Chapter 6

Surface Water Resources

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Texas has approximately 191,000 miles of streams and rivers, 15 major river basins, and eight coastal basins.

Texas has 196 major reservoirs, 175 of which have a water supply, irrigation, or industrial water use.

TWDB estimates that Texas' major reservoirs are losing approximately 90,000 acre-feet of storage per year from sedimentation. This equates to a loss of roughly 0.27 percent of the total major reservoir capacity in Texas per year, or approximately 4.5 million acre-feet by 2060, which is more than the capacity expected to be gained through the construction of new major reservoirs.

Numerous estuaries extend along the Texas coast, differing in size and hydrologic and ecological characteristics, but together contribute $2.5 billion per year to the state economy.

The amount of water permitted through permanent consumptive surface water permits in Texas is estimated to be 20.0 million acre-feet per year. Of this amount, the surface water availability during drought is 13.3 million acre-feet per year.

In 2010, there will be only 9.0 million acre-feet per year of existing surface water supply in Texas that is physically and legally available. Existing surface water supplies are projected to decrease to 8.4 million acre-feet by 2060, partly due to sediment accumulation in reservoirs.

Surface water is an important source of water for Texas and one that is growing in its significance. It accounted for approximately 40 percent of the 15.6 million acre-feet of the water used in the state in 2003. This critical water source faces several challenges in the coming years; chief among them are the state's reservoirs. Aging reservoirs are filling with sediment and few viable sites remain for new reservoirs.

There are 23 surface water basins in Texas, including 15 major river basins and eight coastal basins, each with varying hydrological regimes and abilities to provide water supplies. The state's water availability models estimate that available surface water during drought is 13.3 million acre-feet in 2010. Of this amount, only 9.0 million acre-feet can be used as existing supply due to physical and legal constraints. Existing surface water supply is projected to decrease to 8.4 million acre-feet by 2060, primarily from sedimentation of existing reservoirs. As a measure of the important role reservoirs serve in the state, most of the existing surface water supply, almost 6.3 million acre-feet, is a direct result of the state's major and minor reservoirs. The remaining 2.7 million acre-feet of the existing surface water supplies in the state is the result of run-of-river water right permits or local surface water supplies.

Surface water in Texas is owned by the state, which, in turn, grants the right to use this water to individuals, as well as to cities, industries, businesses, and other public and private interests. Anyone who wants to use surface water in Texas must first get permission from the state (a water right) unless the use is exempt; exempt uses are defined in the Texas Water Code. Each water right is assigned a priority date that determines its place in line for available water. Water rights do not guarantee that water will always be available.

6.1 Major River and Coastal Basins of Texas

Texas has approximately 191,000 miles of streams and rivers, 15 major river basins, and eight coastal basins (Figure 6.1). The unique features of each of

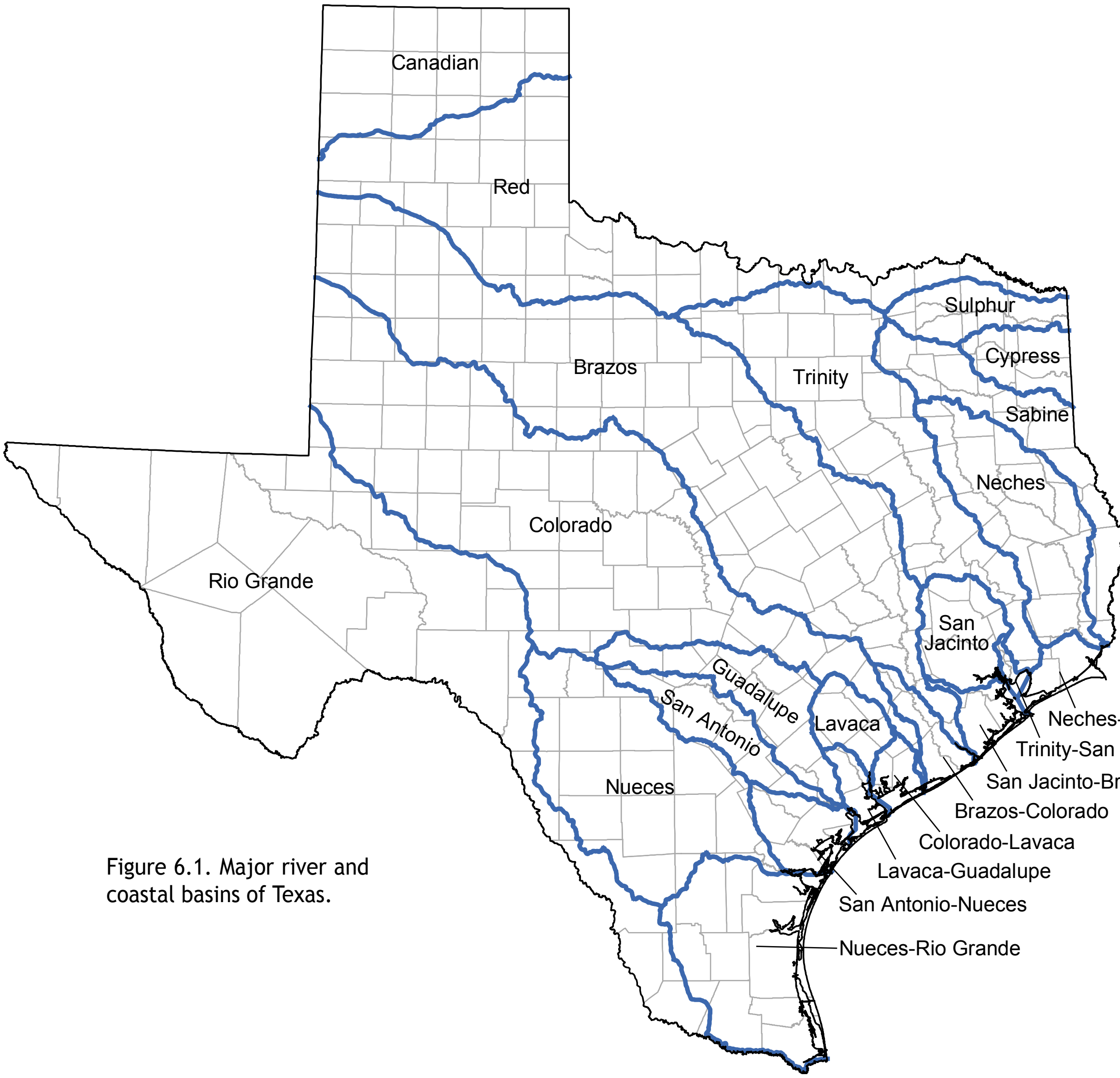


Figure 6.1. Major river and coastal basins of Texas.

these basins are a function of many factors, but one of the most critical is precipitation, which varies from less than 10 inches per year in the western part of the state to more than 55 inches per year in the east (see Chapter 5, Figure 5.3). Other factors include evaporation, vegetation, soil type, surface slope, geology, land use practices, and runoff (Figure 6.2).

A brief summary of the major river basins in Texas is provided on the following pages. The summaries include: total surface area of the basin; the major river in each basin and its approximate length and average annual flow volume (the average of the annual flow volume recorded at the most downstream streamflow gage on that river in Texas) (Table 6.1); average annual yield (the average annual flow volume per acre of drainage area); and water supply reservoirs, described in terms of their storage capacity and estimated yield. Yield is expressed as either firm yield or safe yield. In

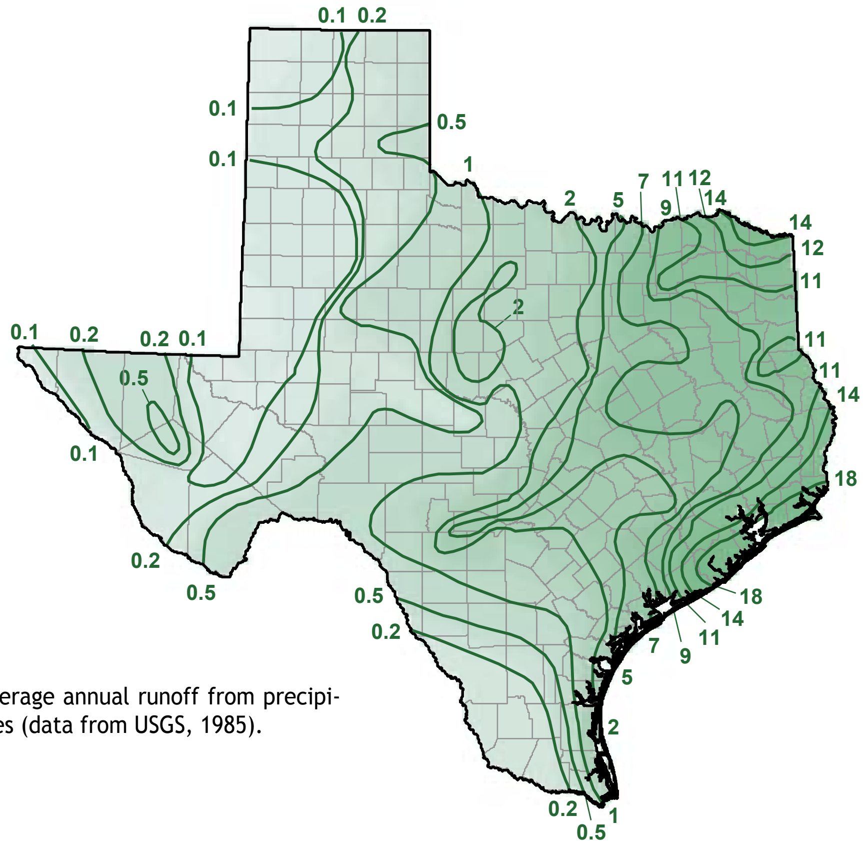


Figure 6.2. Average annual runoff from precipitation in inches (data from USGS, 1985).

some cases the yield is limited by permit amounts. Conservation storage is the total volume of water available for water supply use when a reservoir is filled to the water surface elevation corresponding to the top of the conservation pool (when the reservoir is "full" for water supply purposes).

In the basin descriptions, conservation storage and yield are provided for the five largest reservoirs in the basin, if applicable. Conservation storage and yield data are also provided for reservoirs recommended as water management strategies within each river basin.

The amount of surface water supply for each basin is an estimate of the amount of surface water that is currently legally and physically available for use. Estimated values of existing surface water supplies plus water from new surface water strategies through 2060 are shown in the graphs associated with each basin description. A contributing factor to changes in water supply during this period is reservoir sedimentation (which reduces yield and can, thus, reduce supply). Water rights are divided by their category of use, including municipal/domestic, industrial, irrigation, mining, hydropower, recreation, and other uses.

There are eight designated coastal basins in Texas: the Neches-Trinity, Trinity-San Jacinto, San Jacinto-Brazos, Brazos-Colorado, Colorado-Lavaca, Lavaca-Guadalupe, San Antonio-Nueces, and Nueces-Rio Grande. Each coastal basin is named according to the major river basins that bound them. For example, the Nueces-Rio Grande Coastal Basin is bounded on the north by the Nueces River Basin and on the south by the Rio Grande Basin. Each coastal basin is also bounded by a bay or other outlet to the Gulf of Mexico.

A major concern in coastal basins is the limited freshwater supply available to growing cities in

Table 6.1. Features of major river basins of Texas

River basin	Basin area Total (square miles)	Basin area In Texas (square miles)	Approximate major river length Total (miles)	Approximate major river length In Texas (miles)	Average flow (acre-feet per year)
Brazos	45,573	42,865	840	840	6,074,000
Canadian	47,705	12,865	906	213[a]	196,000
Colorado	42,318	39,428	865	865	1,904,000
Cypress	3,552[b]	2,929[c]	90[d]	75[d]	493,700
Guadalupe	5,953[b]	5,953[b]	409[a]	409[a]	1,422,000
Lavaca	2,309[b]	2,309[b]	117[a]	117[a]	277,000
Neches	9,937[b]	9,937[b]	416	416	4,323,000
Nueces	16,700[b]	16,700[b]	315	315	539,700
Red	93,450[c]	24,297	1,360	695[a]	3,464,000
Rio Grande	182,215	49,387	1,896	889	645,500[f]
Sabine	9,756	7,570	360	360	5,864,000
San Antonio	4,180[b]	4,180[b]	238[a]	238[a]	562,700
San Jacinto	3,936[b]	3,936[b]	85	85	1,365,000[e]
Sulphur	3,767[b]	3,580[c]	222[d]	222[a]	932,700
Trinity	17,913[b]	17,913[b]	550	550	5,727,000

Notes:
Source for total basin area and river length data is USGS (1985) unless otherwise specified.
Source for basin area within Texas data is TWDB unless otherwise specified.
Source for average flow data is USGS (2004) unless otherwise specified.
[a] Source for this data is TCEQ (2004) and does not include length of in-channel reservoirs or lakes.
[b] Source for this data is TWDB.
[c] The Sulphur and Cypress River basins in Texas are sub-basins of the entire Red River Basin.
[d] Sources for this data are TCEQ (2004) and ADEQ (2004) or LDEQ (2004) and do not include length of in-channel reservoirs or lakes.
[e] This value combines data from USGS (2004) for several tributaries.
[f] Source for this data is IBWC (2003).

their areas. Coastal basins have historically relied on groundwater to meet water supply needs. However, overpumping has led to problems with ground subsidence and seawater intrusion into aquifers. Coastal basins depend heavily on nearby river basins for water supply. Growing population centers, such as the Houston metropolitan area in the San Jacinto-Brazos Coastal Basin and Brownsville and Corpus Christi in the Nueces-Rio Grande Coastal Basin, face difficult challenges to meet future water supply needs.

The basin summaries that follow on the next pages include several terms that may be unfamiliar:

Average annual flow—Average annual volume of water, as measured at the most downstream streamgage of the watershed

Average watershed yield—Average annual flow of a watershed, divided by its surface area

Existing surface water supplies—Maximum amount of surface water available from existing sources for use during drought of record conditions that is physically and legally available

Firm yield—Maximum volume of water a reservoir can provide each year under a repeat of the drought of record

Estuary—Bay or inlet, often at the mouth of a river, in which large quantities of freshwater and seawater mix together

Run-of-river diversion—Water right permit that allows the permit holder to divert water directly out of a stream or river

Safe yield—Firm yield in addition to an amount of water supply for an additional period of time

Surface water availability—Maximum amount of surface water available during the drought of record, regardless of whether the supply is physically or legally available

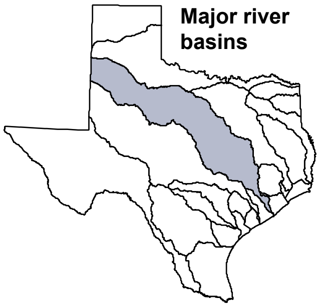
6.2 Reservoirs

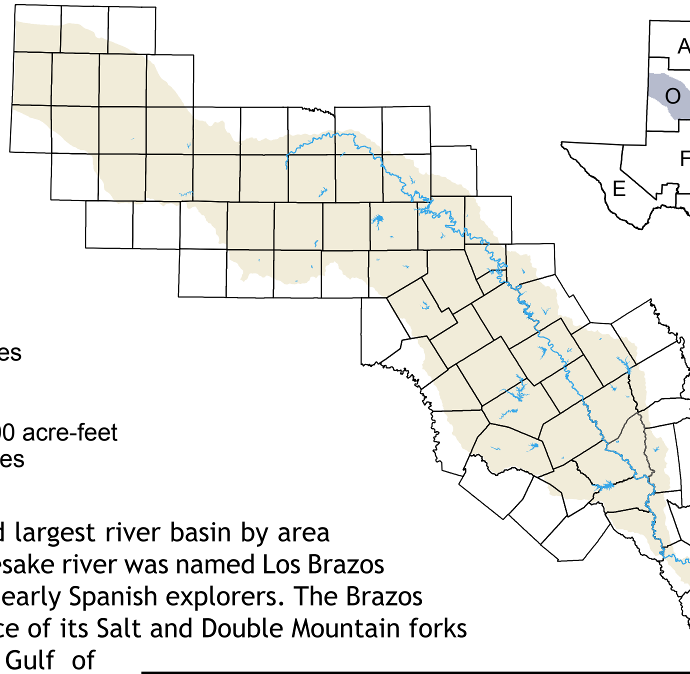
Texas has 196 major reservoirs, a major reservoir being defined as an impoundment that currently has at least 5,000 acre-feet of storage capacity at its normal operating level. Of the 196 major reservoirs, 175 have a water supply function. The major reservoirs of the state vary in size from 5,200 acre-feet conservation storage capacity for the Upper Nueces Lake to 4,472,900 acre-feet for the Toledo Bend Reservoir, which includes both the Louisiana and Texas portions of the reservoir (Appendix 6.1). Making the best use of existing reservoirs, controlling watershed erosion to maintain their holding capacity, and identifying viable sites for new reservoirs are key to effective long-term water supply management and planning in Texas.

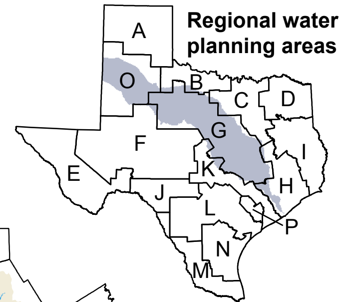
6.2.1. History of Reservoir Construction in Texas

Reservoirs are important for providing water supplies, particularly in a state with such variable streamflow. More than half of the available surface water in the state is from reservoirs (8.9 million acre-feet per year for reservoirs out of a total of 13.3 million acre-feet per year). Reservoirs are able to capture and store floodwaters for use during times of drought when the rivers are low or dry. In fact, many of the state's major reservoirs were constructed principally for flood control, with water supply as a secondary benefit. The history of construction of the state's major reservoirs illustrates that there was a flurry of activity in the 1960s and 1970s, but there has been a dramatic decrease in reservoir construction since that time (see Figure 3.2). In the 1984 State Water Plan there were 44 reservoirs proposed to meet water supply needs. In the 2002 State Water Plan, there were eight major and ten minor reservoirs recommended; in the 2007 State Water Plan there are 14 major and two minor reservoirs recommended in this state water plan (see Chapter 10, section 10.2.2). The slowdown in reservoir construction is due, in part, to the fact that there remain very few viable sites for new major reservoirs, permits are much more difficult to obtain due primarily to environmental concerns, and the cost of construction has gone up faster than the rate of inflation.

Brazos Basin







Basin area: 42,865 square miles
Major river: Brazos River
River length: 840 miles
Average annual flow: 6,074,000 acre-feet
Average annual yield: 3.2 inches

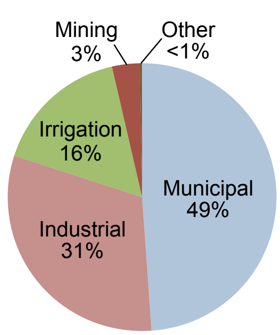
The Brazos Basin is the second largest river basin by area within Texas. The basin's namesake river was named Los Brazos de Dios, "the arms of God," by early Spanish explorers. The Brazos River flows from the confluence of its Salt and Double Mountain forks in Stonewall County to the Gulf of Mexico. It is the state's third longest river and has the largest average annual flow volume of any river in the state. Other streams in the basin include the Salt, Double Mountain, and Clear forks of the Brazos River; Gabriel, Lampasas, Little, Leon, Navasota, Nolan, Paluxy, Sabana, and White rivers; and many creeks such as Big Sandy, Cedar, Millers, Salt, Sweetwater, and Yegua creeks. One of the issues in this basin is the increasing demand on surface water resources in the upper basin as groundwater supplies decline, particularly in the Ogallala Aquifer, which has historically supplied the majority of water there.

Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Possum Kingdom Lake	540,340	230,750
Belton Lake	435,225	211,856
Waco, Lake	144,546	79,869
Granbury, Lake	128,046	64,462
Limestone, Lake	208,015	63,519
Total for 43 major existing reservoirs	**3,724,032**	**850,468**
Allens Creek Reservoir (permitted)	145,533	99,650
Cedar Ridge Reservoir (recommended)	310,705	34,520[a]
Little River Off-Channel Reservoir (recommended)	155,812	40,000
Lake 07 (recommended)	20,700	21,200[b]
Lake 08 (recommended)	49,900	0[c]
Brushy Creek Reservoir (permitted)	6,560	2,000
Wheeler Branch Reservoir (permitted)	4,118	1,800

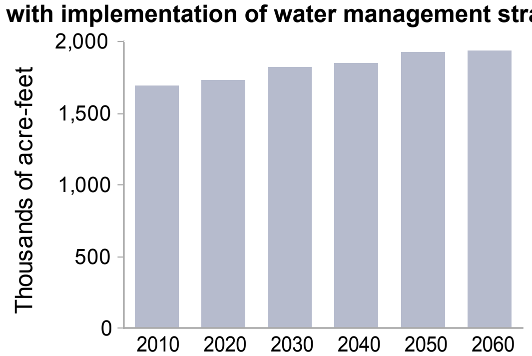
[a]Includes Abilene's existing return flow.
[b]Combined yield of Lakes 07 and 08.
[c]Operated as a system with Lake 07.

Yield for existing reservoirs is for 2010, and yield for recommended or permitted reservoirs is upon construction.

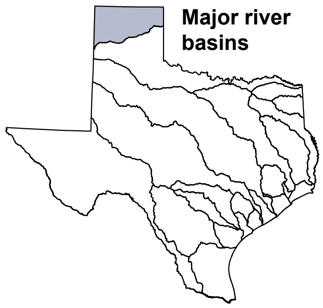
Surface water rights

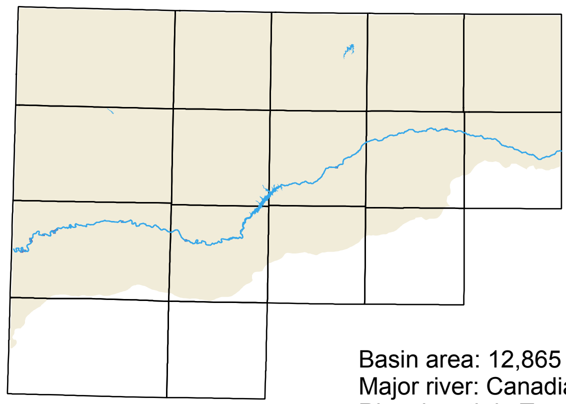


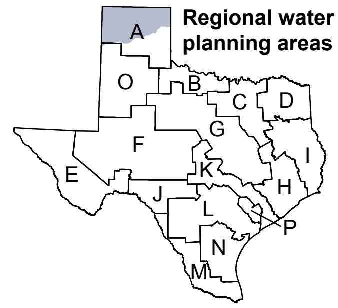
Approximate surface water supply with implementation of water management strategies



Canadian Basin







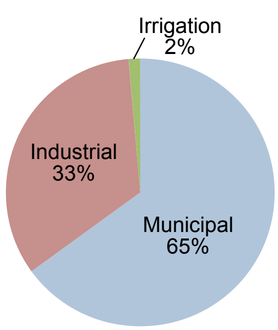
Basin area: 12,865 square miles
Major river: Canadian River
River length in Texas: 213 miles
Average annual flow: 196,000 acre-feet
Average annual yield: 0.2 inches

The Canadian Basin is the northernmost river basin in Texas. Due to low precipitation and high evaporation rates that predominate in the region, the basin has a low average watershed yield. The basin's namesake river may have received its name from early explorers who thought that it flowed into Canada. From headwaters in the Sangre de Cristo Mountains of New Mexico, the Canadian River flows across the northern Panhandle of Texas to its confluence with the Arkansas River in Oklahoma. Smaller streams in the basin include Punta De Agua, Palo Duro, and Wolf creeks. The Canadian River Compact between New Mexico, Oklahoma, and Texas places limits on conservation pool storage in reservoirs in the Texas and New Mexico portions of the basin. Limited surface water supplies, often further depleted by drought, are an issue in the basin. In addition, groundwater supplies, which have historically provided the majority of water used in the basin, are experiencing long-term decline, especially in the Ogallala Aquifer.

Reservoir yield Three largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Meredith, Lake	779,556	69,750
Palo Duro Reservoir	60,897[a]	3,958
Rita Blanca, Lake	12,100[b]	0
Total for 3 major existing reservoirs	**852,553**	**73,708**
No proposed reservoirs		

[a]Total volume up to the top of conservation pool.
[b]Operated for wildlife use, no yield value.
Yield for existing reservoirs is for 2010.

Surface water rights



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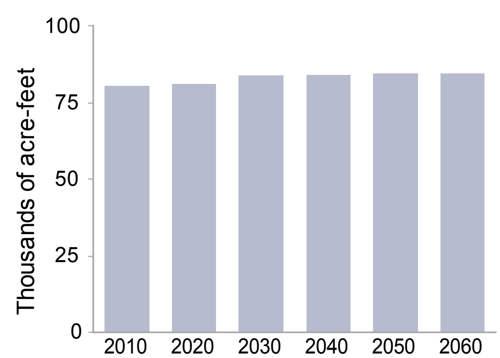
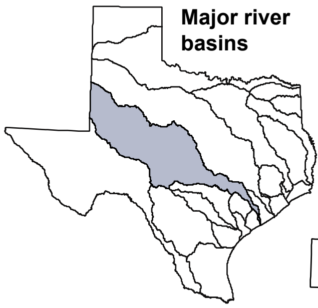
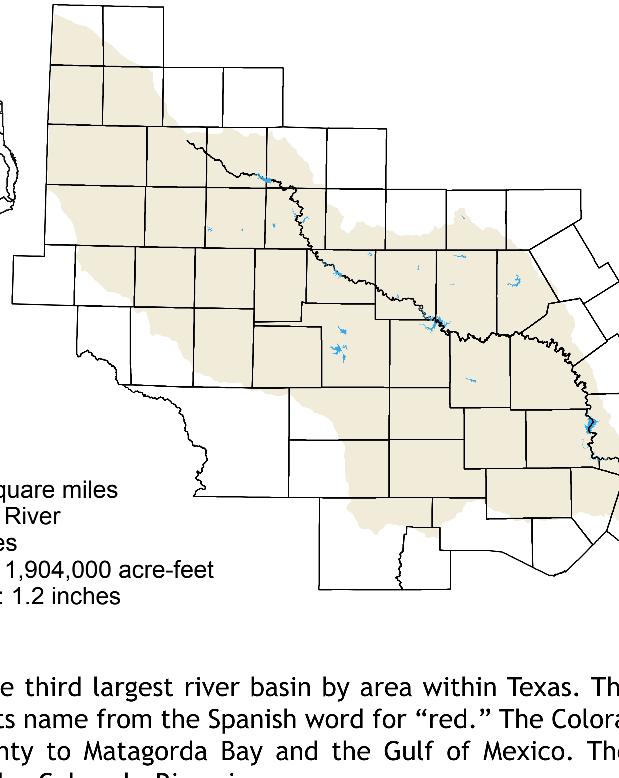
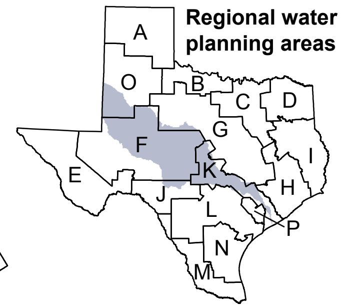


Colorado Basin







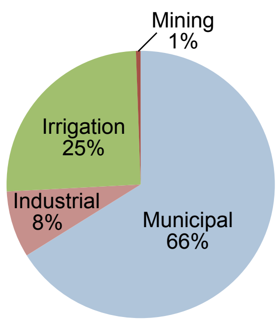
Basin area: 39,428 square miles
Major river: Colorado River
River length: 865 miles
Average annual flow: 1,904,000 acre-feet
Average annual yield: 1.2 inches

The Colorado Basin is the third largest river basin by area within Texas. The basin's namesake river derives its name from the Spanish word for "red." The Colorado River flows from Dawson County to Matagorda Bay and the Gulf of Mexico. The second longest river in Texas, the Colorado River is only the sixth largest by average annual flow volume. A large portion of the basin is located within relatively arid regions of Texas, resulting in a low average watershed yield. Other water courses in the basin include the Concho, Llano, Pedernales, and San Saba rivers; Pecan Bayou; and many creeks, such as Beals, Champion, Elm, Oak, Onion, and Redgate creeks. Balancing human water demands and environmental needs is an important issue in the basin.

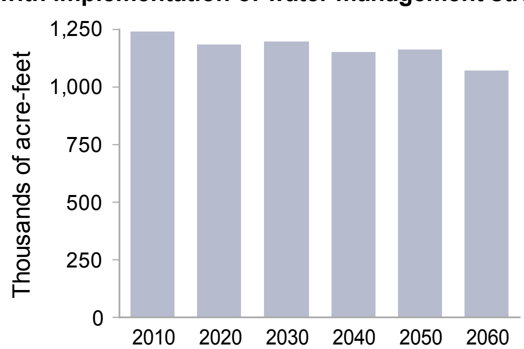
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Highland Lakes system[a]	2,155,917	381,545
O.H. Ivie Reservoir	554,340	66,350
Brownwood, Lake	131,429	29,712
E.V. Spence Reservoir	517,272	560
Clyde, Lake	5,748[b]	500
Total for 32 major existing reservoirs	**4,472,705**	**478,667**
Goldthwaite Reservoir (recommended)	400	0

[a]Lakes Travis, Buchanan, Marble Falls, LBJ, Inks, and Austin are operated as a system. Storage capacity and yield are for the entire system.
[b]Total volume up to the top of conservation pool.
Yield for existing reservoirs is for 2010, and yield for recommended reservoirs is upon construction.

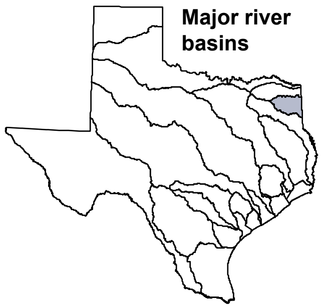
Surface water rights

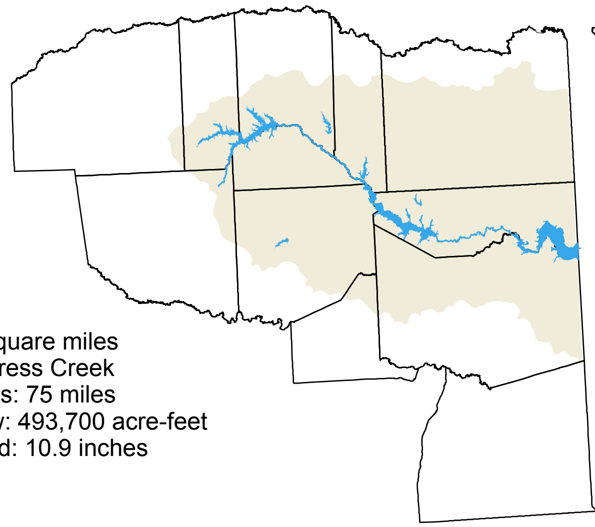


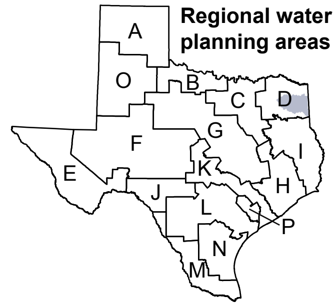
Approximate surface water supply with implementation of water management strategies



Cypress Basin







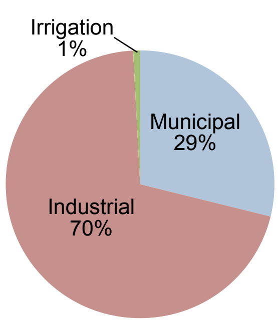
Basin area: 2,929 square miles
Major river: Big Cypress Creek
River length in Texas: 75 miles
Average annual flow: 493,700 acre-feet
Average annual yield: 10.9 inches

The Cypress Basin is one of the smallest major river basins in Texas. However, because of high precipitation and low evaporation rates in the region, the basin has a large average watershed yield. Cypress Creek (sometimes called Cypress Bayou) flows from headwaters in eastern Hopkins County to its confluence with the Red River in Louisiana. Along the way, it flows through Caddo Lake, one of the state's only natural lakes. Other streams in the basin include Big Cypress, Black Cypress, and Little Cypress creeks. Because it is a tributary watershed of the Red River, surface water within the basin is apportioned by the Red River Compact between Texas, Oklahoma, Arkansas, and Louisiana. Protecting environmental resources and water quality are important issues in the basin.

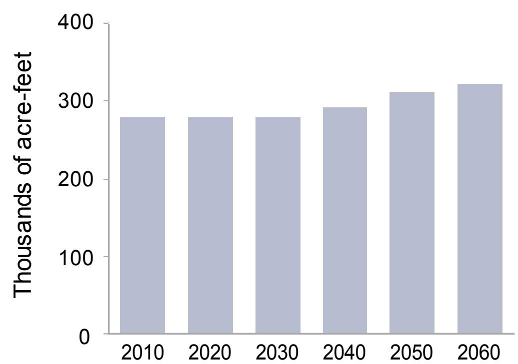
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
O' the Pines, Lake	238,933	181,869
Bob Sandlin, Lake	200,579	60,430
Ellison Creek Reservoir	24,700[a]	13,857
Cypress Springs, Lake	67,689	10,737
Caddo Lake	59,800	10,000
Total for 10 major existing reservoirs	**674,792**	**294,695**
No proposed reservoirs		

[a]Total volume up to the top of conservation pool.
Yield for existing reservoirs is for 2010.

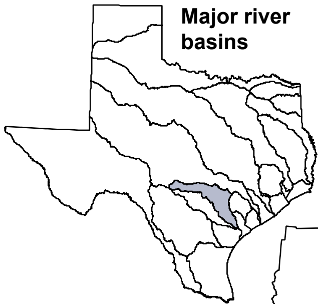
Surface water rights

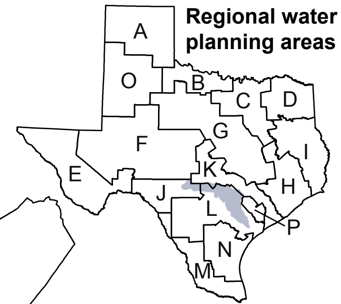


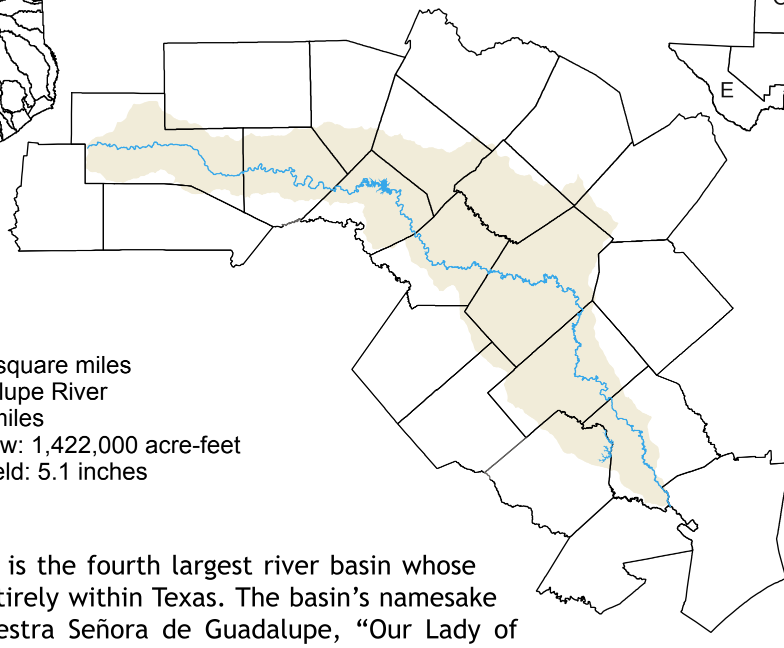
Approximate surface water supply with implementation of water management strategies



Guadalupe Basin







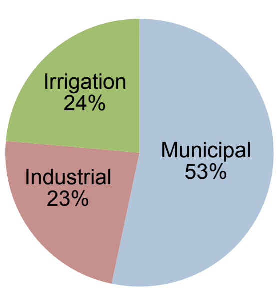
Basin area: 5,953 square miles
Major river: Guadalupe River
River length: 409 miles
Average annual flow: 1,422,000 acre-feet
Average annual yield: 5.1 inches

The Guadalupe Basin is the fourth largest river basin whose watershed area is entirely within Texas. The basin's namesake river was named Nuestra Señora de Guadalupe, "Our Lady of Guadalupe," by early Spanish explorers. From the confluence of its North and South forks in Kerr County, the Guadalupe River flows to San Antonio Bay, which drains to the Gulf of Mexico. Other streams within the basin include the Blanco, Comal, and San Marcos rivers and Sandies and Coleto creeks. A major concern in the Guadalupe River Basin is over-pumping of the underlying aquifers. In the past, irrigators, cities in the basin (such as New Braunfels and San Marcos), and cities outside the basin (San Antonio) have relied on groundwater from these aquifers. Due to the groundwater and surface water interactions in the basin, overpumping has led to reduced base flows in the Guadalupe River and its tributaries.

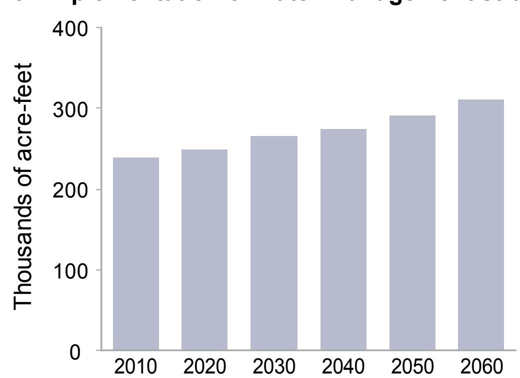
Reservoir yield Four largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Canyon Lake	378,781	88,107
Coleto Creek Reservoir	31,040[a]	20,848
Gonzales (H-4), Lake	6,500[a]	0[b]
Dunlap, Lake	5,900[a]	0[b]
Total for 4 major existing reservoirs	**422,221**	**108,955**
No proposed reservoirs		

[a]Total volume up to the top of conservation pool.
[b]Operated for hydroelectric and recreation use, no yield value.
Yield for existing reservoirs is for 2010.

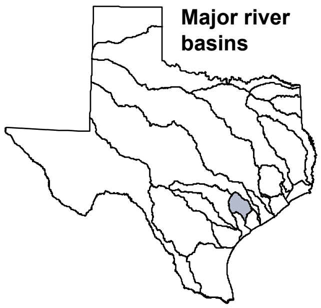
Surface water rights

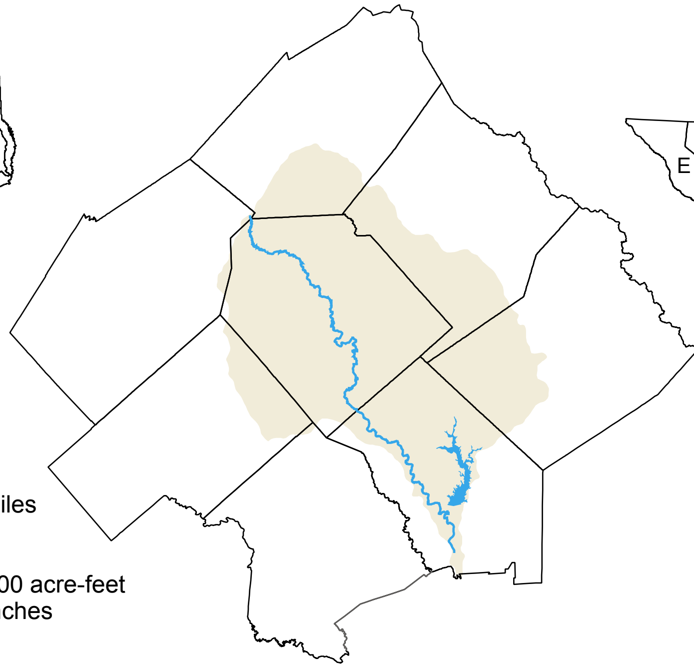


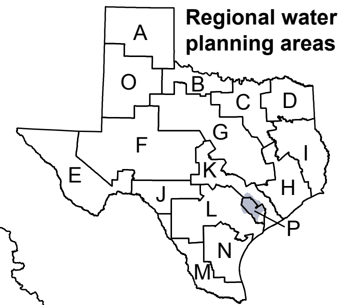
Approximate surface water supply with implementation of water management strategies



Lavaca Basin







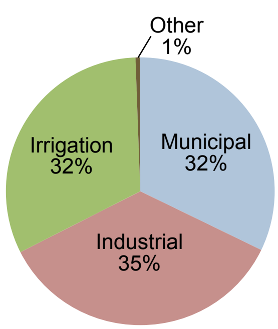
Basin area: 2,309 square miles
Major river: Lavaca River
River length: 117 miles
Average annual flow: 277,000 acre-feet
Average annual yield: 6.4 inches

The Lavaca Basin covers the smallest area of the major river basins of Texas. The basin's namesake river derives its name from the Spanish word for "cow." From its headwaters in Gonzales County, the Lavaca River flows to Lavaca Bay, which drains to the Gulf of Mexico. Other streams within the basin include the Navidad River, Sandy Creek, and East and West Mustang creeks. Groundwater supplies have historically provided the majority of water used in the basin. The Lavaca Basin is an important water supply to coastal areas outside the basin that are experiencing population growth and increased demands for water.

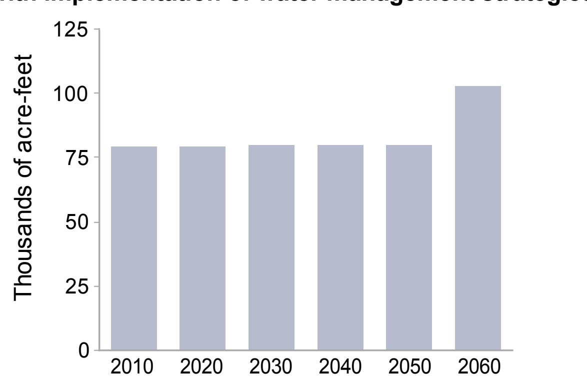
Reservoir yield Largest existing reservoir Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Lake Texana	153,246	74,500
Total for 1 major existing reservoir	**153,246**	**74,500**
Texana Stage II (permitted)	62,454	23,000

Yield for existing reservoirs is for 2010, and yield for permitted reservoirs is upon construction.

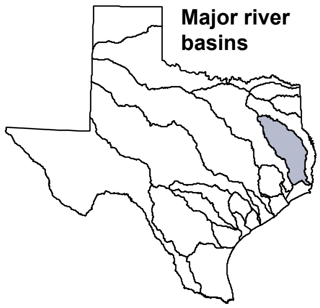
Surface water rights

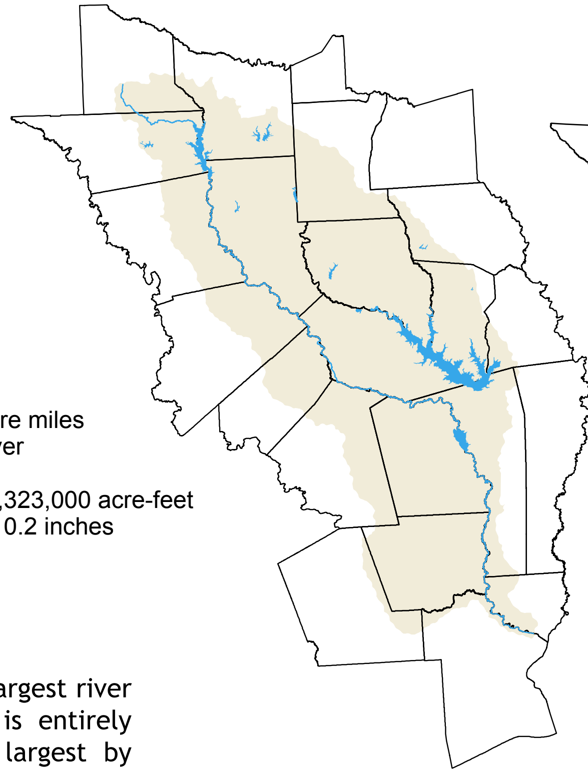


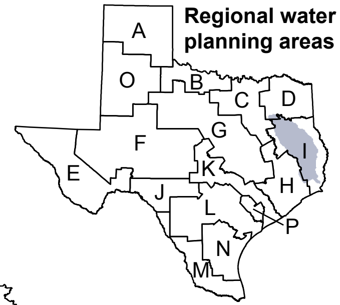
Approximate surface water supply with implementation of water management strategies



Neches Basin







Basin area: 9,937 square miles
Major river: Neches River
River length: 416 miles
Average annual flow: 4,323,000 acre-feet
Average annual yield: 10.2 inches

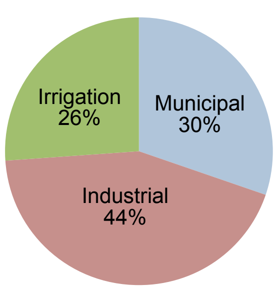
The Neches Basin is the third largest river basin whose watershed area is entirely within Texas and the fourth largest by average flow volume. Named by early explorers after the Neches Indian Tribe, the Neches River flows from headwaters in Van Zandt County to its confluence with Sabine Lake, which drains to the Gulf of Mexico. Smaller rivers and streams within the basin include the Angelina River, Village Creek, and Attoyac, Ayish, and Pine Island bayous. The basin is an important source of surface water supply for growing cities outside the basin. Balancing environmental needs with continued development of surface water supplies is an important issue in the basin.

Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Sam Rayburn Reservoir	2,857,076	820,000[a]
Palestine, Lake	370,908	220,933[b]
Tyler, Lake	73,256	35,458
Striker, Lake	16,934	20,183
Kurth, Lake	14,769	18,421
Total for 10 major existing reservoirs	**3,506,545**	**1,138,749**
Fastrill Reservoir (recommended)	495,000	148,780
Lake Columbia (permitted)	187,839	75,700

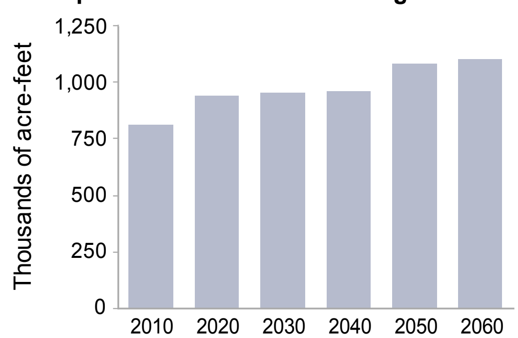
[a]Includes yield from B.A. Steinhagen Lake.
[b]Includes yield from Lake Diversion.

Yield for existing reservoirs is for 2010, and yield for recommended or permitted reservoirs is upon construction.

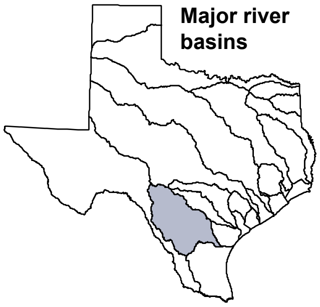
Surface water rights

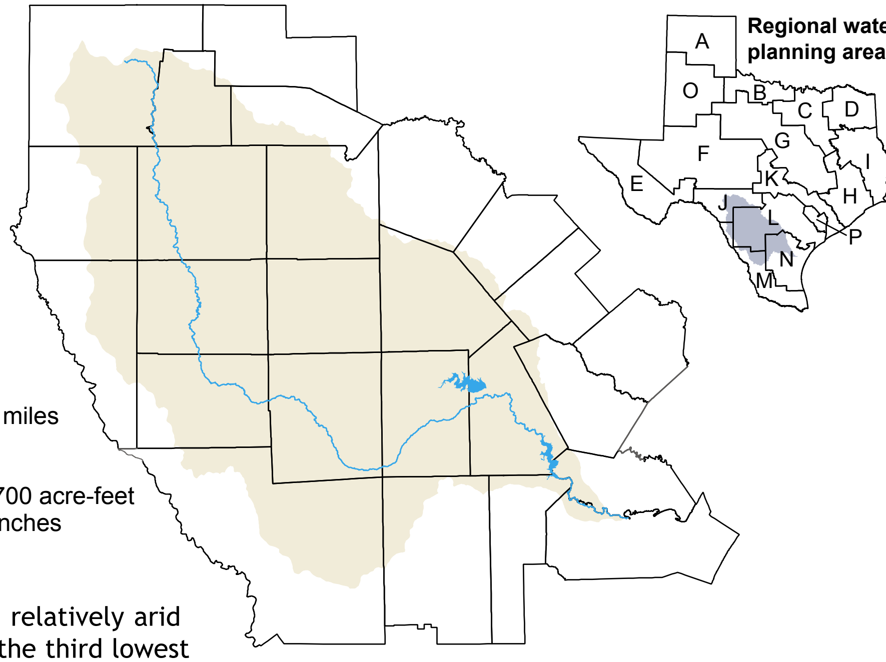


Approximate surface water supply with implementation of water management strategies



Nueces Basin





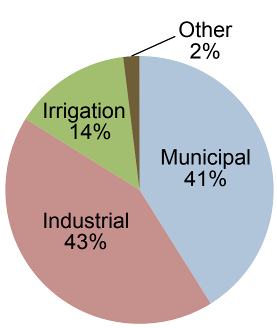
Basin area: 16,700 square miles
Major river: Nueces River
River length: 315 miles
Average annual flow: 539,700 acre-feet
Average annual yield: 0.6 inches

The Nueces Basin occupies a relatively arid region of Texas, resulting in the third lowest value of average annual watershed yield among major river basins of Texas. Apparently in reference to pecan trees growing on its banks, the basin's namesake river was called Río de las Nueces, "River of Nuts," by early Spanish explorers. From headwaters in Edwards and Real counties, the Nueces River flows to Nueces Bay, which drains to the Gulf of Mexico. Other streams within the basin include the Leona, Frio, Sabinal and Atacosa rivers and San Casimiro, Seco, Hondo, and San Miguel creeks. An important issue in the Nueces Basin, exacerbated by drought, is the limited water supply. Groundwater supplies, which have historically provided the majority of water used in the basin, are expected to decline in the future. The basin is an important water supply for portions of the Nueces-Rio Grande Coastal Basin, including the city of Corpus Christi.

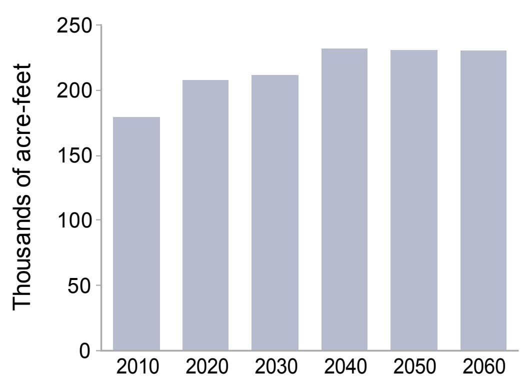
Reservoir yield Three largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Choke Canyon Reservoir	695,262	168,299[a]
Corpus Christi, Lake	256,961	0[b]
Upper Nueces Lake	5,200[c]	0
Total for 3 major existing reservoirs	**957,423**	**168,299**
Nueces Off-Channel Reservoir (recommended)	200,000	19,005

[a]Combined yield of Choke Canyon Reservoir and Lake Corpus Christi system.
[b]Operated as a system with Choke Canyon Reservoir.
[c]Total volume up to the top of conservation pool.
Yield for existing reservoirs is for 2010, and yield for recommended reservoirs is upon construction.

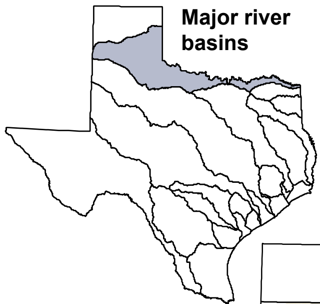
Surface water rights

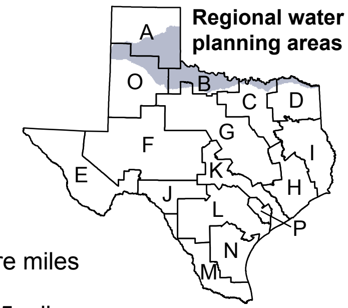


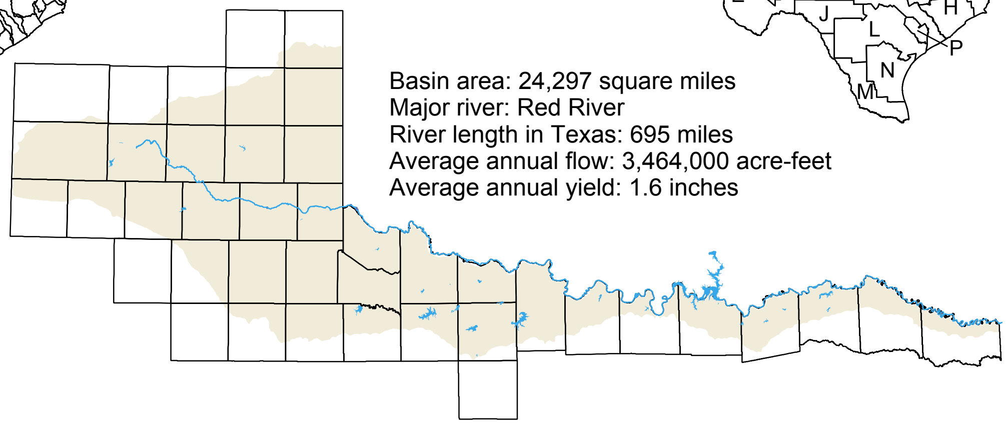
Approximate surface water supply with implementation of water management strategies



Red River Basin





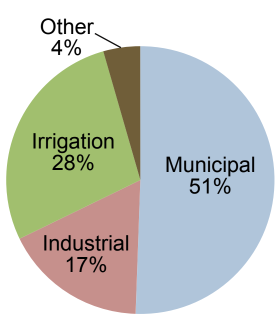


The Red River Basin is the fourth largest river basin by area within Texas. The region's red-colored soil gives the basin's namesake river its characteristic color during high flow events. From its headwaters in New Mexico, the Red River flows across Texas, along the Texas-Oklahoma border, and into Arkansas before reaching its confluence with the Mississippi River in Louisiana. Smaller streams within the Texas portion of the basin include the forks of the Red River and the Pease, Wichita, and Little Wichita rivers. The Red River Compact between Arkansas, Louisiana, Oklahoma, and Texas apportions the waters of the Red River and its tributaries. High levels of naturally occurring chloride in some surface waters of the basin are a concern, and federally funded chloride control projects have been operating there since 1962. In the past, the region has depended heavily on groundwater supplies, but these supplies are projected to decline in the future.

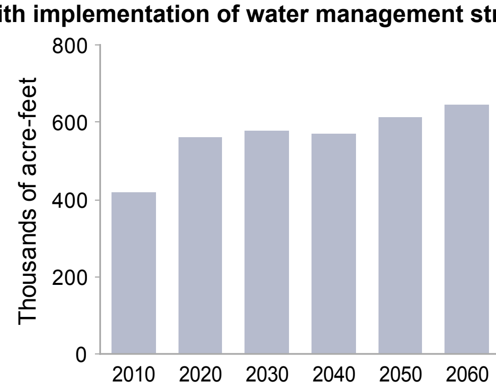
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Texoma, Lake	2,516,225	138,700[b]
Kemp, Lake	268,095	90,417[c]
Pat Mayse Lake	118,110[a]	59,750
Arrowhead, Lake	235,997	30,197
Kickapoo, Lake	85,825	19,901
Total for 23 major existing reservoirs	**3,650,608**	**365,257**
Lower Bois D'Arc Reservoir (recommended)	353,240	123,000

[a]Total volume up to the top of conservation pool.
[b]Texas share of the yield.
[c]Yield of Kemp-Diversion system.
Yield for existing reservoirs is for 2010, and yield for recommended reservoir is upon construction.

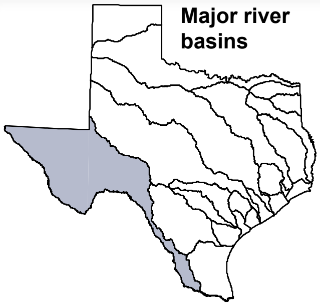
Surface water rights

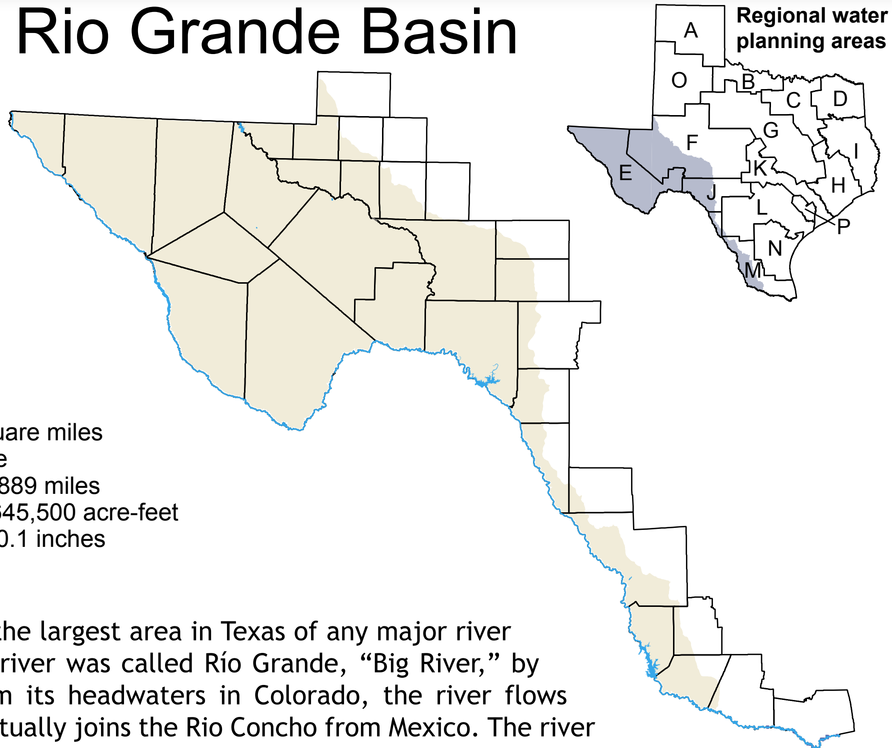


Approximate surface water supply with implementation of water management strategies



Rio Grande Basin





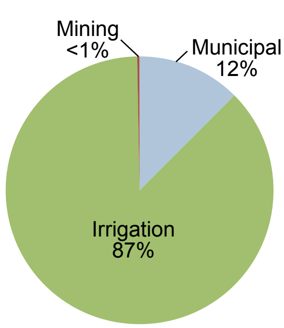
Basin area: 49,387 square miles
Major river: Rio Grande
River length in Texas: 889 miles
Average annual flow: 645,500 acre-feet
Average annual yield: 0.1 inches

The Rio Grande Basin covers the largest area in Texas of any major river basin. The basin's namesake river was called Río Grande, "Big River," by early Spanish explorers. From its headwaters in Colorado, the river flows through New Mexico and eventually joins the Rio Concho from Mexico. The river forms the international boundary between the United States and Mexico from El Paso to the Gulf of Mexico. The Rio Grande Basin has an extremely low average annual watershed yield due to arid or semiarid climate conditions throughout much of the basin. Smaller streams in the Texas portion of the basin include the Pecos and Devils rivers; Alamito, Mud, and Pinto creeks; and Arroyo Colorado. Surface water within the basin is apportioned by the Pecos River Compact between New Mexico and Texas; the Rio Grande Compact between Colorado, New Mexico, and Texas; and the Convention of 1906 and United States and Mexico Water Treaty of 1944.

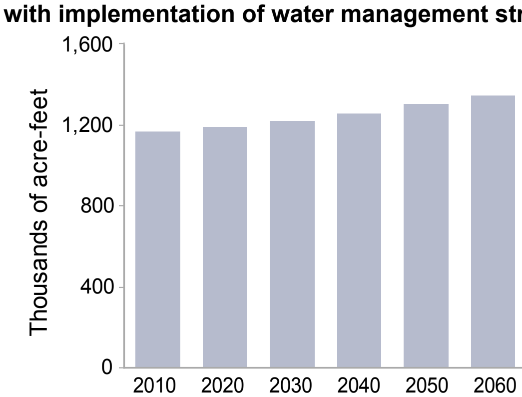
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Amistad, International Reservoir	3,151,267	1,011,976[a]
Red Bluff Reservoir	289,670[b]	41,199
Falcon, International Reservoir	2,653,636	0[c]
Casa Blanca Lake	20,000[b]	0
San Esteban Lake	18,770	0[d]
Total for 8 major existing reservoirs	**6,159,603**	**1,053,175**
Brownsville Weir and Reservoir (permitted)	6,000	20,643

[a]Texas share of combined yield of International Amistad and Falcon reservoirs system.
[b]Total volume up to the top of conservation pool.
[c]Operated as a system with International Amistad Reservoir.
[d]Operated for recreational use, no yield value.
Yield for existing reservoirs is for 2010, and yield for permitted reservoirs is upon construction.

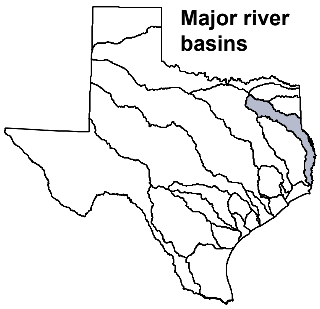
Surface water rights

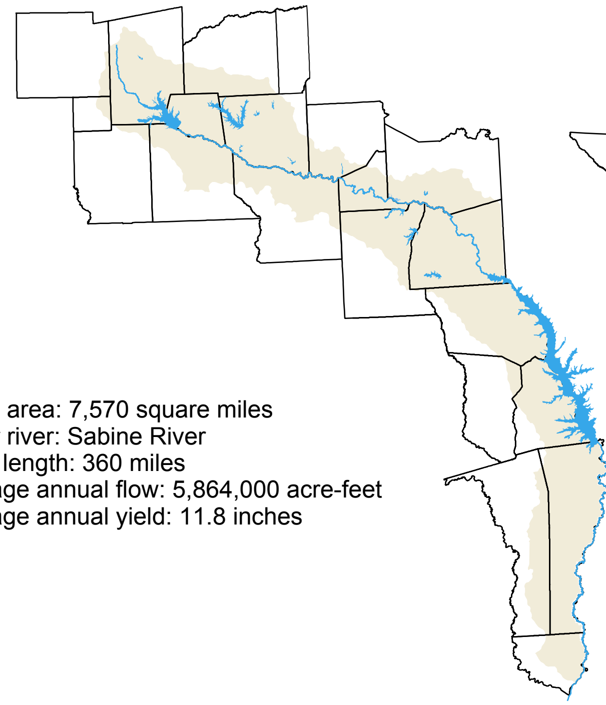


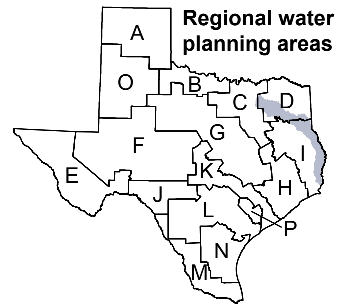
Approximate surface water supply with implementation of water management strategies



Sabine Basin







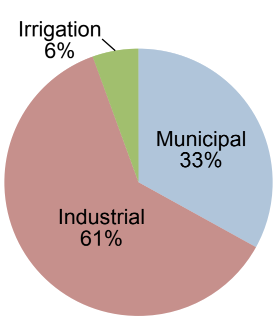
Basin area: 7,570 square miles
Major river: Sabine River
River length: 360 miles
Average annual flow: 5,864,000 acre-feet
Average annual yield: 11.8 inches

The Sabine Basin has the second largest average watershed yield of any major river basin in Texas because of the region's high precipitation and low evaporation rates. The major river in the basin was named Rio de Sabinas or "River of the Cypress" by Spanish explorers. Flowing from its headwaters in Hunt County, the Sabine River forms much of the border between Texas and Louisiana before draining to the Gulf of Mexico through Sabine Lake. The Sabine River has the second largest average flow volume of any river in Texas. Smaller streams within the Texas portion of the basin include Cow, Big Sandy, and Fork creeks and the South Fork of the Sabine River. Surface water use within the basin is subject to the Sabine River Compact between Louisiana and Texas.

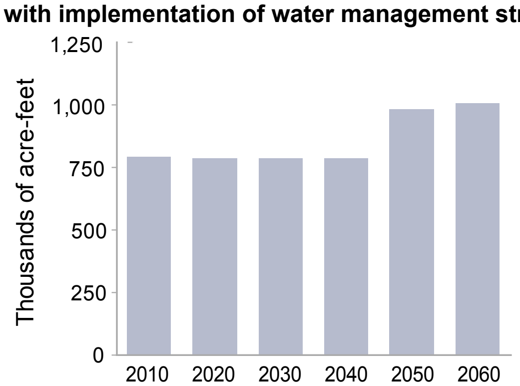
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Toledo Bend Reservoir	4,472,900	750,000[a]
Tawakoni, Lake	888,126	229,807
Fork Reservoir, Lake	604,927	173,035
Cherokee, Lake	39,023	28,885
Martin Lake	75,116	25,000
Total for 11 major existing reservoirs	**6,183,309**	**1,239,519**
No proposed reservoirs		

[a]Texas share of the yield.
Yield for existing reservoirs is for 2010.

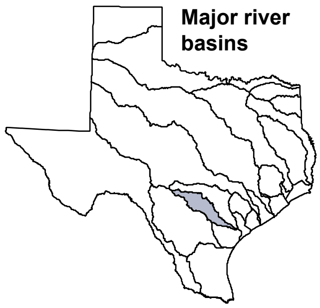
Surface water rights

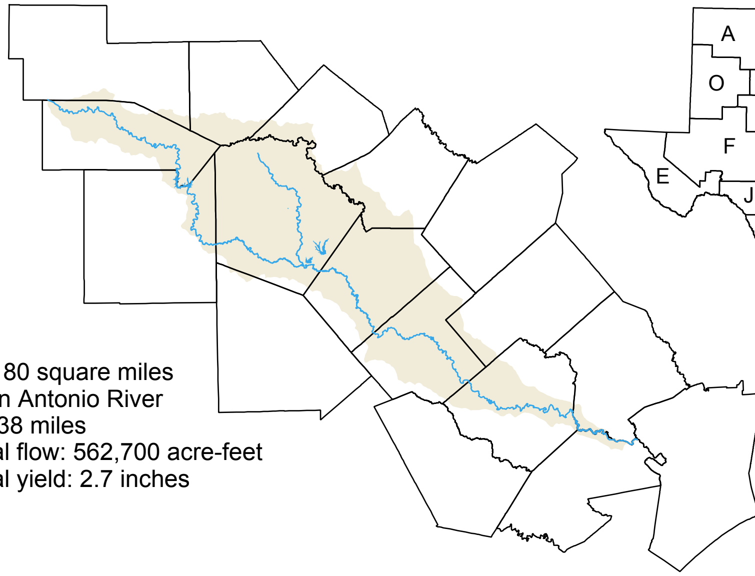


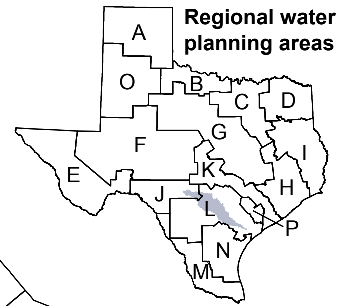
Approximate surface water supply with implementation of water management strategies



San Antonio Basin







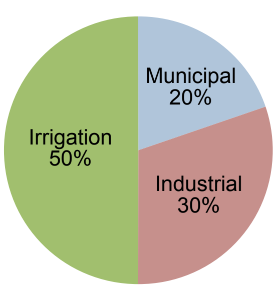
Basin area: 4,180 square miles
Major river: San Antonio River
River length: 238 miles
Average annual flow: 562,700 acre-feet
Average annual yield: 2.7 inches

The San Antonio Basin is relatively modest in both size and average annual watershed yield. Early Spanish explorers named the basin's namesake river after San Antonio de Padua, "Saint Anthony of Padua." From its spring-fed headwaters in Bexar County, the San Antonio River flows to its confluence with the Guadalupe River near Tivoli. Other streams within the basin include the Medina River and Leon, Salado, Calaveras, and Cibolo creeks. The overall limited water supply is an important issue in the basin. Groundwater has historically supplied the majority of water used in the basin, but overpumping has reduced base flows in rivers and in several springs that are home to threatened and endangered species. Despite conservation efforts, municipal water demands are expected to increase due to population growth, particularly within the city of San Antonio.

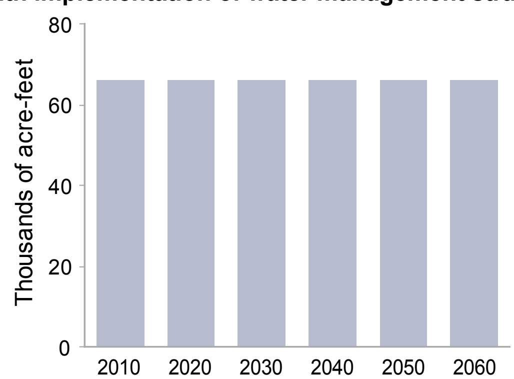
Reservoir yield Three largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Calaveras Lake	63,200[a]	36,900
Victor Braunig Lake	26,500[a]	12,000
Medina Lake	254,843	0
Total for 3 major existing reservoirs	**344,543**	**48,900**
No proposed reservoirs		

[a]Total volume up to the top of conservation pool.
Yield for existing reservoirs is for 2010.

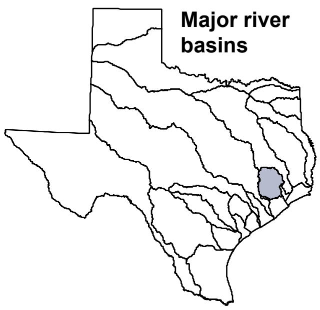
Surface water rights

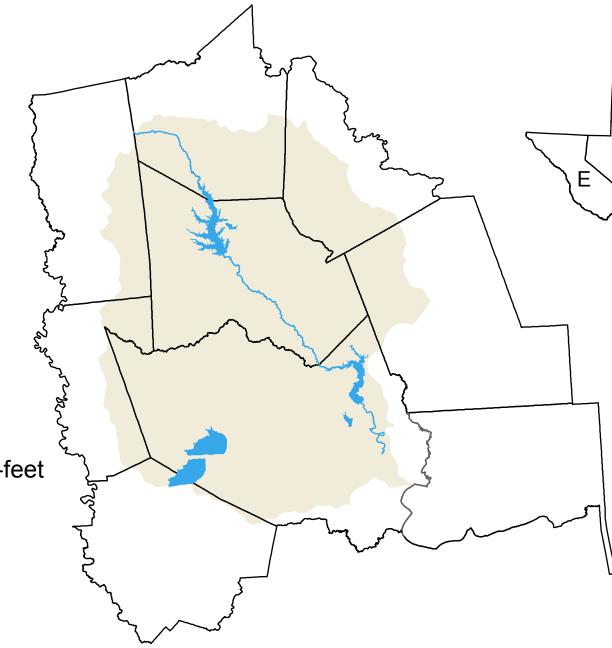


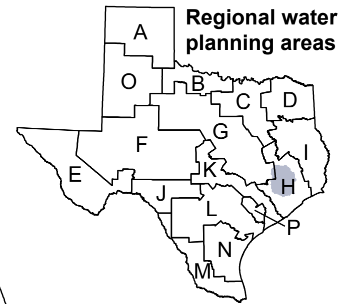
Approximate surface water supply with implementation of water management strategies



San Jacinto Basin







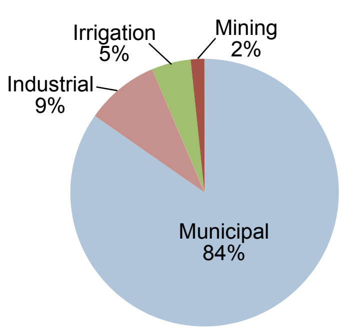
Basin area: 3,936 square miles
Major river: San Jacinto River
River length: 85 miles
Average annual flow: 1,365,000 acre-feet
Average annual yield: 10.3 inches

The San Jacinto Basin is one of the smallest river basins in Texas. The basin's namesake river derives its name from the Spanish word for "hyacinth." From headwaters in Walker County, the San Jacinto River flows southeast to Galveston Bay, which drains to the Gulf of Mexico. Other streams within the basin include the East and West forks of the San Jacinto River; Caney, Cypress, Peach, and Spring creeks; and Luce and Buffalo bayous. An important issue in the basin is meeting the water supply needs of the Houston metropolitan area. Available groundwater supplies are decreasing, even as demands from the metropolitan area are increasing. Groundwater pumping in the basin has caused land subsidence and seawater intrusion into aquifers.

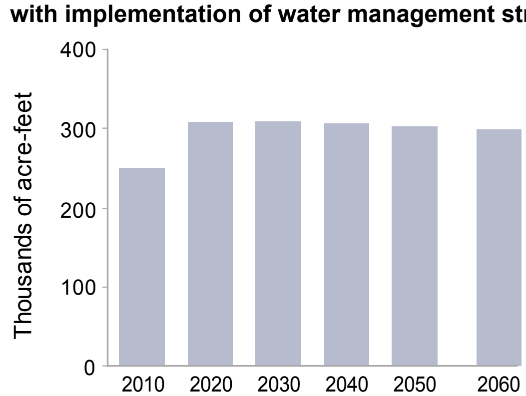
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Houston, Lake	128,863	168,000
Conroe, Lake	416,188	79,800
Barker Reservoir	209,000	0[a]
Lewis Creek Reservoir	16,400	0[b]
Addicks Reservoir	200,800	0[b]
Total for 5 major existing reservoirs	**971,251**	**247,800**
No proposed reservoirs		

[a]Operated for flood control, no yield value.
[b]Operated for cooling water supply, no yield value.
Yield for existing reservoirs is for 2010.

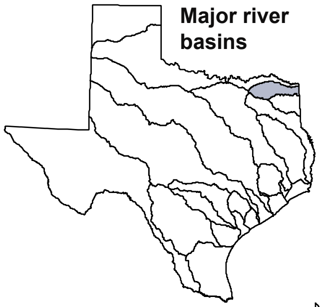
Surface water rights



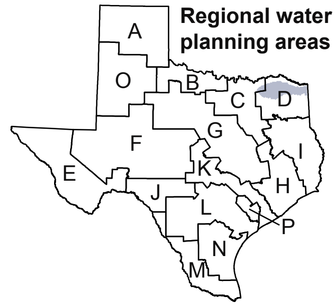
Approximate surface water supply with implementation of water management strategies

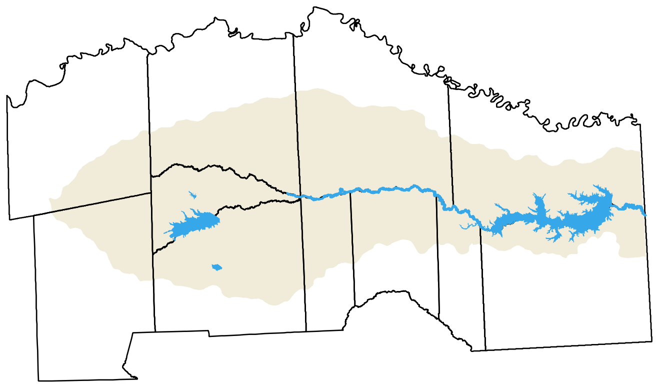


Sulphur Basin



Basin area: 3,580 square miles
Major river: Sulphur River
River length in Texas: 200 miles
Average annual flow: 932,700 acre-feet
Average annual yield: 12.4 inches



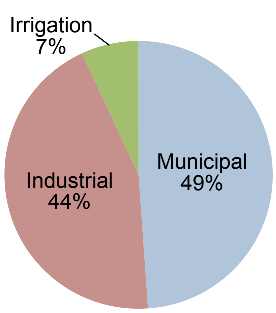


The Sulphur Basin has the largest average watershed yield of any major river basin in Texas because of the region's high precipitation and low evaporation rates. From the confluence of the North and South Sulphur rivers in East Texas, the Sulphur River flows to its confluence with the Red River in Arkansas. Smaller streams in the basin include the North, Middle, and South Sulphur rivers and White Oak Creek. Because the Sulphur River is a tributary of the Red River, surface water within the basin is apportioned by the Red River Compact between Texas, Oklahoma, Arkansas, and Louisiana. The basin is an important source of surface water supply for surrounding regions. Balancing environmental needs with continued development of surface water supplies is an issue in the basin.

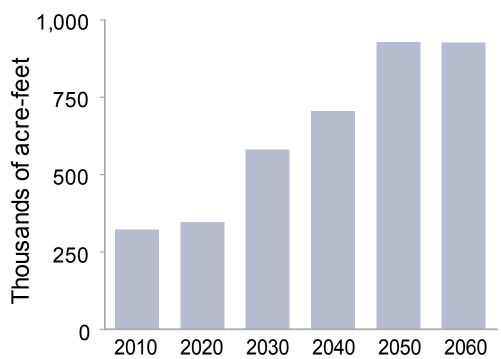
Reservoir yield Four largest yielding reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Wright Patman Lake	110,853	180,000
Jim Chapman Lake	310,019	127,983
Sulphur Springs, Lake	17,838[a]	9,800
River Crest Lake	7,000[a]	8,635
Total for 4 major existing reservoirs	**445,710**	**326,418**
Marvin Nichols Reservoir (recommended)	1,369,717	612,300
Ralph Hall Reservoir (recommended)	73,687	32,940

[a]Total volume up to the top of conservation pool.
Yield for existing reservoirs is for 2010, and yield for recommended reservoirs is upon construction.

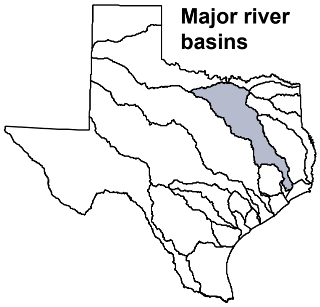
Surface water rights

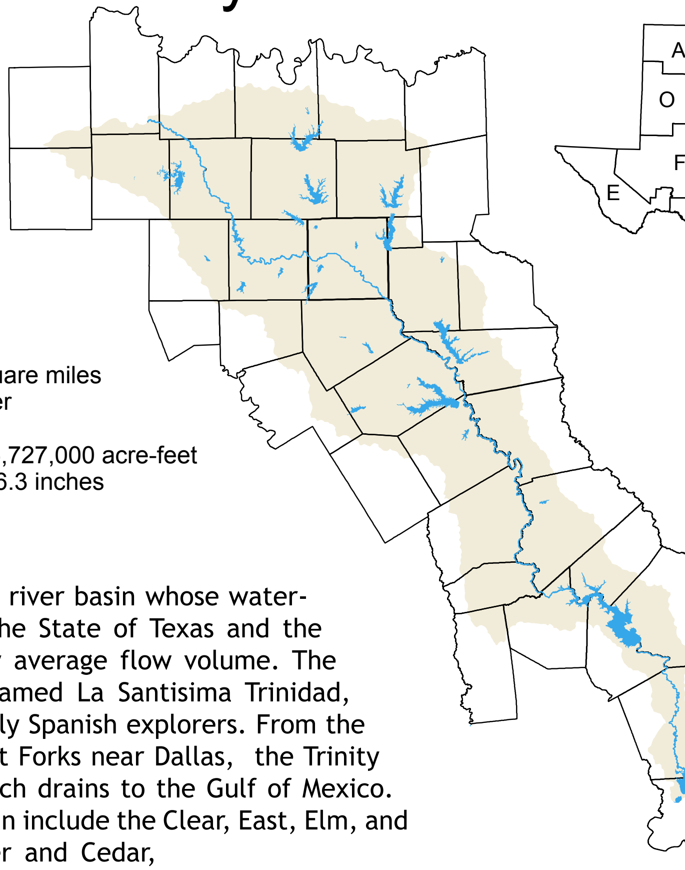


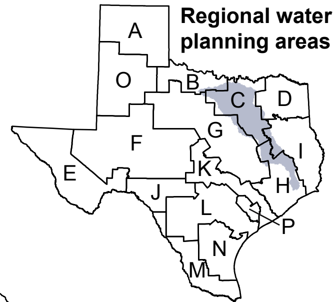
Approximate surface water supply with implementation of water management strategies



Trinity Basin







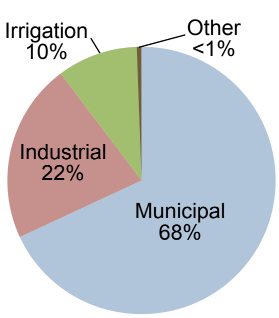
Basin area: 17,913 square miles
Major river: Trinity River
River length: 550 miles
Average annual flow: 5,727,000 acre-feet
Average annual yield: 6.3 inches

The Trinity Basin is the largest river basin whose watershed area is entirely within the State of Texas and the third largest river in Texas by average flow volume. The basin's namesake river was named La Santisima Trinidad, "the Most Holy Trinity," by early Spanish explorers. From the confluence of its Elm and West Forks near Dallas, the Trinity River flows to Trinity Bay, which drains to the Gulf of Mexico. Smaller streams within the basin include the Clear, East, Elm, and West forks of the Trinity River and Cedar, Chambers, and Richland creeks. The Dallas-Fort Worth metropolitan area is located in the upper basin. In the lower basin, water is exported to the Houston area. Water supply demands in both metropolitan areas are increasing. As a result, balancing environmental requirements with these demands is an important issue in the basin.

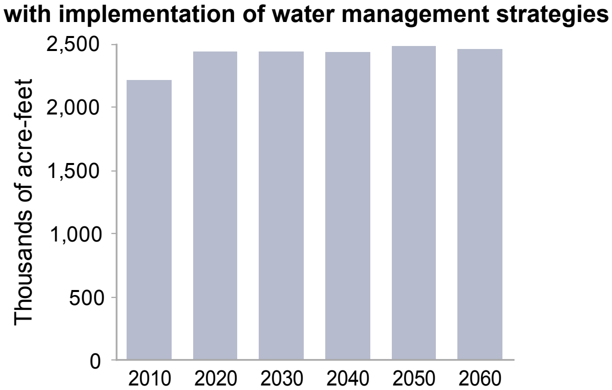
Reservoir yield Five largest existing reservoirs Name	Conservation storage capacity (acre-feet)	Yield (acre-feet per year)
Livingston, Lake	1,741,867[a]	1,344,000
Richland-Chambers Reservoir	1,103,816	222,625
Ray Roberts, Lake	798,758[a]	219,424
Cedar Creek Reservoir Trinity	644,686	175,000
Eagle Mountain Lake	182,500	108,500
Total for 31 major existing reservoirs	**7,117,131**	**2,371,859**
No proposed reservoirs		

[a]Total volume up to the top of conservation pool.
Yield for existing reservoirs is for 2010.

Surface water rights



Approximate surface water supply with implementation of water management strategies



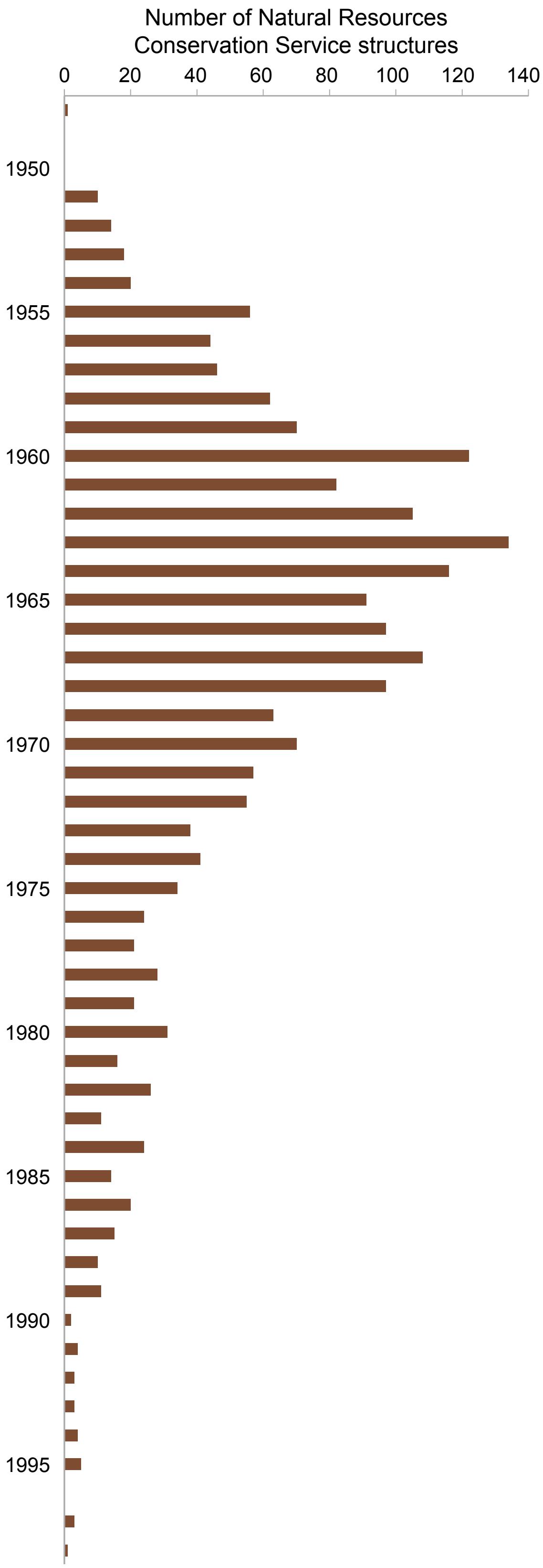


Figure 6.3. History of construction of Natural Resources Conservation Service flood retention structures in Texas.

Information on existing reservoirs, including real-time elevation and contents, engineering plates, and maps can be found on the TWDB Web site at http://wiid.twdb.state.tx.us/ims/resinfo.

6.2.2 Reservoir System Operation

One strategy water managers can use to make better use of existing reservoirs is system operation. The concept is a simple one: manage the operation of a group of reservoirs so that their holding capacity and ability to capture water is maximized. Traditionally, water needs downstream are met either by normal run-of-river flow or through releases from a specific upstream reservoir. If the reservoir operating rules in a given basin are such that releases to meet needs can be made from the most appropriate reservoir, then the group of reservoirs can be said to be operating as a system. Depending on the configuration of the reservoirs and a number of other factors, the total yield of the system can be significantly larger than the sum of the yields of the individual reservoirs.

6.2.3 Reservoir Sedimentation

The difficulty water providers have in permitting and constructing reservoirs is compounded by the fact that sedimentation rates are difficult to predict. A number of variables influence the rate of sedimentation, including watershed soil type, slope, and land use. Another important factor in Texas is the presence of Natural Resources Conservation Service flood retention structures in the watersheds above some reservoirs. In addition to their primary purpose of holding back floodwaters, these reservoirs also hold back sediment that might otherwise accumulate in the larger reservoirs downstream. Since the early 1950s the Natural Resources Conservation Service has built almost 2,000 flood and sediment retention structures in Texas, most of which were constructed between the late 1950s and early 1970s (Figure 6.3). These structures were originally designed for a 50-year life. In other words, after 50 years it was expected that these structures would either be full of sediment or in need of major renovation work, so most have either already reached or are rapidly approaching their design life. From the 1970s onward, the design life of new structures was increased to 100 years. However, a large number of Natural Resource Conservation Service reservoirs in the state will soon no longer be able to retain sediment, raising questions and concerns for the larger water supply reservoirs downstream.

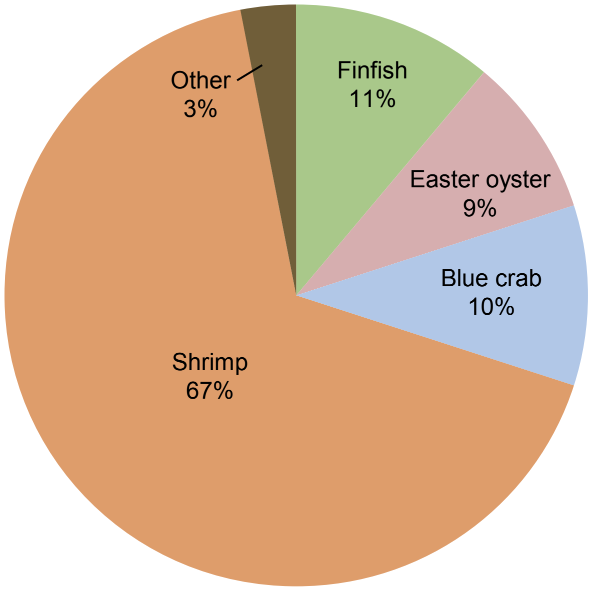


Figure 6.4. Commercially important seafood species in Texas.

Sedimentation rates are notoriously difficult to estimate, both for proposed and existing reservoirs. In 1991, the Texas Legislature authorized the creation of the Lake Hydrographic Survey Program at TWDB to help water resource planners, water providers, and operators determine how quickly the state's reservoirs are filling with sediment. Based on the storage capacity difference between past and recent hydrographic surveys, it is possible to estimate the volume of sediment that has built up in a reservoir and the rate at which it is accumulating.

Recent technological developments allow surveyors to estimate the thickness of sediment in existing reservoirs using a depth sounder that operates at a range of frequencies. The different frequencies penetrate the mud at the bottom of the reservoir to different degrees, depending on the hardness of the substrate. This information, combined with core samples at select locations, is used to determine sediment thickness throughout the reservoirs, which, in turn, allows reservoir sedimentation rates to be estimated without the need for prior survey information.

TWDB has either surveyed or obtained survey information for 95 of the major reservoirs in Texas, representing 70 percent of the total reservoir storage capacity. Some reservoirs have been surveyed twice in order to get a better understanding of sedimentation rates. By extrapolating the survey information to the entire state, TWDB estimates that Texas' major reservoirs are losing approximately 90,000 acre-feet of storage per year due to sedimentation. This equates to a loss of roughly 0.27 percent of the total major reservoir capacity per year, or approximately 13 percent over the 50-year planning horizon. Thirteen percent of the total current storage capacity of the state's major water supply reservoirs is approximately 4.5 million acre-feet, which is more than the 3.4 million acre-feet expected to be gained through the construction of 14 new major and two minor reservoirs recommended in this plan. In other words, the state is losing more reservoir capacity than it is gaining.

6.2.4 Dredging

Currently, dredging sediment from existing reservoirs is not economically competitive with constructing new reservoirs when compared on an equal volume basis. Dredging costs are highly variable but generally cost a minimum of $2 per cubic yard of sediment removed, or roughly twice the cost of new reservoirs, including conveyance costs, for the same capacity gained (as determined based on the estimates to construct lakes Ralph Hall and Columbia). However, when other factors such as aesthetic appeal, boater navigation, safety issues, and public interest are considered, dredging may be more appealing. Several lakes in Texas have been dredged primarily for these reasons, including White Rock, Bachman, and Lytle lakes.

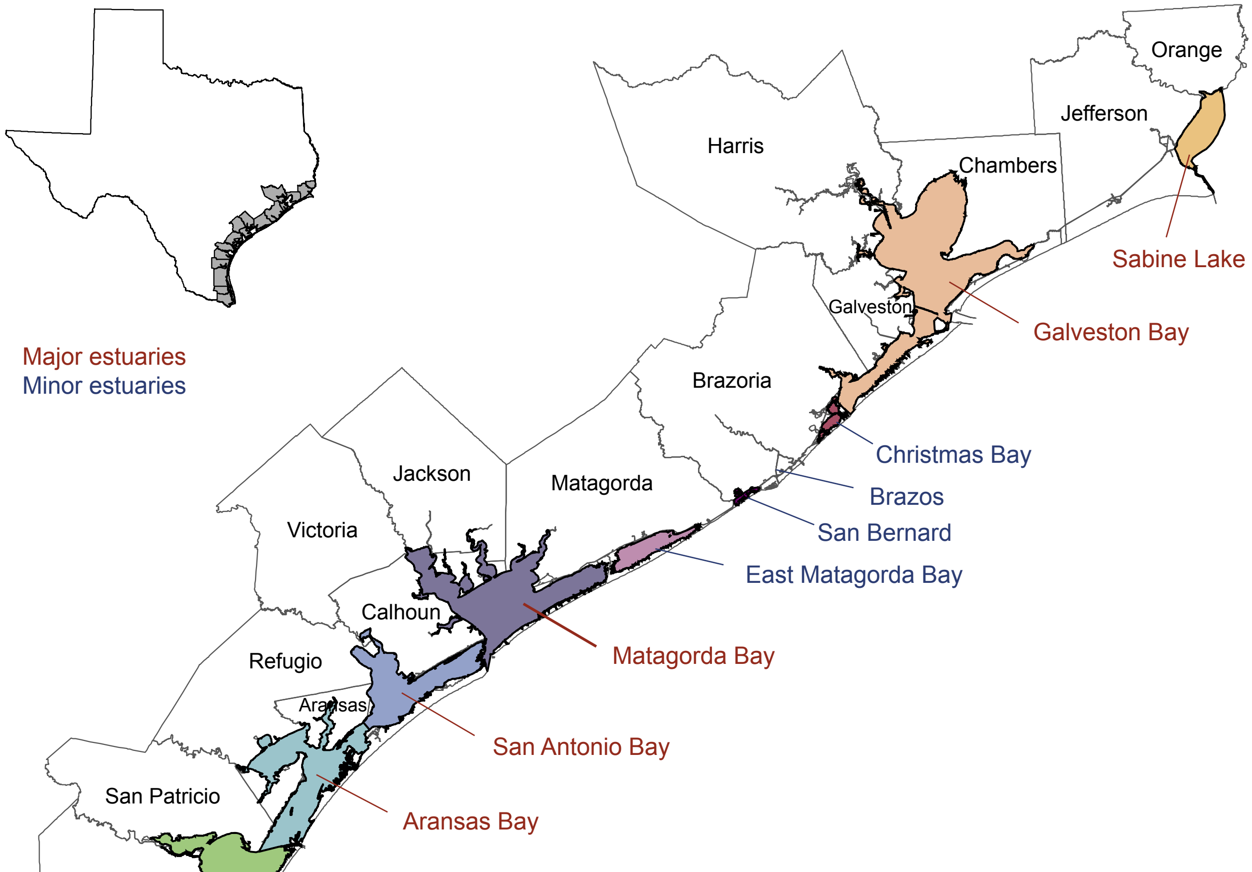
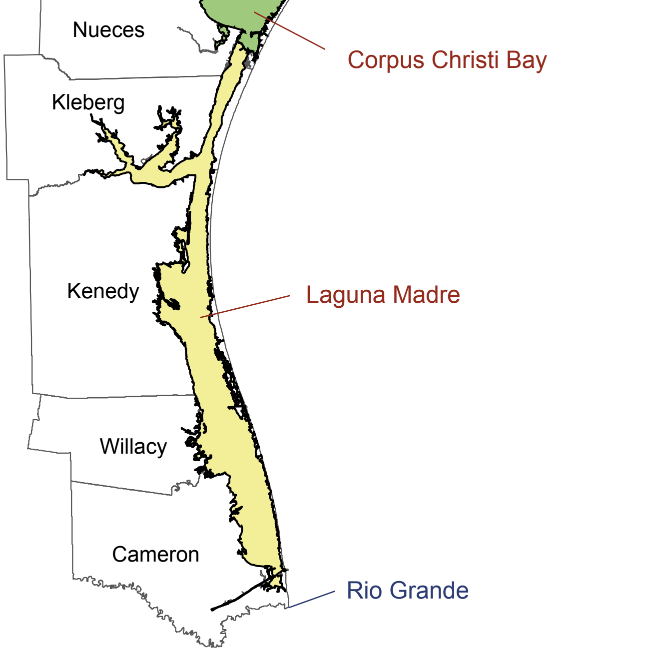



Figure 6.5. Estuaries of Texas.

6.3 Bays and Estuaries

Texas' bays, characterized by a mixture of fresh and salt waters, are significant sources of seafood and an important part of the state's tourism industry. Numerous estuaries extend along the Texas coast differing in size and hydrologic and ecological characteristics, but together they support a diverse array of marine species. These serve as the raw materials for a variety of economic activities associated with commercial and recreational fishing. Commercially important species and their relative contribution to total seafood harvest vary significantly from bay to bay but are dominated by shrimp (Culbertson and others, 2004) (Figure 6.4).

Texas' seven major estuaries contribute $2.5 billion per year to the state economy (Jones and Tanyeri-Abur, 2001). These include Sabine, Galveston, Matagorda, San Antonio, Aransas, Corpus Christi, and Laguna Madre estuaries. Additionally, there are five minor estuaries: Brazos, San Bernard, Rio Grande, East Matagorda Bay, and Christmas Bay (Figure 6.5).

The state's major estuaries have few direct connections with the Gulf of Mexico and tend to be broad, shallow, warm-water habitats whose conditions range from nearly fresh water (less than 5 parts per thousand in Sabine Lake) to hypersaline (greater than 60 parts per thousand in Baffin Bay in Laguna Madre Estuary). Freshwater inflow to bays and estuaries from rivers is, therefore, important to maintaining natural salinity, and nutrient and sediment delivery that support these unique biological communities and ensure healthy ecosystems. Moreover, beneficial freshwater inflows translate to direct economic benefits

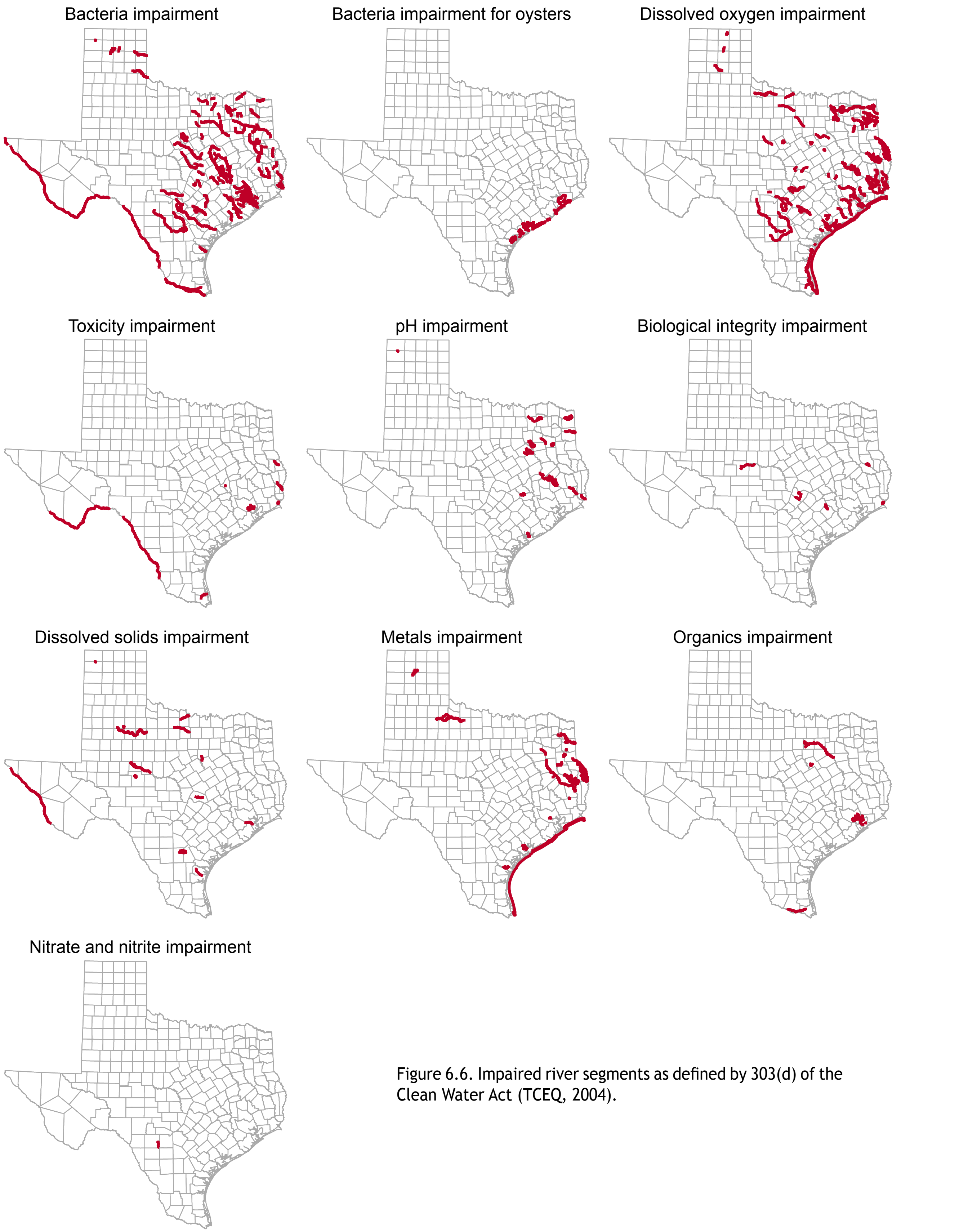


Figure 6.6. Impaired river segments as defined by 303(d) of the Clean Water Act (TCEQ, 2004).

by supporting many species that are targeted by commercial and recreational fishermen, both in near- and off-shore environments.

The state's growing population continues to demand more freshwater, which could limit the volume of freshwater that reaches the bays and estuaries. TWDB works with the Texas Parks and Wildlife Department to understand how freshwater inflows may affect fish and shellfish species and the estuarine life upon which they depend. The Texas Commission on Environmental Quality assesses these studies when considering applications for permits to store, take, or divert surface water within 200 river miles of the coast.

6.4 Surface Water Quality

Water quality concerns may determine how much water can be drawn from a river or stream without causing significant damage to the environment. Water quality issues are also important to planners and water providers because of the cost of treating water in certain water bodies to drinking water standards. Water quality is an integral component of riverine health, as well as being an important consideration in water supply treatment and planning. The state's water quality programs are based on the federal Clean Water Act and Chapter 26 of the Texas Water Code. The Texas Commission on Environmental Quality has jurisdiction over the state's water quality programs. It monitors water quality throughout the state, classifies surface water bodies based on the category of use, adopts water quality standards designed to support these identified uses, regulates and permits discharges, and works to improve the quality of water bodies that do not meet standards. The four general categories of water use are defined as: aquatic life use, contact recreation, public water supply, and fish consumption.

River segments where one or more of these four categories of use are impaired are submitted to the U.S. Environmental Protection Agency, as required under Section 303(d) of the Clean Water Act. Impaired river segments are scattered throughout the state and appear both in upper and lower river basins (Figure 6.6).

6.4.1 Surface Water Treatment

In some parts of the state, treatment costs to bring water up to drinking water standards are a significant obstacle. The concentration of dissolved salts, in particular chlorides, presents difficult challenges and may limit the use of these

waters, even for agricultural purposes. If the concentration of total dissolved solids is greater than 1,000 milligrams per liter, it is considered unsuitable for drinking water supplies. Concentration of dissolved solids in excess of 1,500 milligrams per liter is generally too high for irrigated agriculture, depending on the chemical constituents present.

Certain types of infrastructure can help reduce the concentration of salts in water supply reservoirs. For example, when flows are low in the South Fork of the Wichita River, the highly saline water is diverted and conveyed 13 miles downstream to the Truscott Brine Reservoir. High flows that are less saline are allowed to pass through to Lake Kemp and are subsequently used for irrigated agriculture.

If the concentration of dissolved salts is not too high, water providers may be able to blend the water with other sources in order to bring the diluted product up to U.S. Environmental Protection Agency standards for municipal supply. Reverse-osmosis provides an alternative to blending. For example, the Brazos River Authority currently operates a reverse-osmosis plant on Lake Granbury for municipal water supply.

6.4.2 Total Maximum Daily Load Program

The Total Maximum Daily Load Program works to improve water quality in impaired river segments by determining the extent to which a certain pollutant must be reduced in order for the river segment to support its identified uses. Once the total maximum daily loads for a given basin are developed and adopted by the Texas Commission on Environmental Quality, they are submitted to the U.S. Environmental Protection Agency for review and approval.

Based on the total maximum daily load target, a plan is developed that identifies steps for reducing pollutant loads through regulatory and voluntary activities. For example, a city may be asked to reduce or treat storm water runoff, or farmers may be asked to change their fertilizer or pesticide application methods.

Funds to develop total maximum daily loads are provided by the Texas Legislature to both the Texas Commission on Environmental Quality and the Texas State Soil and Water Conservation Board. Both agencies also receive federal money and are able to leverage additional resources from

stakeholders, academia, and other governmental entities.

6.4.3 Clean Rivers Program

In 1991, the Texas Legislature passed the Clean Rivers Act. This legislation dictates that water quality assessments be performed in each river basin of the state. To fund a comprehensive data collection program, the Texas Commission on Environmental Quality uses fees generated from water use and wastewater discharge permit holders. The Texas Commission on Environmental Quality has also developed partnerships with river authorities, the International Boundary and Water Commission, and other entities. Standardized water quality sampling procedures help ensure that data are collected in a uniform and accurate manner. Once collected, the data are maintained by the Texas Commission on Environmental Quality in their ambient water quality database.

6.5 Surface Water Monitoring

Up-to-date and accurate information on the flow in streams and rivers and the contents of reservoirs is crucial, not only for assisting in reservoir and water supply operations, monitoring environmental conditions, and forecasting floods, but also for water resources planning. Quantitative surface water information is required to run water availability models, which, in turn, provide

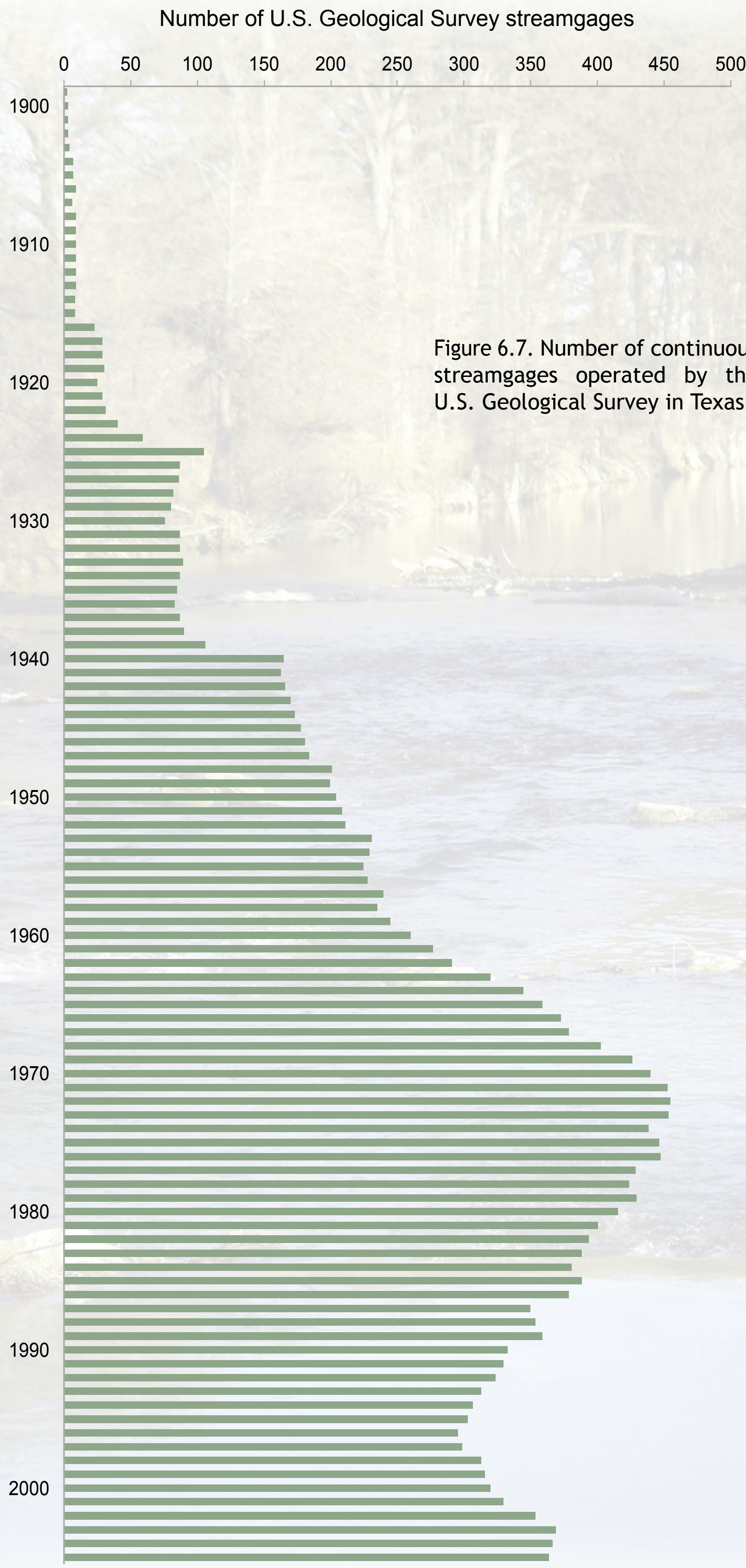


Figure 6.7. Number of continuous streamgages operated by the U.S. Geological Survey in Texas.

information water planners need to determine existing water supplies and estimate water supply from new surface water management strategies. Real time flow information helps determine whether water right holders can divert water at any point in time and, in basins with watermasters, helps with enforcement. Analyzing and modeling flow also helps the Texas Commission on Environmental Quality make determinations on water right applications.

TWDB is the primary state agency charged with monitoring the state's surface water and lake levels. It contracts with the U.S. Geological Survey to conduct the field work and install and maintain monitoring equipment. Other agencies, cities, and local sponsors also contribute funds to help ensure that flow in the state's streams and levels in its lakes are adequately monitored. The U.S. Geological Survey provides some matching funds, and the U.S. Army Corps of Engineers and Bureau of Reclamation also provide financial support for streamgaging and lake level monitoring. There are approximately 392 streamgage sites and 125 lake and reservoir monitoring sites in Texas operated by the U.S. Geological Survey.

6.5.1 Surface Water Monitoring by the U.S. Geological Survey

The U.S. Geological Survey has two main programs for surface water monitoring—the Cooperative Water Program and the National Streamflow Information Program. The majority of the state's active monitoring stations are part of the Cooperative Water Program. Established in 1895, the Cooperative Water Program provides a mechanism for states, counties, municipalities, tribes, and other governmental entities to work cooperatively with the federal government on a cost-share basis. The cooperating groups monitor groundwater and surface water resources and provide answers to questions about water supply, water quality, and hydrologic hazards. At a national level, about 65 percent of the cost of the U.S. Geological Survey streamgaging program is funded through the Cooperative Water Program. Originally conceived as a 50 percent cost-share program, local cooperators now provide some 68 percent of the total cost of operating the Cooperative Water Program.

From the early 1970s until the mid-1990s, the number of streamgages operated by the U.S. Geological Survey in Texas decreased steadily. However, the economic upturn of the mid-1990s and the passage of Senate Bill 1 by the 75th Legislature (and associated legislative appropriation) in 1997 resulted in reversing this trend. More recently, there has once again been a downturn in the number of operational streamgages due to budget constraints and inflation (Figure 6.7).

Recognizing that the nation was losing many critical gages, in 2002 Congress created and partially funded the National Streamflow Information Program. The primary purpose of the National Streamflow Information Program is to ensure secure funding for sites for which flow information has been identified as being nationally important. As part of the National Streamflow Information Program, the U.S. Geological Survey identified 415 nationally important stream and river monitoring sites in Texas. Of these 415 sites, only 289 are currently active. Funding by cooperators and the Cooperative Water Program supports 259 sites and the National Streamflow Information Program supports 30 sites.

6.5.2 Streamflow Data Collected by Other Agencies

In addition to the U.S. Geological Survey, the Lower Colorado River Authority and International Boundary and Water Commission also monitor streamflow and lake levels. For various reasons, including the intended purposes for the collected data, it can make economic sense for local entities to collect their own streamflow information. The Lower Colorado River Authority operates approximately 40 streamgages in the Lower Colorado Basin. The network of stations provides real time flow information, and many are associated with local meteorological stations that provide, among other climate variables, real time rainfall for their flood forecasting models.

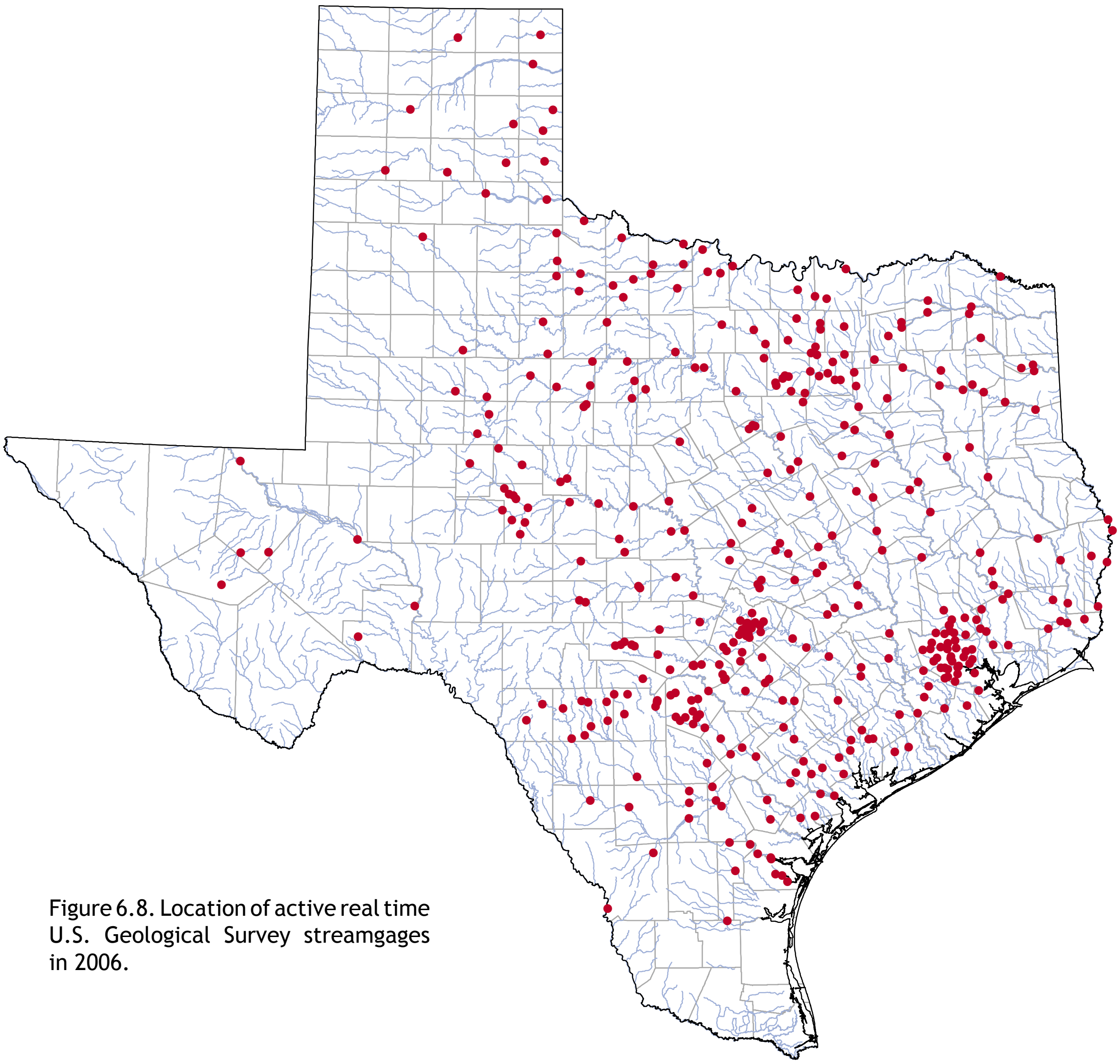


Figure 6.8. Location of active real time U.S. Geological Survey streamgages in 2006.

6.5.3 Surface Water Data Sources

Streamgages are scattered throughout the state, but there are higher concentrations around major cities, where the information is used for multiple purposes and plays a critical role in flood forecasting. There is also a high concentration in East Texas, where there are more water courses to monitor (Figure 6.8). Real time information on these streamgages can be downloaded from the U.S. Geological Survey Web site at http://waterdata.usgs.gov/tx/nwis/rt. Lake level information can be found on the same Web site, but more information, such as the associated reservoir contents, dam engineering plates, maps, and location of adjacent streamgages can be found on the TWDB Web site http://wiid.twdb.state.tx.us/ims/resinfo. TWDB provides conversion tables for reservoirs that enable the U.S. Geological Survey and others to determine the volume of water contained within a reservoir based on water level information.

6.6 Surface Water Availability Modeling

Water availability models are computer-based simulations used to predict the amount of water

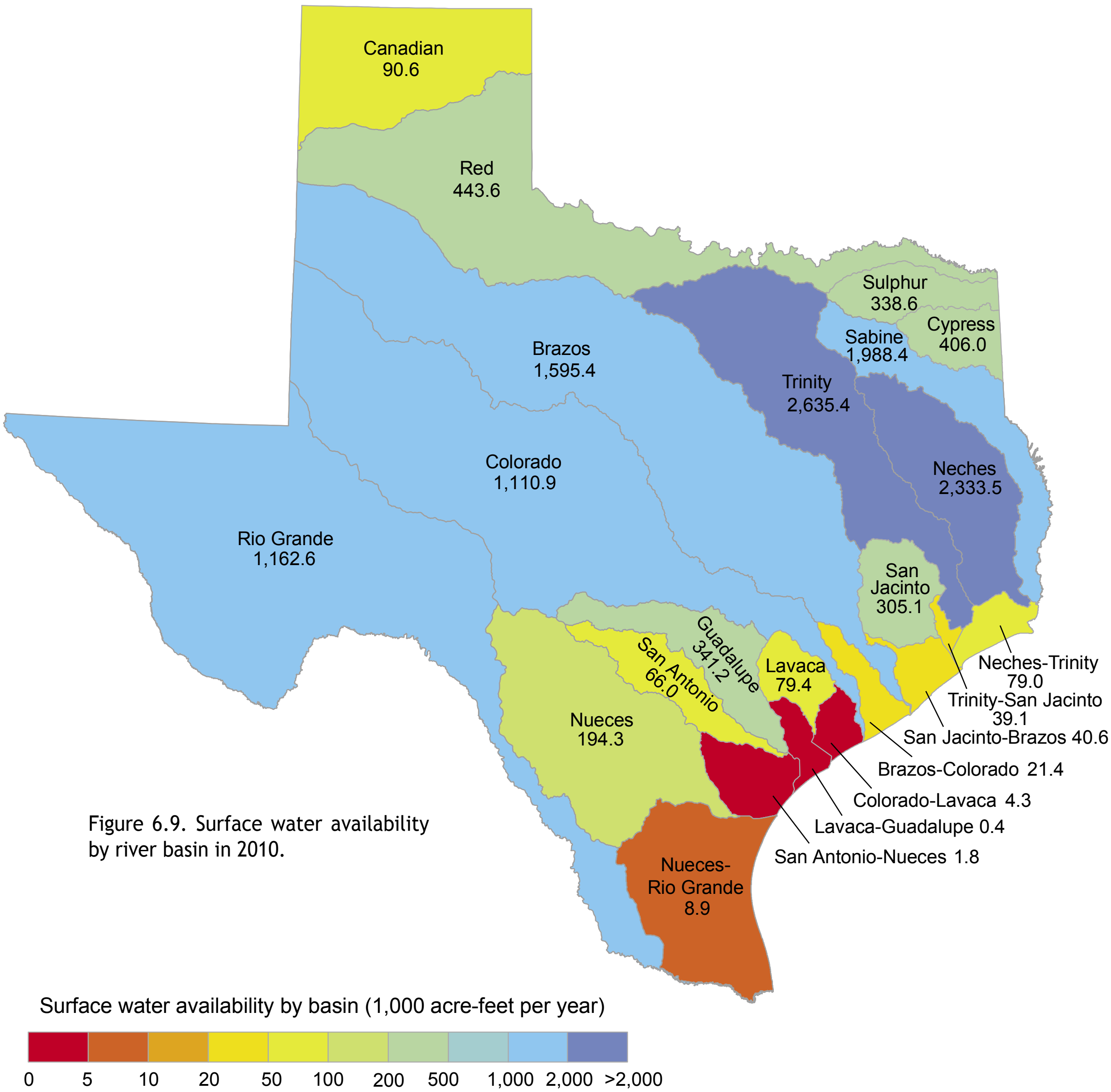
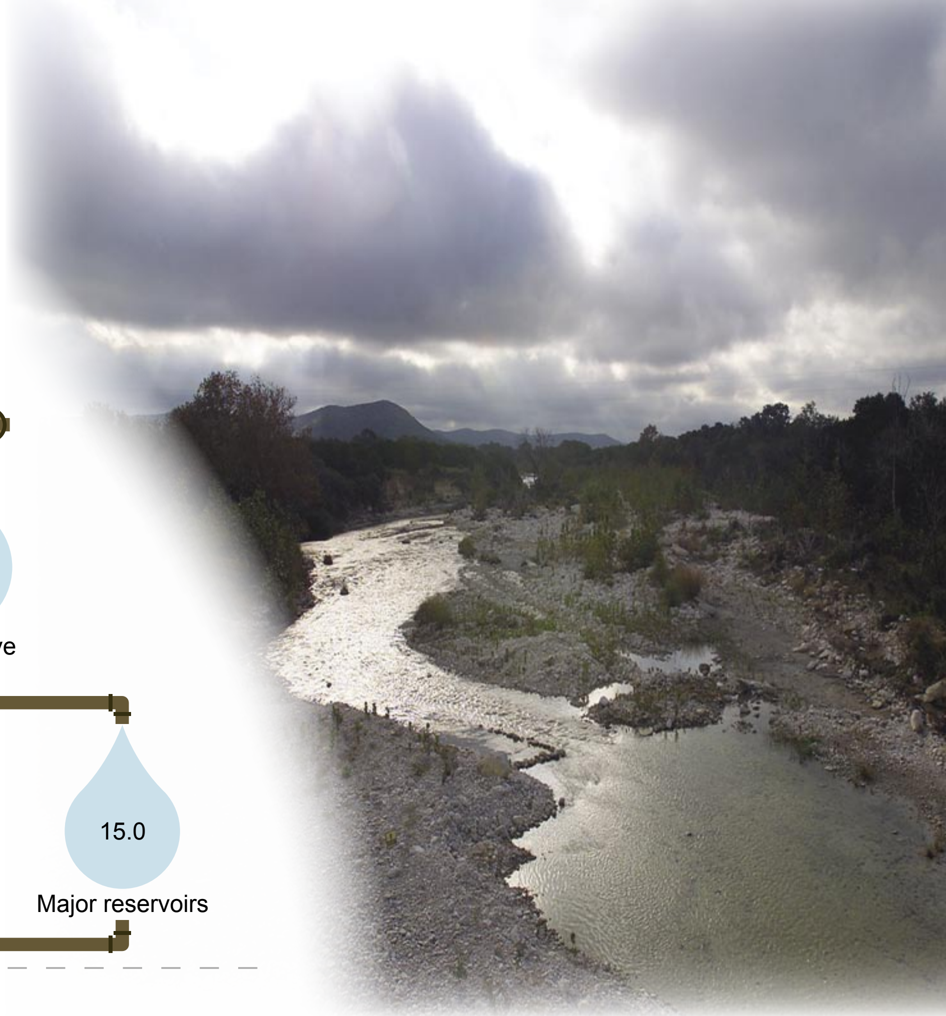


Figure 6.9. Surface water availability by river basin in 2010.

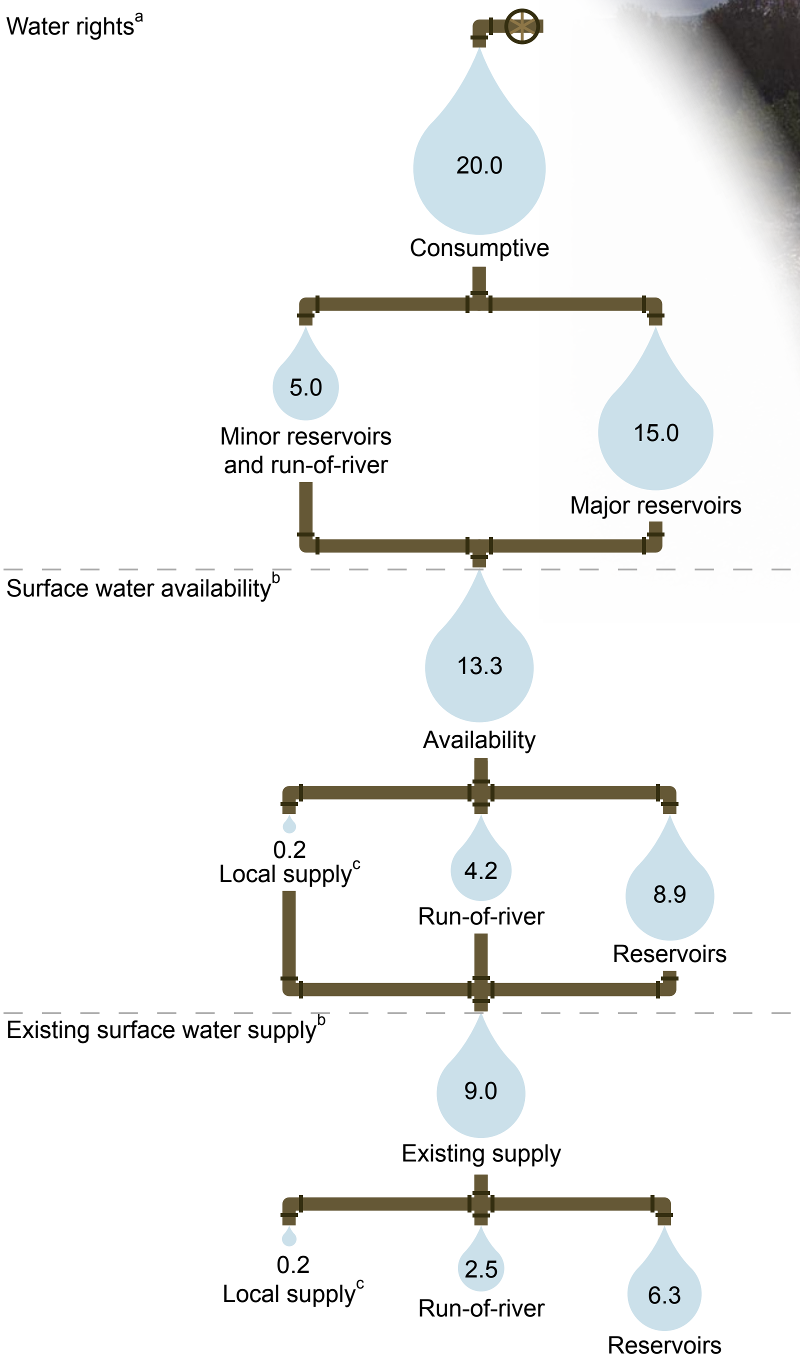
that would remain in a river or stream under a specified set of conditions. The primary purpose of the water availability models is to serve as a decision support system for administering the state's surface water right permitting program and to help planners determine how and where to develop new supplies of water to meet future needs. Water availability models are the primary tool for determining reservoir firm yield and for estimating the hydrological impact of future water supply strategies.

In response to Senate Bill 1, enacted by the 75th Texas Legislature in 1997, the Texas Commission on Environmental Quality initiated the Water Availability Modeling Project. By 2003, water availability models had been developed for all 15 major river basins and eight coastal basins of the state. Because some basins are grouped together for modeling purposes, there are 21 basin water availability models in total. This is the first round of regional water planning that has benefited from a full complement of surface water availability models. To ensure consistency and comparabil-



ity in the 2006 Regional Water Plans, the planning groups were required to use these water availability models for their surface water availability analyses.

Water availability models are dynamic, changing when new water right applications are administratively complete and permits are issued. The Texas Commission on Environmental Quality maintains two model scenarios for evaluating water right applications: the full authorization version, which is used to evaluate applications for perpetual rights, and the current conditions version, which is used to make decisions on term water rights and sometimes amendment applications. These models may be downloaded from their Web site at http://www.tceq.state.tx.us.



Note: All units are in millions of acre-feet. This chart excludes reuse.
[a]Source: Texas Commission on Environmental Quality Water Availability Model data.
[b]Source: Regional Water Planning Groups.
[c]Local supplies consist of exempt domestic and livestock reservoirs.

Figure 6.10. Water rights, availability, and existing supply in 2010.

6.6.1 Streamflow Assessment

In response to requests from stakeholders after the last round of planning in 2002, TWDB has estimated the impact that recommended water management supply strategies in the 2006 Regional Water Plans would have on streamflow. To determine those impacts, TWDB used the water availability models from the Texas Commission on Environmental Quality, developed a methodology, and chose a total of 156 water availability model control points for comparing flows before and after water management strategy implementation. These assessments provide scientists and engineers information on possible changes in future streamflow resulting from water management strategies. However, these assessments are not intended to fulfill the requirements for planning groups to provide a quantitative reporting of environmental impacts of water management strategies. Results of these analyses are presented in Appendix 6.2: Streamflow Assessments.

6.7 Surface Water Availability Projections

Surface water availability represents the maximum amount of water available during the drought of record over the period of simulation of the water availability model, regardless of whether the supply is physically or legally available. Surface water availability depends on a number of factors, including, hydrology, size and number of reservoirs, and water rights. The wetter parts of the state naturally have more water availability

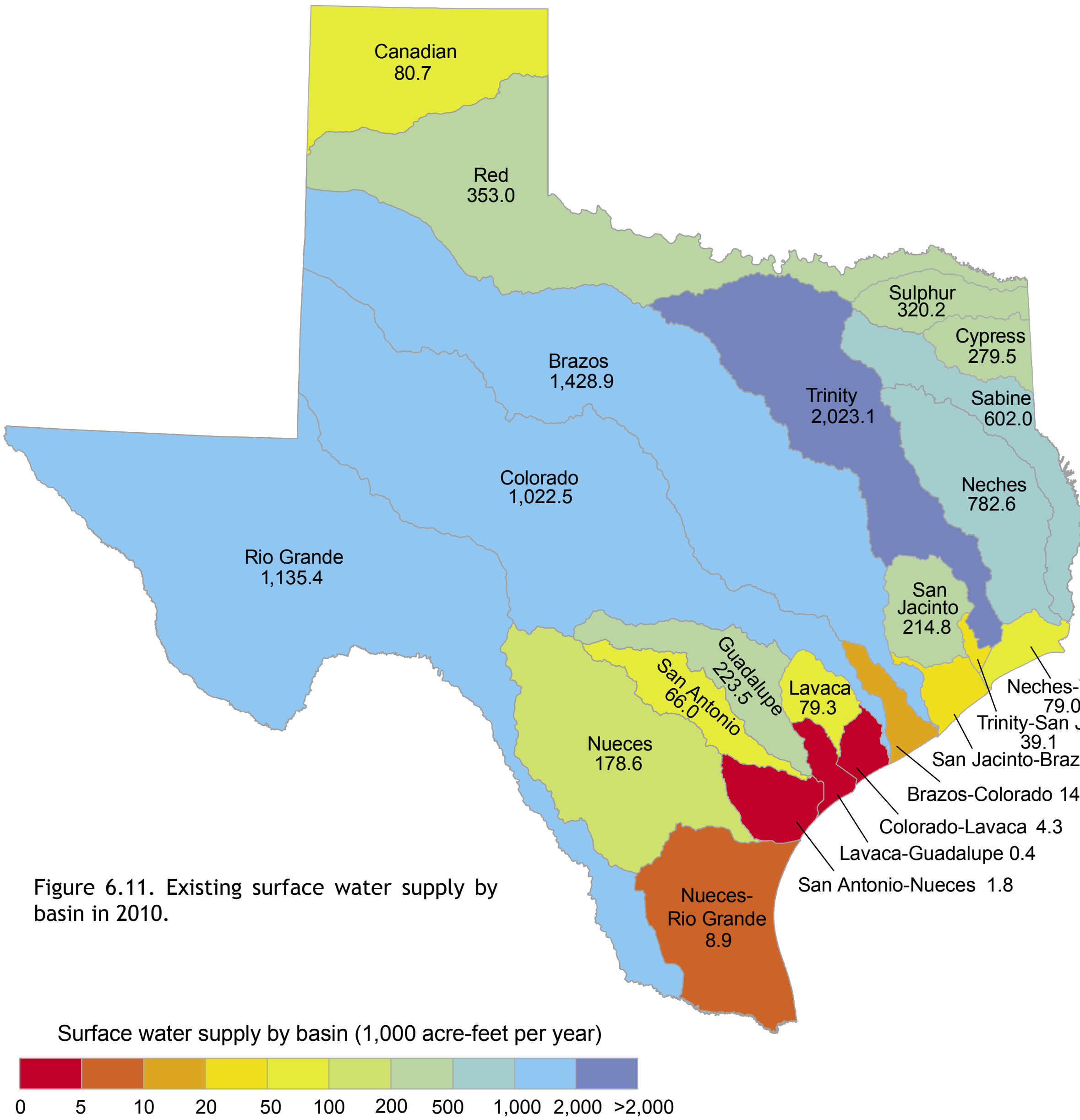


Figure 6.11. Existing surface water supply by basin in 2010.

on a surface area basis (Figure 6.9). The planning groups report surface water availability is 13.3 million acre-feet in 2010. Primarily due to reservoir sedimentation, the total surface water availability for the state is expected to decrease 188,000 acre-feet by 2060.

Although the total surface water available during a repeat of the drought of record in 2010 is estimated to be 13.3 million acre-feet, the amount of water permitted through permanent consumptive surface water permits in Texas is estimated to be 20.0 million acre-feet per year. The total volume of water permits exceeds the water availability because many of these rights are unreliable (water right holders cannot divert water during low flow conditions). For some reservoirs the water rights far exceed the water availability. For example, Lake Meredith Reservoir has the right to impound and divert no more than 151,200 acre-feet per year, but the water available is estimated to be 69,750 acre-feet per year.

6.8 Existing Surface Water Supply Projections

Existing surface water supply and surface water availability differ in that existing surface water supply projections consider only supplies that are physically and legally available. Of the total surface water available, only 9.0 million acre-feet per year is existing water supply (Figure 6.10). Planning groups are required to use existing water supply in the planning process to determine water supply needs. If no new strategies are implemented, surface water supplies are projected to decrease to 8.4 million acre-feet per year by 2060, partly due to the sedimentation of existing reservoirs. Most of the existing surface water supply, almost 6.3 million acre-feet per year, is a direct result of the state's major and minor reservoirs.

Existing surface water supply accounts for more than 50 percent of the 17.9 million acre-feet of total water supply in 2010. Wetter basins containing more reservoirs are able to capture more water and generally have significant infrastructure in place to supply that water (Figure 6.11).

The difference between water availability and existing water supply provides an estimate of the amount of water that can be recommended as water management strategies to meet needs.

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