco River Authority | $4,400,000 | | | | | | 96,521 | 287,647 | - | 25,000 |
| *Guadalupe Blanco River Authority | $2,500,000 | | | | | | - | - | - | 49,777 |
| Montgomery County Municipal Utility District Nos. 8 and 9 | $1,290,000 | | | | | | 6,900 | 12,445 | - | 1,120 |
| San Angelo, City of | | $120,000,000 | | | | | 94,261 | 105,445 | - | 12,000 |
| West Harris County Regional Water Authority | $11,195,000 | | | | | | 334,247 | 484,587 | 21,678 | 78,839 |
| West Harris County Regional Water Authority | $2,465,000 | | | | | | - | - | - | - |
| Eden, City of | | | | $995,000 | $1,000,000 | | 2,885 | 2,988 | - | - |
| Eden, City of | | | | | $2,680,000 | | - | - | - | - |
| *Somervell County Water District | | | | $700,000 | $700,000 | | - | - | - | 960 |
| | $189,260,000 | $677,015,000 | $9,494,000 | $11,189,000 | $19,360,000 | $93,845,000 | 11,495,539 | 20,947,419 | 169,840 | 1,503,561 |

* denotes water user groups with projects that are related and therefore the population and/or strategy supply may only be listed once to prevent double counting as the population and strategy supply are the same for both projects.

fully implemented. Of the 74 projects (15 percent) that reported incomplete progress, 13 (3 percent) reported that project construction had begun.

In comparison to the implementation results reported in the 2007 State Water Plan, a significantly larger number of projects are reported to have been implemented (65 projects, up from 21 in the 2002 State Water Plan). The percentage of projects reporting at least some progress is lower than reported in the 2007 plan, largely because more responses were submitted that reported no progress. It should also be noted that Senate Bill 660, passed by the 82nd Legislature in 2011, included a requirement for the state water plan to include an evaluation of the implementation progress of water management strategies in the previous plan, and allows TWDB to obtain implementation data from the regional planning groups. The 2016 regional water plans will be required to include an implementation progress report, which will be included in the 2017 State Water Plan.

## 9.5 FINANCING WATER MANAGEMENT STRATEGIES

In Texas, local governments have traditionally provided the majority of the financing for water infrastructure projects. Water and wastewater providers finance projects primarily through municipal debt on the open bond market and less frequently with cash or private equity sources such as banks. The federal government has also historically implemented water projects, and earlier state water plans relied heavily on the federal government for financial assistance. Federal agencies such as the U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service), the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers have constructed a number of surface water reservoirs in Texas. These reservoirs were built for the primary purpose of flood control, but also provide a large portion of the state's current water supply. The pace of federal spending on reservoir construction has declined considerably since the 1950s and 1960s, when most of the major federal reservoirs in the state were constructed. Federal policy has recognized a declining federal interest in the long-term management of water supplies and assigns the financial burden of water supply to local users (USACE, 1999).

### 9.5.1 FINANCIAL ASSISTANCE PROGRAMS

Traditional funding mechanisms will continue to assist with financing water projects, but they are not enough to meet the needs for water that Texans face during drought. Meeting these needs is particularly challenging for rural and disadvantaged communities where citizens cannot afford higher water rates to repay the cost of traditional project financing. Because of the difficulty in financing projects on their own, many water providers seek financial assistance from the state or federal government.

#### *TWDB Financial Assistance*

TWDB provides financial assistance to water providers for implementation of projects through several state and federally funded TWDB programs. These programs provide loans and some grants for projects that range from serving the immediate needs of a community to meeting regulatory requirements to providing long-term water supply. While not all programs target state water plan projects, water management strategies recommended in the regional water plans and state water plan have been funded from many of TWDB's major financial assistance programs. In accordance with state statute, TWDB may provide financial assistance for water supply projects only if the needs to be addressed by the project will be addressed in a manner that is consistent with the regional water plans and the state water plan.

TWDB's state programs are primarily funded by the sale of general obligation bonds that are secured by the "full faith and credit" of the state of Texas. Because of the state's good credit rating, TWDB is able to offer a lower interest rate than many providers can obtain through traditional financing. Under the supervision and approval of the Texas Legislature, TWDB issues bonds and uses the proceeds to make loans to political subdivisions of the state such as cities, counties, and river authorities, as well as non-profit water supply and wastewater service corporations. The recipients make payments of principal and interest to TWDB, which then uses the proceeds to pay debt service on the general obligation bonds. Some programs receive subsidization by the state through reduced interest rates or deferred repayments. Such programs require legislative authorization and appropriations to cover the debt service associated with the authorized subsidy. Through subsidization by the state, some programs are able to offer grants and low-cost loans to communities and provide a significant incentive to implement state water plan projects.

TWDB's authority to issue general obligation bonds to provide financial assistance programs was first approved by the Texas Legislature and the state's electorate in 1957. The 1957 constitutional amendment approved by voters created TWDB and authorized the agency to issue $200 million in general obligation bonds for the construction of dams, reservoirs, and other water storage projects. Further amendments to the Texas Constitution and additional statutory authority expanded the types of facilities eligible for TWDB financial assistance to include

- all components of water supply;
- wastewater collection, treatment, and disposal;
- flood control;
- municipal solid waste management; and
- agricultural water conservation projects.

TWDB's federal programs—the Clean Water and Drinking Water State Revolving Funds—are capitalized by federal grants, with state matching funds provided primarily by the sale of general obligation bonds along with a smaller amount of appropriations by the legislature. The Clean Water State Revolving Fund program is also leveraged with revenue bonds, a type of municipal bond that is secured by revenue from the recipient's loan repayments. These revenue bonds allow TWDB to increase the amount of funding offered through the Clean Water State Revolving Fund without the guarantee of the full faith and credit of the state.

With its original and expanded authority, TWDB has provided financing for over $12.6 billion of water and wastewater projects. TWDB has delivered an average of over $694 million per year in state assistance in the previous five years.

### *State-Funded Programs*

The **Texas Water Development Fund** is the oldest of TWDB's programs. It was originally created in 1957, with the passage of the agency's first constitutional amendment, for the purpose of helping communities develop water supplies and drinking water infrastructure. Over time, further constitutional amendments have provided additional authority to fund wastewater and flood control projects. TWDB issues general obligation bonds to support the program.

The **State Participation Program** was created in 1962 to encourage regional water supply, wastewater, and flood control projects. The program enables TWDB to assume a temporary ownership in a regional project when the local sponsors are unable to assume debt for the optimally sized facility, thus allowing for the "right sizing" of projects to accommodate future growth. To support the program, TWDB issues general obligation bonds. General revenue appropriations pay a portion of the related debt service until the local participants are able to begin purchasing the state's interest.

Created in 2001, the **Rural Water Assistance Fund** provides small, rural water utilities with low-cost financing for water and wastewater planning, design, and construction projects. The fund also can assist small, rural systems with participation in regional projects that benefit from economies of scale; the development of groundwater sources; desalination; and the acquisition of surface water and groundwater rights. The program is funded with general obligation bonds.

The **Agricultural Water Conservation Program** was created in 1989 to provide loans to political subdivisions either to fund conservation programs or projects. TWDB may also provide grants to state agencies and political subdivisions for agricultural water conservation programs, including demonstration projects, technology transfers, and educational programs. The program is funded by assets in the Agricultural Water Conservation Fund as well as general obligation bonds.

The **Economically Distressed Areas Program** provides grants and loans for water and wastewater services in economically distressed areas where services do not exist or existing systems do not meet state standards. Created in 1989, the program is focused on delivering water and wastewater services to meet immediate health and safety concerns, and to stop the proliferation of sub-standard water and wastewater services through the development and enforcement of minimum standards. The program is funded by general obligation bonds. Debt service on the general obligation bonds is paid first by the principal and interest payments received from loans, with general revenue appropriations from the legislature paying the remaining debt service.

The **Water Infrastructure Fund** was created in 2001 to provide financial incentives for the implementation of strategies recommended in the state water plan. The program was first funded in 2008 to offer loans at discounted interest rates for the planning, design, and construction of state water plan projects. Other incentives previously provided were deferral of payments for up to 10 years for projects with significant planning, design, and permitting requirements and zero percent interest loans for rural providers. Applications are prioritized based on the demonstration of significant future or prior water conservation savings and the date of need for the proposed project. The program is funded with general obligation bonds, with debt service paid primarily by principal and interest repayments from borrowers, as well as general revenue appropriations from the legislature.

### *Federally Funded TWDB Programs*

The **Clean Water State Revolving Fund** program was created by the federal Clean Water Act amendments of 1987 to promote water quality and to help communities meet the goals of the Clean Water Act. The fund provides low-cost loans and loan forgiveness for wastewater projects with special assistance for disadvantaged communities. Currently all 50 states and Puerto Rico operate Clean Water State Revolving Fund programs.

The program is funded by annual "capitalization" grants by the U.S. Congress, through the U.S. Environmental Protection Agency. TWDB provides a 20 percent match from state Development Fund general obligation bonds, which are repaid by interest received on Clean Water State Revolving Fund loans.

The Safe Drinking Water Act, as amended in 1996, established the **Drinking Water State Revolving Fund** to finance infrastructure improvements to the nation's drinking water systems. The fund provides low-cost loans and loan forgiveness for drinking water projects and special assistance for disadvantaged communities.

Like the Clean Water State Revolving Fund, the program is funded by annual capitalization grants by the U.S. Congress, through the U.S. Environmental Protection Agency. The program also has a 20 percent state match requirement, which TWDB provides primarily through Texas Water Development Fund general obligation bonds, with a portion provided by state appropriations to subsidize disadvantaged communities.

The **American Recovery and Reinvestment Act of 2009** provided additional funding for TWDB's Clean Water and Drinking Water State Revolving Fund programs. The state received an additional grant of $326 million from the U.S. Environmental Protection Agency to assist communities in improving their water and wastewater infrastructure through both grants and loans. The program required that at least 50 percent of the funding be for disadvantaged communities and at least 20 percent for "green" projects that demonstrated water or energy efficiency or environmental innovation. The program resulted in the funding of 20 Clean Water State Revolving Fund and 25 Drinking Water State Revolving Fund projects across the state. These projects are completing construction and the program has not been renewed by the U.S. Congress.

### *Other Federal Funding for Water Projects*

Other federal programs administer financial assistance for agricultural and rural and disadvantaged communities through grants and low-interest loans. The North American Development Bank Border Environment Infrastructure Fund administers grants provided by the U.S. Environmental Protection Agency to help finance the construction of water and wastewater projects within 100 kilometers (62 miles) of the U.S.-Mexico border. The U.S. Department of Agriculture Rural Development offers financial assistance to rural areas to support public facilities and services such as water and sewer systems, housing, health clinics, emergency service facilities, and electric and telephone service. While the U.S. Army Corps of Engineers does not provide funding for the construction of single-purpose water supply projects, they still play an important role in meeting the state's water supply needs by contracting with local and regional providers for municipal and industrial water use.

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# 10 Challenges and Uncertainty

**The five-year cycle of adopting regional and state water plans allows the state to respond to challenges and uncertainties in water supply planning. To reduce risks associated with planning for and providing sufficient water supplies, every five years TWDB and regional water planning groups evaluate changes in population, demand, and supply projections; new climate information; improvements in technologies; and policy and statutory changes.**

Regional water planning groups must develop plans to meet needs for water during a drought within the context of an uncertain future, both near and far. Water planning would be simpler if it were known when the next drought is going to happen and how severe it will be. But in reality, water planning has to be conducted in the context of uncertainty. The cyclical design of water planning in Texas, with regional water plans and the state water plan developed every five years, helps planning groups and the state monitor and respond to uncertainties. This chapter discusses some of the sources of uncertainty relevant to state and regional water planning, the challenges presented by uncertainty, and some strategies that planning groups use to deal with these challenges.

## 10.1 RISK AND UNCERTAINTY

The two related concepts of risk and uncertainty are fundamental to water planning. A risk is any negative outcome that might occur. In Texas, there is a risk that some demands for water may exceed availability under some conditions. The purpose of state and regional water planning is to minimize the negative effects of drought by planning to meet the needs for water during a repeat of the drought of record that occurred during the 1950s. Uncertainty is the unavoidable fact of not knowing what the future will bring, such as when the next drought may occur. The number of people that will live in Texas in the next 50 years, the amount of water that they will require, and the amount of water supplies that will be available are all future uncertainties. Good planning means being prepared for risks in spite of uncertainty.

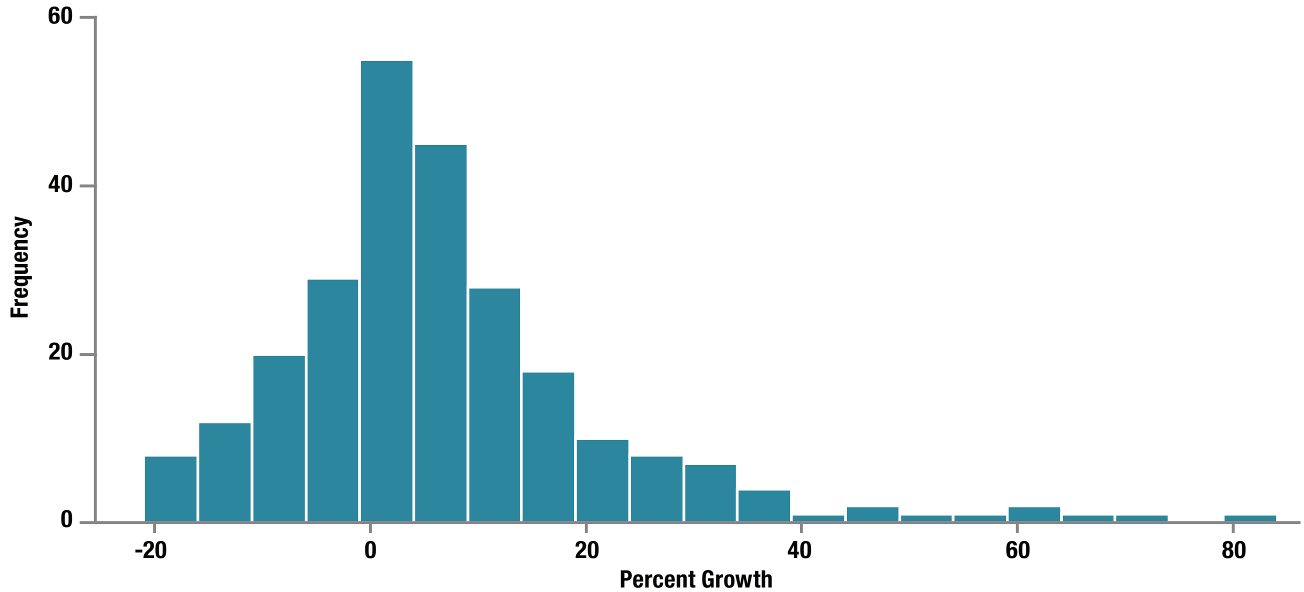
The National Research Council (a nonprofit institution that provides science, technology, and health policy advice to improve government decision making) recommends responding to risk with a cycle of analysis and deliberation, where analysis is the gathering and assessment of technical facts and deliberation is the dialogue that leads to a plan of action (NRC, 1996). The council advocates that stakeholder participation in the deliberation stage is critical because stakeholders have unique knowledge and perspectives, because they have a right to contribute to plans that will involve them, and because plan execution depends on everyone working together. A coordinated plan is more important than perfect foresight, so the most important planning strategy for reducing risk is stakeholder participation. The regional water planning process is fundamentally based on stakeholder participation by the inclusion of stakeholder interests groups as required by Texas statute.

The risk analysis stage is necessary because it is much more effective to plan for risks that are clearly understood. Measurements, readings, reports, and surveys are all used to get a clearer picture of present conditions so that more certain future projections can be made. TWDB considers state and national data sources, as well as local information from each region, in making these projections. Nevertheless, unforeseeable events occasionally happen, with distant future conditions more difficult to predict than immediate future conditions. One solution to future uncertainty is updating, which is why the state and regional water plans are developed every five years. The dynamic updating built into the water planning process by Texas statute is the regional and state water plan's strongest defense against uncertainty.

Even with the latest information and the best predictive models, some uncertainty will always remain, complicating the task of planning a focused, coordinated risk response. Rather than preparing for every possible outcome, it is more efficient to focus on a benchmark risk. In Texas water planning, the benchmark is the drought of record of the 1950s. The drought of record is better understood than other projected drought risks because it actually happened. If we prepare for the drought of record, then the state will be better positioned to respond to future droughts. Using the drought of record as a benchmark also coincides with the concept of firm yield—the maximum water volume a reservoir can provide each year under a repeat of the drought of record—which engineers use to calculate reservoir yield.

While all planning groups are required to plan based on firm yield, some regions are even more cautious when addressing climate variability and other uncertainties. Several planning regions planned for a drought worse than the drought of record by making changes to the assumptions in the availability of surface water during development of their regional water plans. Regions D and G modified the water availability models that they use in their planning process to include hydrology from later, more severe droughts that occurred within their particular regions. To address the possibility of a drought that is more severe than the drought of record, Regions A, B, F, and G assumed safe yield (the annual amount of water that can be withdrawn from a reservoir for a period of time longer than the drought of record) for some reservoirs in their regions. Since the planning process is repeated every five years, planning groups have the opportunity to update their planning assumptions each cycle as needed to address risk and uncertainty.

## FIGURE 10.1. VARIABILITY IN COUNTY POPULATION GROWTH, 2000–2010.




Beyond participation, updating, and benchmarking, the best response to uncertainty is simply to be aware of it. Population growth, water demands, and the weather are all naturally variable and can lead to uncertainty.

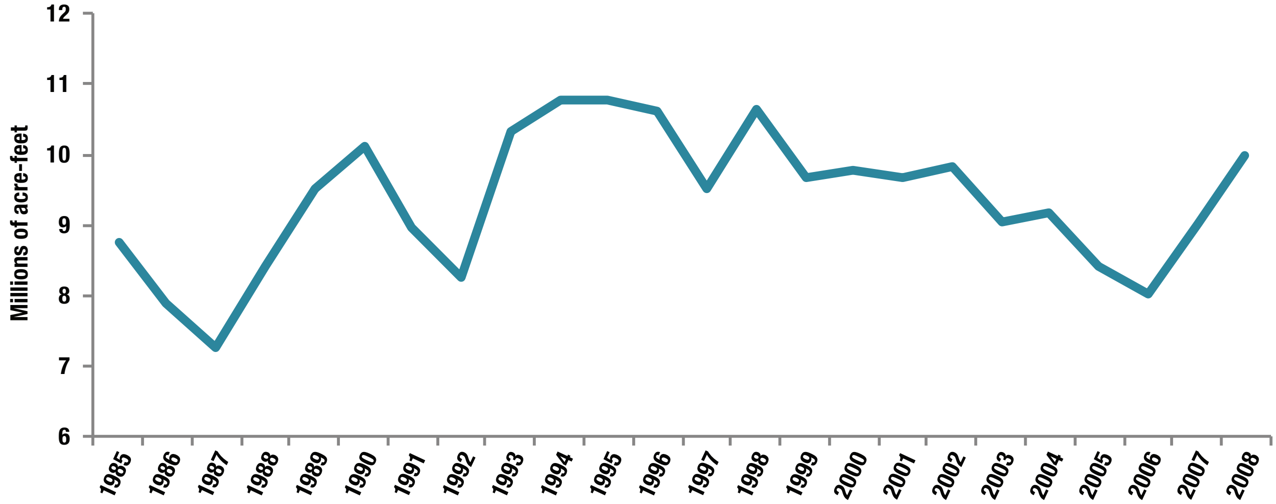
## 10.2 UNCERTAINTY OF DEMAND

Every category of water demand—municipal, manufacturing, irrigation, steam-electric, mining, and livestock—is naturally variable. Municipal demand depends on how many residents are using water and how much water they are using. Population growth depends on social and economic factors including individual preferences. Per capita, or per person, water use depends on preferences, habits, and water-using appliances, all of which are influenced by the economy and the weather. Irrigation and livestock demands are also strongly influenced by the economy and the weather. Manufacturing and mining demands are influenced by economic factors and government regulation but are less sensitive to the weather than other water uses. All of these underlying factors that influence water use are difficult to predict and result in uncertainty in water demand projections.

The population of Texas increased over 20 percent between 2000 and 2010; however, this growth was not distributed evenly throughout the state. The median Texas county grew by only 4.2 percent during the last decade. Some counties have less population now than they did in 2000, while others grew by as much as 82 percent. One way of representing this type of variability is in the form of a histogram, a bar chart representing a frequency distribution. Figure 10.1 is a histogram of the population growth for each county in Texas between 2000 and 2010, showing the number of counties whose growth was in each percentage range. The tallest bar in the middle of the histogram represents all of the counties whose growth was between zero and +5 percent (about 55 counties). Since the bars representing growth are taller and more numerous than the bars representing population decline, it is evident that most counties experienced positive population growth over the past decade.

Because population growth is so variable, projections have to be adjusted every decade when each new U.S. census is released. Between each census, TWDB relies on estimates from the Texas State Data Center.

## FIGURE 10.2. IRRIGATION WATER DEMAND, 1985–2008 (ACRE-FEET PER YEAR).



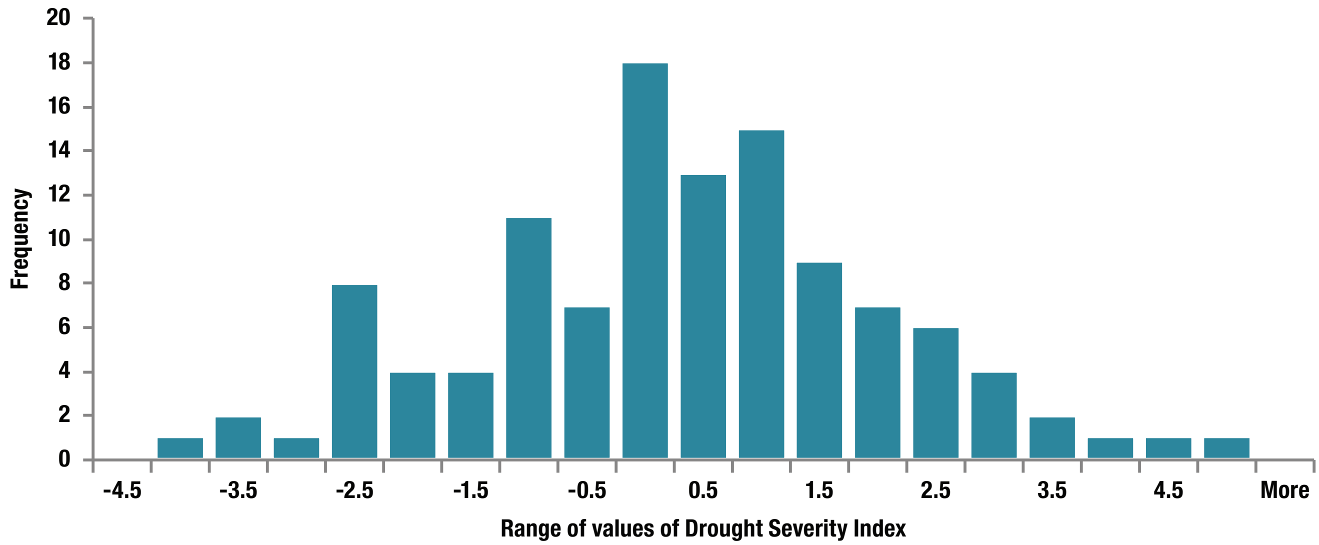

For example, population projections for some water user groups in the 2007 State Water Plan were revised upward for the next planning cycle, based on information from the State Data Center that indicated growth in excess of the original projections. The state population projected for 2010 in the 2007 State Water Plan turned out to be about 1 percent lower than the actual 2010 census. The revisions made for the 2012 State Water Plan resulted in projected Texas population about 1 percent above the census (Chapter 3, Population and Water Demand Projections). Since communities often want to plan for the highest potential growth scenario, such projections may prove to be slight overestimates. However, planning for a high-growth scenario is a way to manage risk.

Irrigation demand depends on how many acres of each crop are planted, the water needs of each crop type, and the weather. Neither an upward nor a downward overall trend is evident in irrigation demand over the years 1985 through 2008 (Figure 10.2).

Irrigation for agriculture has historically been the category of greatest water use in Texas. Variability in irrigation demand therefore translates to variability in total state water demand. Irrigation demand depends on farmers' decisions on how much acreage and what crops to plant. These decisions depend on prices of both agricultural commodities and inputs like fuel and fertilizer. Government policies can also be influential. For example, the combination of an ethanol subsidy and an ethanol import tariff has encouraged corn production.

Rather than attempt to guess at future policies and commodity prices, TWDB projects irrigation water use based on current levels. Important future developments then can be reflected through adjustments in the assumptions in future planning cycles. For example, recent crop prices have been relatively high by historical standards. If these prices decrease, projected irrigation water demand may require a downward adjustment, while the lower cost of feed might require projected demand for water for livestock to be adjusted upward. More recently, studies have explored the potential for expanded production of biofuels using "energy cane" and algae as feedstocks, which could also result in increased water demand.

## FIGURE 10.3. VARIABILITY IN STATEWIDE PALMER DROUGHT SEVERITY INDEX, 1895–2010.



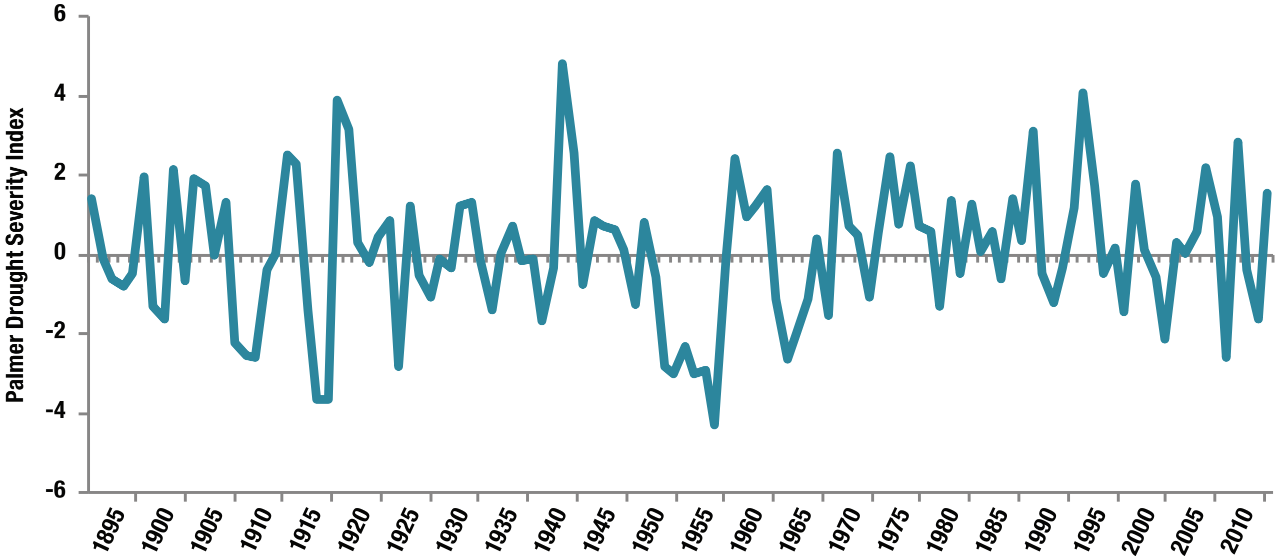

Manufacturing, mining, and power production also depend on price levels of their inputs and outputs, or the resources needed for production and the products or results of that production. Because practically all industrial processes are energy intensive, the prices of energy sources such as gasoline, natural gas, and coal are of particular importance. The hydrocarbon mining industry produces energy and uses it at the same time. Higher energy prices could shift water use away from manufacturing and toward mining and power production. The new technology of hydraulic fracturing is a method of producing hydrocarbon energy that experienced a boom during this planning cycle; thus, new developments in the hydraulic fracturing industry that could result in increased water use in the mining water use category will be monitored closely in the next regional water planning cycle.

## 10.3 UNCERTAINTY OF SUPPLY AND NEED

The regional water plans recommend water management strategies to increase future water supplies to meet needs during a severe drought. The actual water volume that will result from any recommended strategy is always uncertain, but it is also uncertain whether or not each strategy will be implemented, and when implementation will occur. Each water supply strategy requires some amount of funding and often political consensus to accomplish, both of which are ultimately uncertain. Projected yield of a strategy might not be realized. To avoid this possibility, regional planning groups may prioritize their recommended strategies, generally planning to execute cheaper, simpler, or more important strategies first.

Hydrology, the study of water movements in the natural environment, is also a source of uncertainty because it is so complex. Hydrologic drought is a condition of below average water content in aquifers and reservoirs, which results in reduced water supplies. It usually follows agricultural drought—an adverse impact on crop or range production—where soil and surface moisture are reduced, stressing natural ecosystems and crops. Agricultural drought increases irrigation water demands. Both hydrologic and agricultural droughts are consequences of meteorological drought, which is the occurrence of

## FIGURE 10.4. STATEWIDE AVERAGE PALMER DROUGHT SEVERITY INDEX, 1895–2010.




abnormally dry weather, usually less precipitation than is seasonally normal for the region.

Levels of precipitation and evaporation are naturally variable, along with the amount of water that flows to a reservoir or recharges an aquifer. Exchanges between groundwater and surface water are not only variable but incompletely understood. Hydrologic modeling has advanced rapidly in recent years, but no model of a system so complex can completely address all uncertainty.

Hydrological drought can be measured by the Palmer Drought Index, which rates dry conditions on a scale relative to the normal conditions for each location. A Palmer Index of "zero" indicates a normal year; negative numbers indicate drought, whereas positive numbers indicate above-normal moisture. The National Oceanographic and Atmospheric Administration computes and records the Palmer Index monthly for each of the 10 climatic divisions in Texas. The Palmer Index is constructed so that the mean will be zero as long as the climate maintains its historical pattern. Figure 10.3 shows a histogram of the same series of averaged Palmer Indexes, illustrating its variability.

Figure 10.4 illustrates the 1950s as a cluster of negative values that correspond to the drought of record. Even though Palmer Index values in this period are noticeably low, no single value constitutes an outlier, or a value far apart from the rest of the data set. The most unusual feature of the drought of record is that so many dry years occurred consecutively. Annual Palmer Index values as low as they were during the drought of record occur about 10 percent of the time, but they occurred 6 years in a row during the 1950s with water supplies unable to recover from the preceding drought before the next drought started.

Agricultural drought can appear suddenly, causing almost instantaneous damage to agriculture and encouraging wildfires. Most recently, Texas experienced severe agricultural droughts in 1996, 1998, 2009, and 2011. Prolonged agricultural drought is often an indicator of impending hydrologic drought. Since 1997, public water suppliers and irrigation districts in Texas have been required to develop drought contingency plans to respond to the early warnings of hydrologic drought. Contingency plans help to manage risk by promoting preparation and coordination before a drought emergency appears.

## 10.4 UNCERTAIN POTENTIAL FUTURE CHALLENGES

Although the processes discussed so far all exhibit natural variability, historical distributions indicate what values they will probably take most of the time. Some risks, called ambiguous risks, are so uncertain that it is not known when they will happen, what their impacts will be, or even whether they will occur at all. The potential consequences of natural disasters, terrorism, and climate change are examples of ambiguous risks. Developments in new technology, as well as future state and federal policy decisions, can also be ambiguous, with unforeseeable implications. Awareness may be the only defense against this kind of uncertainty. This section discusses some of the challenges to water planning that may arise in the future from ambiguous risks.

### 10.4.1 NATURAL DISASTERS

Natural disasters include floods, hurricanes, tornados, and fires. The worst natural disaster in the history of the United States occurred in Galveston in 1900, when a hurricane killed more than 6,000 people. Hurricanes and floods generally increase water availability, so they do not usually pose a serious challenge for drought planning; however, they can degrade water infrastructure and water quality and can result in the redistribution of populations. An example is Hurricane Katrina, which forced many people to evacuate to Texas from Louisiana and Mississippi, adding to population variability. Hurricane Ike caused tremendous devastation to the Bolivar Peninsula, damaging a new water treatment plant's distribution system in addition to much of the residential housing, leaving a considerably smaller population to pay for the investment already incurred. Wildfires generally occur during drought conditions, so they may inflict additional damages on communities already suffering from drought. Fires also cause erosion that may affect streamflow positively or negatively.

Although less frequent than either flood or fire, earthquakes also occur occasionally in Texas. magnitude 5.7 earthquake hit Marathon in 1995. Earthquakes are a serious risk to dams and infrastructure in some states, but it is unlikely that Texas will experience an earthquake significant enough to damage water infrastructure. A terrorist attack, much like a natural disaster, could damage infrastructure, degrade water quality, or result in only minimal impacts.

### 10.4.2 CLIMATE VARIABILITY

Chapter 4 (Climate of Texas) presents information on climate variability, including that during the last 10 to 15 years, temperatures have become as warm as during earlier parts of the 20th century. Climate change or climatic variability both pose challenges to water planning because they add uncertainty. Scientists on the Intergovernmental Panel on Climate Change believe this warming trend is "unequivocal" (IPCC, 2007). While TWDB is not endorsing this panel's conclusions, additional challenges, primarily to agriculture, could arise if the climate of Texas becomes permanently warmer.

If precipitation decreases or evaporation increases as a result of climate change, farmers and ranchers will be forced to pump more groundwater, change their crop mix, or plant less. In one possible scenario, Texas could experience a 20 percent decline in cropped acreage. At the same time, cotton and grain sorghum could replace broilers, cattle, corn, rice, and wheat (McCarl, 2011). In areas of declining water availability, a change toward more cotton is plausible because cotton may be grown with deficit irrigation. On the other hand, research in the Northern High Plains has focused on producing corn with only 12 inches of supplemental irrigation, so the projected changes in production due to climate change may be overstated. Improvements in water use efficiency and adoption of new technologies or crop varieties may allow farmers the ability to grow more crops with less irrigation water applied. While technological advancements may further extend the useful life of the Ogallala Aquifer in the Panhandle and moderate changes to the climate may benefit rain-fed agriculture, future climate change impacts could increase the vulnerability of unsustainable practices in agricultural systems in the High Plains (IPCC, 2007).

Even though surface water would be the most vulnerable to projected climatic changes through increased evaporation and decreased streamflows, some groundwater sources would also be vulnerable. Aquifers with relatively fast recharge, such as those in the Edwards Aquifer in central Texas, are fed directly from the surface. For these types of aquifers, low runoff translates to low water recharge. More intense rainfall or flooding could impact recharge as well, by altering soil permeability or simply by forcing water courses away from recharge zones. Climate change resulting in higher temperatures in the Edwards Aquifer region could be especially damaging for agriculture, since increased irrigation pumping may not be legal or feasible.

TWDB has taken a number of steps to address uncertainty related to climate variability in the regional planning process. The agency monitors climate science for applicability to the planning process, consults with subject experts, and solicits research. TWDB also co-hosted the Far West Texas Climate Change Conference in 2008 (Chapter 4, Climate of Texas). TWDB will continue to monitor drought conditions to determine if a new drought of record occurs, which would change water planning assumptions.

## 10.5 WATER AND SOCIETY

The greatest uncertainty pertaining to water planning is the future of human society. Economic cycles can affect the use of water inputs in productive processes like agriculture and industry. In the long run, these processes adapt to water availability and the needs of society. For example, most industrial users have dramatically increased their reuse of water in recent years. These users respond to the price and reliability of water as a signal of increased water scarcity, motivating them to develop new technology, which can improve the efficiency of water use, locate new supplies, and provide new supplies more efficiently. Desalination and reuse are two examples.

Society's values change as well. Over the past 40 years, public interest in protecting natural resources has increased dramatically. Water-based recreation is also much more popular now than it was 40 years ago. These new values have translated into new behaviors, new industries, and even new laws. Predicting which new values will emerge in the future is probably futile; the only solution to changing values is to recognize them early and to adapt plans accordingly.

Whether new challenges come from the values of society, the weather, or the economy, the regional water planning groups are prepared to deal with challenges and uncertainty through the five-year regional water planning cycle. Most importantly, they meet regularly to coordinate their activities and to assimilate new information. They employ conservative measures like firm yield and safe yield and include model drought contingency plans. Although the challenge of uncertainty can never completely be overcome, it can be managed through vigilance and adaptive planning.

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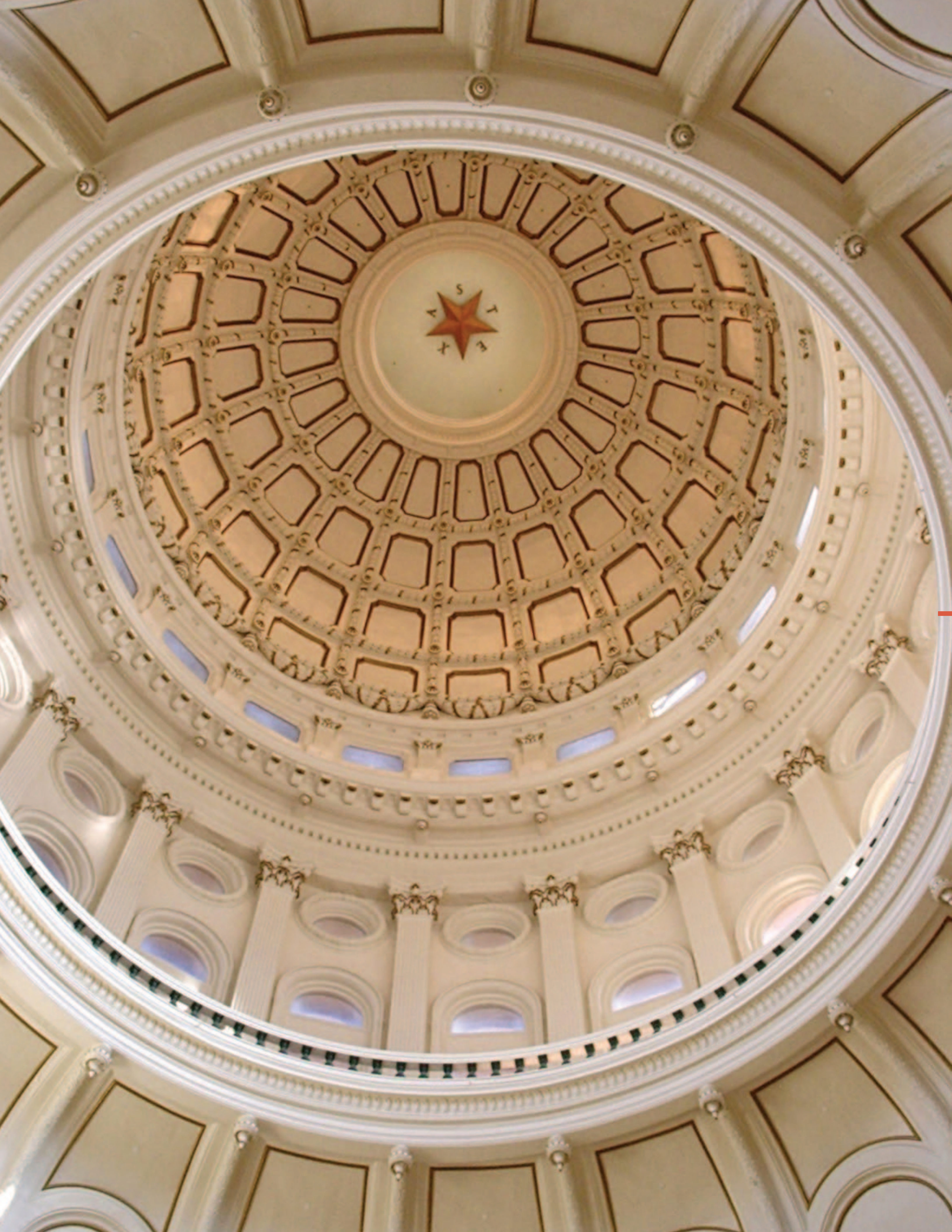
### UNCERTAINTY IN THE WEATHER

It is often said that Texas' weather can best be described as drought punctuated by floods. Our climate is certainly marked by extremes in temperature, precipitation, and catastrophic weather events such as droughts, floods, and hurricanes. While our daily weather is compared to precipitation and temperature "averages," these averages can obscure the sometimes impressive day-to-day, season-to-season, and year-to-year extremes that are imbedded within them (TWDB, 1967).

The variability in Texas' weather is largely due to the state's location and topography. When moisture-laden air from the Gulf of Mexico collides with cooler, drier air masses moving southeast from the interior of the continent, storms and flooding can result. The Texas Hill Country is particularly susceptible to heavy thunderstorms when moist air rises over the Balcones Escarpment of the Edwards Plateau. Central Texas holds some of the highest rainfall rates in the state and the nation. In 1921, when the remnants of a hurricane moved over Williamson County, the town of Thrall received almost 40 inches of rain in 36 hours. The storm resulted in the most deadly flooding in Texas history (Jones, 1990).

This "flashiness" of the state's precipitation is an important consideration in water supply planning, particularly when addressing uncertainty. Constant variability means that much of the time river and streamflows are an undependable source of water supply in Texas (Ward, 2011). This problem is dealt with through the construction of reservoirs, which impound rivers and capture some high flows for use during dry periods (Ward, 2011). So not only are reservoirs needed for the control of flooding, but they also help replenish surface water resources when the state receives intense rains and resulting floods.


T E X A S

# 11 Policy Recommendations

TWDB's statutory requirement to develop a state water plan every five years includes provisions that the plan should be a guide to state water policy that includes legislative recommendations that TWDB believes are needed and desirable to facilitate more voluntary water transfers. TWDB based the following recommendations, in part, on recommendations from the regional water planning process.

During the development of their regional water plans, planning groups made regulatory, administrative, and legislative recommendations (Appendix D) that they believe are needed and desirable to

- facilitate the orderly development, management, and conservation of water resources;
- facilitate preparation for and response to drought conditions so 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 regional water planning areas.

Along with general policy and statutory recommendations, planning groups also made recommendations for designating unique reservoir sites and stream segments of unique ecological value; however, the Texas Legislature is responsible for making the official designations of these sites.

Planning groups may recommend the designation of sites of unique value for construction of reservoirs within their planning areas. The recommendations include descriptions of the sites, reasons for the unique designation, and expected beneficiaries of the water supply to be developed at the site. A planning group may recommend a site as unique for reservoir construction based upon several criteria:

- 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; or
- location; hydrology; geology; topography; 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) to meet needs beyond the 50-year planning period.

Planning groups may also recommend the designation of all or parts of river and stream segments of unique ecological value located within their planning areas. A planning group may recommend a river or stream segment as being of unique ecological value based upon several criteria:

- biological function
- hydrologic function
- riparian conservation areas
- high water quality
- exceptional aquatic life
- high aesthetic value
- threatened or endangered species/unique communities

The recommendations include physical descriptions of the stream segments, maps, and other supporting documentation. The planning groups coordinate each recommendation with the Texas Parks and Wildlife Department and include, when available, the Texas Parks and Wildlife Department's evaluation of the river or stream segment in their final plans.

Based on planning groups' recommendations and other policy considerations, TWDB makes the following recommendations that are needed to facilitate the implementation of the 2012 State Water Plan:

## ISSUE 1: RESERVOIR SITE AND STREAM SEGMENT DESIGNATION

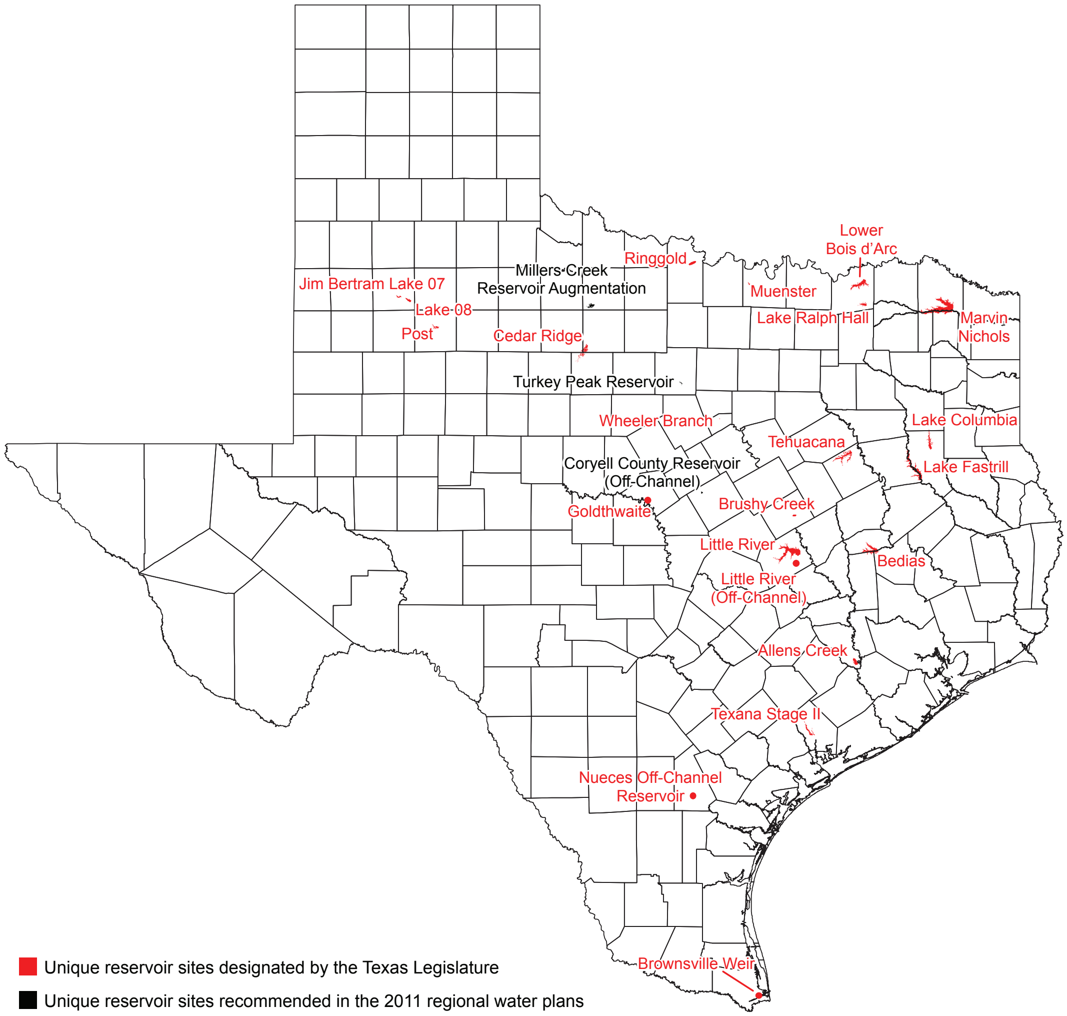
*The legislature should designate the three additional sites of unique value for the construction of reservoirs recommended in the 2011 regional water plans (Turkey Peak Reservoir, Millers Creek Reservoir Augmentation, and Coryell County Reservoir) for protection under Texas Water Code, Section 16.051(g) (Figure 11.1).*

*The legislature should designate the nine river stream segments of unique ecological value recommended in the 2011 regional water plans (Pecan Bayou, Black Cypress Creek, Black Cypress Bayou, Alamito Creek, Nueces River, Frio River, Sabinal River, Comal River, and San Marcos River) for protection under Texas Water Code, Section 16.051(f) (Figure 11.2).*

### SUMMARY OF THE RECOMMENDATION

Recent regional water plans reflect the recognition that major reservoir projects absolutely must remain a strong and viable tool in our water supply development toolbox if the state is to meet its future water supply needs. The 2011 regional water plans include recommendations to develop 26 major reservoirs, which by 2060 would provide nearly 1.5 million acre-feet of water annually (16.7 percent of the total water management strategy volume).

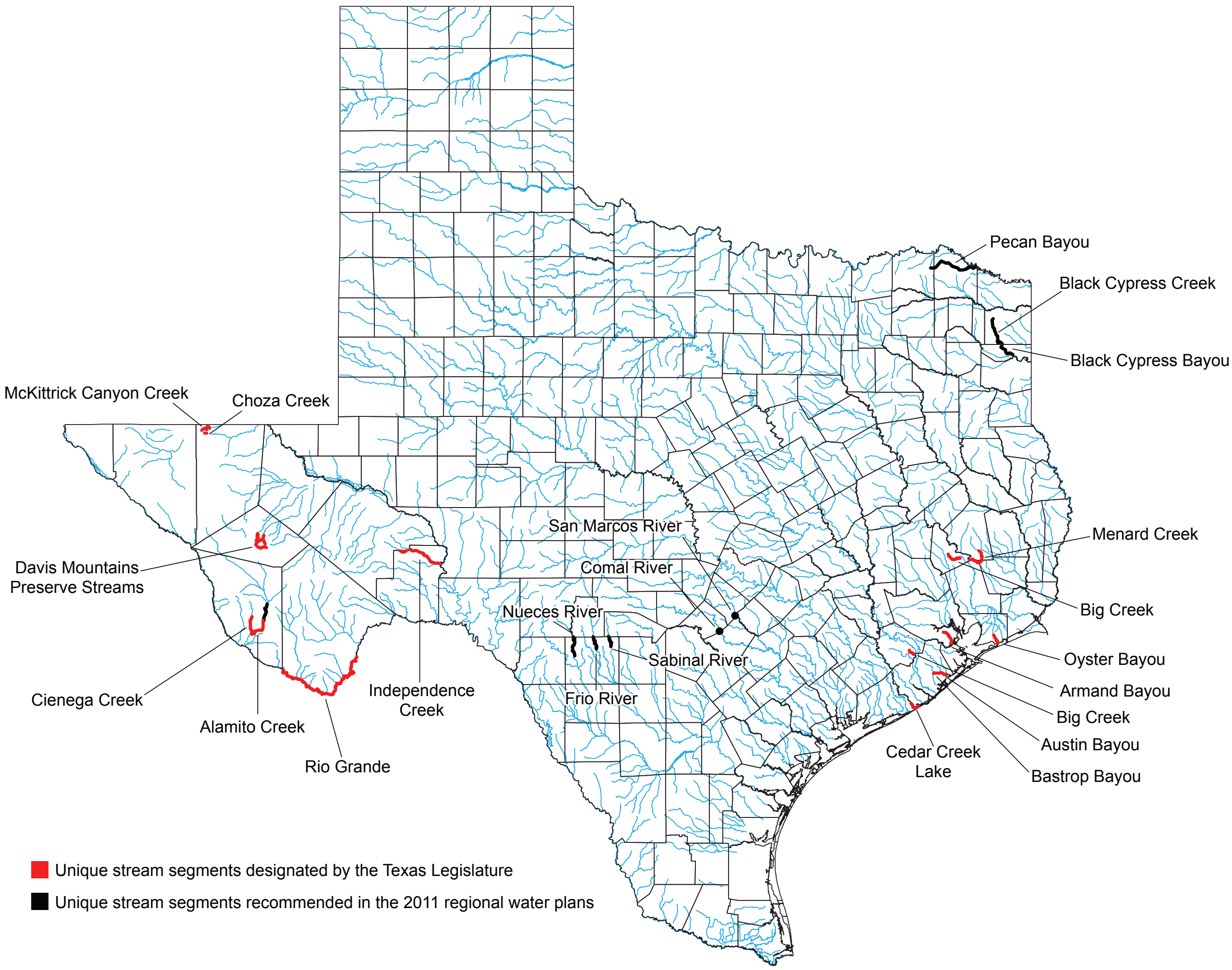
## FIGURE 11.1. DESIGNATED AND RECOMMENDED UNIQUE RESERVOIR SITES.




In response to the drought of record of the 1950s, Texas embarked on a significant program of reservoir construction. In 1950, Texas had about 53 major water supply reservoirs, with conservation storage amounting to less than one-half acre-foot per resident of the state. By 1980, the state had 179 major reservoirs, and conservation storage per capita (Chapter 1, Introduction) had increased to nearly 2.5 acre-feet. However, reservoir construction and storage capacity have slowed considerably. Texas currently has 188 major water supply reservoirs, storing just over 1.5 acre-feet per capita. If nothing is done to implement the strategies in the regional water plans, population growth will result in per capita storage declining to less than 1 acre-foot per resident, the lowest since immediately following the drought of record.

A number of factors have contributed to the slowdown in reservoir development. The earlier period of construction captured many of the most logical and prolific sites for reservoirs. However, increased costs and more stringent requirements for obtaining state and federal permits for reservoir construction have

## FIGURE 11.2. DESIGNATED AND RECOMMENDED UNIQUE STREAM SEGMENTS.




also been major factors. A significant factor in whether or not the major reservoirs recommended in the 2011 regional water plans can actually be developed involves the reservoir site itself and the manner in which the state addresses issues associated with preserving the viability of the reservoir site for future reservoir construction purposes.

Actions by federal, state, or local governments to protect natural ecosystems located within the reservoir footprint can significantly impact the viability of a site for future construction of a proposed reservoir. Development of Waters Bluff Reservoir on the main stem of the Sabine River was prevented in 1986 by the establishment of a private conservation easement. In addition, the proposed Lake Fastrill, which was included in the 2007 State Water Plan as a recommended water management strategy to meet the future water supply needs of the City of Dallas, was effectively precluded from development by the U.S. Fish and Wildlife Service's designation of the Neches River National Wildlife Refuge on the basis of a 1-acre conservation easement. Lack of action by the state legislature in protecting reservoir sites has been cited as a problem in precluding federal actions that could otherwise be considered to be in contravention of the state's primacy over water of the state.

Texas Water Code, Sections 16.051(e) and 16.053(e)(6), provide that state and regional water plans shall identify any sites of unique value for the construction of reservoirs that the planning groups or TWDB recommend for protection. Texas Water Code, Section 16.051(g) provides for legislative designation of sites of unique value for the construction of a reservoir. By statute, this designation means that a state agency or political subdivision of the state may not obtain a fee title or an easement that would significantly prevent the construction of a reservoir on a designated site.

Designation by the Texas Legislature provides a limited but important measure of protection of proposed reservoir sites for future development and provides a demonstration of the legislature's support for protection of potential sites.

The 80th Texas Legislature in 2007 designated all reservoir sites recommended in the 2007 State Water Plan as sites of unique value for the construction of a reservoir (Senate Bill 3, Section 4.01, codified at Texas Water Code Section 16.051 [g-1]). Senate Bill 3 (Section 3.02, codified at Texas Water Code Section 16.143) also added provisions providing certain protections to owners of land within a designated reservoir site. A former owner of land used for agricultural purposes within a designated reservoir site whose property is acquired either voluntarily or through condemnation is entitled to lease back the property and continue to use it for agricultural purposes until such time that the use must be terminated to allow for physical construction of the reservoir. In addition, a sunset provision was included that terminates the unique reservoir site designation on September 1, 2015, unless there is an affirmative vote by a project sponsor to make expenditures necessary to construct or file applications for permits required in connection with construction of the reservoir under federal or state law.

Texas Water Code, Sections 16.051(e) and 16.053(e)(6), also provide that state and regional water plans shall identify river and stream segments of unique ecological value that the planning groups or TWDB recommend for protection. Texas Water Code Section 16.051(f) also provides for legislative designation of river or stream segments of unique ecological value. By statute, this designation means that a state agency or political subdivision of the state may not finance the actual construction of a reservoir in a specific river or stream segment that the legislature has designated as having unique ecological value. Senate Bill 3, passed by the 80th Texas Legislature, also provided that all river or stream segment sites recommended in the 2007 State Water Plan were designated as being of unique ecological value.

### ISSUE 2: RESERVOIR SITE ACQUISITION

*The legislature should provide a mechanism to acquire feasible reservoir sites so they are available for development of additional surface water supplies to meet the future water supply needs of Texas identified in the 2011 regional water plans and also water supply needs that will occur beyond the 50-year regional and state water planning horizon.*

#### SUMMARY OF THE RECOMMENDATION

If the major reservoir sites recommended for construction in the 2011 regional water plans are not developed, the state will be short 1.5 million acre-feet of water in 2060, about 16.7 percent of the total water supply needed. Without additional water supplies, the state is facing a total water deficit of 8.3 million acre-feet in 2060. Failure to meet the state's water supply needs in drought conditions could cost Texas businesses and workers up to $115.7 billion in 2060.

The cost of acquiring the remaining sites recommended as water management strategies is estimated to be $558.2 million, based on 2011 regional water planning data. The advantages of acquiring these reservoir sites include the following:

- Provides for more efficient and economical long-term infrastructure planning
- Provides certainty to project sponsors that recommended reservoirs could be constructed on designated sites for future water supplies
- Provides some protection from actions by federal agencies that could prohibit the development of reservoirs
- Ensures these sites would be available to meet future water supply needs
- Demonstrates the state's commitment to provide sufficient water supply for Texas citizens to ensure public health, safety, and welfare and to further economic development
- Allows the state to lease sites, prior to reservoir construction, to existing landowners or others for land use activities, such as crops and livestock, wildlife, or recreation, thereby also generating income for the state through lease revenue

Although prior legislative designation helps with preserving reservoir sites, purchasing future sites would provide significant additional protection, including much better protection from unilateral actions by federal agencies that could preempt major water supply projects. If the state owned the sites, it would be highly unlikely that a federal agency could take an action related to those sites, such as the U.S. Fish and Wildlife Service action establishing the Neches Wildlife Refuge at the location of the proposed Fastrill Reservoir.

## ISSUE 3: INTERBASIN TRANSFERS OF SURFACE WATER

*The legislature should enact statutory provisions that eliminate unreasonable restrictions on the voluntary transfer of surface water from one basin to another.*

### SUMMARY OF THE RECOMMENDATION

Interbasin transfers of surface water have been an important, efficient, and effective means of meeting the diverse water supply needs of an ever-increasing population in Texas. Interbasin transfers that have already been permitted are or will be used to meet a wide variety of water demands, including municipal, manufacturing, steam-electric power generation, and irrigated agriculture demands.

Prior to the passage of Senate Bill 1, 75th Legislative Session (1997), Texas Water Code, Section 11.085, was entitled Interwatershed Transfers and contained the following provisions:

- Prohibited transfers of water from one watershed to another to the prejudice of any person or property within the watershed from which the water is taken.
- Required a permit from the Texas Commission on Environmental Quality to move water from one watershed to another.
- Required the Texas Commission on Environmental Quality to hold hearings to determine any rights that might be affected by a proposed interwatershed transfer.
- Prescribed civil penalties for violations of these statutory requirements.

In Senate Bill 1, 75th Texas Legislative Session, Texas Water Code, Section 11.085, was amended to replace the above provisions with significantly expanded administrative and technical requirements for obtaining an interbasin transfer authorization. Since the amendments to the Texas Water Code requirements for interbasin transfers in 1997, there has been a significant drop in the amount of interbasin transfer authorizations issued and a significant amount of public discussion about whether the 1997 amendments to Texas Water Code, Section 11.085, have had a negative effect on issuing interbasin transfer authorizations.

Any impediments to obtaining interbasin transfer permits will severely impact the implementation of the projects included in the 2011 regional water plans. There are 15 recommended water management strategies which would rely on an interbasin transfer and will still require a permit to be granted.

## ISSUE 4: THE PETITION PROCESS ON THE REASONABLENESS OF DESIRED FUTURE CONDITIONS

*The legislature should remove TWDB from the petition process concerning the reasonableness of a desired future condition except for technical review and comment.*

### SUMMARY OF THE RECOMMENDATION

Prior to the passage of House Bill 1763 in 2005, regional water planning groups decided how much groundwater was available for use in the water planning process after considering groundwater conservation districts' management plans and rules. Groundwater conservation districts also decided how much groundwater was available for use for purposes of their management plans and permitting rules but with the requirement that their number not be inconsistent with the implementation of the state water plan. The passage of House Bill 1763 granted groundwater conservation districts the sole role of deciding how much groundwater was available for use for both regional water planning and groundwater conservation districts' purposes. Regional water planning groups are now required to use numbers called modeled available groundwater, known as managed available groundwater before statutory changes effective September 1, 2011 (Chapter 5, Supplies). These availability numbers are determined by TWDB on the basis of the specific desired future conditions adopted by the groundwater districts.

Current statute allows a petition to be filed with TWDB challenging the reasonableness of a desired future condition. A person with a legally defined interest in a groundwater management area, a groundwater conservation district in or adjacent to a groundwater management area, or regional water planning group with territory in a groundwater management area can file the petition.

If TWDB finds that a desired future condition is not reasonable, it recommends changes to the desired future condition. The groundwater conservation districts then must prepare a revised plan in accordance with the recommendations and hold another public hearing, but at the conclusion of the hearing the districts may adopt whatever desired future condition they deem appropriate. The final decision by the districts is not reviewable by TWDB, and at the conclusion of the process districts are free to retain the same desired future condition that existed before a petition was filed.

TWDB's Legislative Priorities Report for the 82nd Texas Legislative Session (TWDB, 2011) recommended that the legislature repeal the petition process concerning the reasonableness of desired future conditions or modify the process to provide a judicial remedy exclusive of TWDB, except for the agency's technical review and comment. This recommendation was made because the process, as is, allows districts to make the final decision on their desired future condition regardless of TWDB's determination of reasonableness. TWDB recommended a judicial remedy exclusive of TWDB because the agency is not regulatory and is therefore ill-suited for a regulatory process.

The Sunset Advisory Commission (2010) recommended that the petition process with TWDB be repealed and that district adoption of a desired future condition be appealed to district court in the same manner as any challenge to a district rule under substantial evidence review. Although the petition process was discussed and debated during the 82nd Texas Legislative Session, the legislature ultimately did not pass legislation to change the process. Because the same concerns remain on the petition process, TWDB continues to recommend that the legislature should remove TWDB from the petition process except for technical review and comment.

## ISSUE 5: WATER LOSS

*The legislature should require all retail public utilities to conduct water loss audits on an annual basis, rather than every five years.*

### SUMMARY OF THE RECOMMENDATION

System water loss refers to the difference between how much water is put into a water distribution system and how much water is verified to be used for consumption. Water loss includes theft, under-registering meters, billing adjustments and waivers, main breaks and leaks, storage tank overflows, and customer service line breaks and leaks. High values of water loss impact utility revenues and unnecessarily increase the use of water resources, especially during drought. During reviews of loan applications, TWDB has seen water losses as high as 50 percent for some water systems. Smaller municipal water systems tend to have higher percentage water losses than larger systems. Based on information collected in 2005, statewide water losses were estimated at 250,000 to 460,000 acre-feet per year (Alan Plummer Associates, Inc. and Water Prospecting and Resource Consulting, LLC, 2007).

The first step toward addressing high water losses is measuring where the water is going in a system with a water loss audit. An audit shows a utility how much of its water is lost and where they may need to focus efforts to reduce those losses. Water loss audits done over time help a utility identify progress with minimizing water losses as well as identifying any new water loss issues.

Currently, the Texas Water Code requires all retail public utilities (about 3,600 in all) to submit a water loss audit to TWDB every five years. During the 82nd Legislative Session, based, in part, on TWDB's Legislative Priorities report for the 81st Legislative Session, the legislature required annual reporting for retail public utilities that receive financial assistance from TWDB (about 200). While this is a step in the right direction, TWDB believes that all retail public utilities would benefit from annual water loss surveys. Municipal water conservation is expected to account for about 7 percent of new water supplies (about 650,000 acre-feet per year) by 2060 in the state water plan. Measuring—and ultimately addressing—water loss will help achieve those conservation goals.

## DROUGHT AND PUBLIC POLICY

Droughts and other natural disasters have often served as the impetus behind significant changes in public policy. A severe drought in the mid-1880s resulted in the state's first disaster relief bill and set off a public policy debate on how the federal government should respond to disasters.

Many of the settlers that arrived in Texas in the mid-1800s had little knowledge of the variability of the state's climate. As a result, they were often ill-prepared to respond to droughts. While struggling to survive the effects of a drought that began in 1885, local leaders in Albany, Texas, selected John Brown, a local minister, to solicit donations of wheat for farmers in nearby counties. Believing it was just as appropriate to ask for drought relief as it was to seek aid following hurricanes, Brown appealed to financial institutions and churches throughout the eastern United States. He persisted despite attacks from Texas newspaper editors and land promoters, who feared that the negative publicity would harm the state's economic development (Caldwell, 2002).

In response to Brown's efforts and those of Clara Barton, founder and first president of the American Red Cross, Congress passed the Texas Seed Bill of 1887. The bill appropriated $10,000 for the purchase of seed grain for distribution to farmers in Texas counties that had suffered from the drought. The legislation was quickly vetoed by President Grover Cleveland, citing his belief that the government should not provide assistance, "to individual suffering which is in no manner properly related to the public service or benefit" (Bill of Rights Institute, 2011). It is still widely known as the most famous of President Cleveland's many vetoes.

Despite the defeat of federal aid, the Texas Legislature appropriated $100,000 for drought relief, providing a little over $3 to each needy person. The Red Cross and other donors also sent clothing, household goods, tools, and seed to drought-stricken areas. This type of response to disasters—government aid, combined with private charitable donations—is a template that is still in use today (Caldwell, 2002).

## ISSUE 6: FINANCING THE STATE WATER PLAN

*The legislature should develop a long-term, affordable, and sustainable method to provide financing assistance for the implementation of the state water plan.*

### SUMMARY OF THE RECOMMENDATION

Following publication of the 2007 State Water Plan, TWDB conducted an Infrastructure Finance Survey to evaluate the amount of funding needed from state financial assistance programs to support local and regional water providers in implementing water management strategies recommended in the 2007 State Water Plan. The survey reported an anticipated need of $17.1 billion in funds from TWDB financial assistance programs. Steps toward meeting these needs were made in the form of subsidized funding for state water plan projects provided during each of the previous two biennia to provide incentives for state water plan projects to be implemented. The 80th Legislature appropriated funds to subsidize the debt service for $762.8 million in bonds, and the 81st Legislature appropriated funds to subsidize the debt service for $707.8 million in bonds. The 82nd Legislature approved the issuance of up to $200 million in Water Infrastructure Funds bonds for state water plan projects; however, the funds appropriated to subsidize the debt service will provide for approximately $100 million to be issued.

To date, incentives for state water plan projects have included reduced interest rates and deferral of payments and some grants, depending on the program. While these incentives have proven successful, they are a steady draw on general revenues of the state as long as there is debt outstanding.

During the 82nd Legislative session a new model of funding state water plan projects was discussed. This model would involve a deposit of funding, either from general revenue, a fee, or another appropriate source designated by the legislature. This funding, one-time or ongoing over a period of time, could be utilized to make loans to entities for state water plan projects. As the loan payments are received by TWDB, these funds would be available to be lent out again. In this way, the original funding would provide "capital" for the fund. Once established, this model could be expanded to include bond funding and reduced interest rates without being a draw on general revenue.

The latest estimate of funding needed to implement the 2012 State Water Plan is $53 billion, with financial assistance needed from the state estimated to be $26.9 billion, based on the planning groups' financing survey. With a need of this size identified, it is imperative that the state determine a sustainable, long-term methodology to provide funding necessary to implement state water plan projects.

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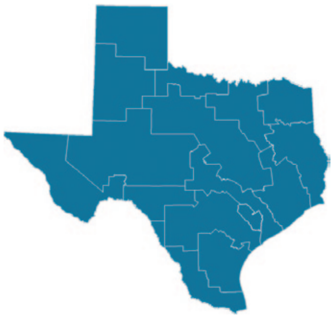


# Glossary

## ACRE-FOOT
Volume of water needed to cover 1 acre to a depth of 1 foot. It equals 325,851 gallons.

## AQUIFER
Geologic formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. The formation could be sand, gravel, limestone, sandstone, or fractured igneous rocks.

## AVAILABILITY
Maximum amount of water available during the drought of record, regardless of whether the supply is physically or legally available.

## BRACKISH WATER
Water with total dissolved solids between 1,000 and 10,000 milligrams per liter.

## CAPITAL COST
Portion of the estimated cost of a water management strategy that includes both the direct costs of constructing facilities, such as materials, labor, and equipment, and the indirect expenses associated with construction activities, such as costs for engineering studies, legal counsel, land acquisition, contingencies, environmental mitigation, interest during construction, and permitting costs.

## CONJUNCTIVE USE
The combined use of groundwater and surface water sources that optimizes the beneficial characteristics of each source.

## COUNTY-OTHER
An aggregation of residential, commercial, and institutional water users in cities with less than 500 people or utilities that provide less than an average of 250,000 gallons per day, as well as unincorporated rural areas in a given county.

### DESALINATION
Process of removing salt from seawater or brackish water.

### DROUGHT
Term is generally applied to periods of less than average precipitation over a certain period of time. Associated definitions include *meteorological drought* (abnormally dry weather), *agricultural drought* (adverse impact on crop or range production), and *hydrologic drought* (below average water content in aquifers and/or reservoirs).

### DROUGHT OF RECORD
Period of time during recorded history when natural hydrological conditions provided the least amount of water supply. For Texas as a whole, the drought of record is generally considered to be from about 1950 to 1957.

### ESTUARY
Bay or inlet, often at the mouth of a river, in which large quantities of freshwater and seawater mix together.

### EXISTING WATER SUPPLY
Maximum amount of water available from existing sources for use during drought of record conditions that is physically and legally available for use.

### FIRM YIELD
Maximum water volume a reservoir can provide each year under a repeat of the drought of record.

### FLOOD CONTROL STORAGE
Storage in a lake or reservoir, between two designated water surface elevations, that is dedicated to storing floodwater so that flood damages downstream are eliminated or reduced.

### FRESHWATER INFLOW NEEDS
Freshwater flows required to maintain the natural salinity and nutrient and sediment delivery in a bay or estuary that supports their unique biological communities and ensures a healthy ecosystem.

### GROUNDWATER AVAILABILITY MODEL
Numerical groundwater flow models used by TWDB to determine groundwater availability of the major and minor aquifers in Texas.

### GROUNDWATER MANAGEMENT AREA
Area designated and delineated by TWDB as an area suitable for management of groundwater resources.

### INFRASTRUCTURE
Physical means for meeting water and wastewater needs, such as dams, wells, conveyance systems, and water treatment plants.

### INSTREAM FLOW
Water flow and water quality regime adequate to maintain an ecologically sound environment in streams and rivers.

### INTERBASIN TRANSFER
Physical conveyance of surface water from one river basin to another.

### MAJOR RESERVOIR
Reservoir having a storage capacity of 5,000 acre-feet or more.

### MODELED AVAILABLE GROUNDWATER
The total amount of groundwater, including both permitted and exempt uses, that can be produced from the aquifer in an average year, that achieves the desired future condition for the aquifer.

### NEEDS
Projected water demands in excess of existing water supplies for a water user group or a wholesale water provider.

### PLANNING GROUP
Team of regional and local leaders of different backgrounds and various social, environmental, and economic interests responsible for developing and adopting a regional water plan for their planning area at five-year intervals.

### RECHARGE
Amount of water that infiltrates to the water table of an aquifer.

### RECOMMENDED WATER MANAGEMENT STRATEGY
Specific project or action to increase water supply or maximize existing supply to meet a specific need.

### REUSE
Use of surface water that has already been beneficially used once under a water right or the use of groundwater that has already been used.

### RUN-OF-RIVER DIVERSION
Water right permit that allows the permit holder to divert water directly out of a stream or river.

### SAFE YIELD
The annual amount of water that can be withdrawn from a reservoir for a period of time longer than the drought of record.

### SEDIMENTATION
Action or process of depositing sediment in a reservoir, usually silts, sands, or gravel.

### STORAGE
Natural or artificial impoundment and accumulation of water in surface or underground reservoirs, usually for later withdrawal or release.

### SUBORDINATION AGREEMENT
Contracts between junior and senior water right holders where the senior water right holder agrees not to assert its priority right against the junior.

### UNMET NEEDS
Portion of the demand for water that exceeds water supply after inclusion of all recommended water management strategies in a regional water plan.

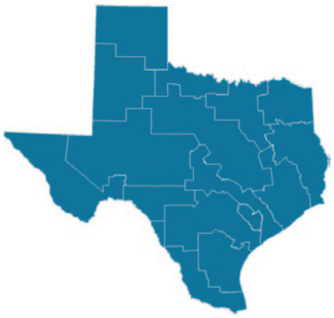
### WATER AVAILABILITY MODEL
Numerical surface water flow models to determine the availability of surface water for permitting in the state.

### WATER DEMAND
Quantity of water projected to meet the overall necessities of a water user group in a specific future year.

### WATER USER GROUP
Identified user or group of users for which water demands and water supplies have been identified and analyzed and plans developed to meet water needs. Water user groups are defined at the county level for the manufacturing, irrigation, livestock, steam-electric power generation, and mining water use categories. Municipal water user groups include (a) incorporated cities and selected Census Designated Places with a population of 500 or more; (b) individual or groups of selected water utilities serving smaller municipalities or unincorporated areas; and (c) rural areas not included in a listed city or utility, aggregated for each county.

### WHOLESALE WATER PROVIDER
Person or entity, including river authorities and irrigation districts, that had contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last regional water plan.


DANGER
KEEP AWAY



# Appendices

## APPENDIX A.1. ACRONYMS

| Region | Acronym | Key |
|---|---|---|
| A | CRMWA | Canadian River Municipal Water Authority |
| B | None | None |
| C | DWU | Dallas Water Utilities |
| C | GTUA | Greater Texoma Utility Authority |
| C | NTMWD | North Texas Municipal Water District |
| C | TRA | Trinity River Authority |
| C | TRWD | Tarrant Regional Water District |
| C | UTRWD | Upper Trinity Regional Water District |
| D | None | None |
| E | EPWU | El Paso Water Utility |
| E | LVWD | Lower Valley Water District |
| F | None | None |
| G | BRA | Brazos River Authority |
| H | BRA | Brazos River Authority |
| H | CHCRWA | Central Harris County Regional Water Authority |
| H | CLCND | Chambers-Liberty Counties Navigation District |
| H | GCWA | Gulf Coast Water Authority |
| H | LNVA | Lower Neches Valley Authority |
| H | MUD | Municipal Utility District |
| H | NCWA | North Channel Water Authority |
| H | NFBWA | North Fort Bend Water Authority |
| H | NHCRWA | North Harris County Regional Water Authority |
| H | SJRA | San Jacinto River Authority |
| H | TRA | Trinity River Authority |
| H | WCID | Water Control and Improvement District |
| H | WHCRWA | West Harris County Regional Water Authority |
| I | None | None |
| J | UGRA | Upper Guadalupe River Authority |
| K | LCRA | Lower Colorado River Authority |
| K | SAWS | San Antonio Water System |
| L | CRWA | Canyon Regional Water Authority |
| L | GBRA | Guadalupe-Blanco River Authority |
| L | LCRA | Lower Colorado River Authority |
| L | LNRA | Lavaca Navidad River Authority |
| L | LGWSP | Lower Guadalupe Water Supply Project |
| L | SAWS | San Antonio Water System |
| L | SSLGC | Schertz-Seguin Local Government Corporation |
| L | TWA | Texas Water Alliance |
| M | None | None |
| N | None | None |
| O | CRMWA | Canadian River Municipal Water Authority |
| O | WRMWD | White River Municipal Water District |
| P | None | None |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| **Region A** | | | | | | | | | |
| CRMWA acquisition of water rights | $88,200,000 | na | - | - | - | - | - | - | na |
| CRMWA Roberts County well field | $21,824,000 | $239 | - | - | 15,000 | 15,000 | 15,000 | 15,000 | $112 |
| Drill additional groundwater well | $98,400,920 | $288 - $2,911 | 2,718 | 8,718 | 12,013 | 16,472 | 20,519 | 23,000 | up to $1,311 |
| Irrigation conservation | $0 | $19 - $25 | - | 297,114 | 485,080 | 540,861 | 549,383 | 552,385 | $18 - $27 |
| Municipal conservation | $0 | $490 | - | 1,963 | 3,641 | 3,979 | 4,278 | 4,529 | $490 |
| Palo Duro reservoir | $114,730,000 | $2,976 | - | - | 3,875 | 3,833 | 3,792 | 3,750 | $408 |
| Potter County well field | $128,511,300 | $1,518 | - | 9,467 | 10,292 | 11,182 | 11,141 | 10,831 | $293 |
| Precipitation enhancement | $0 | $6 | - | 15,206 | 15,206 | 15,206 | 15,206 | 15,206 | $6 |
| Roberts County well field - Amarillo | $287,377,200 | $1,447 | - | - | - | 11,210 | 11,210 | 22,420 | $889 |
| Voluntary transfer from other users | $0 | na | - | - | 100 | 100 | 1,100 | 1,100 | na |
| Voluntary transfer from other users[1] | $0 | na | 200 | 800 | 2,458 | 3,579 | 5,311 | 6,563 | na |
| ***Region A Subtotal*** | **$739,043,420** | | **2,718** | **332,468** | **545,207** | **617,843** | **631,629** | **648,221** | |
| **Region B** | | | | | | | | | |
| Construct Lake Ringgold | $382,900,000 | $1,408 | - | - | - | - | 27,000 | 27,000 | $1,408 |
| Develop other aquifer supplies | $957,975 | $615 | 245 | 245 | 245 | 245 | 245 | 245 | $274 |
| Develop Trinity Aquifer supplies | $1,059,638 | $615 | 271 | 271 | 271 | 271 | 271 | 271 | $274 |
| Develop Trinity Aquifer supplies (includes overdrafting) | $265,887 | $615 | 68 | 68 | 68 | 68 | 68 | 68 | $274 |
| Enclose canal laterals in pipe | $7,658,469 | $52 | 13,034 | 13,034 | 13,034 | 13,034 | 13,034 | 13,034 | $1 |
| Increase water conservation pool at Lake Kemp | $130,000 | na | - | 24,834 | 24,776 | 24,718 | 24,660 | 24,600 | na |
| Municipal conservation | $0 | $0 - $1,667 | 197 | 764 | 799 | 841 | 857 | 1,668 | $0 - $556 |
| Nitrate removal plant | $647,000 | $1,363 - $2,550 | 50 | 50 | 50 | 50 | 50 | 50 | $388 - $800 |
| Purchase water from local provider | $2,798,700 | $1,059 - $2,266 | 1,508 | 1,046 | 1,046 | 1,046 | 1,046 | 1,046 | $936 - $1,642 |
| Wastewater reuse | $1,206,500 | $950 | - | - | - | 171 | 171 | 171 | $950 |
| Wichita River diversion | $5,380,000 | $73 | - | - | - | 8,850 | 8,850 | 8,850 | $20 |
| Emergency interconnect Millers Creek Reservoir[1] | $714,000 | $1,252 | 250 | 250 | 250 | 250 | 250 | 250 | $1,000 |
| Purchase water from local provider[1] | $0 | $1,059 | - | 462 | 462 | 462 | 462 | 462 | $1,059 |
| Wichita Basin chloride control project[1] | $95,450,000 | $286 | 26,500 | 26,500 | 26,500 | 26,500 | 26,500 | 26,500 | $47 |
| ***Region B Subtotal*** | **$499,168,169** | | **15,373** | **40,312** | **40,289** | **49,294** | **76,252** | **77,003** | |
| **Region C** | | | | | | | | | |
| Additional dry year supply | $1,750,000 | na | 25,000 | - | - | - | - | - | na |
| Additional pipeline from Lake Tawakoni (more Lake Fork supply) | $496,243,000 | $558 | - | 77,994 | 75,777 | 73,563 | 71,346 | 69,128 | $108 |
| Collin-Grayson Municipal Alliance System | $77,366,000 | $3,045 | - | 3,255 | 8,614 | 14,192 | 20,604 | 27,412 | $982 |
| Cooke County project | $50,280,000 | $1,658 | - | 2,240 | 2,240 | 3,360 | 4,480 | 4,480 | $394 |
| Dallas Water Utilities reuse | $82,920,000 | $233 | - | 34,902 | 41,326 | 39,907 | 47,001 | 50,382 | $42 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Direct reuse | $264,783,000 | $691 | 1,552 | 14,327 | 29,283 | 38,649 | 43,184 | 46,250 | $139 |
| Direct reuse - Frisco | $31,448,606 | $1,359 | - | 2,240 | 3,359 | 5,650 | 5,649 | 5,650 | $134 |
| Ennis reuse | $31,779,000 | $14,739 | - | - | - | 333 | 2,199 | 3,696 | $1,328 |
| Facility improvements | $2,314,558,600 | na | - | - | - | - | - | - | na |
| Facility improvements - reuse sources | $590,686,000 | na | - | - | - | - | - | - | na |
| Fannin County project | $38,471,000 | $3,838 | - | 1,254 | 2,400 | 3,862 | 4,439 | 5,113 | $395 |
| Fastrill replacement (Region C component)[2] | $1,980,278,000 | $1,724 | - | - | - | - | - | 112,100 | $1,724 |
| Golf course conservation | $0 | $279 | 56 | 942 | 1,808 | 2,261 | 2,690 | 3,121 | $278 |
| Grayson County project | $136,016,000 | na | 200 | 7,560 | 10,920 | 13,440 | 19,040 | 24,640 | $141 |
| Indirect reuse | $0 | na | - | 4,368 | 4,368 | 4,368 | 4,368 | 4,368 | na |
| Indirect reuse - Jacksboro for Jack County mining | $200,000 | na | 385 | 385 | 385 | 385 | 385 | 385 | na |
| Lake Palestine connection (integrated pipeline with TRWD) | $887,954,000 | $773 | - | 111,776 | 110,670 | 109,563 | 108,455 | 107,347 | $204 |
| Lake Ralph Hall | $286,401,000 | $727 | - | 34,050 | 34,050 | 34,050 | 34,050 | 34,050 | $116 |
| Lake Ralph Hall - indirect reuse | $0 | na | 0 | 6,129 | 12,258 | 18,387 | 18,387 | 18,387 | na |
| Lake Texoma - authorized (blend) | $336,356,000 | $496 | - | - | 69,200 | 68,500 | 113,000 | 113,000 | $87 |
| Lake Texoma - interim purchase from GTUA | $0 | na | - | 21,900 | 21,900 | 21,899 | - | - | na |
| Lake Wright Patman - reallocation of flood pool | $896,478,000 | $762 | - | - | - | 112,100 | 112,100 | 112,100 | $762 |
| Lower Bois d'Arc Creek Reservoir | $615,498,000 | $972 | - | 54,796 | 117,800 | 114,138 | 111,361 | 108,487 | $79 |
| Main stem pump station (additional East Fork) NTMWD | $0 | na | - | 34,900 | 15,100 | - | - | - | na |
| Main stem Trinity pump station (Lake Ray Hubbard indirect reuse - DWU) | $142,567,000 | $730 | - | 17,168 | 15,004 | 20,010 | 13,700 | 11,105 | $196 |
| Manufacturing conservation | $0 | na | 1 | 131 | 1,530 | 2,259 | 2,457 | 2,618 | $211 |
| Marvin Nichols Reservoir | $3,345,052,000 | $364 | - | - | 227,400 | 227,400 | 472,300 | 472,300 | $83 |
| Municipal conservation - basic | $1,151,575 | $200 | 41,967 | 97,040 | 137,705 | 175,858 | 216,941 | 264,429 | $85 |
| Municipal conservation - expanded | $480,774 | $169 | 4,756 | 9,862 | 13,907 | 16,910 | 18,824 | 20,541 | $396 |
| New wells - Carrizo Wilcox Aquifer | $1,853,000 | $345 | 154 | 181 | 183 | 465 | 466 | 467 | $446 |
| New wells - Trinity Aquifer | $7,778,150 | $410 | 1,882 | 2,042 | 2,306 | 2,306 | 2,306 | 2,306 | $229 |
| New wells - Woodbine Aquifer | $14,543,000 | $663 | 763 | 1,932 | 1,932 | 1,932 | 1,932 | 1,932 | $339 |
| Oklahoma water to Irving | $194,825,000 | $810 | - | - | 25,000 | 25,000 | 25,000 | 25,000 | $244 |
| Oklahoma water to NTMWD, TRWD, UTRWD | $756,044,500 | $290 | - | - | - | - | - | 115,000 | $290 |
| Overdraft Trinity Aquifer - existing wells | $0 | $105 | 2,168 | - | - | - | - | - | na |
| Overdraft Trinity Aquifer - new wells | $269,000 | $493 | 75 | - | - | - | - | - | na |
| Purchase from water provider (1) | $0 | na | 46 | - | - | - | - | - | na |
| Redistribution of supplies | $0 | na | 530 | 13,979 | 18,526 | 24,028 | 33,981 | 58,031 | na |
| Subordination agreement - future-only sources | $8,217,000 | $2,561 | - | 280 | 220 | 219 | 217 | 215 | $558 |
| Supplemental wells | $495,381,934 | na | - | - | - | - | - | - | na |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Toledo Bend project (Region I entities responsible for 20 percent of cost) | $2,406,236,000 | na | 363 | 329 | 272 | 232 | 400,229 | 400,217 | $1,072 |
| TRA 10-Mile Creek reuse project | $14,895,000 | $259 | - | - | 6,760 | 6,760 | 6,760 | 6,760 | $99 |
| TRA Denton Creek wastewater treatment plant reuse | $9,506,000 | na | - | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | $229 |
| TRA Ellis County reuse | $10,384,000 | $505 | - | - | - | - | - | 2,200 | $505 |
| TRA Freestone County reuse | $17,266,000 | $323 | - | - | - | - | 6,760 | 6,760 | $323 |
| TRA Kaufman County reuse | $9,761,000 | $901 | - | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | $192 |
| TRA Las Colinas reuse | $14,530,000 | $284 | - | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | $134 |
| TRA Tarrant County project | $59,008,000 | na | - | - | - | - | - | - | na |
| TRWD third pipeline and reuse | $914,424,000 | $1,016 | - | 105,500 | 105,500 | 105,500 | 105,500 | 105,500 | $324 |
| Water treatment plant - expansion | $19,970,000 | na | - | 1,260 | 1,081 | 3,180 | 2,786 | 2,268 | $1,090 |
| Water treatment plant - new | $308,309,400 | na | - | 192 | 523 | 587 | 613 | 807 | $19,346 |
| Conveyance project (1)[1] | $413,884,000 | $11,561 | 194 | 10,417 | 17,255 | 19,490 | 23,046 | 25,178 | $679 |
| Conveyance project (2)[1] | $69,299,100 | na | - | 1,672 | 1,299 | 1,234 | 1,226 | 1,237 | $3,154 |
| Conveyance project (3)[1] | $6,465,400 | $6,531 | - | 213 | 1,009 | 1,717 | 1,957 | 2,016 | $1,027 |
| Grayson County project[1] | $146,071,000 | $3,693 | - | 5,600 | 8,400 | 8,400 | 14,000 | 19,600 | $514 |
| Purchase from water provider (1)[1] | $164,114,900 | na | 402 | 27,039 | 32,425 | 31,243 | 30,709 | 30,103 | $1,067 |
| Purchase from water provider (2)[1] | $3,538,000 | $5,950 | - | 52 | 50 | 50 | 50 | 86 | $609 |
| Purchase from water provider (3)[1] | $65,481,250 | $2,384 | - | 4,004 | 4,493 | 6,083 | 5,626 | 6,417 | $1,706 |
| Water treatment plant - expansion - reuse sources[1] | $32,750,000 | na | - | - | - | - | - | - | na |
| Water treatment plant - expansion[1] | $2,708,430,000 | na | - | 484 | 828 | 2,279 | 2,545 | 2,618 | $106,249 |
| ***Region C Subtotal*** | $21,481,952,189 | | 79,898 | 674,664 | 1,131,057 | 1,303,003 | 2,045,260 | 2,360,302 | |
| **Region D** | | | | | | | | | |
| Drill new well | $32,260,219 | $2,342 | 1,094 | 1,636 | 1,969 | 3,100 | 4,888 | 6,757 | $336 |
| Increase existing contract | $0 | $591 | 1,576 | 2,001 | 3,345 | 13,199 | 34,692 | 59,478 | $476 |
| New surface water contract | $6,247,886 | $311 | 8,660 | 12,523 | 14,866 | 17,678 | 22,512 | 32,231 | $144 |
| Increase existing contract[3] | $0 | na | - | 340 | 558 | 711 | 1,280 | 1,471 | na |
| ***Region D Subtotal*** | $38,508,104 | | 11,330 | 16,160 | 20,180 | 33,977 | 62,092 | 98,466 | |
| **Region E** | | | | | | | | | |
| Additional one well | $702,770 | $10 | - | 500 | 500 | 500 | 500 | 500 | $10 |
| Additional wells | $1,006,762 | $29 | - | 175 | 175 | 350 | 350 | 350 | $29 |
| Additional wells and desalination plant expansions | $34,344,000 | $1,114 | - | 1,607 | 3,304 | 4,764 | 6,245 | 7,726 | $564 |
| Arsenic treatment facility | $1,996,232 | $34 | - | 276 | 276 | 276 | 276 | 276 | $34 |
| Integrated water management strategy - conjunctive use with additional surface water | $0 | $525 | - | - | - | 3,600 | 3,600 | 3,600 | $525 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Integrated water management strategy - conservation | $0 | $333 | - | 3,000 | 7,000 | 11,000 | 16,000 | 22,000 | $45 |
| Integrated water management strategy - desalination of agricultural drain water | $16,675,000 | $930 | - | 2,700 | 2,700 | 2,700 | 2,700 | 2,700 | $476 |
| Integrated water management strategy - direct reuse | $25,257,000 | $538 | - | 2,000 | 4,000 | 6,000 | 6,000 | 6,000 | $334 |
| Integrated water management strategy - import from Dell Valley | $214,113,000 | $1,529 | - | - | - | - | 10,000 | 20,000 | $1,309 |
| Integrated water management strategy - import from Diablo Farms | $245,506,000 | $2,353 | - | - | - | 10,000 | 10,000 | 10,000 | $2,353 |
| Integrated water management strategy - recharge of groundwater with treated surface water | $14,625,000 | $542 | - | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | $330 |
| Irrigation scheduling | $0 | $70 | - | 5,275 | 5,275 | 5,275 | 5,275 | 5,275 | $70 |
| Purchase water from EPWU | $0 | varies | 3,376 | 16,939 | 21,512 | 18,156 | 14,074 | 13,569 | varies |
| Purchase water from LVWD | $0 | $451 | - | 1,441 | 2,812 | 3,883 | 5,050 | 6,218 | $1,470 |
| Tailwater reuse | $0 | $478 | - | 2,312 | 2,312 | 2,312 | 2,312 | 2,312 | $478 |
| Water district delivery systems | $147,635,869 | $8 | - | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | $8 |
| Integrated water management strategy - conjunctive use with additional surface water[1] | $140,238,000 | $1,671 | - | 5,000 | 15,000 | 16,400 | 16,400 | 16,400 | $525 |
| Purchase water from EPWU[1] | $0 | varies | - | 605 | 1,161 | 9,193 | 18,231 | 24,706 | varies |
| ***Region E Subtotal*** | **$842,099,633** | | **3,376** | **66,225** | **79,866** | **98,816** | **112,382** | **130,526** | |
| **Region F** | | | | | | | | | |
| Advanced treatment | $2,582,000 | na | - | - | - | - | - | - | na |
| Bottled water program | $3,000 | $1,400 - $28,400 | 1 | 1 | 1 | 1 | 1 | 1 | $1,400 - $28,400 |
| Brush control | $23,020,000 | na | 8,362 | 8,362 | 8,362 | 8,362 | 8,362 | 8,362 | na |
| Desalination | $213,760,990 | $1,163 | - | 950 | 950 | 16,050 | 16,050 | 16,050 | $346 |
| Develop Cenozoic Aquifer supplies | $244,775,000 | $251 - $342 | - | - | 19,600 | 19,600 | 19,600 | 19,600 | $251 - $342 |
| Develop Dockum Aquifer supplies | $17,855,000 | $445 | - | 2,200 | 2,200 | 2,200 | 2,200 | 2,200 | $445 |
| Develop Ellenburger Aquifer supplies | $5,148,000 | $370 | - | 200 | 200 | 200 | 200 | 200 | $370 |
| Develop Hickory Aquifer supplies | $174,991,000 | $610 - $1,670 | 160 | 6,860 | 10,160 | 12,160 | 12,160 | 12,160 | $610 - $1,670 |
| Irrigation conservation | $68,650,668 | $69 | - | 36,125 | 72,244 | 72,244 | 72,244 | 72,244 | $69 |
| Municipal conservation | $0 | $498 | 3,197 | 6,988 | 8,307 | 8,897 | 9,525 | 10,179 | $154 |
| New water treatment plant and storage facilities | $2,436,000 | na | - | - | - | - | - | - | na |
| New/renew water supply | $8,964,000 | $477 | 392 | 5,622 | 15,629 | 16,180 | 17,073 | 16,866 | $477 |
| Rehabilitation of pipeline | $7,521,900 | $315 | - | - | 2,281 | 2,267 | 2,254 | 2,240 | $448 |
| Replacement well | $13,941,000 | na | - | - | - | - | - | - | na |
| Reuse | $130,906,000 | $1,072 | - | 12,380 | 12,380 | 12,490 | 12,490 | 12,490 | $383 |
| Subordination | $0 | na | 78,832 | 77,555 | 66,391 | 65,436 | 63,241 | 62,606 | na |
| ***Region F Subtotal*** | **$914,554,558** | | **90,944** | **157,243** | **218,705** | **236,087** | **235,400** | **235,198** | |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| **Region G** | | | | | | | | | |
| Additional Carrizo Aquifer development (includes overdrafting) | $23,676,071 | $585 | 1,481 | 1,884 | 2,184 | 5,084 | 6,963 | 6,963 | $182 |
| Additional Edwards-Trinity (Plateau) Aquifer development (includes overdrafting) | $679,000 | $588 | 114 | 114 | 114 | 114 | 114 | 114 | $70 |
| Additional Gulf Coast Aquifer development | $31,630,000 | $638 | - | - | - | 5,600 | 5,600 | 5,600 | $146 |
| Additional Trinity Aquifer development (includes overdrafting) | $19,278,000 | $264 | 723 | 322 | 522 | 1,357 | 1,708 | 2,025 | $553 |
| Aquifer storage and recovery (Brazos River to Seymour Aquifer) | $38,625,000 | $701 | 6,208 | 6,208 | 6,208 | 6,208 | 6,208 | 6,208 | $159 |
| Belton to Stillhouse pipeline | $36,038,000 | $133 | - | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 | $45 |
| Bosque County regional project | $5,150,000 | $2,895 | - | - | 190 | 190 | 190 | 190 | $532 |
| BRA supply through the East Williamson County Regional Water Treatment System | $44,706,000 | $1,680 | 4,601 | 6,260 | 6,260 | 6,958 | 6,958 | 6,958 | $430 |
| BRA surface water and treatment system expansion | $39,971,000 | $2,933 | 375 | 3,545 | 3,545 | 3,545 | 3,545 | 3,545 | $573 |
| BRA system operations permit | $204,281,000 | $2,808 | 750 | 77,020 | 82,242 | 84,742 | 84,742 | 84,899 | $314 |
| Brushy Creek Reservoir | $18,553,000 | $484 | 2,090 | 2,090 | 2,090 | 2,090 | 2,090 | 2,090 | $67 |
| Cedar Ridge Reservoir | $285,214,000 | $1,168 | - | 23,380 | 23,380 | 23,380 | 23,380 | 23,380 | $241 |
| City of Groesbeck off-channel reservoir | $10,412,000 | $565 | - | - | - | - | 1,755 | 1,755 | $565 |
| Conjunctive management of Champion well field and Oak Creek Reservoir with subordination agreement | $0 | na | 688 | 755 | 878 | 948 | 953 | 963 | na |
| Coryell County Reservoir (BRA System) | $37,489,000 | $1,007 | - | 3,365 | 3,365 | 3,365 | 3,365 | 3,365 | $193 |
| Expansion of Champion well field | $15,015,000 | $1,643 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | $334 |
| Future phases of Lake Whitney water supply project | $110,843,000 | $926 | - | 7,572 | 7,572 | 7,572 | 7,572 | 7,572 | $926 |
| Groundwater/ surface water conjunctive use (Lake Granger Augmentation) | $643,928,000 | $838 | 26,505 | 26,001 | 25,496 | 47,435 | 70,751 | 70,246 | $1,154 |
| Increase treatment capacity | $195,654,000 | $546 | 15,176 | 28,176 | 36,016 | 40,047 | 51,330 | 58,435 | $294 |
| Interconnection of City of Waco system with neighboring communities | $14,652,000 | $3,387 | 837 | 837 | 837 | 1,564 | 1,664 | 1,814 | $1,136 |
| Irrigation water conservation | $0 | $235 | 3,390 | 5,519 | 7,550 | 7,376 | 7,206 | 7,041 | $228 |
| Limestone County Carrizo-Wilcox Aquifer development | $18,458,000 | $562 | 2,500 | 3,000 | 3,000 | 3,600 | 3,600 | 3,600 | $115 |
| Manufacturing water conservation | $0 | na | 140 | 275 | 440 | 494 | 545 | 594 | na |
| Midway pipeline project (West Central Brazos distribution system) | $13,524,731 | $2,046 | 843 | 843 | 843 | 843 | 843 | 843 | $648 |
| Millers Creek augmentation | $46,948,000 | $217 | 17,582 | 17,582 | 17,582 | 17,582 | 17,582 | 17,582 | $217 |
| Mining water conservation | $0 | na | 340 | 611 | 885 | 913 | 941 | 973 | na |
| Municipal water conservation | $0 | $475 | 4,873 | 13,572 | 14,379 | 15,865 | 18,497 | 21,347 | $475 |
| New water treatment plant | $3,522,000 | $2,179 | 224 | 224 | 224 | 224 | 224 | 224 | $808 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| New West Loop reuse line | $5,495,500 | $591 | 680 | 680 | 680 | 680 | 680 | 680 | $120 |
| Oak Creek Reservoir with subordination agreement | $0 | na | 1,679 | 1,671 | 1,557 | 1,435 | 1,301 | 1,154 | na |
| Phase I Lake Whitney water supply project | $41,453,000 | $2,852 | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 | $1,153 |
| Purchase water from City of Bryan | $1,201,000 | $262 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | 1,500 | $192 |
| Raise level of Gibbons Creek Reservoir | $12,140,600 | $237 | - | 3,870 | 3,870 | 3,870 | 3,870 | 3,870 | $29 |
| Reallocation of source | $0 | na | 9,081 | 35,928 | 35,928 | 40,028 | 45,728 | 52,628 | na |
| Regional surface water supply to Williamson County from Lake Travis | $391,533,000 | $1,308 | 600 | 34,148 | 41,187 | 41,187 | 44,459 | 44,459 | $938 |
| Rehabilitate existing wells | $350,000 | $30 | - | 1,100 | 1,100 | 1,100 | 1,100 | 1,100 | $30 |
| Restructure contract | $0 | na | 502 | 470 | 437 | 406 | 373 | 341 | na |
| Somervell County water supply project (phases 1-4) | $29,923,000 | $2,841 | 840 | 840 | 840 | 840 | 840 | 840 | $508 |
| Somervell County water supply project (phases 5-13) | $74,228,000 | $1,147 | - | - | 960 | 960 | 960 | 960 | $174 |
| Steam-electric conservation | $0 | na | 2,114 | 4,896 | 8,219 | 9,109 | 10,822 | 11,803 | na |
| Stonewall, Kent, and Garza chloride control project | $163,226,000 | na | - | - | - | - | - | - | na |
| Storage reallocation of federal reservoirs - Lake Aquilla | $11,447,000 | $406 | - | - | - | 2,050 | 2,050 | 2,050 | $406 |
| Turkey Peak Reservoir | $50,227,000 | $924 | - | 7,600 | 7,600 | 7,600 | 7,600 | 7,600 | $441 |
| Voluntary redistribution | $6,391,000 | $312 | 11,251 | 11,942 | 13,564 | 14,425 | 15,236 | 16,558 | $469 |
| Wastewater reuse | $115,432,500 | $340 | 17,043 | 38,653 | 40,523 | 51,114 | 64,830 | 70,087 | $317 |
| Coryell County Reservoir (BRA system)[1] | $14,399,000 | $2,867 | - | - | 3,365 | 3,365 | 3,365 | 3,365 | $1,522 |
| Groundwater/surface water conjunctive use (Lake Granger augmentation)[1] | $229,822,000 | $865 | - | - | - | 33,814 | 37,839 | 39,710 | $864 |
| Increase current contract[1] | $0 | $401 | 43 | 43 | 543 | 1,043 | 1,543 | 2,143 | $831 |
| Increase treatment capacity[1] | $13,951,000 | $648 | - | 2,800 | 2,800 | 2,800 | 2,800 | 2,800 | $213 |
| Limestone County Carrizo-Wilcox Aquifer development[1] | $0 | $562 | 148 | 146 | 144 | 142 | 141 | 141 | $115 |
| New water treatment plant[1] | $35,822,000 | $627 | - | 8,400 | 8,400 | 8,400 | 8,400 | 8,400 | $255 |
| Storage reallocation of federal reservoirs - Lake Aquilla[1] | $0 | na | - | - | - | 375 | 745 | 999 | na |
| Turkey Peak Reservoir[1] | $0 | $924 | - | 7,600 | 7,600 | 7,600 | 7,600 | 7,600 | $441 |
| Voluntary redistribution[1] | $91,940,000 | $860 | 3,529 | 19,162 | 28,296 | 29,099 | 29,903 | 30,757 | $472 |
| Wastewater reuse[1] | $39,128,901 | $436 | 9,232 | 10,831 | 11,760 | 11,760 | 11,760 | 11,760 | $107 |
| ***Region G Subtotal*** | $3,186,357,303 | | 137,858 | 405,581 | 436,895 | 496,528 | 562,803 | 587,084 | |
| **Region H** | | | | | | | | | |
| Allens Creek reservoir | $222,752,400 | $326 | - | 57,393 | 55,096 | 87,781 | 99,650 | 99,650 | $39 |
| BRA system operations permit | $0 | na | - | 6,621 | 18,870 | 25,350 | 25,350 | 25,350 | na |
| Brazoria County interruptible supplies for irrigation | $0 | na | 104,977 | 86,759 | 64,000 | 64,000 | 64,000 | 64,000 | na |
| Brazoria off-channel reservoir | $173,898,602 | $1,206 | - | - | - | - | - | 24,000 | $1,206 |
| Brazos saltwater barrier | $44,470,739 | na | - | - | - | - | - | - | na |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES

| | | | Water Supply Volume (acre-feet/year) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
| Cities of Richmond-Rosenberg Groundwater Reduction Plan - West Fort Bend surface water treatment plant | $117,220,150 | $887 | - | 7,500 | 7,500 | 7,500 | 7,500 | 7,500 | $2,325 |
| City of Houston bayous permit | $20,956,000 | na | - | - | - | - | - | - | na |
| City of Houston Groundwater Reduction Plan participation | $58,235,873 | $378 | 3,762 | 11,417 | 16,809 | 19,870 | 22,399 | 24,990 | $214 |
| City of Houston indirect reuse | $721,822,850 | $725 | - | - | - | 66,420 | 114,679 | 128,801 | $799 |
| City of Missouri City Groundwater Reduction Plan - aquifer storage and recovery | $58,967,437 | na | - | 4,147 | 4,147 | 4,147 | 4,147 | 4,147 | na |
| City of Missouri City Groundwater Reduction Plan - reuse | $9,100,352 | na | - | 640 | 640 | 640 | 640 | 640 | na |
| City of Missouri City Groundwater Reduction Plan participation | $6,618,706 | $378 | - | 1,004 | 1,860 | 1,896 | 1,896 | 1,896 | $248 |
| City of Sugar Land Groundwater Reduction Plan - reuse | $78,783,825 | na | - | 560 | 5,040 | 5,040 | 5,040 | 5,040 | na |
| City of Sugar Land Groundwater Reduction Plan participation | $6,360,101 | $379 | - | 480 | 1,763 | 2,380 | 2,381 | 2,155 | $223 |
| CLCND West Chambers System | $20,380,000 | $1,171 | - | 1,691 | 1,978 | 2,235 | 2,511 | 2,804 | $73 |
| Contract with Brazosport Water Authority | $22,363,694 | $193 | 7,750 | 7,750 | 7,750 | 7,750 | 7,750 | 7,750 | $94 |
| Contract with CHCRWA | $2,048,820 | $196 | - | 977 | 862 | 720 | 631 | 546 | $50 |
| Contract with City of Galveston | $10,542,328 | $172 | - | 7,262 | 7,262 | 7,262 | 7,262 | 7,262 | $46 |
| Contract with City of Houston | $63,420,357 | $596 | - | 6,128 | 4,816 | 4,742 | 5,400 | 6,027 | $428 |
| Contract with Fort Bend County WCID #1 | $1,815,739 | $259 | - | 148 | 824 | 940 | 1,016 | 1,016 | $60 |
| Contract with Galveston County WCID #1 | $1,807,960 | $207 | - | 766 | 909 | 940 | 975 | 1,014 | $60 |
| Contract with GCWA | $132,634,164 | $406 | - | 29,718 | 30,708 | 31,618 | 32,719 | 34,057 | $223 |
| Contract with LNVA | $405,835 | $1,392 | 16 | 23 | 26 | 29 | 33 | 37 | $642 |
| Contract with NHCRWA | $42,207,965 | $68 | - | 56,453 | 83,041 | 64,491 | 34,726 | 27,478 | $50 |
| Contract with SJRA | $264,926,229 | $829 | 23,008 | 27,754 | 37,090 | 54,777 | 54,805 | 54,849 | $206 |
| Contract with TRA | $249,479,472 | $1,044 | 13,823 | 17,083 | 19,972 | 22,888 | 25,732 | 28,672 | $620 |
| Dow off-channel reservoir | $124,468,000 | $481 | - | 21,800 | 21,800 | 21,800 | 21,800 | 21,800 | $389 |
| Expanded use of groundwater | $165,928,999 | $238 | - | 40,159 | 62,297 | 68,916 | 80,337 | 90,617 | $175 |
| Fort Bend County MUD #25 Groundwater Reduction Plan - reuse | $776,145 | $568 | - | 589 | 589 | 589 | 589 | 589 | $453 |
| Fort Bend off-channel reservoir | $202,514,788 | $484,074 | - | - | - | - | 90 | 45,943 | $948 |
| Freeport desalination plant | $255,699,000 | $854 | - | - | - | - | 33,600 | 33,600 | $854 |
| Fulshear reuse | $566,625 | $568 | - | 287 | 430 | 430 | 430 | 430 | $453 |
| GCWA off-channel reservoir | $197,448,012 | $827 | - | - | 39,500 | 39,500 | 39,500 | 39,500 | $827 |
| Industrial conservation | $0 | na | - | 558 | 558 | 558 | 558 | 558 | na |
| Interim strategies | $1,155,965 | $369 | 503 | - | - | - | - | - | na |
| Interim strategies - temporary overdraft | $85,545,570 | $303 | 45,009 | - | - | - | - | - | na |
| Irrigation conservation | $757,436 | $100 | 71,275 | 71,275 | 71,275 | 71,275 | 77,881 | 77,881 | $100 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Montgomery MUD #8/9 indirect reuse | $12,245,687 | $1,387 | - | 657 | 816 | 1,120 | 1,120 | 1,120 | $436 |
| Municipal conservation | $0 | $213 | 1,680 | 3,635 | 3,954 | 4,269 | 4,716 | 5,232 | $213 |
| Municipal conservation - large water user group | $0 | $213 | 31,612 | 38,940 | 42,664 | 46,276 | 50,073 | 54,484 | $213 |
| Municipal conservation - medium water user group | $0 | $311 | 2,658 | 4,377 | 5,062 | 5,684 | 6,384 | 7,189 | $311 |
| Municipal conservation - small water user group | $0 | $202 | 9,655 | 18,366 | 24,016 | 28,274 | 33,219 | 38,589 | $202 |
| New groundwater wells for livestock | $18,635 | $61 | - | 41 | 41 | 41 | 41 | 41 | $21 |
| NFBWA Groundwater Reduction Plan participation | $1,638,063 | $380 | - | 106 | 258 | 295 | 466 | 687 | $241 |
| NHCRWA Groundwater Reduction Plan participation | $17,814,585 | $377 | 761 | 2,933 | 4,243 | 5,573 | 6,664 | 8,088 | $206 |
| NHCRWA indirect reuse | $66,778,694 | $822 | - | - | - | 7,300 | 16,300 | 16,300 | $589 |
| Reallocation of existing supplies | $275,269,912 | $351 | 59,614 | 56,931 | 54,011 | 66,006 | 76,391 | 152,895 | $148 |
| River Plantation Groundwater Reduction Plan - reuse | $484,926 | $568 | 168 | 368 | 368 | 368 | 368 | 368 | $453 |
| SJRA Water Resources Assessment Plan participation | $89,604,231 | $235 | - | 21,441 | 27,020 | 30,247 | 28,720 | 26,896 | $282 |
| TRA to City of Houston contract | $0 | na | - | - | 116,738 | 123,524 | 123,524 | 123,524 | na |
| TRA to SJRA contract | $302,781,597 | $4,676 | - | - | - | 7,935 | 39,096 | 76,476 | $140 |
| Wastewater reclamation for municipal irrigation | $48,043,249 | $568 | - | - | 7,272 | 15,425 | 25,561 | 36,388 | $520 |
| Wastewater reuse for industry | $332,051,761 | $893 | - | - | - | - | - | 67,200 | $893 |
| WHCRWA Groundwater Reduction Plan participation | $35,268,970 | $378 | 2,488 | 7,689 | 10,105 | 11,683 | 13,340 | 15,104 | $219 |
| BRA to Brazosport Water Authority contract[1] | $0 | na | - | 232 | 248 | 3,114 | 6,366 | 10,870 | na |
| BRA to Cities of Richmond-Rosenberg contract[1] | $0 | na | - | - | - | 2,182 | 6,120 | 11,290 | na |
| BRA to City of Sugar Land contract[1] | $0 | na | - | 2,054 | 5,894 | 7,232 | 7,750 | 9,512 | na |
| BRA to GCWA contract[1] | $0 | na | - | 35,558 | 80,016 | 100,410 | 112,400 | 131,128 | na |
| BRA to NRG Energy contract[1] | $0 | na | - | - | - | - | - | 17,000 | na |
| CHCRWA Groundwater Reduction Plan[1] | $0 | na | 2,375 | 4,146 | 4,789 | 4,806 | 4,806 | 4,806 | na |
| CHCRWA internal distribution[1] | $0 | na | 2,375 | 4,146 | 4,789 | 4,806 | 4,806 | 4,806 | na |
| CHCRWA transmission line[1] | $0 | na | 2,375 | 4,146 | 4,789 | 4,806 | 4,806 | 4,806 | na |
| City of Houston distribution expansion[1] | $261,040,000 | $80 | - | 280,000 | 128,000 | 64,000 | 48,000 | 48,000 | $54 |
| City of Houston to Baytown Area Water Authority contract[1] | $0 | na | - | 26 | 262 | 398 | 535 | 692 | na |
| City of Houston to BRA contract[1] | $0 | na | - | 54,996 | 50,402 | 115,772 | 139,510 | 139,510 | na |
| City of Houston to CHCRWA contract[1] | $0 | na | - | 1,771 | 2,414 | 2,431 | 2,431 | 2,431 | na |
| City of Houston to City of Pasadena contract[1] | $0 | na | 1,865 | 2,278 | 2,665 | 3,153 | 3,579 | 4,068 | na |
| City of Houston to NCWA contract[1] | $0 | na | 1,954 | 2,392 | 2,869 | 3,511 | 4,157 | 4,912 | na |
| City of Houston to NFBWA contract[1] | $0 | na | - | 888 | 35,942 | 62,322 | 82,344 | 100,884 | na |
| City of Houston to NHCRWA contract[1] | $0 | na | - | 56,453 | 83,041 | 83,041 | 78,041 | 83,041 | na |
| City of Houston to SJRA contract[1] | $0 | na | - | 36,377 | 55,538 | 54,582 | 53,581 | 52,534 | na |
| City of Houston to WHCRWA contract[1] | $0 | na | 1,241 | 31,837 | 46,324 | 52,759 | 55,549 | 58,402 | na |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| City of Houston treatment expansion[1] | $2,045,672,161 | $479 | 16,000 | 280,000 | 128,000 | 64,000 | 48,000 | 48,000 | $1,867 |
| City of Huntsville water treatment plant[1] | $61,023,906 | $904 | 11,200 | 11,200 | 11,200 | 11,200 | 11,200 | 11,200 | $429 |
| City of Missouri City Groundwater Reduction Plan[1] | $24,003,201 | $1,110 | - | 395 | 4,644 | 8,362 | 8,362 | 12,775 | $131 |
| City of Pearland surface water treatment plant[1] | $265,000,000 | $1,656 | 6,720 | 6,720 | 6,720 | 13,420 | 13,420 | 13,420 | $544 |
| City of Sealy groundwater treatment expansion[1] | $6,450,000 | $2,176 | - | 360 | 360 | 360 | 360 | 888 | $269 |
| City of Sugar Land Groundwater Reduction Plan[1] | $82,576,224 | $11,066 | - | 1,027 | 2,947 | 3,616 | 3,875 | 4,756 | $357 |
| Contract with Baytown Area Water Authority | $900,444 | $180 | - | - | 191 | 349 | 496 | 496 | $122 |
| Contract with BRA[1] | $652,480,634 | $704 | - | 49,416 | 35,211 | 62,308 | 100,156 | 145,264 | $514 |
| Contract with Brazosport Water Authority | $2,102,169 | na | - | 116 | 124 | 1,557 | 3,183 | 5,435 | na |
| Contract with CHCRWA[1] | $1,867,449 | $196 | - | 794 | 1,129 | 1,500 | 1,668 | 1,668 | na |
| Contract with Cities of Richmond-Rosenberg[1] | $0 | na | - | - | - | 1,091 | 3,060 | 5,645 | na |
| Contract with City of Houston[1] | $183,896,349 | na | - | 14,981 | 31,413 | 30,449 | 34,995 | 34,995 | $361 |
| Contract with City of Missouri City[1] | $4,807,747 | $100 | - | 713 | 6,330 | 10,661 | 10,911 | 15,435 | $12 |
| Contract with City of Pasadena[1] | $2,918,547 | $65 | - | 967 | 1,941 | 2,765 | 3,317 | 3,317 | $72 |
| Contract with City of Sugar Land[1] | $4,982,927 | na | - | 1,027 | 2,947 | 3,616 | 3,875 | 4,756 | na |
| Contract with CLCND[1] | $30,827,919 | $1,383 | - | 1,691 | 1,978 | 2,235 | 2,511 | 2,804 | $635 |
| Contract with Dow[1] | $155,206,615 | $745 | - | 21,800 | 21,800 | 21,800 | 21,800 | 21,800 | $646 |
| Contract with Fort Bend County WCID #2[1] | $2,049,847 | $233 | - | 491 | 1,092 | 1,092 | 1,092 | 1,092 | $49 |
| Contract with GCWA[1] | $144,117,128 | na | - | 135 | 54,513 | 58,116 | 60,587 | 65,213 | na |
| Contract with NCWA[1] | $3,632,614 | $55 | - | - | 2,088 | 3,078 | 3,852 | 3,852 | $84 |
| Contract with NFBWA[1] | $44,964,481 | $176 | - | 444 | 13,085 | 27,315 | 38,155 | 38,155 | $85 |
| Contract with NRG Energy[1] | $0 | na | - | - | - | - | - | 8,500 | na |
| Contract with SJRA[1] | $43,842,177 | na | - | - | - | 7,935 | 39,096 | 76,476 | na |
| Contract with WHCRWA[1] | $44,753,636 | $90 | - | 31,837 | 46,324 | 40,241 | 43,031 | 38,961 | $55 |
| Fort Bend County WCID #2 Groundwater Reduction Plan[1] | $24,828,857 | $571 | - | 2,296 | 5,753 | 5,753 | 5,753 | 5,753 | $200 |
| GCWA to City of Galveston contract[1] | $0 | na | - | 7,262 | 7,262 | 7,262 | 7,262 | 7,262 | na |
| GCWA to City of Missouri City contract[1] | $0 | na | - | 713 | 6,330 | 10,661 | 10,911 | 15,435 | na |
| GCWA to Fort Bend County WCID #2 contract[1] | $0 | na | - | 491 | 1,092 | 1,092 | 1,092 | 1,092 | na |
| GCWA to Galveston County WCID #1 contract[1] | $0 | na | - | 766 | 909 | 940 | 975 | 1,014 | na |
| Harris County MUD #50 water treatment plant[1] | $6,131,600 | $1,382 | 560 | 560 | 560 | 560 | 588 | 632 | $427 |
| Lake Livingston Water Supply and Sewer Service Corporation surface water project[1] | $3,087,974 | $561 | 954 | 954 | 954 | 954 | 954 | 954 | $279 |
| Luce Bayou transfer[1] | $253,916,914 | $248 | - | 128,259 | 206,276 | 207,629 | 205,171 | 270,742 | $36 |
| NFBWA Groundwater Reduction Plan[1] | $0 | na | 35,009 | 61,021 | 70,363 | 84,943 | 96,103 | 106,402 | na |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| NFBWA internal distribution[1] | $225,000,000 | $184 | 35,009 | 61,021 | 70,363 | 84,943 | 96,103 | 106,402 | $16 |
| NFBWA shared transmission line[1] | $213,000,000 | $56 | - | 21,878 | 39,405 | 52,595 | 62,606 | 71,876 | na |
| NHCRWA Groundwater Reduction Plan[1] | $0 | na | 34,714 | 91,167 | 117,755 | 99,625 | 81,126 | 117,755 | na |
| NHCRWA internal 2010 distribution[1] | $153,149,640 | $429 | 34,714 | 34,714 | 34,714 | 34,714 | 34,714 | 34,714 | $44 |
| NHCRWA internal 2020 distribution[1] | $345,292,192 | $368 | - | 91,167 | 91,167 | 91,167 | 91,167 | 91,167 | $38 |
| NHCRWA internal 2030 distribution[1] | $37,439,584 | $31 | - | - | 117,755 | 117,755 | 117,755 | 117,755 | $3 |
| NHCRWA transmission 2010[1] | $80,690,624 | $226 | 34,714 | 34,714 | 34,714 | 34,714 | 34,714 | 34,714 | $23 |
| NHCRWA transmission 2020[1] | $172,558,512 | $184 | - | 91,167 | 91,167 | 91,167 | 91,167 | 91,167 | $19 |
| NHCRWA transmission 2030[1] | $0 | na | - | - | 117,755 | 117,755 | 117,755 | 117,755 | na |
| Pecan Grove Groundwater Reduction Plan[1] | $15,960,000 | $2,150 | 866 | 866 | 1,731 | 1,731 | 1,731 | 1,731 | $544 |
| SJRA to City of Houston contract[1] | $0 | na | - | - | 1,356 | 5,300 | 3,875 | 2,428 | na |
| SJRA Water Resources Assessment Plan partipation[1] | $128,252,622 | $136 | - | 36,377 | 55,538 | 54,582 | 53,581 | 52,534 | $125 |
| SJRA Water Resources Assessment Plan[1] | $900,000,000 | $1,172 | - | 36,377 | 55,538 | 62,517 | 92,677 | 129,010 | $269 |
| WHCRWA Groundwater Reduction Plan[1] | $0 | na | 21,678 | 52,274 | 66,761 | 73,196 | 75,985 | 78,839 | na |
| WHCRWA internal distribution[1] | $552,472,000 | $607 | 21,678 | 52,274 | 66,761 | 73,196 | 75,985 | 78,839 | $70 |
| WHCRWA transmission line[1] | $290,084,193 | $202 | 21,678 | 52,274 | 66,761 | 73,196 | 75,985 | 78,839 | $37 |
| ***Region H Subtotal*** | $12,019,061,335 | | 378,759 | 622,426 | 863,980 | 1,040,504 | 1,202,010 | 1,501,180 | |
| **Region I** | | | | | | | | | |
| Angelina County Regional Project | $53,164,000 | $1,577 | - | - | - | 11,210 | 11,210 | 11,210 | $1,164 |
| Expand local surface water supplies | $1,983,800 | $164 | 50 | 150 | 707 | 990 | 1,000 | 1,190 | $78 |
| Fastrill replacement (Region I component)[2] | $0 | na | - | - | - | - | - | 22,400 | na |
| Forest Grove Reservoir project | $26,619,000 | $1,173 | - | - | - | 2,240 | 2,240 | 2,240 | $310 |
| Indirect reuse* | $0 | $33 | - | 2,872 | 2,872 | 2,872 | 2,872 | 2,872 | $33 |
| Infrastructure improvements | $1,000,000 | $97 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | $97 |
| Lake Kurth Regional System | $56,488,600 | $1,233 | 6,800 | 18,400 | 18,400 | 18,400 | 18,400 | 18,400 | $314 |
| Lake Noconiche Regional Supply System | $24,890,050 | $1,686 | - | 800 | 1,200 | 1,200 | 1,700 | 1,700 | $796 |
| Lake Palestine infrastructure | $79,389,250 | $830 | - | - | 16,815 | 16,815 | 16,815 | 16,815 | $418 |
| Municipal conservation | $0 | $579 | 111 | 480 | 811 | 1,085 | 1,381 | 1,701 | $81 |
| New source - Lake Columbia | $231,865,000 | $215 | - | 75,700 | 75,700 | 75,700 | 75,700 | 75,700 | $12 |
| New wells - Carrizo Wilcox Aquifer | $39,623,385 | $332 | 11,787 | 13,493 | 15,656 | 17,006 | 20,433 | 21,403 | $175 |
| New wells - Gulf Coast Aquifer | $6,818,213 | $515 | 804 | 1,992 | 2,199 | 3,033 | 3,038 | 3,043 | $159 |
| New wells - Queen City Aquifer | $5,646,042 | $761 | 137 | 231 | 318 | 455 | 650 | 1,097 | $3,313 |
| New wells - Yegua Jackson Aquifer | $2,581,793 | $253 | 710 | 730 | 971 | 1,110 | 1,302 | 1,376 | $216 |
| Overdraft Carrizo Wilcox Aquifer | $4,209,789 | $49 | 100 | 1,400 | 1,400 | 1,500 | 1,500 | 1,540 | $176 |
| Overdraft Gulf Coast Aquifer | $2,359,067 | $426 | 844 | 996 | 996 | 996 | 1,149 | 1,149 | $236 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| | | | Water Supply Volume (acre-feet/year) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
| Permit amendment - Houston County Lake | $0 | na | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | 3,500 | na |
| Permit amendment for Sam Rayburn Reservoir | $0 | $154 | - | 28,000 | 28,000 | 28,000 | 28,000 | 28,000 | $154 |
| Purchase water from provider (1) | $17,495,246 | $186 | 5,396 | 42,367 | 46,133 | 51,148 | 51,167 | 54,200 | $90 |
| Purchase water from provider (2) | $109,419,358 | $769 | 2,152 | 29,995 | 38,839 | 42,939 | 86,040 | 89,365 | $188 |
| Purchase water from provider (3) | $0 | $978 | 27 | - | - | - | 5,175 | 5,175 | na |
| Reallocation of flood storage (Rayburn) | $0 | $25 | - | - | - | - | 122,000 | 122,000 | $25 |
| Saltwater barrier conjunctive operation with Rayburn/Steinhagen | $2,000,000 | $5 | - | 111,000 | 111,000 | 111,000 | 111,000 | 111,000 | $5 |
| Wholesale customer conservation | $1,400,000 | $2 | 20,000 | 30,000 | 33,000 | 35,000 | 40,000 | 40,000 | $1 |
| Angelina-Neches River Authority Treatment and Distribution System[1] | $35,127,250 | na | - | - | - | - | - | - | na |
| Indirect reuse[1] | $0 | $35 | - | 1,377 | 1,589 | 1,784 | 1,993 | 2,198 | $41 |
| New water treatment plant[1] | $12,387,000 | $560 | - | - | - | - | - | 2,240 | $560 |
| Purchase water from provider (1)[1] | $0 | $651 | 1,080 | 2,508 | 2,633 | 2,908 | 3,308 | 3,708 | $642 |
| Purchase water from provider (2)[1] | $113,947,150 | $586 | 13,350 | 45,201 | 33,051 | 34,351 | 45,751 | 56,251 | $371 |
| Purchase water from provider (3)[1] | $56,415,750 | $955 | - | 10,251 | 10,251 | 10,251 | 10,251 | 10,251 | $475 |
| ***Region I Subtotal*** | **$884,829,743** | | **53,418** | **363,106** | **399,517** | **427,199** | **607,272** | **638,076** | |
| **Region J** | | | | | | | | | |
| Additional groundwater wells | $240,350 | $7 | 222 | 222 | 222 | 222 | 222 | 222 | $7 |
| Conservation: brush management[4] | $3,937,790 | $14 | 10,500 | 10,500 | 10,500 | 10,500 | 10,500 | 10,500 | $14 |
| Conservation: public information | $0 | $234 | 65 | 69 | 71 | 71 | 76 | 77 | $251 |
| Conservation: system water audit and water loss audit | $0 | $43 | 514 | 553 | 570 | 572 | 593 | 604 | $36 |
| Groundwater wells | $247,250 | $7 | 172 | 172 | 172 | 172 | 172 | 172 | $7 |
| Increased water treatment and aquifer storage and recovery capacity | $6,650,000 | $364 | 2,240 | 2,240 | 2,240 | 2,240 | 2,240 | 2,240 | $150 |
| Purchase water from UGRA | $0 | $1,000 | - | - | 3,840 | 3,840 | 3,840 | 5,450 | $1,000 |
| Replace pressure tank | $7,000 | na | - | - | - | - | - | - | na |
| Surface water acquisition, treatment and aquifer storage and recovery | $36,660,000 | $1,620 | - | 1,624 | 1,624 | 2,124 | 2,124 | 2,624 | $518 |
| Surface water storage | $7,050,000 | $581 | - | 1,121 | 1,121 | 1,121 | 1,121 | 1,121 | $581 |
| ***Region J Subtotal*** | **$54,792,390** | | **13,713** | **16,501** | **20,360** | **20,862** | **20,888** | **23,010** | |
| **Region K** | | | | | | | | | |
| Additional municipal conservation | $0 | $548 | - | - | - | 522 | 1,027 | 1,844 | $243 |
| Amend LCRA contract | $0 | $98 | 3,708 | 5,265 | 6,165 | 8,503 | 10,955 | 12,911 | $125 |
| Aquifer storage and recovery | $168,711,000 | $3,802 | - | - | - | 10,000 | 10,000 | 10,000 | $3,802 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Blend brackish surface water in South Texas Project Nuclear Operating Company Reservoir | $0 | na | - | 17,505 | 17,505 | 17,505 | 17,505 | 17,625 | na |
| City of Austin conservation | $0 | $215 | 11,030 | 18,795 | 24,036 | 25,385 | 30,401 | 36,370 | $47 |
| City of Austin direct reuse (municipal and manufacturing) | $302,250,510 | $851 | 5,143 | 13,620 | 22,077 | 30,268 | 36,218 | 40,468 | $851 |
| City of Austin direct reuse (steam-electric) | $302,250,510 | $851 | 2,315 | 3,315 | 7,315 | 8,315 | 12,315 | 13,315 | $851 |
| City of Austin return flows | $0 | na | 46,853 | 45,641 | 49,862 | 62,330 | 64,645 | 74,366 | na |
| Conjunctive use of groundwater - includes overdraft | $0 | na | - | 62,000 | 62,000 | 62,000 | 62,000 | 62,000 | na |
| Development of Carrizo-Wilcox Aquifer | $12,242,071 | $771 | - | 1,687 | 1,687 | 1,687 | 2,662 | 2,933 | $748 |
| Development of Ellenburger-San Saba Aquifer | $5,601,523 | $1,542 | 478 | 478 | 478 | 478 | 519 | 542 | $1,869 |
| Development of Gulf Coast Aquifer | $164,000 | $376 | - | - | - | - | - | 82 | $376 |
| Development of Hickory Aquifer | $4,697,200 | $1,711 | 512 | 488 | 406 | 331 | 261 | 196 | $3,815 |
| Development of new rice varieties | $0 | na | - | 40,800 | 40,800 | 40,800 | 40,800 | 40,800 | na |
| Development of other aquifer | $3,104,788 | $23 | 4,291 | 4,291 | 4,370 | 4,582 | 4,839 | 5,180 | $104 |
| Development of Queen City Aquifer | $4,190,135 | $1,082 | - | - | - | - | - | 580 | $1,082 |
| Development of saline zone of Edwards-Balcones Fault Zone Aquifer | $19,753,964 | $979 | - | 250 | 2,750 | 2,850 | 5,500 | 7,100 | $979 |
| Development of Trinity Aquifer | $4,084,198 | $8,140 | - | - | 75 | 200 | 301 | 400 | $1,657 |
| Downstream return flows | $0 | na | - | - | 460 | 1,836 | 3,443 | 4,590 | na |
| Drought management | $0 | na | 461 | 461 | 461 | 461 | 461 | 1,912 | $38 |
| Enhanced municipal and industrial conservation | $0 | $400 | - | - | 2,000 | 10,000 | 20,000 | 20,000 | $400 |
| Expand supply from South Texas Project Nuclear Operating Company Reservoir | $0 | na | 193 | - | - | - | - | - | na |
| Expansion of Carrizo-Wilcox Aquifer | $16,872,960 | $357 | 4,350 | 5,815 | 8,476 | 9,779 | 12,950 | 12,920 | $484 |
| Expansion of Ellenburger-San Saba Aquifer | $14,482,800 | $1,989 | 681 | 756 | 788 | 1,229 | 1,633 | 2,076 | $1,827 |
| Expansion of Gulf Coast Aquifer | $1,475,140 | $85 | 4,486 | 4,261 | 3,659 | 2,573 | 1,185 | 1,409 | $350 |
| Expansion of Hickory Aquifer | $611,320 | $4,943 | 62 | 62 | 62 | 62 | 62 | 62 | $4,943 |
| Expansion of other aquifer | $1,721,920 | $626 | - | 416 | 777 | 1,366 | 2,017 | 2,814 | $118 |
| Expansion of Queen City Aquifer | $0 | $20 | 98 | 40 | 40 | 31 | 24 | 17 | $20 |
| Expansion of Sparta Aquifer | $0 | $37 | 188 | 208 | 129 | 129 | 129 | 129 | $37 |
| Expansion of Trinity Aquifer | $3,609,180 | $789 | 428 | 431 | 988 | 937 | 1,147 | 1,124 | $745 |
| Expansion of Yegua-Jackson Aquifer | $0 | $37 | - | - | - | - | - | 9 | $37 |
| Firm-up run-of-river with off-channel reservoir - LCRA/SAWS project (Region K Component) | $0 | na | - | - | - | - | - | 47,000 | na |
| Goldthwaite Channel Dam | $1,841,800 | $1,383 | 300 | 300 | 300 | 300 | 300 | 300 | $1,383 |
| House Bill 1437 on-farm conservation | $3,817,897 | $13 | 4,000 | 4,000 | 4,000 | 4,000 | 14,800 | 25,000 | $13 |
| Irrigation district conveyance improvements | $0 | na | - | 65,000 | 65,000 | 65,000 | 65,000 | 65,000 | na |
| LCRA Water Management Plan interruptible water supply | $0 | na | 255,493 | 196,568 | 137,643 | 78,718 | 19,793 | - | na |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Municipal conservation | $0 | $567 | 3,468 | 6,462 | 9,644 | 12,684 | 15,444 | 18,380 | $90 |
| New LCRA contracts | $17,556,000 | $138 | - | 35,564 | 36,782 | 59,422 | 60,177 | 69,910 | $181 |
| On-farm conservation | $0 | na | - | 34,150 | 34,150 | 34,150 | 34,150 | 34,150 | na |
| Purchase water from City of Austin | $2,280,200 | $963 | 1,100 | 1,100 | 1,100 | 1,100 | 1,100 | 1,100 | $963 |
| Purchase water from West Travis County Regional Water Supply | $0 | $138 | 846 | 925 | 989 | 1,015 | 990 | 958 | $138 |
| Reuse by Highland Lakes communities | $15,920,000 | $550 | - | 500 | 2,000 | 5,000 | 5,000 | 5,000 | $550 |
| Temporary drought period use of Gulf Coast Aquifer | $0 | $37 | - | - | - | - | - | 47 | $37 |
| Temporary drought period use of Queen City Aquifer | $0 | $20 | 21 | 10 | - | - | - | - | na |
| Water allocation | $0 | na | 67 | 110 | - | - | - | - | na |
| Water right permit amendment | $0 | na | - | 5,500 | 5,500 | 5,500 | 5,500 | 5,500 | na |
| Water transfer | $0 | na | 11 | 21 | 30 | 37 | 43 | 48 | na |
| House Bill 1437 for Williamson County[1] | $0 | $173 | 126 | 246 | 349 | 426 | 536 | 645 | $173 |
| New LCRA contracts[1] | $0 | $138 | 300 | 300 | 300 | 300 | 300 | 300 | $138 |
| ***Region K Subtotal*** | **$907,239,116** | | **350,583** | **576,795** | **554,504** | **571,085** | **565,296** | **646,167** | |
| **Region L** | | | | | | | | | |
| Aquifer storage and recovery project and phased expansion | $0 | na | 3,800 | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 | na |
| Brackish groundwater desalination (Wilcox Aquifer) | $378,330,000 | $1,245 - $1,823 | - | 12,000 | 28,600 | 35,120 | 40,720 | 42,220 | $465 - $766 |
| Construction of Lavaca River off-channel reservoir diversion project (Region L component) | $85,429,083 | $701 | - | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | $100 |
| CRWA Siesta project | $53,481,000 | $1,421 | - | - | 1,000 | 5,042 | 5,042 | 5,042 | $497 |
| CRWA Wells Ranch project Phase I | $0 | na | 5,200 | 5,200 | 5,200 | 5,200 | 5,200 | 5,200 | na |
| CRWA Wells Ranch project Phase II (including Gonzales County) | $34,910,000 | $725 | 5,800 | 5,800 | 5,800 | 5,800 | 5,800 | 5,800 | $200 |
| Drought management | $0 | na | 41,240 | - | - | - | - | - | na |
| Edwards Aquifer recharge - Type 2 projects | $527,643,000 | $2,005 | - | 13,451 | 13,451 | 13,451 | 13,451 | 21,577 | $340 |
| Edwards transfers | $0 | $454 | 45,896 | 47,479 | 48,931 | 49,870 | 50,855 | 51,875 | na |
| Facilities expansion | $142,282,000 | na | - | - | - | - | - | - | na |
| Firm-up- run-of-river with off-channel reservoir - LCRA/SAWS project (Region L component) | $1,986,684,000 | $2,394 | - | - | 90,000 | 90,000 | 90,000 | 90,000 | $829 |
| GBRA Exelon project | $280,598,000 | $646 | - | 49,126 | 49,126 | 49,126 | 49,126 | 49,126 | $224 |
| GBRA lower basin storage | $33,800,000 | $104 | - | - | 28,369 | 28,369 | 28,369 | 28,369 | $60 |
| GBRA mid basin (surface water) | $546,941,000 | $1,879 | - | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | $370 |
| GBRA new appropriation (lower basin) | $246,849,000 | $1,910 | - | - | 11,300 | 11,300 | 11,300 | 11,300 | $223 |
| GBRA Simsboro project (overdraft) | $330,782,000 | $982 | - | 30,000 | 30,000 | 30,000 | 49,777 | 49,777 | $386 |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Hays/Caldwell Public Utility Authority Project (including Gonzales County) | $307,717,752 | $1,245 | - | 7,289 | 14,597 | 19,418 | 25,868 | 33,314 | $439 |
| Industrial, steam-electric power generation, and mining water conservation | $0 | na | 521 | 726 | 1,771 | 1,992 | 2,293 | 2,493 | na |
| Irrigation water conservation | $0 | $143 | 20,087 | 17,561 | 14,429 | 11,421 | 8,543 | 7,238 | $136 |
| Livestock water conservation | $0 | na | 3 | 1 | - | - | - | - | na |
| Local groundwater (Gulf Coast Aquifer) | $2,194,000 | $1,823 | - | - | - | 161 | 161 | 161 | $637 |
| Local groundwater (Trinity Aquifer) | $30,224,000 | $644 | 2,016 | 3,145 | 3,468 | 3,629 | 3,952 | 4,436 | $440 |
| Local groundwater Carrizo-Wilcox Aquifer (includes overdrafts) | $166,718,000 | $577 | 6,773 | 11,610 | 15,441 | 17,256 | 23,946 | 33,874 | $464 |
| Medina Lake firm-up (aquifer storage and recovery) | $146,237,000 | $1,696 | 9,933 | 9,933 | 9,933 | 9,933 | 9,933 | 9,933 | $450 |
| Municipal water conservation | $0 | $648 | 13,232 | 22,744 | 31,618 | 40,531 | 53,925 | 72,566 | $572 |
| Purchase from New Braunfels Utilities/redistribution of supplies | $0 | varies | 1,443 | 552 | 552 | 552 | 552 | 552 | varies |
| Purchase from wholesale water provider (GBRA) | $0 | varies | 8,940 | 4,805 | - | - | - | - | na |
| Purchase from wholesale water provider (LNRA)/redistribution of supplies | $0 | varies | 46 | 145 | 322 | 499 | 489 | 489 | varies |
| Purchase from wholesale water provider (SSLGC)/redistribution of supplies | $0 | varies | 581 | 719 | 876 | 1,034 | 1,197 | 1,376 | varies |
| Recycled water programs | $465,339,000 | varies | 21,666 | 26,046 | 30,151 | 34,178 | 37,706 | 41,737 | varies |
| Regional Carrizo for SAWS (including Gonzalas County) | $136,550,000 | $1,343 | - | 11,687 | 11,687 | 11,687 | 11,687 | 11,687 | $324 |
| Regional Carrizo for SSLGC project expansion (including Gonzales County) | $28,189,000 | $568 | - | 10,364 | 10,364 | 10,364 | 10,364 | 10,364 | $331 |
| Seawater desalination | $1,293,827,000 | $2,284 | - | - | - | - | - | 84,012 | $2,284 |
| Storage above Canyon Reservoir (aquifer storage and recovery) | $37,326,000 | $1,772 | - | 3,140 | 3,140 | 3,140 | 3,140 | 3,140 | $587 |
| TWA Regional Carrizo (including Gonzales County) | $313,060,000 | $1,523 | - | 27,000 | 27,000 | 27,000 | 27,000 | 27,000 | $512 |
| Western Canyon water treatment plant expansion | $11,727,436 | $315 | - | - | - | - | 5,600 | 5,600 | $315 |
| Wimberley and Woodcreek water supply project | $33,771,000 | $2,429 | 1,120 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 | $4,480 |
| Brackish groundwater desalination (Wilcox Aquifer)[1] | $0 | na | - | - | 3,596 | 3,596 | 9,196 | 9,196 | na |
| CRWA Siesta Project[1] | $0 | na | - | - | 1,000 | 5,042 | 3,711 | 4,211 | na |
| CRWA Wells Ranch Project Phase I[1] | $0 | $725 | 5,200 | 5,200 | 5,200 | 5,200 | 5,200 | 5,200 | $200 |
| CRWA Wells Ranch Project Phase II (including Gonzales County)[1] | $0 | $725 | 1,296 | 4,626 | 5,800 | 5,800 | 5,800 | 5,800 | $200 |
| Edwards transfers[1] | $0 | na | 5,259 | 6,220 | 8,297 | 12,483 | 20,823 | 21,138 | na |
| Facilities expansion[1] | $2,277,000 | na | - | - | - | - | - | - | na |
| GBRA lower basin storage[1] | $0 | na | - | - | 7,786 | 10,755 | 13,416 | 16,391 | na |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| GBRA mid-basin (surface water)[1] | $0 | na | - | 12,855 | 13,554 | 13,988 | 14,424 | 14,794 | na |
| GBRA new appropriation (lower basin)[1] | $0 | na | - | - | - | 81 | 193 | 310 | na |
| GBRA Simsboro project (overdraft)[1] | $0 | na | - | 9,268 | 14,174 | 20,954 | 28,024 | 35,786 | na |
| Hays/Caldwell Public Utility Authority project (including Gonzales County)[1] | $0 | na | - | 1,370 | 7,521 | 5,344 | 5,986 | 7,502 | na |
| Local groundwater (Trinity Aquifer)[1] | $0 | na | 296 | 283 | 403 | 705 | 963 | 1,216 | na |
| Local groundwater Carrizo-Wilcox Aquifer (includes overdrafts)[1] | $0 | na | 120 | 120 | 120 | 120 | 120 | 120 | na |
| Medina Lake firm-up (aquifer strorage and recovery)[1] | $0 | na | 500 | 500 | 500 | 500 | 500 | 500 | na |
| Recycled water programs[1] | $0 | na | 4,240 | 7,367 | 15,127 | 15,127 | 15,127 | 15,127 | na |
| Regional Carrizo for SSLGC project expansion (including Gonzales County)[1] | $0 | $568 | - | 616 | 2,302 | 4,082 | 5,764 | 7,573 | na |
| Storage above Canyon Reservoir (aquifer storage and recovery)[1] | $0 | na | - | 3,140 | 3,140 | 3,140 | 3,140 | 3,140 | na |
| TWA Regional Carrizo (including Gonzales County)[1] | $0 | na | - | 6,828 | 13,717 | 17,591 | 21,556 | 25,575 | na |
| Western Canyon water treatment plant expansion[1] | $0 | $315 | - | - | - | - | - | 650 | $315 |
| Wimberley and Woodcreek water supply project[1] | $0 | na | 1,120 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 | $1,772 |
| ***Region L Subtotal*** | $7,622,886,271 | | 188,297 | 376,003 | 542,606 | 571,553 | 631,476 | 765,738 | |
| **Region M** | | | | | | | | | |
| Acquisition of water rights through contract | $16,263,877 | $724 | 312 | 738 | 1,665 | 2,352 | 3,198 | 4,671 | $430 |
| Acquisition of water rights through purchase | $631,081,709 | $782 | 9,611 | 19,461 | 41,602 | 70,944 | 110,913 | 151,237 | $424 |
| Acquisition of water rights through urbanization | $56,167,089 | $719 | 299 | 3,433 | 6,467 | 9,496 | 12,868 | 16,406 | $430 |
| Advanced water conservation | $22,583,710 | varies | 2,917 | 6,339 | 11,986 | 16,512 | 24,867 | 32,793 | varies |
| Banco Morales Reservoir | $25,790,900 | $9,370 | - | 238 | 238 | 238 | 238 | 238 | $2,542 |
| Brackish water desalination | $267,290,631 | $775 | 56,553 | 63,239 | 67,221 | 73,984 | 86,708 | 92,212 | $468 |
| Brownsville weir and reservoir | $98,411,077 | $585 | - | 20,643 | 20,643 | 20,643 | 20,643 | 23,643 | $183 |
| Expand existing groundwater wells | $27,474,302 | $433 | 3,772 | 8,572 | 17,139 | 20,492 | 22,284 | 24,520 | $254 |
| Irrigation conveyance system conservation | $131,899,803 | $12 | 11,204 | 37,711 | 63,762 | 89,347 | 114,465 | 139,217 | $15 |
| Laredo low water weir | $294,400,000 | na | - | - | - | - | - | - | na |
| Non-potable reuse | $174,944,916 | $466 | 2,417 | 9,891 | 16,425 | 28,087 | 42,938 | 64,116 | $130 |
| On-farm water conservation | $194,569,720 | $315 | 1,622 | 10,419 | 26,299 | 49,073 | 78,550 | 114,619 | $29 |
| Potable reuse | $7,519,850 | $717 | 1,120 | 1,120 | 1,120 | 1,120 | 1,150 | 1,290 | $180 |
| Proposed elevated storage tank and infrastructure improvements for City of Elsa | $8,325,386 | $7,241 | 105 | 105 | 105 | 105 | 105 | 105 | $102 |
| Resaca restoration | $52,000,000 | $5,583 | 877 | 877 | 877 | 877 | 877 | 877 | $2,542 |

# APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| Seawater desalination | $185,940,937 | $1,611 | 125 | 125 | 143 | 6,049 | 6,421 | 7,902 | $1,051 |
| ***Region M Subtotal*** | **$2,194,663,908** | | **90,934** | **182,911** | **275,692** | **389,319** | **526,225** | **673,846** | |
| **Region N** | | | | | | | | | |
| Construction of Lavaca River off-channel reservoir diversion project (Region N component) | $138,753,917 | $1,027 | - | - | - | - | - | 16,242 | $1,027 |
| Garwood Pipeline | $112,798,000 | $685 | - | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 | $402 |
| Gulf Coast Aquifer Supplies | $13,413,000 | $100 - $144 | 1,975 | 2,535 | 11,535 | 11,535 | 13,551 | 13,551 | $24 - $100 |
| Gulf Coast Aquifer Supplies (regional) | $59,245,000 | $853 | - | - | 11,000 | 11,000 | 11,000 | 18,000 | $566 |
| Irrigation water conservation | $0 | $228 | 17 | 52 | 103 | 169 | 248 | 342 | $228 |
| Manufacturing water conservation | $0 | na | 1,260 | 1,418 | 1,576 | 1,734 | 1,892 | 2,050 | na |
| Mining water conservation | $0 | na | 281 | 626 | 998 | 1,410 | 1,863 | 2,343 | na |
| Municipal water conservation | $0 | $423 - $448 | 106 | 353 | 721 | 1,153 | 1,763 | 2,415 | $423 - $448 |
| O.N. Stevens Water Treatment Plant improvements | $31,324,000 | $178 | 42,329 | 40,048 | 38,102 | 36,366 | 34,817 | 32,996 | $146 |
| Off-channel reservoir near Lake Corpus Christi | $300,577,000 | $715 | - | - | 30,340 | 30,340 | 30,340 | 30,340 | $578 |
| Reclaimed wastewater supplies | $0 | $826 | 250 | 250 | 250 | 250 | 250 | 250 | $826 |
| Voluntary redistribution | $0 | $685 - $798 | 736 | 738 | 914 | 1,060 | 2,706 | 2,797 | $685 - $798 |
| ***Region N Subtotal*** | **$656,110,917** | | **46,954** | **81,020** | **130,539** | **130,017** | **133,430** | **156,326** | |
| **Region O** | | | | | | | | | |
| CRMWA Region O local groundwater development | $56,574,000 | $358 | - | - | 15,500 | 14,130 | 12,717 | 11,445 | $412 |
| Irrigation water conservation | $345,824,000 | $63 | 479,466 | 431,517 | 388,366 | 349,528 | 314,577 | 283,118 | $106 |
| Lake Alan Henry Pipeline for the City of Lubbock | $294,329,000 | $1,310 | 21,880 | 21,880 | 21,880 | 21,880 | 21,880 | 21,880 | $1,310 |
| Lake Alan Henry Supply for Lake Alan Henry Water Supply Corporation | $7,334,502 | $3,349 | 270 | 270 | 270 | 270 | 270 | 270 | $3,349 |
| Local groundwater development | $21,438,369 | na | 10,034 | 12,711 | 15,253 | 15,871 | 16,841 | 16,175 | na |
| Lubbock brackish groundwater desalination | $13,167,000 | $663 | - | 3,360 | 3,360 | 3,360 | 3,360 | 3,360 | $663 |
| Lubbock Jim Bertram Lake 7 | $68,288,400 | $451 | - | 17,650 | 17,650 | 17,650 | 17,650 | 17,650 | $451 |
| Lubbock North Fork diversion operation (A) | $153,040,000 | $6,340 | - | 3,675 | 3,675 | 3,675 | 3,675 | 3,675 | $6,340 |
| Municipal water conservation | $0 | $668 | 5,809 | 10,583 | 10,729 | 10,264 | 10,206 | 10,424 | $550 |
| Post Reservoir - Delivered to Lake Alan Henry Pipeline | $110,307,000 | $695 | - | - | 25,720 | 25,720 | 25,720 | 25,720 | $695 |
| Reclaimed water - White River Municipal Water District | $38,089,684 | $1,593 | - | 2,240 | 2,240 | 2,240 | 2,240 | 2,240 | $1,593 |
| ***Region O Subtotal*** | **$1,108,391,955** | | **517,459** | **503,886** | **504,643** | **464,588** | **429,136** | **395,957** | |

## APPENDIX A.2. RECOMMENDED WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Recommended Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| **Region P** | | | | | | | | | |
| Conjunctive use of groundwater (temporary overdraft) - Jackson County | $0 | $42 | 5,053 | 5,053 | 5,053 | 5,054 | 5,053 | 5,053 | $42 |
| Conjunctive use of groundwater (temporary overdraft) - Wharton County | $0 | $42 | 62,686 | 62,686 | 62,686 | 62,686 | 62,686 | 62,686 | $42 |
| ***Region P Subtotal*** | $0 | | 67,739 | 67,739 | 67,739 | 67,740 | 67,739 | 67,739 | |

1 - Denotes strategies with supply volumes included in other strategies

2 - Estimated planning costs and water supply associated with this strategy are based on the Neches River Run-of River strategy. This project, however is only one of several water management strategies being considered to meet these 2060 needs, and through action by the Region C Water Planning Group, any of those other strategies may be substituted into the plan to represent the 'Fastrill Reservoir Replacement' strategy. Those other strategies include: additional water conservation, Lake Texoma, Toledo Bend Reservoir, Lake O' the Pines, Lake Livingston, Ogallala groundwater in Roberts County (Region A), Marvin Nichols Reservoir, Lake Columbia, George Parkhouse Reservoir (North), George Parkhouse Reservoir (South), and Oklahoma Water.

3 - Denotes strategies with supply volumes included in Region C Strategies (including supply from Bois D'Arc reservoir)
4 - Supply would not available during drought of record conditions
"na" = not available/applicable

## APPENDIX A.3. ALTERNATIVE WATER MANAGEMENT STRATEGIES AND COST ESTIMATES

| Alternative Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| **Region A** | | | | | | | | | |
| Palo Duro Reservoir Transmission System | $107,839,700 | $2,891 | 0 | 0 | 3,758 | 3,758 | 3,758 | 3,750 | $390 |
| Precipitation enhancement | $0 | $6 | 0 | 87,558 | 87,558 | 87,558 | 87,558 | 87,558 | $6 |
| Voluntary transfers from other users | $3,116,400 | $1,870 | 0 | 0 | 300 | 500 | 800 | 1,000 | $871 |
| **Region B** | | | | | | | | | |
| Develop Trinity Aquifer supplies | $1,650,000 | $1,200 | 171 | 171 | 171 | 171 | 171 | 171 | $357 |
| Develop Trinity Aquifer supplies (including overdrafting) | $654,000 | $446 | 177 | 177 | 177 | 177 | 177 | 177 | $125 |
| Purchase water from local provider (alternative 1) | $364,500 | $1,200 | 584 | 584 | 584 | 584 | 584 | 584 | $1,145 |
| Purchase water from local provider (alternative 2) | $239,671 | $1,200 | 384 | 384 | 384 | 384 | 384 | 384 | $1,145 |
| Purchase water from local provider (alternative 3) | $848,000 | $3,050 | 40 | 40 | 40 | 40 | 40 | 40 | $1,200 |
| Wastewater reuse | $57,100,000 | $770 | 0 | 0 | 0 | 11,000 | 11,000 | 11,000 | $317 |
| **Region C** | | | | | | | | | |
| Brazos groundwater project to DWU | $801,451,000 | $1,222 | 0 | 0 | 0 | 100,000 | 100,000 | 100,000 | $1,222 |
| Brazos groundwater project to NTMWD | $913,344,000 | $1,416 | 0 | 0 | 100,000 | 100,000 | 100,000 | 100,000 | $752 |
| Cooke County project | $3,254,000 | $2,110 | 0 | 200 | 200 | 200 | 200 | 200 | $930 |
| Indirect reuse | $195,183,000 | na | 0 | 0 | 26,000 | 26,000 | 26,000 | 26,000 | $380 |
| Lake Columbia to DWU | $179,945,000 | $536 | 0 | 0 | 0 | 35,800 | 35,800 | 35,800 | $536 |
| Lake George Parkhouse North for DWU | $521,281,000 | $4,650 | 0 | 0 | 0 | 112,100 | 112,100 | 112,100 | $4,650 |
| Lake George Parkhouse North for NTMWD | $1,029,185,000 | $580 | 0 | 0 | 203,960 | 203,960 | 203,960 | 203,960 | $156 |
| Lake George Parkhouse South for DWU | $692,921,000 | $568 | 0 | 0 | 0 | 115,260 | 115,260 | 115,260 | $568 |
| Lake George Parkhouse South for NTMWD | $1,282,503,000 | $758 | 0 | 0 | 193,480 | 193,480 | 193,480 | 193,480 | $177 |
| Lake Livingston to DWU | $1,855,538,000 | $982 | 0 | 0 | 0 | 200,000 | 200,000 | 200,000 | $982 |
| Lake Livingston to NTMWD | $2,115,111,000 | $1,103 | 0 | 200,000 | 200,000 | 200,000 | 200,000 | 200,000 | $334 |
| Lake Livingston to TRWD | $2,084,210,000 | $1,120 | 0 | 0 | 200,000 | 200,000 | 200,000 | 200,000 | $363 |
| Lake O' the Pines to DWU | $541,534,000 | $705 | 0 | 0 | 0 | 89,600 | 89,600 | 89,600 | $705 |
| Lake O' the Pines to NTMWD | $402,431,000 | $576 | 0 | 0 | 87,900 | 87,900 | 87,900 | 87,900 | $244 |
| Lake Ralph Hall | $143,201,000 | $847 | 0 | 0 | 29,219 | 29,219 | 29,219 | 29,219 | $135 |
| Lake Tehuacana | $746,345,000 | $1,118 | 0 | 0 | 56,800 | 56,800 | 56,800 | 56,800 | $163 |
| Lake Texoma - authorized (desalinate) | $796,532,000 | $994 | 0 | 105,000 | 105,000 | 105,000 | 105,000 | 105,000 | $443 |
| Lake Texoma - not authorized (blend) | $673,749,300 | $463 | 0 | 8,400 | 146,400 | 146,400 | 146,400 | 146,400 | $112 |
| Lake Texoma - not authorized (desalinate) | $925,918,000 | $1,099 | 0 | 0 | 105,000 | 105,000 | 105,000 | 105,000 | $459 |
| Lake Texoma to DWU (blend) | $56,334,000 | $306 | 0 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | $101 |
| Marvin Nichols Reservoir with DWU | $322,326,000 | $455 | 0 | 0 | 50,000 | 50,000 | 50,000 | 50,000 | $127 |
| New wells - other aquifer | $7,000,000 | $219 | 0 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 | $106 |

## APPENDIX A.3. ALTERNATIVE WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Alternative Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| NTMWD interim purchase from DWU (alternative strategies) | $1,777,000 | $464 | 0 | 11,200 | 11,200 | 0 | 0 | 0 | na |
| Oklahoma water to DWU | $343,934,000 | $702 | 0 | 0 | 0 | 0 | 0 | 50,000 | $702 |
| Purchase water from local provider (alternative 1) | $20,133,000 | $1,084 | 0 | 0 | 6,726 | 6,726 | 6,726 | 6,726 | $866 |
| Roberts County project to DWU | $2,435,534,000 | $1,109 | 0 | 0 | 0 | 200,000 | 200,000 | 200,000 | $1,109 |
| Roberts County project to NTMWD | $2,434,529,000 | $1,127 | 0 | 200,000 | 200,000 | 200,000 | 200,000 | 200,000 | $243 |
| Toledo Bend Project | $1,433,774,000 | $813 | 0 | 0 | 0 | 0 | 200,000 | 200,000 | $813 |
| Water treatment plant - expansion | $14,548,000 | na | 0 | 0 | 0 | 0 | 0 | 0 | na |
| Water treatment plant - new | $17,000,000 | $259 | 0 | 8,960 | 8,960 | 8,960 | 8,960 | 8,960 | $121 |
| Water treatment plant - new (alternative strategies) | $48,972,000 | $1,204 | 0 | 0 | 6,726 | 6,726 | 6,726 | 6,726 | $675 |
| Wright Patman - reallocation of flood pool NTMWD | $1,433,524,000 | $797 | 0 | 0 | 230,000 | 230,000 | 230,000 | 230,000 | $227 |
| Wright Patman - reallocation of flood pool TRWD (180K) | $1,694,140,000 | $954 | 0 | 0 | 180,000 | 180,000 | 180,000 | 180,000 | $270 |
| Wright Patman - Texarkana sale to NTMWD | $1,192,489,000 | $1,090 | 0 | 0 | 150,000 | 150,000 | 150,000 | 150,000 | $390 |
| Wright Patman - Texarkana sale to TRWD | $1,081,475,000 | $1,167 | 0 | 0 | 100,000 | 100,000 | 100,000 | 100,000 | $382 |
| Wright Patman system operation | $2,954,940,000 | $1,057 | 0 | 0 | 298,000 | 298,000 | 298,000 | 298,000 | $337 |
| Marvin Nichols Reservoir with DWU[1] | $634,154,000 | $661 | 0 | 0 | 95,931 | 95,931 | 95,931 | 95,931 | $181 |
| Wright Patman system operation[1] | $403,387,000 | $2,023 | 0 | 0 | 50,000 | 50,000 | 50,000 | 50,000 | $582 |
| **Region D** | | | | | | | | | |
| Alternative Grand Saline Reservoir | $54,613,652 | $225,204 | 0 | 0 | 29 | 57 | 104 | 161 | $11,402 |
| Alternative reuse City of Canton | $3,761,806 | $18,397 | 0 | 0 | 29 | 57 | 104 | 161 | $1,617 |
| **Region F** | | | | | | | | | |
| Advanced treatment | $78,000 | $664 | 113 | 113 | 113 | 113 | 113 | 113 | $566 |
| Steam-electric alternative generation technology | $626,502,088 | $1,032 - $1,660 | 4,077 | 5,524 | 8,533 | 12,210 | 17,468 | 24,306 | $1,962 |
| Aquifer storage recovery | $1,752,000 | $1,271 | 240 | 240 | 240 | 240 | 240 | 240 | $633 |
| Bottled water program | $176,000 | $24,522 | 1 | 1 | 1 | 1 | 1 | 1 | $24,522 |
| Desalination | $14,494,000 | $1,740 - $1,879 | 500 | 850 | 850 | 850 | 850 | 850 | $314 - $349 |
| Develop Edwards Trinity Aquifer supplies | $57,062,000 | $660 - $1,080 | 1,000 | 1,000 | 1,000 | 13,000 | 13,000 | 13,000 | $288 - $311 |
| Develop other aquifer supplies | $287,925,000 | $2,060 - $2,643 | 150 | 650 | 650 | 12,650 | 12,650 | 12,650 | $173 - $626 |
| New/renew water supply - new infrastructure | $6,795,000 | $3,361 | 220 | 220 | 220 | 220 | 220 | 220 | $670 |
| Off-channel reservoir | $25,273,000 | $4,430 | 500 | 500 | 500 | 500 | 500 | 500 | $758 |
| Reuse | $2,567,000 | $1,473 | 0 | 220 | 220 | 220 | 220 | 220 | $455 |

## APPENDIX A.3. ALTERNATIVE WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Alternative Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| **Region G** | | | | | | | | | |
| Additional Carrizo Aquifer development (includes overdrafting) | $212,042,000 | $842 | 0 | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 | $314 |
| BRA system operations permit | $14,086,000 | $943 | 0 | 1,530 | 1,530 | 1,530 | 1,530 | 1,530 | $140 |
| Interconnection from Abilene to Sweetwater | $46,964,000 | $2,365 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | $1,342 |
| Lake Aquilla Augmentation | $64,749,000 | $552 | 0 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | $232 |
| Lake Palo Pinto off-channel reservoir | $25,399,000 | $804 | 0 | 3,110 | 3,110 | 3,110 | 3,110 | 3,110 | $92 |
| Possum Kingdom supply[1] | $189,947,000 | $2,077 | 0 | 12,400 | 12,400 | 12,400 | 12,400 | 12,400 | $741 |
| **Region H** | | | | | | | | | |
| Little River Reservoir, off-channel | $137,356,000 | $436 | 0 | 0 | 27,225 | 27,225 | 27,225 | 27,225 | $317 |
| Montgomery MUD 8 and 9 brackish desalination | $12,000,000 | $1,171 | 2,240 | 2,240 | 2,240 | 2,240 | 2,240 | 2,240 | $1,171 |
| Sabine to Region H transfer | $760,813,320 | $203 | 0 | 0 | 486,500 | 486,500 | 486,500 | 486,500 | $67 |
| **Region I** | | | | | | | | | |
| New wells - Carrizo-Wilcox Aquifer | $299,452 | $285 | 0 | 0 | 0 | 212 | 212 | 212 | $162 |
| Purchase water from provider (1) | $1,021,000 | $1,482 | 100 | 100 | 100 | 100 | 100 | 100 | $592 |
| Purchase water from provider (2) | $1,389,500 | $285 | 700 | 700 | 700 | 700 | 700 | 700 | $112 |
| Purchase water from provider (3) | $114,418,981 | $2,049 | 0 | 0 | 0 | 0 | 5,175 | 5,175 | $2,049 |
| Purchase water from provider (1)[1] | $0 | $1,140 | 0 | 688 | 688 | 688 | 688 | 688 | $1,140 |
| **Region K** | | | | | | | | | |
| Alternative conjunctive use of groundwater - includes overdrafts | $19,483,200 | $964 | 0 | 0 | 0 | 0 | 15,000 | 15,000 | $964 |
| Alternative irrigation division delivery system improvements | $4,944,000 | $39 | 0 | 20,000 | 25,000 | 40,000 | 48,000 | 48,000 | $39 |
| Alternative on-farm conservation | $5,425,000 | $51 | 0 | 20,000 | 20,000 | 35,000 | 35,000 | 35,000 | $51 |
| Desalination of Ellenburger-San Saba Aquifer | $6,285,000 | $3,168 | 0 | 0 | 384 | 384 | 384 | 384 | $3,168 |
| Desalination of Brackish Gulf Coast Aquifer | $177,600,000 | $1,260 | 0 | 0 | 0 | 22,400 | 22,400 | 22,400 | $1,260 |
| Enhanced recharge of groundwater (Gulf Coast Aquifer) | $56,296,000 | $354 | 0 | 0 | 0 | 0 | 17,200 | 17,200 | $354 |
| Expansion of Gulf Coast Aquifer | $0 | $80 | 0 | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 | $80 |
| Groundwater importation | $395,900,000 | $1,330 | 0 | 0 | 0 | 35,000 | 35,000 | 35,000 | $1,330 |
| Off-channel storage in additional reservoirs | $53,388,000 | $345 | 0 | 0 | 30,000 | 40,000 | 40,000 | 40,000 | $345 |

## APPENDIX A.3. ALTERNATIVE WATER MANAGEMENT STRATEGIES AND COST ESTIMATES - CONTINUED

| Alternative Water Management Strategy | Total Capital Costs | First Decade Estimated Annual Average Unit Cost ($/acre-foot/year) | Water Supply Volume (acre-feet/year) 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Year 2060 Estimated Annual Average Unit Cost ($/acre-feet/year) |
|---|---|---|---|---|---|---|---|---|---|
| **Region L** | | | | | | | | | |
| Calhoun County brackish groundwater project | $24,887,000 | $2,679 | 0 | 1,344 | 1,344 | 1,344 | 1,344 | 1,344 | $1,063 |
| GBRA Lower Basin storage (500 acre site) | $77,876,000 | $109 | 0 | 0 | 59,569 | 59,569 | 59,569 | 59,569 | $73 |
| GBRA Mid-Basin project (conjuctive use) | $282,072,000 | $1,779 | 0 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | $425 |
| LGWSP for upstream GBRA needs | $1,003,219,000 | $1,921 | 0 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | $476 |
| LGWSP for upstream GBRA needs at reduced capacity | $750,352,000 | $2,565 | 0 | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 | $726 |
| Local groundwater Carrizo-Wilcox Aquifer (includes overdrafts) | $5,813,000 | $517 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | $99 |
| Local groundwater supply (Barton Springs Edwards) | $4,321,000 | $203 | 0 | 0 | 0 | 1,358 | 1,358 | 1,358 | $84 |
| Medina Lake firm-up (off-channel reservoir) | $121,751,000 | $1,197 | 9,078 | 9,078 | 9,078 | 9,078 | 9,078 | 9,078 | $199 |
| Regional Carrizo for Guadalupe Basin (GBRA) | $239,245,000 | $1,280 | 0 | 25,000 | 25,000 | 25,000 | 25,000 | 25,000 | $454 |
| **Region N** | | | | | | | | | |
| Brackish groundwater desalination | $108,331,000 | $977 | 0 | 0 | 0 | 18,000 | 18,000 | 18,000 | $977 |
| Desalination | $260,914,000 | $1,696 | 0 | 0 | 0 | 28,000 | 28,000 | 28,000 | $1,696 |
| Pipeline from Choke Canyon Reservoir to Lake Corpus Christi | $48,324,000 | $588 | 0 | 0 | 0 | 21,905 | 21,905 | 21,905 | $588 |
| Stage II of Lake Texana/construction of Palmetto Bend Phase II on the Lavaca River | $232,828,000 | $1,213 | 0 | 0 | 0 | 0 | 0 | 12,963 | $1,213 |

[1] Denotes strategies with supply volumes included in other strategies
na = Not available/not applicable

## APPENDIX B. PROJECTED POPULATION OF TEXAS COUNTIES

| County | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| ANDERSON | 59,390 | 62,720 | 65,230 | 67,838 | 69,873 | 71,619 |
| ANDREWS | 14,131 | 15,078 | 15,737 | 16,358 | 16,645 | 16,968 |
| ANGELINA | 91,399 | 104,853 | 120,936 | 140,497 | 165,783 | 197,878 |
| ARANSAS | 26,863 | 30,604 | 32,560 | 32,201 | 30,422 | 28,791 |
| ARCHER | 9,689 | 10,542 | 11,237 | 11,449 | 11,054 | 10,649 |
| ARMSTRONG | 2,171 | 2,240 | 2,163 | 2,074 | 2,053 | 1,994 |
| ATASCOSA | 45,504 | 52,945 | 59,598 | 64,844 | 69,320 | 72,578 |
| AUSTIN | 27,173 | 30,574 | 32,946 | 34,355 | 35,031 | 35,958 |
| BAILEY | 7,060 | 7,558 | 7,875 | 8,207 | 8,238 | 8,086 |
| BANDERA | 26,373 | 37,265 | 48,577 | 54,829 | 56,642 | 60,346 |
| BASTROP | 84,449 | 120,740 | 151,364 | 199,548 | 239,588 | 288,683 |
| BAYLOR | 3,865 | 3,735 | 3,534 | 3,353 | 3,230 | 3,066 |
| BEE | 34,298 | 36,099 | 37,198 | 37,591 | 37,598 | 36,686 |
| BELL | 289,672 | 327,610 | 364,632 | 396,478 | 424,255 | 449,460 |
| BEXAR | 1,631,935 | 1,857,745 | 2,059,112 | 2,222,887 | 2,369,950 | 2,500,731 |
| BLANCO | 9,946 | 11,756 | 13,487 | 15,002 | 16,641 | 18,544 |
| BORDEN | 792 | 820 | 782 | 693 | 644 | 582 |
| BOSQUE | 19,831 | 22,646 | 24,622 | 25,364 | 25,667 | 26,032 |
| BOWIE | 96,953 | 103,397 | 108,397 | 113,397 | 113,397 | 113,397 |
| BRAZORIA | 305,649 | 354,708 | 401,684 | 444,981 | 490,875 | 538,795 |
| BRAZOS | 178,187 | 205,099 | 229,850 | 248,962 | 271,608 | 279,182 |
| BREWSTER | 9,468 | 9,944 | 10,155 | 10,297 | 10,684 | 10,770 |
| BRISCOE | 1,862 | 1,899 | 1,865 | 1,779 | 1,747 | 1,700 |
| BROOKS | 8,607 | 9,303 | 9,909 | 10,288 | 10,399 | 10,349 |
| BROWN | 39,324 | 40,602 | 40,959 | 40,959 | 40,959 | 40,959 |
| BURLESON | 18,477 | 20,663 | 22,249 | 23,465 | 24,358 | 25,146 |
| BURNET | 47,160 | 61,191 | 78,133 | 94,716 | 105,095 | 115,056 |
| CALDWELL | 45,958 | 59,722 | 71,459 | 83,250 | 95,103 | 106,575 |
| CALHOUN | 23,556 | 26,610 | 29,964 | 33,046 | 34,642 | 36,049 |
| CALLAHAN | 12,829 | 12,980 | 12,750 | 12,492 | 12,206 | 11,968 |
| CAMERON | 424,762 | 510,697 | 599,672 | 688,532 | 777,607 | 862,511 |
| CAMP | 12,586 | 13,735 | 14,798 | 15,639 | 16,291 | 17,006 |
| CARSON | 6,541 | 6,610 | 6,557 | 6,345 | 5,767 | 5,237 |
| CASS | 30,990 | 32,240 | 33,490 | 34,740 | 34,740 | 34,740 |
| CASTRO | 9,070 | 9,762 | 10,224 | 10,587 | 10,567 | 10,381 |
| CHAMBERS | 34,282 | 40,786 | 46,838 | 52,083 | 57,402 | 62,850 |
| CHEROKEE | 50,093 | 54,024 | 57,393 | 60,492 | 63,563 | 67,191 |
| CHILDRESS | 7,847 | 7,977 | 8,090 | 8,129 | 8,133 | 7,925 |
| CLAY | 11,376 | 11,699 | 11,628 | 11,147 | 10,462 | 9,778 |
| COCHRAN | 4,086 | 4,338 | 4,449 | 4,375 | 4,193 | 3,989 |
| COKE | 3,748 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 |
| COLEMAN | 9,141 | 9,149 | 9,149 | 9,149 | 9,149 | 9,149 |
| COLLIN | 790,648 | 1,046,601 | 1,265,373 | 1,526,407 | 1,761,082 | 1,938,067 |
| COLLINGSWORTH | 3,134 | 3,139 | 3,029 | 2,880 | 2,767 | 2,578 |
| COLORADO | 21,239 | 22,591 | 23,311 | 23,424 | 23,900 | 24,324 |
| COMAL | 108,219 | 146,868 | 190,873 | 233,964 | 278,626 | 326,655 |
| COMANCHE | 14,273 | 14,721 | 14,860 | 14,816 | 14,503 | 14,045 |
| CONCHO | 4,467 | 4,628 | 4,628 | 4,628 | 4,628 | 4,628 |
| COOKE | 40,674 | 46,141 | 51,749 | 56,973 | 65,099 | 71,328 |
| CORYELL | 87,707 | 102,414 | 116,741 | 126,878 | 135,749 | 142,886 |

## APPENDIX B. PROJECTED POPULATION OF TEXAS COUNTIES - CONTINUED

| County | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| COTTLE | 1,857 | 1,853 | 1,769 | 1,674 | 1,590 | 1,543 |
| CRANE | 4,469 | 4,990 | 5,272 | 5,487 | 5,718 | 5,961 |
| CROCKETT | 4,482 | 4,840 | 4,966 | 5,022 | 5,139 | 5,244 |
| CROSBY | 7,678 | 8,174 | 8,514 | 8,856 | 8,873 | 8,731 |
| CULBERSON | 3,351 | 3,596 | 3,703 | 3,738 | 3,738 | 3,738 |
| DALLAM | 6,851 | 7,387 | 7,724 | 7,808 | 7,645 | 7,291 |
| DALLAS | 2,512,352 | 2,756,079 | 2,950,635 | 3,128,628 | 3,365,780 | 3,695,125 |
| DAWSON | 15,523 | 16,010 | 16,421 | 16,665 | 16,268 | 15,652 |
| DEAF SMITH | 20,533 | 22,685 | 24,568 | 26,152 | 26,716 | 26,911 |
| DELTA | 5,728 | 6,244 | 6,744 | 7,244 | 7,244 | 7,244 |
| DENTON | 674,322 | 889,705 | 1,118,010 | 1,347,185 | 1,573,994 | 1,839,507 |
| DEWITT | 20,460 | 20,964 | 21,251 | 21,341 | 21,021 | 20,648 |
| DICKENS | 2,712 | 2,661 | 2,547 | 2,375 | 2,304 | 2,221 |
| DIMMIT | 10,996 | 11,733 | 12,187 | 12,234 | 11,966 | 11,378 |
| DONLEY | 3,764 | 3,694 | 3,536 | 3,375 | 3,238 | 3,026 |
| DUVAL | 13,881 | 14,528 | 14,882 | 14,976 | 14,567 | 13,819 |
| EASTLAND | 18,336 | 18,382 | 18,061 | 17,566 | 16,989 | 16,226 |
| ECTOR | 132,759 | 144,073 | 154,160 | 163,141 | 170,307 | 177,026 |
| EDWARDS | 2,322 | 2,421 | 2,364 | 2,291 | 2,264 | 2,170 |
| EL PASO | 833,640 | 1,000,651 | 1,141,414 | 1,262,817 | 1,384,220 | 1,505,623 |
| ELLIS | 169,514 | 233,654 | 293,665 | 351,919 | 411,721 | 471,317 |
| ERATH | 36,666 | 40,609 | 44,160 | 47,734 | 57,200 | 63,155 |
| FALLS | 19,600 | 20,884 | 22,196 | 23,350 | 24,267 | 25,346 |
| FANNIN | 38,129 | 42,648 | 49,775 | 60,659 | 74,490 | 86,970 |
| FAYETTE | 24,826 | 28,808 | 32,363 | 35,259 | 38,933 | 44,120 |
| FISHER | 4,264 | 4,259 | 4,097 | 3,972 | 3,910 | 3,717 |
| FLOYD | 8,173 | 8,580 | 8,723 | 8,793 | 8,491 | 8,053 |
| FOARD | 1,614 | 1,630 | 1,584 | 1,507 | 1,457 | 1,384 |
| FORT BEND | 550,121 | 719,737 | 893,875 | 1,090,710 | 1,348,851 | 1,643,825 |
| FRANKLIN | 11,533 | 13,363 | 14,613 | 15,863 | 15,863 | 15,863 |
| FREESTONE | 19,701 | 21,826 | 23,704 | 25,504 | 27,148 | 28,593 |
| FRIO | 18,160 | 20,034 | 21,628 | 22,952 | 23,913 | 24,412 |
| GAINES | 16,130 | 17,663 | 18,774 | 19,560 | 19,434 | 19,169 |
| GALVESTON | 268,714 | 284,731 | 294,218 | 298,057 | 300,915 | 302,774 |
| GARZA | 5,072 | 5,265 | 5,158 | 4,961 | 4,733 | 4,416 |
| GILLESPIE | 25,258 | 29,117 | 30,861 | 30,861 | 30,861 | 30,861 |
| GLASSCOCK | 1,582 | 1,783 | 1,891 | 1,921 | 1,915 | 1,954 |
| GOLIAD | 8,087 | 9,508 | 10,648 | 11,395 | 11,964 | 12,324 |
| GONZALES | 19,872 | 21,227 | 22,260 | 23,003 | 23,219 | 23,151 |
| GRAY | 22,163 | 21,988 | 21,371 | 20,542 | 19,286 | 18,064 |
| GRAYSON | 126,099 | 152,028 | 179,725 | 203,822 | 227,563 | 253,568 |
| GREGG | 118,770 | 126,421 | 134,330 | 143,481 | 155,871 | 173,587 |
| GRIMES | 26,635 | 30,073 | 32,785 | 34,670 | 36,176 | 37,657 |
| GUADALUPE | 114,878 | 146,511 | 180,725 | 214,912 | 252,857 | 293,736 |
| HALE | 39,456 | 42,103 | 44,034 | 45,204 | 44,940 | 44,069 |
| HALL | 3,750 | 3,832 | 3,884 | 3,841 | 3,859 | 3,783 |
| HAMILTON | 7,790 | 7,681 | 7,596 | 7,624 | 7,512 | 7,504 |
| HANSFORD | 5,699 | 6,148 | 6,532 | 6,948 | 7,191 | 7,406 |
| HARDEMAN | 4,665 | 4,626 | 4,496 | 4,329 | 4,144 | 3,792 |
| HARDIN | 54,504 | 59,115 | 61,211 | 63,381 | 65,627 | 67,954 |
| HARRIS | 4,078,231 | 4,629,335 | 5,180,439 | 5,731,543 | 6,282,647 | 6,833,751 |

## APPENDIX B. PROJECTED POPULATION OF TEXAS COUNTIES - CONTINUED

| County | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| HARRISON | 67,547 | 72,930 | 76,824 | 79,759 | 83,191 | 88,241 |
| HARTLEY | 5,697 | 5,889 | 5,989 | 6,026 | 5,950 | 5,646 |
| HASKELL | 5,860 | 5,741 | 5,580 | 5,496 | 5,345 | 5,089 |
| HAYS | 166,342 | 242,051 | 302,795 | 363,678 | 436,388 | 493,320 |
| HEMPHILL | 3,496 | 3,511 | 3,394 | 3,269 | 3,181 | 3,024 |
| HENDERSON | 80,019 | 91,456 | 104,323 | 116,918 | 131,949 | 150,317 |
| HIDALGO | 775,857 | 987,920 | 1,225,227 | 1,481,812 | 1,761,810 | 2,048,911 |
| HILL | 33,416 | 34,947 | 36,679 | 38,407 | 40,252 | 42,300 |
| HOCKLEY | 24,432 | 25,495 | 26,114 | 26,141 | 25,129 | 23,896 |
| HOOD | 49,207 | 58,364 | 66,888 | 75,814 | 87,058 | 100,045 |
| HOPKINS | 35,934 | 39,882 | 42,951 | 45,528 | 45,528 | 45,528 |
| HOUSTON | 23,947 | 24,555 | 25,539 | 26,559 | 27,622 | 28,727 |
| HOWARD | 34,574 | 35,438 | 35,719 | 35,719 | 35,719 | 35,719 |
| HUDSPETH | 3,815 | 4,146 | 4,314 | 4,314 | 4,314 | 4,314 |
| HUNT | 82,948 | 94,401 | 110,672 | 137,371 | 196,757 | 289,645 |
| HUTCHINSON | 24,320 | 24,655 | 24,311 | 23,513 | 22,209 | 21,087 |
| IRION | 1,888 | 1,938 | 1,892 | 1,774 | 1,680 | 1,606 |
| JACK | 9,567 | 10,275 | 10,915 | 11,415 | 11,915 | 12,415 |
| JACKSON | 15,441 | 16,515 | 17,183 | 17,567 | 17,713 | 17,716 |
| JASPER | 38,445 | 40,897 | 42,344 | 42,712 | 42,712 | 42,712 |
| JEFF DAVIS | 2,935 | 3,249 | 3,449 | 3,649 | 3,849 | 4,049 |
| JEFFERSON | 259,700 | 270,686 | 280,590 | 288,225 | 295,924 | 310,478 |
| JIM HOGG | 5,593 | 5,985 | 6,286 | 6,538 | 6,468 | 6,225 |
| JIM WELLS | 42,434 | 45,303 | 47,149 | 47,955 | 47,615 | 46,596 |
| JOHNSON | 159,451 | 200,381 | 238,590 | 268,082 | 304,454 | 346,999 |
| JONES | 21,211 | 21,729 | 21,695 | 21,366 | 20,738 | 19,933 |
| KARNES | 17,001 | 18,830 | 20,759 | 22,305 | 23,256 | 23,774 |
| KAUFMAN | 103,249 | 162,664 | 208,009 | 254,609 | 297,391 | 349,385 |
| KENDALL | 35,720 | 50,283 | 65,752 | 78,690 | 89,312 | 99,698 |
| KENEDY | 467 | 495 | 523 | 527 | 529 | 537 |
| KENT | 840 | 821 | 733 | 602 | 535 | 472 |
| KERR | 49,250 | 54,886 | 57,565 | 58,662 | 61,204 | 62,252 |
| KIMBLE | 4,660 | 4,702 | 4,702 | 4,702 | 4,702 | 4,702 |
| KING | 385 | 424 | 424 | 389 | 369 | 332 |
| KINNEY | 3,403 | 3,462 | 3,529 | 3,601 | 3,653 | 3,662 |
| KLEBERG | 36,959 | 40,849 | 43,370 | 44,989 | 47,118 | 47,212 |
| KNOX | 4,197 | 4,305 | 4,310 | 4,321 | 4,316 | 4,272 |
| LA SALLE | 6,599 | 7,278 | 7,930 | 8,578 | 9,048 | 9,407 |
| LAMAR | 52,525 | 56,536 | 60,286 | 64,036 | 64,036 | 64,036 |
| LAMB | 15,515 | 16,500 | 17,355 | 17,995 | 17,900 | 17,668 |
| LAMPASAS | 20,114 | 22,596 | 24,396 | 25,731 | 26,606 | 27,160 |
| LAVACA | 18,750 | 18,731 | 18,219 | 17,314 | 16,264 | 15,061 |
| LEE | 17,789 | 20,362 | 22,483 | 24,194 | 25,685 | 26,946 |
| LEON | 18,231 | 21,137 | 22,863 | 22,971 | 22,809 | 23,028 |
| LIBERTY | 81,930 | 94,898 | 107,335 | 119,519 | 132,875 | 147,845 |
| LIMESTONE | 23,322 | 24,944 | 25,828 | 26,505 | 27,177 | 28,050 |
| LIPSCOMB | 3,084 | 3,149 | 3,054 | 2,966 | 2,925 | 2,784 |
| LIVE OAK | 13,735 | 14,929 | 15,386 | 15,018 | 13,808 | 12,424 |
| LLANO | 21,284 | 23,007 | 23,471 | 23,932 | 24,393 | 24,855 |
| LOVING | 67 | 67 | 67 | 67 | 67 | 67 |
| LUBBOCK | 265,547 | 280,449 | 289,694 | 294,476 | 299,218 | 303,857 |

## APPENDIX B. PROJECTED POPULATION OF TEXAS COUNTIES - CONTINUED

| County | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| LYNN | 6,969 | 7,280 | 7,243 | 7,216 | 6,891 | 6,413 |
| MADISON | 13,905 | 14,873 | 15,644 | 16,364 | 17,002 | 17,560 |
| MARION | 11,295 | 11,420 | 11,420 | 11,420 | 11,420 | 11,420 |
| MARTIN | 5,203 | 5,696 | 5,935 | 6,082 | 5,934 | 5,633 |
| MASON | 3,817 | 3,856 | 3,876 | 3,886 | 3,891 | 3,896 |
| MATAGORDA | 40,506 | 43,295 | 44,991 | 45,925 | 45,925 | 45,925 |
| MAVERICK | 58,252 | 67,929 | 77,165 | 85,292 | 92,831 | 99,091 |
| MCCULLOCH | 8,235 | 8,377 | 8,377 | 8,377 | 8,377 | 8,377 |
| MCLENNAN | 231,882 | 250,398 | 266,002 | 282,177 | 292,449 | 307,378 |
| MCMULLEN | 920 | 957 | 918 | 866 | 837 | 793 |
| MEDINA | 46,675 | 54,815 | 62,416 | 68,987 | 75,370 | 81,104 |
| MENARD | 2,493 | 2,528 | 2,528 | 2,528 | 2,528 | 2,528 |
| MIDLAND | 124,710 | 134,022 | 140,659 | 145,595 | 148,720 | 151,664 |
| MILAM | 26,053 | 28,086 | 29,396 | 30,201 | 30,405 | 30,496 |
| MILLS | 5,466 | 5,815 | 6,107 | 5,930 | 6,329 | 6,497 |
| MITCHELL | 9,736 | 9,714 | 9,545 | 9,332 | 9,069 | 8,521 |
| MONTAGUE | 19,863 | 20,596 | 20,892 | 21,009 | 21,040 | 21,119 |
| MONTGOMERY | 453,369 | 588,351 | 751,702 | 931,732 | 1,169,199 | 1,444,999 |
| MOORE | 23,049 | 26,241 | 29,057 | 31,293 | 32,655 | 33,474 |
| MORRIS | 13,039 | 13,039 | 13,039 | 13,039 | 13,039 | 13,039 |
| MOTLEY | 1,409 | 1,359 | 1,262 | 1,143 | 1,060 | 1,008 |
| NACOGDOCHES | 67,357 | 75,914 | 84,183 | 92,628 | 108,753 | 124,453 |
| NAVARRO | 52,752 | 58,919 | 65,331 | 72,374 | 80,168 | 89,638 |
| NEWTON | 16,008 | 16,731 | 16,825 | 17,329 | 17,849 | 18,385 |
| NOLAN | 16,550 | 17,177 | 17,464 | 17,412 | 16,747 | 15,954 |
| NUECES | 358,278 | 405,492 | 447,014 | 483,692 | 516,265 | 542,327 |
| OCHILTREE | 9,685 | 10,440 | 11,001 | 11,380 | 11,566 | 11,803 |
| OLDHAM | 2,322 | 2,373 | 2,204 | 1,942 | 1,689 | 1,364 |
| ORANGE | 90,503 | 94,274 | 95,818 | 96,473 | 97,843 | 98,836 |
| PALO PINTO | 28,895 | 31,147 | 33,048 | 34,897 | 37,074 | 39,589 |
| PANOLA | 23,903 | 24,402 | 24,800 | 25,141 | 25,419 | 25,600 |
| PARKER | 121,653 | 193,559 | 262,053 | 301,760 | 324,546 | 342,887 |
| PARMER | 10,641 | 11,302 | 11,585 | 11,666 | 11,301 | 10,674 |
| PECOS | 17,850 | 18,780 | 19,300 | 19,580 | 19,630 | 19,246 |
| POLK | 48,072 | 54,897 | 60,401 | 64,478 | 68,247 | 71,928 |
| POTTER | 127,580 | 142,703 | 156,846 | 172,950 | 190,526 | 204,933 |
| PRESIDIO | 8,825 | 10,184 | 11,508 | 12,421 | 12,872 | 13,130 |
| RAINS | 11,173 | 13,221 | 14,687 | 15,400 | 15,755 | 15,991 |
| RANDALL | 117,420 | 131,546 | 144,757 | 159,800 | 176,218 | 189,811 |
| REAGAN | 3,791 | 4,182 | 4,381 | 4,367 | 4,213 | 4,010 |
| REAL | 3,063 | 3,111 | 3,042 | 2,993 | 3,070 | 3,132 |
| RED RIVER | 14,251 | 14,251 | 14,251 | 14,251 | 14,251 | 14,251 |
| REEVES | 14,281 | 15,451 | 16,417 | 17,219 | 17,949 | 18,527 |
| REFUGIO | 8,217 | 8,505 | 8,609 | 8,799 | 8,915 | 8,877 |
| ROBERTS | 930 | 955 | 857 | 719 | 622 | 561 |
| ROBERTSON | 17,164 | 18,704 | 19,674 | 20,335 | 20,419 | 20,353 |
| ROCKWALL | 89,144 | 141,386 | 171,373 | 199,044 | 215,312 | 232,186 |
| RUNNELS | 11,610 | 12,025 | 12,339 | 12,686 | 12,956 | 13,298 |
| RUSK | 49,874 | 52,241 | 53,585 | 54,255 | 56,120 | 60,705 |
| SABINE | 11,280 | 11,743 | 12,095 | 12,457 | 12,832 | 13,216 |
| SAN AUGUSTINE | 9,715 | 9,911 | 10,164 | 10,470 | 10,785 | 10,999 |

## APPENDIX B. PROJECTED POPULATION OF TEXAS COUNTIES - CONTINUED

| County | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| SAN JACINTO | 27,443 | 32,541 | 36,617 | 39,159 | 40,630 | 41,299 |
| SAN PATRICIO | 80,701 | 95,381 | 109,518 | 122,547 | 134,806 | 146,131 |
| SAN SABA | 6,387 | 6,746 | 7,059 | 7,332 | 7,365 | 7,409 |
| SCHLEICHER | 3,159 | 3,387 | 3,491 | 3,533 | 3,594 | 3,658 |
| SCURRY | 16,998 | 17,602 | 17,923 | 18,092 | 18,203 | 18,203 |
| SHACKELFORD | 3,456 | 3,638 | 3,603 | 3,406 | 2,997 | 2,516 |
| SHELBY | 26,531 | 28,248 | 29,597 | 30,602 | 31,467 | 32,414 |
| SHERMAN | 3,469 | 3,770 | 3,886 | 4,005 | 4,110 | 4,164 |
| SMITH | 194,223 | 208,737 | 223,251 | 237,766 | 262,454 | 295,252 |
| SOMERVELL | 7,542 | 8,393 | 9,094 | 9,554 | 9,740 | 9,804 |
| STARR | 69,379 | 83,583 | 98,262 | 113,102 | 127,802 | 141,961 |
| STEPHENS | 9,873 | 10,030 | 10,102 | 10,005 | 9,624 | 9,321 |
| STERLING | 1,529 | 1,680 | 1,744 | 1,766 | 1,717 | 1,739 |
| STONEWALL | 1,687 | 1,634 | 1,555 | 1,455 | 1,365 | 1,279 |
| SUTTON | 4,479 | 4,737 | 4,780 | 4,762 | 4,773 | 4,725 |
| SWISHER | 8,772 | 9,103 | 9,329 | 9,423 | 9,250 | 8,849 |
| TARRANT | 1,800,069 | 2,061,887 | 2,337,390 | 2,646,559 | 2,964,622 | 3,353,509 |
| TAYLOR | 136,370 | 142,645 | 145,634 | 146,529 | 143,772 | 139,309 |
| TERRELL | 1,156 | 1,200 | 1,200 | 1,200 | 1,200 | 1,200 |
| TERRY | 13,804 | 14,778 | 15,704 | 16,608 | 16,700 | 16,607 |
| THROCKMORTON | 1,851 | 1,793 | 1,713 | 1,584 | 1,483 | 1,407 |
| TITUS | 31,158 | 34,430 | 37,593 | 40,462 | 43,064 | 45,497 |
| TOM GREEN | 112,138 | 118,851 | 123,109 | 125,466 | 127,333 | 127,752 |
| TRAVIS | 1,003,253 | 1,201,256 | 1,402,153 | 1,583,068 | 1,770,347 | 1,918,135 |
| TRINITY | 15,361 | 16,572 | 16,972 | 16,951 | 16,581 | 16,243 |
| TYLER | 24,744 | 28,513 | 30,937 | 31,866 | 31,866 | 31,866 |
| UPSHUR | 38,372 | 41,496 | 43,619 | 44,953 | 46,003 | 47,385 |
| UPTON | 3,757 | 4,068 | 4,185 | 4,278 | 4,400 | 4,518 |
| UVALDE | 28,616 | 31,443 | 33,802 | 35,650 | 36,876 | 37,810 |
| VAL VERDE | 51,312 | 57,500 | 63,265 | 68,175 | 71,761 | 74,348 |
| VAN ZANDT | 55,423 | 63,079 | 69,539 | 74,392 | 80,547 | 87,414 |
| VICTORIA | 93,073 | 102,487 | 110,221 | 116,368 | 121,416 | 125,865 |
| WALKER | 70,672 | 77,915 | 81,402 | 80,547 | 80,737 | 80,737 |
| WALLER | 41,137 | 51,175 | 62,352 | 74,789 | 89,598 | 106,608 |
| WARD | 11,416 | 11,710 | 11,846 | 11,846 | 11,846 | 11,846 |
| WASHINGTON | 32,559 | 35,253 | 36,973 | 37,908 | 38,747 | 39,426 |
| WEBB | 257,647 | 333,451 | 418,332 | 511,710 | 613,774 | 721,586 |
| WHARTON | 43,560 | 46,045 | 47,648 | 48,567 | 48,590 | 48,074 |
| WHEELER | 5,132 | 5,133 | 5,112 | 5,149 | 5,139 | 5,080 |
| WICHITA | 138,058 | 143,805 | 147,606 | 149,595 | 150,981 | 152,102 |
| WILBARGER | 15,279 | 15,928 | 15,993 | 15,672 | 14,908 | 14,027 |
| WILLACY | 22,763 | 25,212 | 27,455 | 29,276 | 30,542 | 31,205 |
| WILLIAMSON | 408,743 | 553,412 | 701,334 | 880,370 | 1,056,891 | 1,240,276 |
| WILSON | 44,078 | 58,621 | 74,641 | 90,187 | 106,373 | 123,135 |
| WINKLER | 7,603 | 7,956 | 8,023 | 8,041 | 7,890 | 7,638 |
| WISE | 66,366 | 89,347 | 108,711 | 127,068 | 148,020 | 170,071 |
| WOOD | 42,727 | 48,200 | 51,236 | 51,565 | 51,565 | 51,565 |
| YOAKUM | 8,183 | 8,966 | 9,470 | 10,006 | 9,738 | 9,408 |
| YOUNG | 18,116 | 18,513 | 18,541 | 18,328 | 18,059 | 17,889 |
| ZAPATA | 14,025 | 16,217 | 18,415 | 20,486 | 22,354 | 23,733 |
| ZAVALA | 12,796 | 14,130 | 15,227 | 16,086 | 16,774 | 17,133 |
| Grand Total | 25,388,403 | 29,650,388 | 33,712,020 | 37,734,422 | 41,924,167 | 46,323,725 |

# APPENDIX C. MAJOR RESERVOIRS OF TEXAS

| Reservoir Name | River Basin | Year of Completion | Year 2010 Firm Yield (acre-feet) from 2011 Regional Water Plans | Original Conservation Pool Capacity (acre-feet) |
|---|---|---|---|---|
| Abilene, Lake | Brazos | 1921 | 1,141 | 7,900 |
| Alan Henry Reservoir | Brazos | 1994 | 22,500 | 115,937 |
| Alcoa Lake | Brazos | 1952 | 14,000 | 15,650 |
| Amistad Reservoir, International | Rio Grande | 1969 | 1,011,976 | 3,505,400 |
| Amon G. Carter, Lake | Trinity | 1956 | 2,107 | 20,050 |
| Anahuac, Lake | Trinity | 1954 | 17,700 | 29,500 |
| Anzalduas Channel Dam | Rio Grande | 1960 | 0 | 13,910 |
| Aquilla Lake | Brazos | 1983 | 13,746 | 52,400 |
| Arlington, Lake | Trinity | 1957 | 9,850 | 45,710 |
| Arrowhead, Lake | Red | 1966 | 26,000 | 262,100 |
| Athens, Lake | Neches | 1963 | 6,064 | 32,790 |
| Austin, Lake | Colorado | 1939 | System Operation | 21,000 |
| B. A. Steinhagen Lake | Neches | 1951 | System Operation | 100,595 |
| Ballinger, Lake / Moonen, Lake | Colorado | 1984 | 30 | 6,850 |
| Balmorhea, Lake | Rio Grande | 1917 | 21,844 | 7,707 |
| Bardwell Lake | Trinity | 1965 | 9,600 | 54,877 |
| Bastrop, Lake | Colorado | 1964 | System Operation | 16,590 |
| Baylor Lake | Red | 1950 | 0 | 9,220 |
| Belton Lake | Brazos | 1954 | 112,257 | 456,884 |
| Benbrook Lake | Trinity | 1950 | 6,833 | 88,250 |
| Bob Sandlin, Lake | Cypress | 1978 | 60,430 | 213,350 |
| Bonham, Lake | Red | 1969 | 5,340 | 11,976 |
| Brady Creek Reservoir | Colorado | 1963 | 0 | 30,430 |
| Brandy Branch Cooling Pond | Sabine | 1983 | 0 | 29,513 |
| Brazoria Reservoir | Brazos | 1954 | Pass-through | 21,970 |
| Bridgeport, Lake | Trinity | 1931 | System Operation | 386,420 |
| Brownwood, Lake | Colorado | 1933 | 47,200 | 149,925 |
| Bryan Utilities Lake | Brazos | 1974 | 85 | 15,227 |
| Buchanan, Lake | Colorado | 1938 | 402,172 | 992,000 |
| Caddo Lake | Cypress | 1968 | 10,000 | 129,000 |
| Calaveras Lake | San Antonio | 1969 | 36,900 | 63,200 |
| Canyon Lake | Guadalupe | 1964 | 87,629 | 386,200 |
| Casa Blanca Lake | Rio Grande | 1951 | 0 | 20,000 |
| Cedar Bayou Generating Pond | Trinity-San Jacinto | 1972 | Cooling | 19,250 |
| Cedar Creek Reservoir Colorado | Colorado | 1977 | System Operation | 74,080 |
| Cedar Creek Reservoir Trinity | Trinity | 1966 | 175,000 | 679,200 |
| Champion Creek Reservoir | Colorado | 1959 | 10 | 42,500 |
| Cherokee, Lake | Sabine | 1948 | 28,885 | 49,295 |
| Choke Canyon Reservoir | Nueces | 1982 | 165,000 | 691,130 |
| Cisco, Lake | Brazos | 1923 | 1,138 | 26,000 |
| Clyde, Lake | Colorado | 1970 | 500 | 5,748 |
| Coleman, Lake | Colorado | 1966 | 5 | 40,000 |
| Coleto Creek Reservoir | Guadalupe | 1980 | 12,500 | 31,040 |
| Colorado City, Lake | Colorado | 1949 | 0 | 31,805 |
| Conroe, Lake | San Jacinto | 1973 | 79,800 | 430,260 |
| Corpus Christi Reservoir, Lake | Nueces | 1958 | System Operation | 308,700 |
| Cox Lake / Raw Water Lake / Recycle Lake | Colorado-Lavaca | 1956 | 0 | 5,034 |
| Crook, Lake | Red | 1923 | 7,290 | 11,487 |

## APPENDIX C. MAJOR RESERVOIRS OF TEXAS - CONTINUED

| Reservoir Name | River Basin | Year of Completion | Year 2010 Firm Yield (acre-feet) from 2011 Regional Water Plans | Original Conservation Pool Capacity (acre-feet) |
|---|---|---|---|---|
| Cypress Springs, Lake | Cypress | 1971 | 10,737 | 72,800 |
| Daniel, Lake | Brazos | 1948 | 230 | 9,515 |
| Davis, Lake | Brazos | 1959 | 220 | 5,454 |
| Delta Lake | Nueces-Rio Grande | 1939 | 0 | 25,000 |
| Diversion, Lake | Red | 1924 | System Operation | 40,000 |
| Dunlap, Lake | Guadalupe | 1928 | Hydropower | 5,900 |
| E. V. Spence Reservoir | Colorado | 1969 | 6,170 | 488,760 |
| Eagle Lake | Colorado | 1900 | System Operation | 9,600 |
| Eagle Mountain Lake | Trinity | 1932 | 109,833 | 189,523 |
| Eagle Nest Lake / Manor Lake | Brazos | 1949 | 1,800 | 18,000 |
| Electra, Lake | Red | 1950 | 462 | 8,730 |
| Ellison Creek Reservoir | Cypress | 1943 | 13,857 | 24,700 |
| Fairfield Lake | Trinity | 1969 | 870 | 50,600 |
| Falcon Reservoir, International | Rio Grande | 1954 | System Operation | 2,830,000 |
| Farmers Creek Reservoir | Red | 1960 | 1,260 | 26,000 |
| Forest Grove Reservoir | Trinity | 1980 | 8,767 | 20,038 |
| Fork Reservoir, Lake | Sabine | 1980 | 173,035 | 675,819 |
| Georgetown, Lake | Brazos | 1982 | 11,803 | 37,080 |
| Gibbons Creek Reservoir | Brazos | 1981 | 9,740 | 28,363 |
| Gilmer, Lake | Cypress | 1999 | 6,180 | 12,720 |
| Gladewater, Lake | Sabine | 1952 | 2,125 | 6,950 |
| Gonzales (H-4), Lake | Guadalupe | 1931 | Hydropower | 6,500 |
| Graham, Lake | Brazos | 1958 | 5,335 | 53,680 |
| Granbury, Lake | Brazos | 1969 | 64,712 | 155,000 |
| Granger Lake | Brazos | 1979 | 18,007 | 56,961 |
| Grapevine Lake | Trinity | 1952 | 19,067 | 188,553 |
| Greenbelt Lake | Red | 1968 | 8,297 | 60,400 |
| Gulf Coast Water Authority Reservoir | San Jacinto-Brazos | 1948 | 0 | 7,308 |
| Halbert, Lake | Trinity | 1921 | 0 | 7,420 |
| Hords Creek Lake | Colorado | 1948 | 0 | 8,640 |
| Houston County Lake | Trinity | 1966 | 3,500 | 19,500 |
| Houston, Lake | San Jacinto | 1954 | 187,000 | 146,769 |
| Hubbard Creek Reservoir | Brazos | 1962 | 27,708 | 317,750 |
| Hubert H. Moss Lake | Red | 1966 | 7,410 | 23,210 |
| Imperial Reservoir | Rio Grande | 1915 | 0 | 6,000 |
| Inks Lake | Colorado | 1938 | System Operation | 17,545 |
| J. B. Thomas, Lake | Colorado | 1952 | 20 | 203,600 |
| Jacksonville, Lake | Neches | 1957 | 6,200 | 30,500 |
| Jim Chapman Lake | Sulphur | 1991 | 127,983 | 310,312 |
| Joe Pool Lake | Trinity | 1991 | 15,192 | 176,900 |
| Johnson Creek Reservoir | Cypress | 1961 | 0 | 10,100 |
| Kemp, Lake | Red | 1923 | 100,983 | 319,600 |
| Kickapoo, Lake | Red | 1945 | 19,800 | 106,000 |
| Kirby, Lake | Brazos | 1928 | 533 | 7,620 |
| Kurth, Lake | Neches | 1961 | 18,421 | 16,200 |
| Lavon Lake | Trinity | 1953 | 112,033 | 456,526 |
| Lake Creek Lake | Brazos | 1952 | 10,000 | 8,400 |
| Lake Fort Phantom Hill | Brazos | 1938 | 11,816 | 74,310 |

## APPENDIX C. MAJOR RESERVOIRS OF TEXAS - CONTINUED

| Reservoir Name | River Basin | Year of Completion | Year 2010 Firm Yield (acre-feet) from 2011 Regional Water Plans | Original Conservation Pool Capacity (acre-feet) |
|---|---|---|---|---|
| Leon, Lake | Brazos | 1954 | 5,938 | 27,290 |
| Lewis Creek Reservoir | San Jacinto | 1969 | 0 | 16,400 |
| Lewisville Lake | Trinity | 1955 | 7,918 | 640,986 |
| Limestone, Lake | Brazos | 1978 | 65,074 | 225,400 |
| Livingston, Lake | Trinity | 1969 | 1,344,000 | 1,750,000 |
| Loma Alta Lake | Nueces-Rio Grande | 1963 | Storage | 26,500 |
| Lost Creek Reservoir | Trinity | 1991 | 1,597 | 11,961 |
| Lyndon B. Johnson, Lake | Colorado | 1951 | System Operation | 138,500 |
| Mackenzie Reservoir | Red | 1974 | 0 | 46,545 |
| Marble Falls, Lake | Colorado | 1951 | System Operation | 8,760 |
| Martin Lake | Sabine | 1974 | 25,000 | 77,619 |
| McQueeney, Lake | Guadalupe | 1928 | Hydropower | 5,000 |
| Medina Lake | San Antonio | 1913 | 0 | 254,000 |
| Meredith, Lake | Canadian | 1965 | 69,750 | 864,400 |
| Mexia, Lake | Brazos | 1961 | 1,320 | 10,000 |
| Millers Creek Reservoir | Brazos | 1974 | 50 | 33,000 |
| Mineral Wells, Lake | Brazos | 1920 | 2,508 | 6,760 |
| Mitchell County Reservoir | Colorado | 1991 | System Operation | 27,266 |
| Monticello Reservoir | Cypress | 1973 | 2,439 | 40,100 |
| Mountain Creek Lake | Trinity | 1936 | 6,400 | 22,840 |
| Mud Lake No. 4 | Colorado-Lavaca | 1974 | 0 | 11,048 |
| Murvaul, Lake | Sabine | 1958 | 21,792 | 45,815 |
| Mustang Lake East/Mustang Lake West | San Jacinto-Brazos | 1969 | 0 | 6,451 |
| Nacogdoches, Lake | Neches | 1977 | 17,067 | 41,140 |
| Nasworthy, Lake | Colorado | 1930 | 0 | 12,390 |
| Navarro Mills Lake | Trinity | 1963 | 19,342 | 63,000 |
| New Terrell City Lake | Trinity | 1955 | 2,283 | 8,712 |
| North Fork Buffalo Creek Reservoir | Red | 1964 | 840 | 15,400 |
| North Lake | Trinity | 1957 | 0 | 17,000 |
| O. C. Fisher Lake | Colorado | 1951 | 0 | 119,200 |
| O. H. Ivie Reservoir | Colorado | 1989 | 85,150 | 554,340 |
| O' the Pines, Lake | Cypress | 1958 | 174,960 | 274,443 |
| Oak Creek Reservoir | Colorado | 1952 | 5 | 39,360 |
| Olney, Lake / Cooper, Lake | Red | 1935 | 960 | 6,650 |
| Palestine, Lake | Neches | 1971 | 207,458 | 411,840 |
| Palo Duro Reservoir | Canadian | 1991 | 3,958 | 61,239 |
| Palo Pinto, Lake | Brazos | 1964 | 9,658 | 44,100 |
| Pat Cleburne, Lake | Brazos | 1964 | 5,075 | 25,560 |
| Pat Mayse Lake | Red | 1967 | 59,670 | 124,500 |
| Pauline, Lake | Red | 1905 | 1,200 | 7,000 |
| Peacock Site 1A Tailings Reservoir | Cypress | 1983 | System Operation | 11,248 |
| Pinkston Reservoir | Neches | 1977 | 3,800 | 7,380 |
| Possum Kingdom Lake | Brazos | 1941 | 230,750 | 724,739 |
| Proctor Lake | Brazos | 1963 | 19,467 | 59,400 |
| Randell Lake | Red | 1909 | 1,400 | 5,400 |
| Ray Hubbard, Lake | Trinity | 1969 | 57,427 | 490,000 |
| Ray Roberts, Lake | Trinity | 1987 | 211,364 | 796,875 |
| Red Bluff Reservoir | Rio Grande | 1936 | 41,725 | 310,000 |

## APPENDIX C. MAJOR RESERVOIRS OF TEXAS - CONTINUED

| Reservoir Name | River Basin | Year of Completion | Year 2010 Firm Yield (acre-feet) from 2011 Regional Water Plans | Original Conservation Pool Capacity (acre-feet) |
|---|---|---|---|---|
| Red Draw Reservoir | Colorado | 1985 | System Operation | 8,538 |
| Richland-Chambers Reservoir | Trinity | 1987 | 223,872 | 1,181,866 |
| River Crest Lake | Sulphur | 1953 | 8,624 | 7,000 |
| Sam Rayburn Reservoir | Neches | 1965 | 820,000 | 2,898,500 |
| Santa Rosa Lake | Red | 1929 | 3,075 | 11,570 |
| Sheldon Reservoir | San Jacinto | 1943 | 0 | 5,420 |
| Smithers Lake | Brazos | 1957 | 34,300 | 18,700 |
| Somerville Lake | Brazos | 1967 | 42,120 | 160,100 |
| South Texas Project Reservoir | Colorado | 1981 | 0 | 202,600 |
| Squaw Creek Reservoir | Brazos | 1977 | 9,238 | 151,008 |
| Stamford, Lake | Brazos | 1953 | 5,667 | 57,632 |
| Stillhouse Hollow Lake | Brazos | 1968 | 66,205 | 235,700 |
| Striker, Lake | Neches | 1957 | 20,183 | 29,000 |
| Sulphur Springs Draw Storage Reservoir | Colorado | 1993 | 0 | 7,997 |
| Sulphur Springs, Lake | Sulphur | 1973 | 9,800 | 14,160 |
| Sweetwater, Lake | Brazos | 1930 | 1,051 | 11,900 |
| Tawakoni, Lake | Sabine | 1960 | 229,807 | 936,200 |
| Texana, Lake | Lavaca | 1981 | 74,500 | 165,918 |
| Texoma, Lake | Red | 1944 | 314,850 | 3,132,000 |
| Toledo Bend Reservoir | Sabine | 1969 | 750,000 | 4,477,000 |
| Tradinghouse Creek Reservoir | Brazos | 1968 | 4,958 | 37,800 |
| Travis, Lake | Colorado | 1942 | System Operation | 1,170,752 |
| Trinidad Lake | Trinity | 1925 | 3,050 | 7,450 |
| Twin Buttes Reservoir | Colorado | 1963 | 0 | 186,200 |
| Twin Oak Reservoir | Brazos | 1982 | 2,892 | 30,319 |
| Tyler, Lake | Neches | 1967 | 30,925 | 80,900 |
| Upper Nueces Lake | Nueces | 1948 | 0 | 7,590 |
| Valley Acres Reservoir | Nueces-Rio Grande | 1947 | 0 | 7,840 |
| Valley Lake | Red | 1961 | 0 | 16,400 |
| Victor Braunig Lake | San Antonio | 1962 | 12,000 | 26,500 |
| Waco, Lake | Brazos | 1965 | 79,098 | 152,500 |
| Wallisville Lake | Trinity | 1999 | System Operation | 58,000 |
| Walter E Long, Lake | Colorado | 1967 | 0 | 33,940 |
| Waxahachie, Lake | Trinity | 1956 | 2,905 | 13,500 |
| Weatherford, Lake | Trinity | 1957 | 2,967 | 21,233 |
| Welsh Reservoir | Cypress | 1975 | 4,476 | 23,587 |
| White River Lake | Brazos | 1963 | 2,431 | 38,650 |
| White Rock Lake | Trinity | 1911 | 3,500 | 10,740 |
| Whitney, Lake | Brazos | 1951 | 18,336 | 627,100 |
| Wichita, Lake | Red | 1901 | System Operation | 14,000 |
| William Harris Reservoir | Brazos | 1947 | 0 | 10,200 |
| Winters, Lake / New Winters, Lake | Colorado | 1983 | 0 | 8,374 |
| Worth, Lake | Trinity | 1914 | System Operation | 37,066 |
| Wright Patman Lake | Sulphur | 1954 | 363,000 | 145,300 |

# APPENDIX C. MAJOR RESERVOIRS OF TEXAS - CONTINUED

| Reservoir Name | River Basin | Year of Completion | Year 2010 Firm Yield (acre-feet) from 2011 Regional Water Plans | Original Conservation Pool Capacity (acre-feet) |
|---|---|---|---|---|
| **Major Reservoirs with no water supply function** | | | | |
| Addicks Reservoir | San Jacinto | 1948 | No water supply function | 200,840 |
| Alders Reservoir | Trinity | 1950s | No water supply function | 7,064 |
| Barker Reservoir | San Jacinto | 1945 | No water supply function | 207,000 |
| Barney M. Davis Reservoir | Nueces-Rio Grande | 1973 | No water supply function | 6,600 |
| Bivins Lake | Red | 1927 | No water supply function | 5,122 |
| Buffalo Lake | Red | 1938 | No water supply function | 18,150 |
| Camp Creek Lake | Brazos | 1949 | No water supply function | 8,550 |
| Coffee Mill Lake | Red | 1938 | No water supply function | 8,000 |
| Hawkins, Lake | Sabine | 1962 | No water supply function | 11,890 |
| Holbrook, Lake | Sabine | 1962 | No water supply function | 7,990 |
| J. D. Murphree Wildlife Impoundment | Neches-Trinity | 1964 | No water supply function | 13,500 |
| Kiowa, Lake | Trinity | 1970 | No water supply function | 7,000 |
| Lower Running Water Draw WS SCS Site 2 Dam | Brazos | 1977 | No water supply function | 5,429 |
| Lower Running Water Draw WS SCS Site 3 Dam | Brazos | 1982 | No water supply function | 8,213 |
| Naconiche, Lake | Neches | 2005 | No water supply function | 15,031 |
| Natural Dam Lake | Colorado | 1989 | No water supply function | 54,560 |
| Quitman, Lake | Sabine | 1962 | No water supply function | 7,440 |
| Rita Blanca, Lake | Canadian | 1939 | No water supply function | 12,100 |
| San Esteban Lake | Rio Grande | 1911 | No water supply function | 18,770 |
| Tailing Ponds | San Antonio-Nueces | 1971 | No water supply function | 6,400 |
| Tailing Ponds No. 2 | San Antonio-Nueces | 1971 | No water supply function | 6,400 |
| Truscott Brine Lake | Red | 1983 | No water supply function | 111,147 |
| Winnsboro, Lake | Sabine | 1962 | No water supply function | 8,100 |
| | | | 9,367,813 | 42,900,519 |

Hydropower: Used to generate hydropower.
Cooling: Used as cooling pond for power plants.
Storage: Used as a water storage facility only.
Pass-through: Temporary storage facility only.
System Operation: Reservoir operated in system operation mode with several reservoirs contributing to one yield number.
(Note: When quantified separately, the sum of individual yields will not equal a system yield.)

Note: The capacity numbers for Amistad, Falcon, Toledo Bend, and Texoma are for total capacity, not Texas' share;
yields are firm as reported by the regional water planning groups and are for the Texas share only.

## AGRICULTURE
### (EIGHT REGIONS: A, B, E, H, J, K, L, AND P)

#### WATER DATA - FIVE REGIONS: A, B, E, J, AND L

- Develop irrigation demand numbers on a regional basis - A
- Provide funding for agricultural water use data collection - B
- Improve accuracy of TWDB historical irrigation pumpage reports - E
- Develop more accurate means of estimating actual irrigation use - J
- Continue supporting evaluations of exotic animal water use to improve demand estimates - J
- Improve accuracy of water use and demand information for irrigation and livestock - L

#### CONSERVATION - FIVE REGIONS: A, H, K, L, AND P

- Create a water conservation reserve program to convert irrigated acreage to dry land - A
- Encourage the federal government to continue to support Conservation Reserve Program participation - A
- Provide funding to expand the High Plains Potential Evapotranspiration network into a statewide network - A
- Fund grants or subsidies to stimulate irrigation conservation practices - H
- Increase funding for TWDB agricultural water conservation programs - H, L
- Collaborate with the Natural Resources Conservation Service state conservationist in identifying projects to fund - K
- Support adequate funding of the Environmental Quality Incentives Program and its water conservation efforts - K
- Support funding of the Natural Resources Conservation Service - K, P
- Leverage federal agricultural conservation grants by providing local matching share - P
- Continue supporting state and federal programs that improve irrigation efficiency and agricultural water conservation - P
- Support adequate funding of State Soil and Water Conservation Board and local soil and conservation districts - P

#### OTHER - THREE REGIONS: K, L, AND P

- Develop water polices that enable agriculture and rural Texas to achieve parity with other users - K
- Provide additional funding to the Irrigation Technology Center at Texas A&M University - L
- Protect groundwater sources for agricultural production - P

## CONJUNCTIVE USE
### FOUR REGIONS: F, G, L, AND N

- Expand definition of conjunctive use - F
- Encourage conceptual modeling for conjunctive use projects - G
- Include conjunctive use projects as management strategies - G
- Develop incentives for conjunctive use projects - L
- Develop policy to manage all water resources on conjunctive use basis - N

## CONSERVATION
### FIFTEEN REGIONS: A, B, C, D, F, G, H, I, J, K, L, M, N, O, AND P

#### REUSE - NINE REGIONS: A, C, F, G, H, I, K, L, AND N

- Encourage Texas Commission on Environmental Quality to evaluate rules governing reuse of wastewater and quantify incentives for its use - A
- Recommend reducing legal obstacles to indirect reuse of treated wastewater - C
- Recommend Texas Commission on Environmental Quality clearly define permitting process for large-scale reuse projects - C

- Encourage legislation for safe and economical water reuse - F
- Work with federal agencies/representatives to develop safe procedures for disposing of reject water - F
- Encourage municipalities to manage return flows through direct and indirect reuse - G
- Encourage river authorities to manage return flows not under others' jurisdictions - G
- Clarify Texas Pollutant Discharge Elimination System after Elimination rules for wastewater permitting to eliminate double-counting of waste loads - H
- Advocate statewide reuse - H
- Resolve permitting issues for indirect reuse, including clarifying Texas Water Code Sections 11.042 and 11.046 - H, I
- Encourage Texas Commission on Environmental Quality to continue thorough review of indirect reuse applications, including environmental and water rights concerns - K
- Fund reuse technologies - L
- Promote water reuse and return flows wherever practical, after evaluating environmental needs - N

### CONSERVATION FUNDING - FOUR REGIONS: F, H, K, AND O

- Fund grants or low-interest loans as incentives to use conservation technologies - F
- Leverage federal conservation grants by providing matching funds - H
- Continue and expand TWDB funding for retail utility water loss projects - K
- Fund conservation incentives for all user groups - O

### WATER CONSERVATION ADVISORY COUNCIL - FOUR REGIONS: A, C, K, AND L

- Adopt definitions and methodology for gallons per capita per day proposed by Water Conservation Advisory Council - A, K
- Maintain the functionality and viability of the Water Conservation Advisory Council - A
- Fund activities of the Water Conservation Advisory Council and a statewide awareness campaign - C, L

### WATER CONSERVATION IMPLEMENTATION TASK FORCE - FOUR REGIONS: C, F, L, AND O

- Follow the Water Conservation Implementation Task Force recommendation to institute voluntary, rather than mandatory, per capita water use goals - C, F
- Fund and implement programs recommended by the Water Conservation Implementation Task Force - L
- Update the 2004 Best Management Practices Guide - O

### VOLUNTARY CONSERVATION - FOUR REGIONS: B, D, F, AND O

- Allow regions to establish voluntary water conservation goals - B, D
- Encourage conservation through technical assistance rather than mandatory goals - F
- Support landowner's voluntary protection of springs and seeps - O

### WATER PROVIDERS - FIVE REGIONS: D, F, G, K, AND M

- Train water utilities to reduce water losses and improve their accountability - D, M
- Encourage retail water providers to use inclining block rate structure - F, G
- Support required use of conservation coordinator by all public water suppliers - K
- Encourage Texas Commission on Environmental Quality to amend 30 Texas Administrative Code Chapter 288 to require designated water conservation coordinators - K

### CONSERVATION MANAGEMENT - FIVE REGIONS: J, K, L, M, AND N

- Develop conservation-oriented management plans for areas particularly susceptible to drought - J

- Encourage legislation to allow water providers to have dedicated funding for longer term water conservation - K
- Encourage legislation to allow property owners' associations to adopt restrictive covenants consistent with their water providers drought and conservation recommendations - K
- Encourage water users to develop and implement conservation plans that meet or exceed legal requirements - L, M
- Encourage municipal providers to develop and implement drought contingency plans that meet or exceed legal requirements - L, M
- Encourage legislation to support conservation strategies that manage water supplies more efficiently - N

### OTHER - TEN REGIONS: A, B, D, F, H, J, K, L, M, AND O

- Evaluate policy barriers to using playa lakes for conservation purposes - A
- Base calculation of gallons per capita per day on residential water use only - B
- Recommend the legislature standardize the measurement of gallons per capita per day - D
- Systems with use greater than 140 gallons per capita per day should perform water audits - D
- Recommends legislature continue to address and improve water conservation in the state - H
- Require conservation on all state-owned lands - J
- Encourage conservation partnerships between water groups - K
- Recommend consideration of drought management as an interim strategy to meet near-term needs - L
- Recommend the state more actively monitor compliance with conservation and drought plans - M
- Recommend conservation and drought plans be consistent with the regional water plan - M
- Regional water planning groups should have a more active role in evaluating conservation and drought plans - M
- Develop a tiered recognition program for conservation achievements - O
- Control aquatic vegetation as water conservation practice - O

## DATA COLLECTION AND RESEARCH

## FOURTEEN REGIONS: A, B, D, E, F, H, I, J, K, L, M, N, O, AND P

### GROUNDWATER AND SURFACE WATER AVAILABILITY MODELING - NINE REGIONS: A, D, E, F, H, J, K, M, AND N

- Fund updates of water availability models - A, M, N
- Continue funding ground-water availability models - D, E, H, J, K, M, N
- Continue water availability modeling for minor Panhandle aquifers - A
- Recommend agencies coordinate with one another and planning groups in developing water availability and groundwater availability models - A
- Fund improvements to groundwater modeling and research in West Texas - E
- Request data from water agencies in Mexico to extend the Presidio Bolson groundwater availability model - E
- Allow more flexibility in the use of water availability models in the planning process - F
- Revise Hill Country Trinity Aquifer ground-water availability model - J
- Fund feasibility study linking groundwater and surface water in next generation of groundwater and water availability models - J, K
- Encourage public and private sector technical review of groundwater and water availability models - K
- Update the Central Gulf Coast Aquifer groundwater availability model - N

## GROUNDWATER STUDIES - EIGHT REGIONS: E, F, J, K, L, N, O, AND P

- Finish study of Presidio Bolson Aquifer - E
- Study and characterize limestone formation in southern Brewster County - E
- Collect groundwater data to carry out Senate Bill 1 and Joint Planning for Groundwater - F
- Continue funding monitoring studies - J
- Study and characterize the Edwards-Trinity (Plateau) Aquifer and associated aquifers - J
- Provide groundwater conservation districts with technical assistance in gathering aquifer data - J
- Study the Frio River alluvium - J
- Study surface water/groundwater interaction in the upper Guadalupe River for springflow analysis - J
- Complete study of Trinity Aquifer use in Hays County and use results in next regional water plan - K
- Encourage legislation requiring economic and environmental studies for any groundwater project - L
- Encourage Railroad Commission of Texas to provide better information for identifying aquifer characteristics - N
- Provide additional funds to expand groundwater data program - N
- Encourage TWDB, Texas Commission on Environmental Quality, and Railroad Commission of Texas to expand and intensify ground-water data gathering and disseminating - N
- Fund computer models that quantify groundwater resources in each aquifer and project future availability based on historical net changes - O
- Continue monitoring static water levels and groundwater pumpage - P

## ENVIRONMENTAL STUDIES - FOUR REGIONS: D, F, H, AND L

- Study mitigation effects as early as possible in reservoir planning - D
- Fund studies to identify and quantify environmental values to be protected and stream flows necessary to maintain priority environmental values - F
- Involve local groups in studies that evaluate streamflow issues - F
- Increase funding for research to determine freshwater inflow needs - H
- Complete the Texas Instream Flow Program - L
- Fund and improve freshwater inflow studies for bays and estuaries - L
- Examine applicability of report by Study Commission on Water for Environmental Flows - L
- Perform studies to evaluate effects of water management strategies on basin ecosystems - L

## AQUIFER RECHARGE - FIVE REGIONS: A, B, J, L, AND O

- Consider the minimal recharge rate in assessments of the Ogallala Aquifer - A
- Study means to improve groundwater recharge - A
- Study the applicability of aquifer recharge programs and their impact to surface water rights - B
- Study quantity of increased groundwater from enhanced recharge structures - B
- Study aquifer recharge with harvested rainwater - J
- Fund research on Edwards (Balcones Fault Zone) Aquifer recharge and recirculation systems water management strategy - L
- Identify and quantify recharge mechanisms for Ogallala Aquifer - O
- Study and describe impact of playas on recharge - O

### AGRICULTURE/RURAL - FIVE REGIONS: E, H, J, L, AND O

- Establish an integrated Rio Grande data management system to better manage irrigation releases and flood control - E
- Provide real time monitoring on the Rio Grande Project delivery system via information systems analysis and hydrologic operations modeling - E
- Fund research on more efficient irrigation practices - H
- Increase funding to research drought-resistant crop species - H, O
- Encourage riparian landowners to implement land stewardship practices - J
- Study impact of transient populations on rural water demand - J
- Undertake economic studies of water management strategies that meet irrigation needs - L

### CONSERVATION - FOUR REGIONS: F, H, K, AND O

- Continue participating in conservation research and demonstration projects - F
- Fund research for advanced conservation technologies - H
- Fund research on developing and implementing conservation goals and successful water management strategies to update the 2004 Best Management Practices Guide - K
- Update the 2004 Best Management Practices Guide - O

### BRUSH CONTROL - THREE REGIONS: D, J, AND K

- Monitor water pollution from Giant Salvinia and research and develop best management practices for its control - D
- Fund multidisciplinary research for defining watersheds with greatest potential for increasing water yields through brush management; quantify costs - J
- Fund voluntary brush control studies - K

### RIVERS - ONE REGION: E

- Study effects of possible rechannelization of Rio Grande below Fort Quitman - E

### GENERAL - ELEVEN REGIONS: A, B, E, F, I, J, K, L, M, N, AND O

- Improve monitoring and quantifying of small communities, manufacturers, livestock operators, and county-other categories - A
- Analyze economic effects of implementing water management strategies - A
- Remove provisions from Open Records Act restricting access to water data on private property - E
- Recommend TWDB meet with regions and consultants to discuss data collection and quality control - F
- Fund study on oral ingestion of radium before enforcing maximum containment load - F
- Fund improved data for next planning cycle - I
- Conduct studies on specific water resource issues - J
- Fund all levels of data collection and analysis - K, L, O
- Fund roles of TWDB and Texas Commission on Environmental Quality in providing data for regional planning - L
- Review the Texas Water Code regarding transfers of water out of groundwater conservation districts and provide sufficient revenue for technical studies - L
- Evaluate the effect of groundwater withdrawals on surface water availability - M
- Evaluate true impact and treaty compliance factors of aqueduct construction from Falcon Reservoir to Matamoros, Mexico - M
- Fund and establish regional research centers at local universities to focus on Coastal Bend water issues - N
- Provide funds to establish and maintain a regional water resources information management system - N

- Recommend TWDB consider local projects when developing mining water demand projections, specifically the Eagle Ford shale - N
- Fund a basic data network that maintains current inventory of surface water and groundwater resources - O
- Develop standardized, comprehensive methodologies for characterizing and computing per capita water use - O

## EDUCATION
## NINE REGIONS: D, F, G, J, K, L, M, N, AND O

### CONSERVATION EDUCATION - EIGHT REGIONS: D, F, G, J, K, L, M, AND O
- Fund and implement conservation education programs for the public - D, F, J, M
- Create and fund a water conservation awareness program through TWDB - G, O
- Fund the Water IQ public education program - K, L
- Supports regional coordination and resource pooling for uniform conservation messaging - K
- Encourage TWDB to assist communities to coordinate on conservation education efforts - K

### GENERAL EDUCATION - FOUR REGIONS: J, K, L, AND O
- Fund education on conservation and about water supplies programs for public sector - J, O
- Fund education on water management and rainwater harvesting programs for private sector - J
- Address sustainability through education - K
- Fund statewide education program and coordinate with Texas Cooperative Extension - L

### AQUATIC WEED CONTROL - ONE REGION: D
- Develop awareness campaign and provide extension and education services to urban and industry stakeholders on giant salvinia threat and mitigation - D

### REGIONAL GROUPS - ONE REGION: N
- Make funds available to planning groups and groundwater conservation districts to educate public on water issues - N

## ENVIRONMENT
## TWELVE REGIONS: A, B, C, D, E, F, G, H, K, L, O, AND P

### UNIQUE STREAM SEGMENTS - FIVE REGIONS: A, B, C, D, AND L
- Clarify intent and uncertainties of unique stream segment designation - A, B, C, D, L
- Examine ancillary issues regarding unique stream segments - C
- Establish a working group on unique stream segments to review legislative intent, agency rules, and impacts of designations - C

### INSTREAM FLOWS - THREE REGIONS: F, G, AND K
- Protect existing water rights when considering instream flows - F
- Oppose adaptive management requirements concerning instream flows - F
- Evaluate return flows to determine impact on instream flows - G
- Provide direction to protect instream/freshwater inflows - K
- Monitor and provide adequate funding for environmental flows - K
- Encourage Colorado and Lavaca Stakeholder Group to develop recommendations protective of long-term ecological productivity - K
- Recommend state evaluate ways to convert existing water rights to environmental uses - K

### RESERVOIRS - TWO REGIONS: D AND P
- Consider environmental and economic impacts of reservoir development - D
- Recommend entities proposing new reservoirs through the planning process include a map of proposed mitigation acreage - D

- Support efforts to mitigate environmental impacts of Palmetto Bend Stage II - P

### OTHER - SEVEN REGIONS:, E, F, G, H, K, L, AND O

- Establish policy to protect aquifers and springs to preserve "the rural way of life" - E
- Support recognition of the importance of springs and spring-fed stream - F
- Encourage responsible land management practices to protect water sources - G, L
- Clarify agency rules on quantitative environmental analysis - H
- Support planning process structure that evaluates environmental needs to determine available water supply - K
- Evaluate land use and ecosystem health in light of sustaining future quality of life - L
- Encourage collaboration of scientists, policy makers, and agricultural representatives in managing threatened species - O

# GROUNDWATER

## FIFTEEN REGIONS: A, C, D, E, F, G, H, I, J, K, L, M, N, O, AND P

### GROUNDWATER CONSERVATION DISTRICTS - TWELVE REGIONS: A, C, F, G, H, I, J, K, L, M, O, AND P

- Manage groundwater resources through local groundwater conservation districts - A, F, G, H, J, K, M, P
- Create or expand groundwater conservation districts in areas not currently served - A, F, I, J, K, M
- Encourage cooperation between groundwater conservation districts - C, F
- Recommend TWDB or Texas Commission on Environmental Quality oversee groundwater districts to standardize regulations - C, F
- Support groundwater conservation districts as local authority on groundwater issues - G, K
- Respect property rights and right to capture when adopting rules and regulations - F
- Base groundwater supply availability on management goals and rules - F
- Restrict export from a district until there is a plan to ensure adequate supplies are available for the district or region - F
- Ensure all state lands are subject to groundwater district rules and limits - F
- Train groundwater conservation districts in use of groundwater availability modeling - J
- Form groundwater conservation districts to administer sound, scientifically based groundwater management objectives - J
- Advocate that groundwater conservation districts consider developing management rules for Edwards (Balcones Fault Zone) Aquifer to sustain spring flows of upper Guadalupe River - J
- Strengthen groundwater conservation districts' abilities to protect groundwater supplies - K
- Encourage TWDB to continue assisting groundwater districts - K
- Support referral of any groundwater district reorganization to the local election process - K
- Recommends groundwater districts manage groundwater as necessary to meet desired future conditions rather than use the Managed Available Groundwater as a permitting cap - K
- Review Texas Water Code to ensure groundwater conservation districts are funded and equipped for comprehensive analysis tasks - L
- Create and operate groundwater conservation districts under Texas Water Code, Chapter 36 - O

### GROUNDWATER MANAGEMENT AREAS - SIX REGIONS: D, E, F, J, K, AND L

- Recommend voting representation for areas without groundwater districts be based upon the areas population, groundwater use, or number of aquifers - D

- Reschedule due dates in the Joint Planning process so Managed Available Groundwater data can be better integrated into the water plans - E, F
- Examine interaction of regional water planning and groundwater management areas processes to improve the resulting economic impacts - J
- Support use of groundwater management area-wide average desired future conditions to expedite establishment of managed available groundwater values - K
- Revise Texas Water Code Chapter 36 to allow groundwater districts to either manage groundwater to achieve the desired future condition or use TWDB-provided managed available groundwater to restrict permitting - K
- Support determinations of Managed Available Groundwater based on Desired Future Conditions Joint Planning process - L

## REGIONAL COLLABORATION - SIX REGIONS: E, F, G, J, K, AND L

- Encourage groundwater conservation districts to collaborate in planning process - E, F, G, K
- Recommend groundwater management councils coordinate efforts with planning groups - E
- Require state lands to abide by ground-water district regulations and submit water withdrawal plans to relevant planning group - F
- Notify planning groups when significant amounts of groundwater are being exported - F
- Assess groundwater availability for regional plans based on groundwater conservation district's goals and requirements - F
- Recommend planning groups J, K, and L collaborate on Trinity Aquifer evaluation - J
- Recommend TWDB-sponsored workshops for regions sharing aquifers - J
- Encourage collaboration between regions sharing aquifers - L

## RULE OF CAPTURE - FIVE REGIONS: F, H, K, O, AND P

- Support rule of capture - F, P
- Maintain rule of capture in areas not subject to defined subsidence or groundwater conservation districts - H, K
- Support rule of capture as modified by rules and regulations of existing ground-water conservation districts - K, O
- Oppose legal recognition of groundwater ownership in place as vested right of surface property owner - K

## OIL AND GAS - FOUR REGIONS: D, F, M, AND N

- Recommend Railroad Commission of Texas review and enforce regulations protecting aquifers from oil well contamination - D, F
- Levy fines for oil and gas producers who violate rules governing aquifer contamination - F
- Support the industry-funded program to plug abandoned wells - F
- Encourage adequate funding for the Railroad Commission of Texas to protect water supplies - F
- Encourage restoring funding to well-plugging account - F
- Appropriate sufficient funds to Railroad Commission of Texas for capping abandoned wells - M, N

## SUSTAINABILITY - THREE REGIONS: G, L, AND P

- Advocate adoption of water management strategies that do not substantially deplete aquifers - G
- Suggest the state continue developing policy that protects historical use and future sustainability - G
- Support management strategies that achieve groundwater sustainability - L
- Support sustainable yield of the Gulf Coast Aquifer as the limit for water development - P
- Recommend sustainable yield as upper limit for all groundwater conservation districts in region - P

### STATE AGENCIES - TWO REGIONS: K AND N

- Encourage funding of TWDB groundwater programs - K
- Expand efforts of TWDB, Texas Commission on Environmental Quality, and Railroad Commission of Texas in managing groundwater - N

### OTHER - THREE REGIONS: F, J, AND L

- Encourage groundwater legislation that is fair to all users - F
- Oppose historical use limits in granting water rights permits - F
- Oppose groundwater fees for wells used exclusively for dewatering - F
- Encourage state to review groundwater resources on state-owned land and determine appropriate management - F
- Standardize groundwater evaluations statewide - J
- Advocate groundwater management based on science, equity, and rationality - L
- Determine water management strategies for Edwards (Balcones Fault Zone) Aquifer during drought of record - L

## INNOVATIVE STRATEGIES

## TWELVE REGIONS: A, B, C, D, E, F, J, K, L, M, N, AND O

### BRUSH CONTROL - NINE REGIONS: A, B, D, F, J, K, L, M, AND O

- Provide funding to implement brush control and land stewardship - B, O
- Encourage funding for new technical resources to combat giant salvinia, saltcedar, and aquatic weeds - D, M
- Request TWDB guidance on including brush control projects as source of new surface water - A
- Support brush control as funding priority - F
- Recommend completing final phase of North Concho River brush control program - F
- Continue funding Twin Buttes brush control project until completed - F
- Fund brush control for region's reservoirs - F
- Give priority funding to land conservation and management practices, including brush and burn management and follow-up grazing - F
- Continue cooperating with federal agencies to secure brush control funds - F
- Fund programs to eradicate nuisance vegetation - J
- Fund a long-term, cost-sharing program for landowners participating in brush management similar to the Natural Resources Conservation Service's Great Plains Conservation Program - J
- Encourage funding for saltcedar eradication and long-term brush management strategies in Rio Grande watershed - J, M
- Fund programs to eradicate saltcedar - J, O
- Provide pro rata funds to landowners for brush control assistance - K
- Fund brush management technologies - L

### DESALINATION - SIX REGIONS: A, C, F, L, M, AND N

- Continue funding salinity control projects in Canadian and Red River basins - A
- Support research to advance desalination and reuse - C
- Provide funding to small communities for desalination projects - C
- Provide funds for desalination - F, L
- Continue funding brackish groundwater projects and seawater desalination demonstration projects - M
- Encourage Texas Commission on Environmental Quality, TWDB, and Texas Parks and Wildlife Department to investigate environmental impacts of seawater desalination discharge and allow it where no damage will occur - N
- Recommend changing regulations governing desalination brine to coincide with those governing petroleum brine - N

### STORMWATER - ONE REGION: E
- Future planning should include stormwater, including aquifer recharge and optimization of surface water resources - E

### WEATHER MODIFICATION - TWO REGIONS: F AND L
- Support funding for researching, evaluating, creating, and operating weather modification programs - F
- Fund weather modification technologies - L

### AQUIFER RECHARGE - TWO REGIONS: J AND L
- Fund recharge structures and provide technical assistance - J
- Fund small aquifer recharge dams - L

### PLAYAS - ONE REGION: O
- Create and preserve native grass buffers to protect playa basins - O

### OTHER - THREE REGIONS: F, J, AND L
- Support state/federal funding for demineralization, reclamation, and aquifer storage and recovery - F
- Encourage and fund rainwater harvesting - J, L
- Increase funds for projects demonstrating alternative water supply strategies - L

## INTERBASIN TRANSFERS
## EIGHT REGIONS: C, D, F, G, H, I, K, AND N

### JUNIOR RIGHTS - THREE REGIONS: F, I, AND N
- Oppose modifying the junior rights provision until basin of origin needs are ensured by reviewing water availability models to determine there are no detrimental impacts - F
- Support legislation to allow junior water rights exemptions from contracts reserving sufficient supply to meet 125 percent of demand in basin of origin - I
- Repeal junior rights provision and additional application requirements for interbasin transfers - N

### BASIN OF ORIGIN - TWO REGIONS: D AND K
- Review the definition of "need" in basin of origin to ensure that needs are met before transfers are permitted - D
- Evaluate compensation to basin of origin - D
- Protect basins of origin in interbasin transfers - K

### OTHER - FOUR REGIONS: C, F, H, AND K
- Recommend that unnecessary, counterproductive barriers to interbasin transfers be removed from Texas Water Code - C, H
- Support interbasin transfers as most efficient method for meeting state water needs - F
- Protect current water rights holders in interbasin transfers - F
- Verify that interbasin transfers are consistent with regional water plans - K
- Complete the Lower Colorado River Authority/ San Antonio Water System study to verify that water transport meets regional water plan guidelines - K

## FUNDING FOR PLAN IMPLEMENTATION
## NINE REGIONS: A, C, E, F, G, H, L, M, AND O
- Fund region-specific water supply strategies - A, E
- Change TWDB regulations to allow Water Infrastructure Funds to be used for acquisition of reservoir sites prior to permitting process - C
- Increase appropriations to the Water Infrastructure Fund - F
- Create statewide mechanism for funding state water plan projects - G, L
- Increase funding of State Participation Program to develop water supply projects meeting long-term demands - H

- Establish financing mechanisms to develop new water supply projects in adopted regional plans - H
- Provide sufficient funding to TWDB and Texas Commission on Environmental Quality for administering state water plan programs - L
- Fund water management strategies identified in regional water plans - M, O

## PROVIDING AND FINANCING WATER AND WASTEWATER SYSTEMS

### SEVEN REGIONS: A, F, H, K, L, M, AND O

#### FEDERAL MONIES - THREE REGIONS: E, H, AND L

- Continue federal and state financial programs for substandard water and wastewater systems (colonia areas) - E
- Investigate opportunities for increased U.S. Army Corps of Engineers funding - H
- Encourage more active state solicitation of federal monies - L

#### STATE FUNDING PROGRAMS - FOUR REGIONS: C, H, I, AND K

- Establish more flexible deferred financing programs for large projects which allow repayment as portions of projects are brought online - C
- Increase funding of the State Loan Program for near-term infrastructure cost projections - H
- Continue state and federal support of Texas Community Development Program - H
- Increase funds for Small Towns Environment Program - H
- Increase funding of Regional Water Supply and Wastewater Facilities Planning Program; expand to include engineering design and cost estimates - H
- Increase future funding of State Revolving Fund to cover system capacity increases - H
- Make State Participation Program available to public/private partnerships and nonprofit water supply corporations - H
- Allow Water Infrastructure Funds to be used for replacement of water supply infrastructure - I
- Increase flexibility in determining categorical exclusions for Environmental Information Documents - I
- Revise Economically Disadvantaged Areas Program requirements to reduce difficult eligibility requirements, including model subdivision planning - I
- Provide low-interest loans and grants to reduce system water loss - K

#### OTHER - SEVEN REGIONS: A, F, H, I, K, M, AND N

- Develop or improve grant and loan programs to replace and repair aging infrastructure - A, I
- Provide grants to small and rural drinking water treatment systems to meet federal drinking water standards - F
- Increase funds for the Galveston Bay and Estuary program - H
- Provide funds for water treatment and radioactive waste disposal threatening rural water supplies - K
- Encourage regionalization of water and wastewater utility service – M
- Fund and support efforts of Groundwater Management Areas – N

## REGIONAL WATER PLANNING

### ALL SIXTEEN REGIONS

#### FUNDING/SUPPORT - ELEVEN REGIONS: B, E, H, I, J, K, L, M, N, O, AND P

- Continue adequate funding of regional water planning process - B, E, H, K, L, M, N, O
- Provide additional state funding for regional planning administrative costs - B, E, J, K,
- Fund technical studies necessary to support the work of the planning groups - H

- Advocate that regions fund administrative costs of planning process - I
- Reimburse planning group members for reasonable expenses - J
- Consider factors other than population in funding the planning process - M
- Request public entities provide their share of funding for regional planning activities - N
- Establish funding for planning groups through TWDB - P

### STATE AGENCIES - SIX REGIONS: C, F, G, J, K, AND M

- Recommend that TWDB and Texas Commission on Environmental Quality collaborate on determining which water availability modeling data to use in regional planning - C, F
- Recommend all state agencies adhere to state water plan - G
- Recommend nonvoting state agencies attend regional planning meetings or relinquish authority to alter adopted plan - J
- Encourage Texas Commission on Environmental Quality to provide technical reviews and draft permits to planning groups to ensure consistency with regional plans - K
- Suggest Texas Commission on Environmental Quality assist Rio Grande area in converting water rights from one use to another - M

### ALTERNATIVE STRATEGIES - FOUR REGIONS: A, D, F, AND I

- Allow small systems to develop alternative near-term scenarios - A
- Allow alternative scenarios in population growth and economic development in determining future water demands - D
- Allow alternative water management strategies in regional plan - F, I

### CONSISTENCY - SIX REGIONS: B, D, E, F, H, AND I

- Recommend waivers for surface water projects that will not significantly impact regional supplies and do not involve new water sources - B
- Recommend TWDB consider entire regional plan when determining consistency - D
- Apply consistent economic principles to water project and strategy evaluation - E
- Allow maximum flexibility in determining consistency with regional plans - F, I
- Recommend Texas Commission on Environmental Quality and TWDB collaborate on consistency determinations and waivers to allow for maximum flexibility - F, I
- Recommend TWDB publish clear criteria for consistency determinations before adopting regional water plans - F
- Recommend waivers for consistency issues for small projects - F
- Clarify rules to address consistency within regional plans - H
- Allow entities smaller than planning criteria that do not have specific needs identified in water plans to be eligible for state funds - I
- Remove willing buyer/seller transactions from consistency requirements - I
- Advocate removing consistency requirements from Senate Bill 1 - I

### WATER DEMAND FIGURES - FIVE REGIONS: D, E, H, J, AND L

- Revise procedure for water demand reductions to recognize areas with low per capita consumption - D
- Allow more time for final demand figures - E
- Recommend more real life analysis of demand figures during drought conditions - E
- Recommend State Demographer explore potential changes in population distribution due to information technology advancements - H
- Develop better methodologies for estimating population and water demand - J

- Modify planning process so that water demand projections allow for regional input - L
- Modify regional planning process to allow for more flexibility in developing growth and water demand methodologies - L

### PLANNING GROUP AUTHORITY - ONE REGION: O

- Oppose legislature empowering planning groups with any regulatory authority - O

### TRAINING - ONE REGION: J

- Provide training for new planning group members - J

### OTHER - TEN REGIONS: A, C, E, F, H, K, L, M, O, AND P

- Clarify relationship between drought contingency planning and regional water supply planning - A
- Include project for future groundwater quality in the region - A
- Ensure eligibility for small cities and entities included as county-other - A
- Allow flexibility in applying water availability models for planning - C, F
- Avoid constraining planning process with technical requirements - E
- Set deadlines for regional plans that avoid legislative sessions - E
- Consider all water resources available to a region including those outside of the state - E
- Recommend rule simplification before next round of planning - F
- Allow planning groups to adopt an existing water plan if there are no significant changes to the recommended water management strategies - F
- Clarify rules on quantitative environmental analysis - H
- Review the administrative provisions of SB1 and subsequent policies to determine if appropriate organizational structure exists - H
- Coordinate regional planning process with Texas Clean Rivers Program - K
- Improve representation of women and minorities on planning groups - K
- Oppose development of new water management strategies to accommodate export of supplies to another county and planning region of state - K
- Oppose use of water availability model Run 3 in regional water planning as being unreasonably restrictive - K
- Include in plan water supplies over and above those required to meet the projected need - L
- Establish contract requirements before grant proposals are submitted - L
- Oppose changes to planning process except through formal rulemaking procedure - L
- Urge prompt and full implementation of these plans - L
- Include wildlife and environmental needs as a category of water use - M
- Recommend shifting to a utility-centric method of planning rather than city-centric - M
- State should consider impacts of climate change on regional water planning and future water supplies - M
- Allow for additional region-specific planning options and forecast scenarios - O
- Review the planning process with a group of stakeholders and identify any revisions to the planning process by the end of 2010 - O
- Support a greater role for inter-regional coordination in future planning - P

## RURAL WATER

### THREE REGIONS: G, H, AND L

- Encourage regionalization, education, and proactive planning of small water systems - G
- Support increased funding of federal Rural Utilities Service programs and funding of the state Rural Water Assistance Fund - H
- Study implications of water export, considering its implications on rural environment and economy - L

## SURFACE WATER
### TEN REGIONS: A, B, C, D, F, G, H, L, M, AND P

#### RESERVOIRS - SIX REGIONS: A, B, D, H, I, AND P

- Recommend TWDB submit reservoir feasibility study plans and results to Compact Commissions - A
- Change definition of water availability in reservoirs to match owner's operational criteria - A
- Include possible reservoir sites and flood control/ aquifer recharge structures in future water plans - A
- Extend designations for unique reservoir sites beyond 2015 - B, I
- Designate Toledo Bend Reservoir as a supply strategy for upper Sabine Basin in Region D and supply option for Region C - D
- Consider potential economic and environmental impacts to reservoir development - D
- Consider raising the level for Lake Wright Patman prior to development of new reservoirs in Region D - D
- Consider development of reservoirs in the Sulphur Basin in Region D as violation of the quantitative evaluations of water management strategies under 31 Texas Administrative Code 357.7(a)(8)(A) and a conflict with the Region D plan - D
- Oppose development of reservoirs in the Sulphur Basin in Region D prior to development of environmental flow standards through Senate Bill 3 process - D
- Establish flood damage liability limits for reservoirs - H
- Develop Lake Texana Stage II as supply strategy - P

#### WATER PERMITS - FOUR REGIONS: C, F, L, AND N

- Encourage TWDB and Texas Commission on Environmental Quality work with U.S. Environmental Protection Agency to revise Section 361(b) regulations on power plant cooling water - C
- Notify all basin water rights holders when a request to amend a water right increases quantity or changes purpose or place of use - F
- Fund Texas Commission on Environmental Quality adequately to ensure appropriate use of permitted surface water rights - L
- Urge Texas Commission on Environmental Quality to enforce existing rules and regulations regarding impoundments - N

#### U.S. ARMY CORPS OF ENGINEERS - FOUR REGIONS: B, D, H, AND I

- Recommend U.S. Army Corps of Engineers transfer flood storage to conservation storage - B
- Recommend the Wetlands Compensatory Mitigation Rule of "avoid, minimize, and compensate" be closely followed - D
- Allow U.S. Army Corps of Engineers to increase water supply storage in new reservoirs - H
- Include TWDB and regional water planning agencies on mitigation bank review teams - I

#### SEDIMENT CONTROL - THREE REGIONS: B, C, AND D

- Support efforts, including land management, to rehabilitate existing sediment control structures and construct new ones - B
- Seek additional federal funding to improve and maintain Natural Resources Conservation Service sediment and flood control structures - C, D

#### UNCOMMITTED WATER - TWO REGIONS: C AND F

- Recommend changing Texas Water Code to exempt from cancellation nonuse associated with developing and managing reservoirs - C
- Oppose canceling uncommitted water contracts/ rights - F

#### WATERMASTER PROGRAM - ONE REGION: M

- Authorize Watermaster Program to manage the Rio Grande water availability model - M
- Direct all appropriate Rio Grande water rights fees to Watermaster operations - M

### OTHER - SIX REGIONS: B, C, F, G, K, AND M

- Recommend all surface water uses, regardless of size, be consistent with regional plan - B
- Continued and increased state support of efforts to develop water supplies in Oklahoma - C
- Review state surface water policy to ensure its appropriateness for next 50 years - F
- Amend state water law to incorporate river basin subordinations in regional water plans - F
- Support long-term contracts for future projects and droughts - F
- Support long-term contracts for reliable water supply planning and shorter-term “interruptible” contracts to meet needs before long-term water rights are fully used - F
- Support coordinated operation of two or more water supply sources - G
- Give priority to water policies that increase surface water availability - K
- Encourage development of an operating plan for Mexican tributary reservoirs that ensures full compliance with 1944 Water Treaty while optimizing supply available to Mexico - M
- Continue considering allocation of Rio Grande Flows upstream of Ft. Quitman for treaty compliance - M

## WATER MARKETING

### FOUR REGIONS: A, F, L, AND P

- Assess potential of transporting water into or out of the Panhandle - A
- Assess potential for transferring groundwater to counties within region - A
- Oppose additional regulations in willing buyer/ willing seller water transactions - F
- Require all water export plans to be submitted to regional planning groups - F
- Recommend legislative review of Water Code to consider changes in light of increasing number of water export proposals - F
- Oppose export of surface water outside of region, except for existing contracts until a comprehensive plan is in place - F
- Allow property owners to capture and market water - F
- Fund development of a standard method for evaluating water export proposals - L
- Clarify that water planning regions are not intended to be barriers to water transport - L
- Consider export fee to offset negative impacts of transferring water out of basin - P
- Allow water transfer out of basin that does not interfere with exempt, existing, or previously permitted wells - P

## WATER QUALITY

### SEVEN REGIONS: A, B, D, F, G, K, AND N

### STANDARDS - THREE REGIONS: B, D, AND F

- Allow flexibility in drinking water standards for small systems, such as use of bottled water programs - B, F
- Recommend TWDB and Texas Commission on Environmental Quality standardize rules for minimum water supply requirements - D
- Recommend that Texas Commission on Environmental Quality revise its policy requiring use of secondary water standards, particularly total dissolved solids, when granting permits - F

### WATER PLANNING - TWO REGIONS: A AND K

- Require Texas Commission on Environmental Quality to attend regional planning meetings and assist with water quality issues - A
- Support integrating water quality into water supply planning - K

### RADIOACTIVE WASTES - TWO REGIONS: F AND K

- Recommend Texas Commission on Environmental Quality develop disposal procedures for the safe handling of radioactive wastes in water treatment process - F, K
- Develop disposal procedures for radioactive wastes threatening water supplies - K

### MINING - ONE REGION: N

- Amend rules to require routine, nonpartisan water quality monitoring of mining operations - N
- Oppose in-situ mining (a process that circulates acidic water through injection and recovery wells to remove minerals) where drinking water will be contaminated - N
- Monitor water quality from mining activities - N

### OTHER - THREE REGIONS: B, D, AND G

- Recognize chloride control project as regional priority - B
- Recommend Texas Commission on Environmental Quality expedite effort to replace methyl tertiary butyl ether in gasoline - D
- Encourage policies and business practices that give priority to water quality - G

## OTHER

### SIX REGIONS: A, J, K, L, M, AND N

- Establish guidelines differentiating between groundwater and surface rights - A
- Recommend basing drought management plans on peak use rather than annual production - J
- New electric generation facilities should utilize the most efficient technologies and conservation practices and assure water is available or can be obtained during the planning and permitting process - K
- Give counties additional authority for regulating land development to protect water resources - L
- Supports providers obtaining land for project through willing buyer-willing seller and using limited condemnation as a last resort - L
- Renew efforts to ensure Mexico's compliance with 1944 Treaty to eliminate water delivery deficits - M
- Amend state laws governing procurement of professional services to allow more flexibility in public works projects - N

# Photo Citations

## COVER

Water tower (Wikimedia Commons)

## EXECUTIVE SUMMARY

Cover: Stream near San Angelo (TWDB)

## CHAPTER 1

Cover: Windmill in Big Bend National Park (TWDB)

## CHAPTER 3

Cover: Corn irrigation near Vick (TWDB)
Last page: Robert Lee Dam morning glory structure, E.V. Spence Reservoir (TWDB)

## CHAPTER 4

Cover: Dry stream near Uvalde (TWDB)

## CHAPTER 5

Cover: Llano dam (TWDB)

## CHAPTER 6

Cover: Sugarcane in the Lower Rio Grande Valley (TWDB)

## CHAPTER 7

Cover: George W. Shannon Wetlands Water Reuse Project (Tarrant Regional Water District)
Last page: Frio River (TWDB)

## CHAPTER 8

Cover: Guadalupe River in Kerrville (TWDB)

## CHAPTER 9

Cover: Trinity Bay area wastewater treatment plant (TWDB)

## CHAPTER 10

Cover: Pedernales Falls (TWDB)

## CHAPTER 11

Cover: Texas Capitol ceiling dome (Istockphoto.com/Suzie Jurado)
Last page: Drought in Gillespie County (TWDB)

## GLOSSARY

Cover: Pedernales Falls (TWDB)

## APPENDICES

Cover: Anzalduas Dam (TWDB)

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