Introduction

Water is not only essential to life, it is essential to our way of life. Moreover, it has no substitute. Without it, our bodies won't function, food crops won't grow, livestock and wildlife won't thrive, electricity can't be generated, and industries and communities can't grow.

The lack of water is costly. Each of the several one- or two-year droughts in Texas in the past decade has cost agricultural producers and businesses impacted by them between $1 billion and $4 billion annually.[1] The infamous eight-year drought in the 1950s, the drought of record against which all droughts in Texas are measured, is estimated to have cost the Texas economy about $3.5 billion in 2008 dollars each year from 1950 to 1957.[2]

In 2002, an agency of the United Nations (U.N.) estimated that 5 billion people in the world would face severe water shortages by 2025 if demand continues at current rates. The resulting effects of these shortages could be crop failure, increased likelihood of disease and, in the extreme, threatened stability of affected governments.[3] While Texas may avoid some of the most severe consequences anticipated by the U.N., water shortages in Texas could still threaten the economy and public health of the Lone Star State.

Historically, more people across the world have lived in rural areas than urban ones, and they depend on more diffuse sources of water. By 2020, however, urban dwellers worldwide will outnumber those living in rural areas.[4] As

Each of the several one- or two-year droughts in Texas in the past decade has cost agricultural producers and businesses impacted by them between $1 billion and $4 billion annually.

Blanco River near Luckenbach, Texas.

people concentrate, so does their need for water, making it increasingly difficult for communities worldwide to provide sufficient amounts of water for their residents.

Texans face the same challenges as the global community. The state's population is expected to nearly double by 2060 and will also become more urban.[5] Total statewide demand for water in Texas is projected to grow 27 percent, from nearly 17 million acre-feet in 2000 to 21.6 million acre-feet in 2060. From 2010 through 2060, water supplies from existing sources are expected to decrease by 18 percent, from 17.9 million acre-feet to 14.6 million acre-feet.[6]

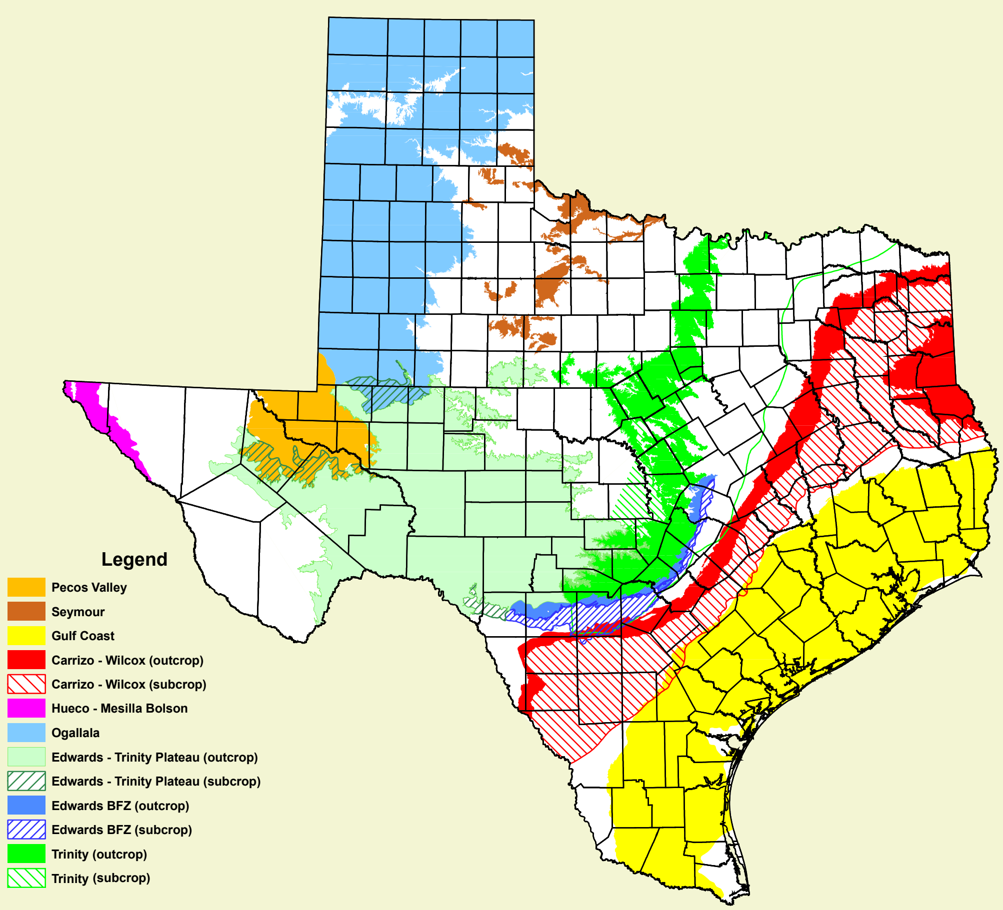
Without a significant, persistent climatological change that brings increased moisture, this growth is likely to mean that more people will live with less water. Ensuring reliable water supplies for the future, and balancing those supplies appropriately between rural and urban areas, and among agricultural, municipal, industrial and electricity-generating users is the challenge of our day.

To meet that challenge, Texas legislators established a comprehensive water planning process in 1997 which assesses current and future needs in each of the state's 16 Regional Water Planning Groups (RWPGs), identifies potential solutions

Total statewide demand for water in Texas is projected to grow 27 percent, from nearly 17 million acre-feet in 2000 to 21.6 million acre-feet in 2060.

Exhibit 1

Major Texas Aquifers



Sources: Texas Water Development Board.

Exhibit 2

Major River Basins of Texas

Source: Texas Water Development Board.

The Texas Water Development Board estimates that groundwater provides 59 percent of all available fresh water in the state, with surface water providing the nearly 40 percent, and the remaining 1 percent coming from both ground water and surface water reuse projects.

and estimates their cost, culminating in a State Water Plan updated every five years.[7] *Liquid Assets: The State of Texas' Water Resources* evaluates the progress that Texas has made toward developing sustainable water supplies since the issuance of the 2007 State Water Plan, with particular emphasis on identifying policy and funding barriers impeding that progress.

Water Supply and Demand in Texas

The Texas Water Development Board (TWDB), the state agency responsible for providing "leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas," estimates that groundwater provides 59 percent of all available fresh water in the state, with surface water providing the nearly 40 percent, and the remaining 1 percent coming from both ground water and surface water reuse projects. Unfortunately, both water sources are decreasing — the former due to pumping in excess of recharge, and the latter primarily because of sediment accumulation in reservoirs.[8] **Exhibits 1** and **2** show the major aquifers and river basins in Texas.

Exhibit 3

Estimated Per Capita Water Use, 2000-2060

40 Largest Texas Cities Ranked by Gallons Used Per Day Per Person in 2060

City	2000	2020 (est.)	2040 (est.)	2060 (est.)
Richardson	282	278	274	272
Dallas	262	262	257	256
Plano	256	253	250	249
Tyler	261	255	249	248
Midland	262	254	248	247
McKinney	220	244	242	242
Irving	220	223	218	217
Brownsville	229	221	217	216
College Station	225	217	213	212
Sugar Land	221	214	211	211
Fort Worth	215	207	203	202
Amarillo	256	201	201	201
Beaumont	216	209	203	201
Lubbock	181	202	196	195
Odessa	208	202	195	194
McAllen	205	197	193	192
Round Rock	201	194	191	191
Laredo	200	192	189	188
San Angelo	162	193	187	186
Waco	183	183	183	183
Carrollton	189	188	184	183
Denton	189	179	176	176
Arlington	165	179	175	174
El Paso	184	176	171	170
Lewisville	167	173	171	170
Austin	175	173	171	169
Wichita Falls	188	172	170	168
Killeen	132	179	174	167
Corpus Christi	179	171	166	165
Garland	159	160	156	155
Abilene	304	161	155	154
Mesquite	160	157	153	152
Houston	159	152	147	146
Harlingen	156	149	144	143
Grand Prairie	153	145	142	141
Bryan	147	140	135	134
San Antonio	147	139	135	134
Baytown	147	140	134	133
Longview	127	120	115	115
Pasadena	117	110	105	104
Average	195.2	189.1	185	183.9

Note: Water use projections from 2020 through 2060 rely on per capita use in 2000 as a baseline. According to TWDB, 2000 was a hot and dry year when much of the state was experiencing a drought. Consequently, year 2000 water use tended to be relatively high across the state.
Source: Texas Water Development Board.

Based on current conditions, TWDB models suggest existing groundwater supplies provide 8.5 million acre-feet. As the state's major aquifers are used increasingly for irrigation, municipal and industrial use, TWDB projects a 32 percent decline in supply from 8.5 to 5.8 million acre-feet by 2060.[9]

As of 2010, Texas is projected to have approximately 13.3 million acre-feet of total surface water available during times of drought, although some 20 million acre-feet are permitted for consumption annually. According to TWDB, only 9 million acre-feet of this amount can be considered existing supply due to legal and other constraints. By 2060, in periods of drought surface water sources are expected to decrease 7 percent, from around 9 million acre-feet to 8.4 million acre-feet.[10] This decline in supply will be the result of reservoir sedimentation, a process in which eroded sediments accumulate in reservoirs, eventually making the reservoirs shallower. In 2060, the total amount of surface water is projected to decrease to approximately 13.1 million acre-feet in non-drought conditions.[11]

While water supplies decrease, demand is expected to increase due largely to population growth. Per capita use among the 40 largest cities in Texas in 2000 averaged just over 195 gallons per day per person, while conservation recommendations aim to reduce demand by 1 percent annually to reach a future statewide average of 140 gallons per capita per day.[12] However, TWDB's projections based on the 40 largest Texas cities suggest that conservation efforts will be far short of that mark. It should also be noted that basic projections of per capita water use do not take into account water conservation strategies, which are anticipated for most cities in 15 of the 16 regions **(Exhibit 3)**.[13]

In addition to conservation, increased efficiency in delivery of water, especially for agricultural uses, is critical to the future of Texas.

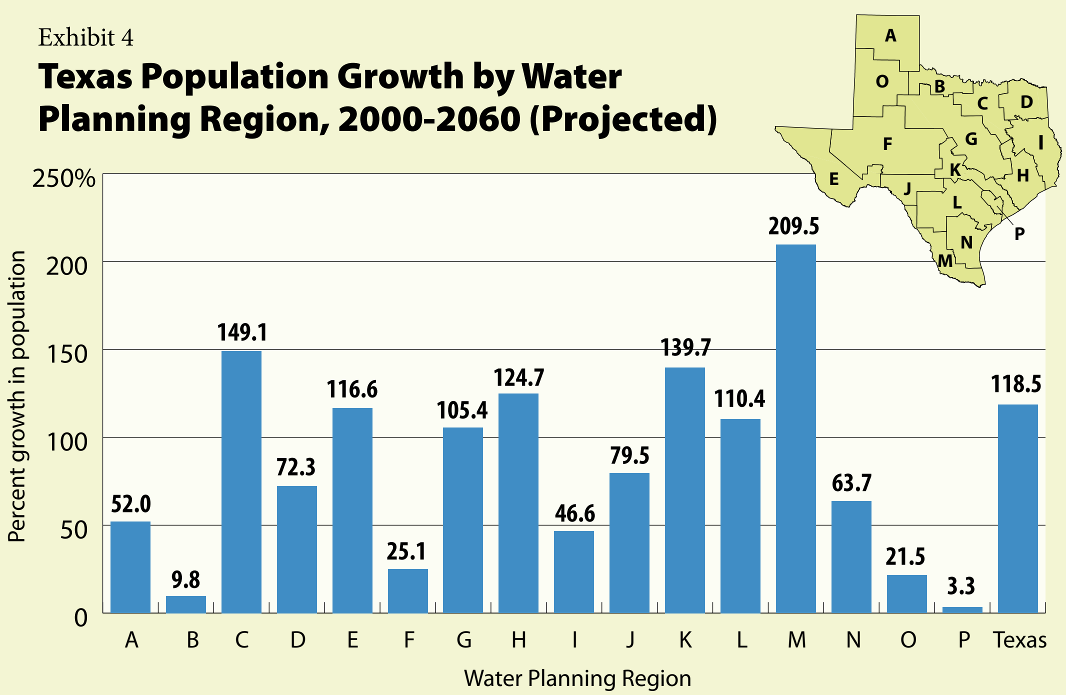
Demographics and Future Water Needs

According to projections from TWDB and the Texas State Data Center, the Texas population will more than double between 2000 and 2060,

The Texas population will more than double between 2000 and 2060, from 21 million to 46 million people.

Exhibit 4

Texas Population Growth by Water Planning Region, 2000-2060 (Projected)



Source: Texas Water Development Board.

from 21 million to 46 million people. This growth will vary widely across the state. **Exhibit 4** shows population growth across the 16 water planning regions. Eight regions, which include most of the state's metropolitan areas, are expected to at least double in population during this period. The population in Region M, which includes Brownsville-Harlingen, Laredo and McAllen, is expected to triple during this period.

Demand for water will not increase as rapidly as population growth, largely due to decreases in irrigation. Demand growth for water will come from the municipal sector (which is made up primarily of household and commercial uses), doubling from 4 million acre-feet to 8.3 million acre-feet **(Exhibit 5)**. Water use for irrigation is expected to decline from 10.2 to 8.6 million acre-feet during this period due to more efficient irrigation systems, reduced groundwater supplies and transfer of water rights from agriculture to municipal uses, according to TWDB.[14] Overall existing water supplies are projected to decrease from 17.9 million acre-feet in 2010 to 14.6 million acre-feet in 2060, an 18 percent drop. The overall existing water supplies consist of the amount that can be produced with current permits, current contracts and the existing infrastructure during droughts.[15]

If new management and conservation strategies are not implemented, water shortages would leave 85 percent of the Texas population in 2060 with insufficient supplies.

Texas does not have enough water now to fulfill all of its estimated future needs. If new management and conservation strategies are not implemented, water needs will increase from 3.7 million acre-feet in 2010 to 8.8 million acre-feet in 2060 (**Exhibit 6**). These water shortages would leave 85 percent of the Texas population in 2060 with insufficient supplies.

Insufficient water supplies can harm the Texas economy in a number of ways. According to TWDB, "without water, farmers cannot irrigate, refineries cannot produce gasoline, and paper mills cannot make paper." Economically, insufficient water supplies could cost Texans $9.1 billion in 2010 and $98.4 billion in 2060. State

San Antonio and the Edwards Aquifer: Striking a Groundwater Balance

Dependent upon the abundant Edwards Aquifer for more than a century, the growing city of San Antonio and neighboring cities and rural areas have made a concerted effort in recent years to lessen their use of water from the Edwards.

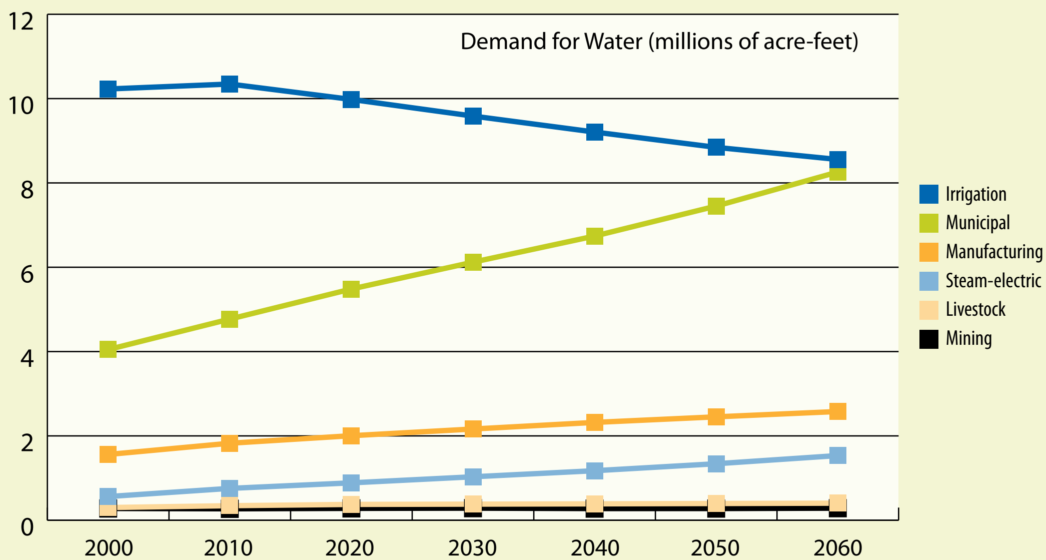
The Edwards Aquifer provides water to many people throughout the Hill Country, not just San Antonio. The area has experienced tremendous growth in recent years, and water use has been apportioned carefully. After many legal proceedings, the Edwards Aquifer Authority, operating since 1996 as a successor to the Edwards Underground Water District established in 1949, was created to regulate water withdrawals from the aquifer, protect endangered species and preserve the aquifer for future generations.[17]

Adding to the management issues of the Edwards are concerns with hydrogeology. Even though the aquifer recharges readily, it cannot recharge without rain, sometimes a rare commodity in Central Texas. Continued pumping from the Edwards has exacerbated droughts in previous years. San Antonio city leaders realized that the city's long-term viability could not be assured with a water source that fluctuated dramatically. As a result, the city, the San Antonio Water System and others have focused on conservation and are considering obtaining rights to more reliable surface waters from the Lower Colorado River Authority and the Guadalupe-Blanco River Authority.

San Antonio's efforts to use water from outside its metropolitan area have had some interesting policy and political consequences. In 1997, the "junior water rights provision" of Senate Bill 1 strongly limited future efforts to export surface water from outside its basin of origin, a management tool known as interbasin transfer, or IBT (see Section 3). At the same time, neighboring counties feared the city would pump and export groundwater from their county, so several created groundwater conservation districts to restrict such activity. Although the city continues to wean itself from the Edwards Aquifer, it faces several formidable challenges in its pursuit of replacement water sources.

Exhibit 5

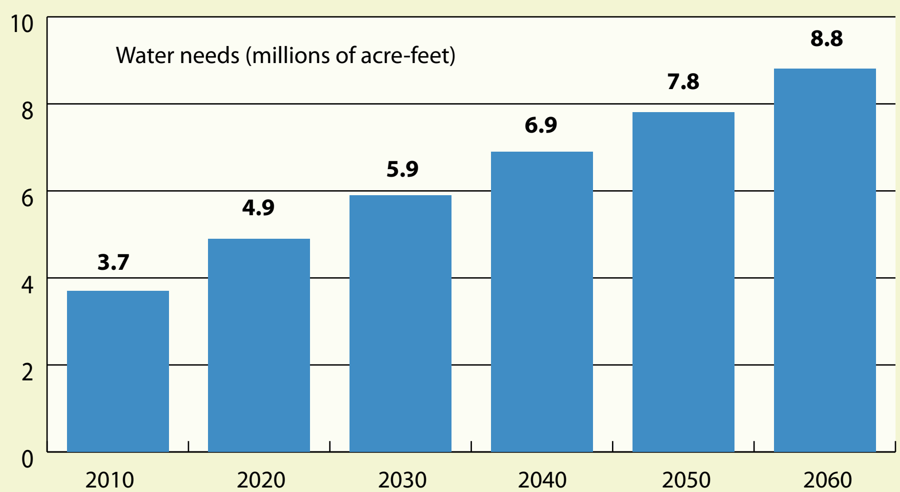
Texas Projected Water Demand by Category, 2000-2060



Sources: Texas Water Development Board.

Exhibit 6

Texas Projected Water Needs in Times of Drought, 2010-2060



Sources: Texas Water Development Board.

Georgia's Drought Crisis

Georgia has been experiencing a severe drought that has caused significant harm to that state's economy. In testimony before a Congressional field hearing in March 2008, the General of the area U.S. Corps of Engineers stated that lakes in Georgia, Alabama and Florida were for the first time experiencing "negative inflows," meaning that "there was more water leaving the system through evaporation than was…coming into the system" through rainfall.[18]

Water management in Georgia is very different than in Texas because the management of certain lake waters include laws that require water releases to protect endangered species downstream in Alabama and Florida. Business interests affiliated with West Point Lake in northwest Georgia estimated that diminished economic activity resulting from the low water level at West Point Lake cost between $800 million and $1.1 billion for 2006-07.[19] Of the state's 159 counties, 40 were in moderate to extreme drought as of October 2008.[20] The cities of Atlanta, Athens, Augusta, Columbus and Macon are engaged in significant water conservation efforts.[21]

A report published in 1959 cited an estimated cumulative agricultural loss in Texas from 1950 to 1956 to be in excess of $3 billion per year in 2008 dollars.

government could lose $466 million in tax revenue in 2010 and up to $5.4 billion by 2060 due to decreased business activity as a direct result of insufficient supply.[16]

New management and conservation strategies identified by the regional planning groups in the State Water Plan could add 9 million acre-feet of water supply by 2060. However, even with these new water supplies, while some regions will have their projected demands met, other regions in Texas will have unmet needs because cost-effective strategies to increase supply could not be identified.[22]

The Economic Consequences of Drought

The American Meteorological Society defines drought as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area."[23] Droughts can be *meteorological* (less than normal precipitation), *agricultural* (soil moisture insufficient to grow crops), *hydrological* (below normal surface and subsurface water supplies) and/or *socioeconomic* (when water shortages begin to affect daily life).[24]

Policymakers look to the "drought of record" as a yardstick for estimating water needs during future droughts. The first drought of record was the Dust Bowl of the 1930s, which covered 70 percent of the U.S. An even more severe drought during the mid- 1950s hit Texas particularly hard.[25] This one was called "the worst drought in recorded history" by the former Texas Water Commission.[26] Today this drought of record is used as a model for the worst-case scenario in most regional and state water plans.

Climatologists studying tree rings and other indicators of past rainfall have discovered that a Dust Bowl-scale drought is likely once or twice a century, continuing a 400-year-old pattern. In the past 800 years, two North American droughts of 20 to 25 years in length occurred.[27] So not only are droughts likely to be frequent in the future, they could also persist long enough to cause severe socioeconomic repercussions. Should global climate change reduce rainfall and increases surface water evaporation as many experts fear, the impact could be even worse.

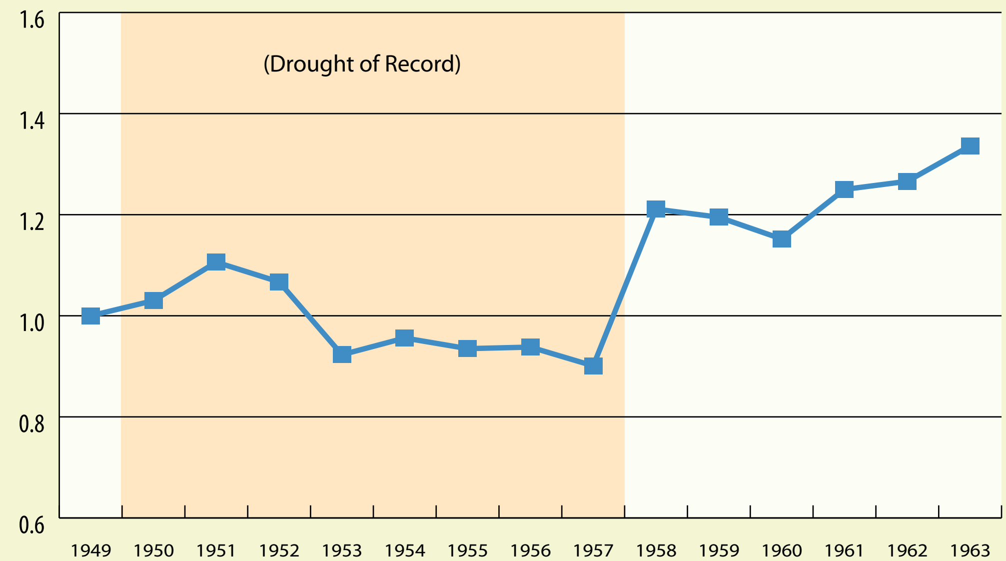
While water planners throughout the state prepare for a future drought of record, history has demonstrated repeatedly that many droughts end, rather ironically, with the appearance of hurricanes, tropical storms and other flood events.[28] So, while we plan for too little water, we must also plan for too much.

Drought losses are felt first, most often and most severely in the agricultural sector. The economic impact of the 1950s drought can be drawn indirectly by studying meteorological or agricultural production data of the time. A report by the Texas Board of Water Engineers, published in 1959,

Exhibit 7

Texas Farm Gross Cash Income Index 1949-1963

1.0 = $1 in 1949



Note: Annual values are indexed to 1949 dollars.

Sources: U.S. Bureau of Economic Analysis and Comptroller of Public Accounts.

cited an estimated cumulative agricultural loss in Texas from 1950 to 1956 to be in excess of $3 billion,[29] the equivalent of more than $24 billion, or almost $3.5 billion annually, in 2008 dollars.[30]

Exhibit 7 shows the effect that the drought of the 1950s had on net cash farm income in Texas, which excludes most governmental sources of income for farmers. Drought swept across the state starting in 1950. Within three years annual farm income decreased below 1949 levels and remained low until the drought lifted. This indicates that this severe drought had a pronounced negative impact on the agricultural sector of the Texas economy.

Data from Texas A&M University's Department of Agricultural Economics indicate that recent, less severe droughts have had significant economic effects on the state's agricultural sector. **Exhibit 8** shows the estimated losses suffered by producers during several one-year droughts in the past 12 years. Losses of $1 billion or more occurred in five separate years between 1996 and 2008.

Regional Water Planning Process

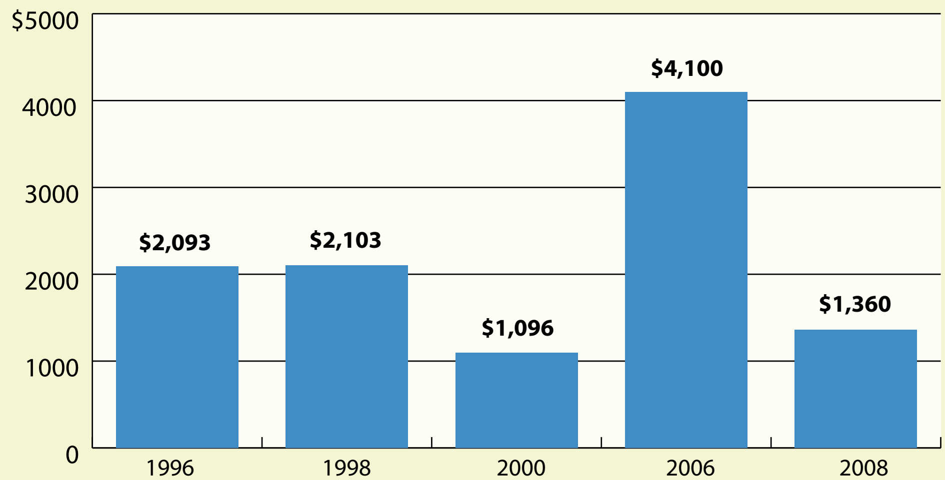
According to TWDB, the goal of the water planning process is to ensure "that Texas will have enough water in the future to sustain our cities and rural communities, our farms and ranches, our businesses and industries, and the environment."[31] Based on the state's growing population and vulnerability to drought, water planning in Texas takes on an important dimension.

In 1997, the Texas Legislature enacted Senate Bill 1, which directed TWDB to designate the areas for which regional water plans should be developed — in essence, creating 16 regional water planning groups and established a water planning process that occurs in 5-year increments and is based on a 50-year planning horizon. Under the bill, water planning in Texas is a collaborative, statewide initiative. Texas uses a "bottom-up" approach to water planning rooted in local, consensus-based decision-making. Each regional water planning group includes members representing various stakeholders, including agriculture,

Exhibit 8

Texas Agriculture Producer Losses Due to Drought, 1996-2008

(in millions)



Sources: Texas A&M University.

Providing adequate freshwater supplies for the future is a critical task that Texas must confront head-on.

industry, the environment, cities, water utilities, power companies and other interests.[32]

Using data from the Texas State Data Center and TWDB, each planning group evaluates population, water demand and water supply projections, along with potential strategies to meet demands over a 50-year planning horizon. After this process is complete, TWDB compiles regional plans from each of the 16 areas into the State Water Plan. These strategies and projects are submitted to the Legislature, along with policy recommendations needed to implement the plan. After the plan is published, the planning process repeats. **Exhibit** 9 shows the water planning regions in the state.

Conclusion

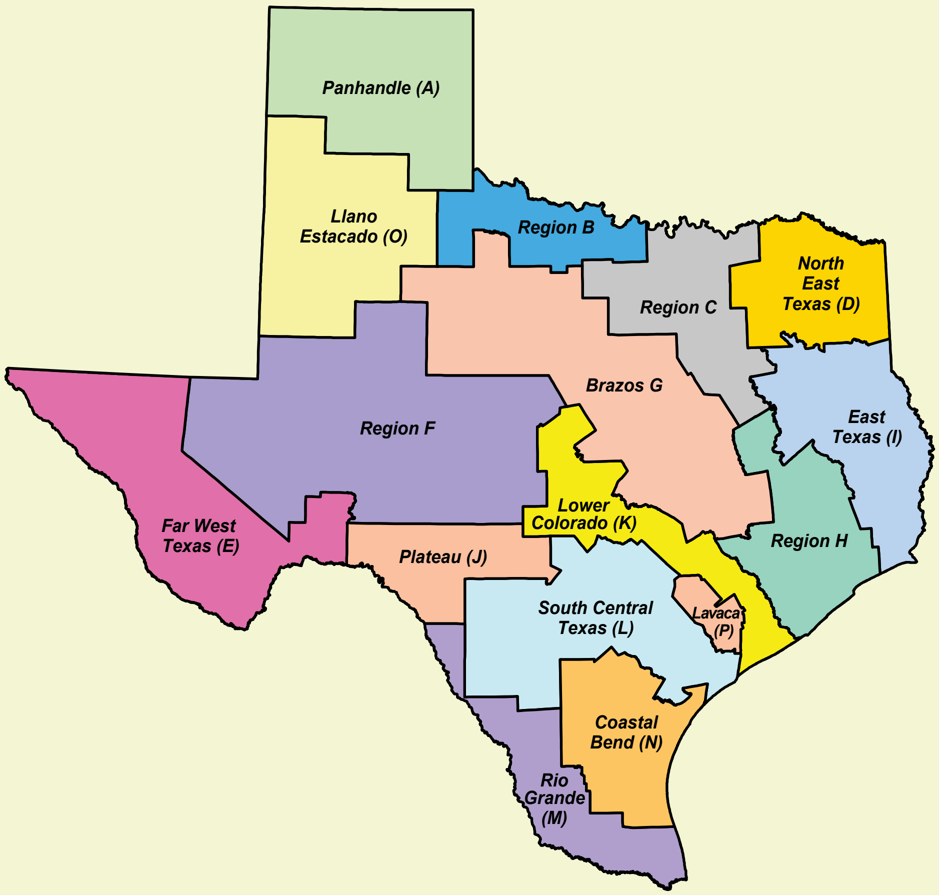
Providing adequate freshwater supplies for the future is a critical task that Texas must confront head-on. The needs are great and varied, and meeting them will be both daunting and expensive. State and local water management entities must evaluate the need for developing new water resources while at the same time determine what effect conservation efforts will have on local and statewide water supplies. In addition, these entities also must consider the impact their actions could have on a landowner's private property rights in the water on or under their land, as well as any potential economic impact.

The following sections will take a more in-depth look at the challenges facing Texas regarding water policy. *Regional Water Planning* of the report reviews the challenges faced by each of the state's 16 regional water planning groups, and provides an update on the progress each group has made in addressing its water needs.

State Water Plan: Issues and Funding looks at several of the water policy issues that need to be confronted to ensure that Texas has sufficient water in the future. This includes a look at various proposals to create a dedicated funding mechanism for water projects and an examination of water infrastructure funding mechanisms in other states.

Exhibit 9

Water Planning Regions



Sources: Texas Water Development Board.

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[9] Texas Water Development Board, *Water for Texas 2007*, Volume II, p. 176.

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[11] Texas Water Development Board, *Water for Texas 2007*, Volume II, p. 172. http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/CHAPTER%206%20FINAL_112906.pdf. (Last visited December 29, 2008.)

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