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Texas Water: Present and Future Needs 2023

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Introduction

Texas has experienced extraordinary growth in the 21st century, owing largely to its low cost of living and inviting business climate. With nearly $2.4 trillion in gross domestic product (GDP) in 2022, Texas would be the eighth-largest economy in the world if it were a country. Between 2000 and 2022, Texas GDP rose by an average annual rate of 2.9 percent, far exceeding the U.S. rate of 1.9 percent, according to data from the U.S. Bureau of Economic Analysis.

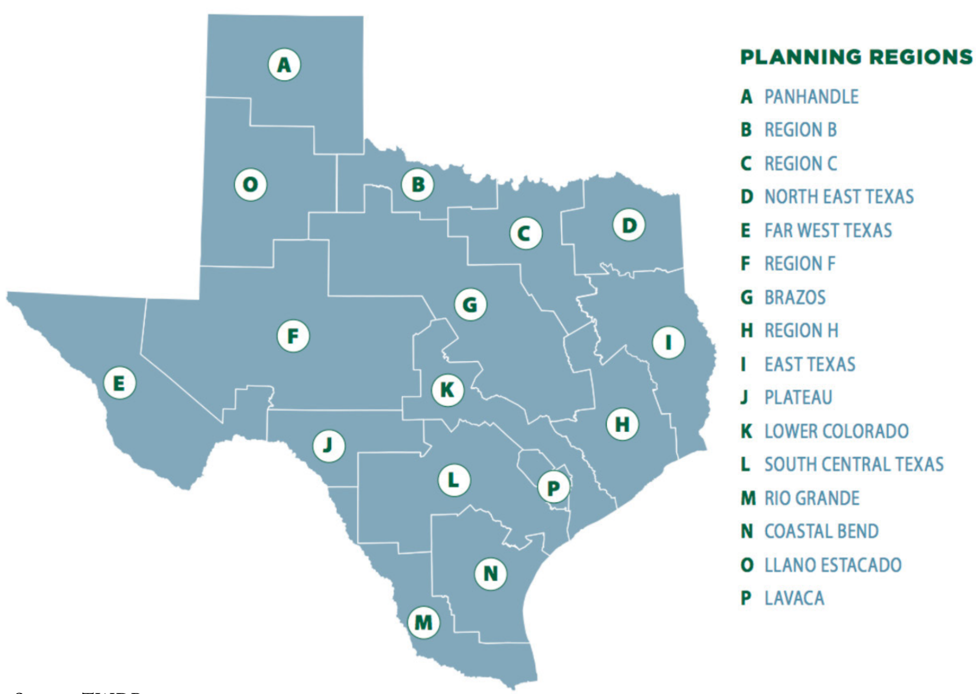
Likewise, Texas' population rose by an average annual rate of 1.8 percent during this period, among the highest rates of all states and more than double the national rate of 0.8 percent. And this growth is expected to continue – the Texas Water Development Board (TWDB) projects that the state's population will increase from 29.7 million in 2020 to 51.5 million in 2070, an average annual increase of 1.1 percent.

These factors make addressing Texas' critical water issues – including an aging water infrastructure, more frequent severe weather events and increasing demand from a rapidly expanding population – more important than ever. The impact of ignoring the state's water needs would have damaging consequences, as the TWDB warned in its *2022 State Water Plan* (SWP): "Insufficient water supplies would negatively affect existing business and industry, future economic development efforts and public health and safety in Texas."[1]

Current and Projected Water Supply and Demand

Every five years the TWDB creates a new state water planning that projects long-term water demands for the 16 water planning regions and recommends water management strategies to address potential water shortages **(Exhibit 1)**. Each SWP uses current and historical data to estimate future water supplies and water supply needs that inform recommended infrastructure projects and water conservation measures to be implemented by entities across the state.

EXHIBIT 1
State Regional Water Planning Groups



Source: TWDB

TWDB defines existing water supplies as water supplies that are physically and legally available to be immediately produced and delivered to water users in the event of an onset of drought of record conditions. As of 2020, groundwater accounted for roughly 53 percent of the existing water supplies in Texas. Surface water – a combination of lakes, ponds, springs, rivers, reservoirs and other aboveground water sources – accounted for 43 percent and reuse water contributed about 4 percent of total existing water supplies in the state.[2]

The 2022 SWP projects that existing water supplies will decrease by 18 percent, while demand will increase by about 9 percent between 2020 and 2070, an imbalance potentially costing the state billions of dollars in economic damages in the cases of a severe drought.[3] In 2020, the state's water supplies totaled approximately 16.8 million acre-feet and are expected to decrease to roughly 13.8 million acre-feet per year by 2070. Groundwater is predicted to have the largest decrease at 32.4 percent between 2020 and 2070.

Existing surface water supplies are projected to decrease by about 2 percent, while reuse water will increase by 15 percent during the same period **(Exhibit 2)**.[4]

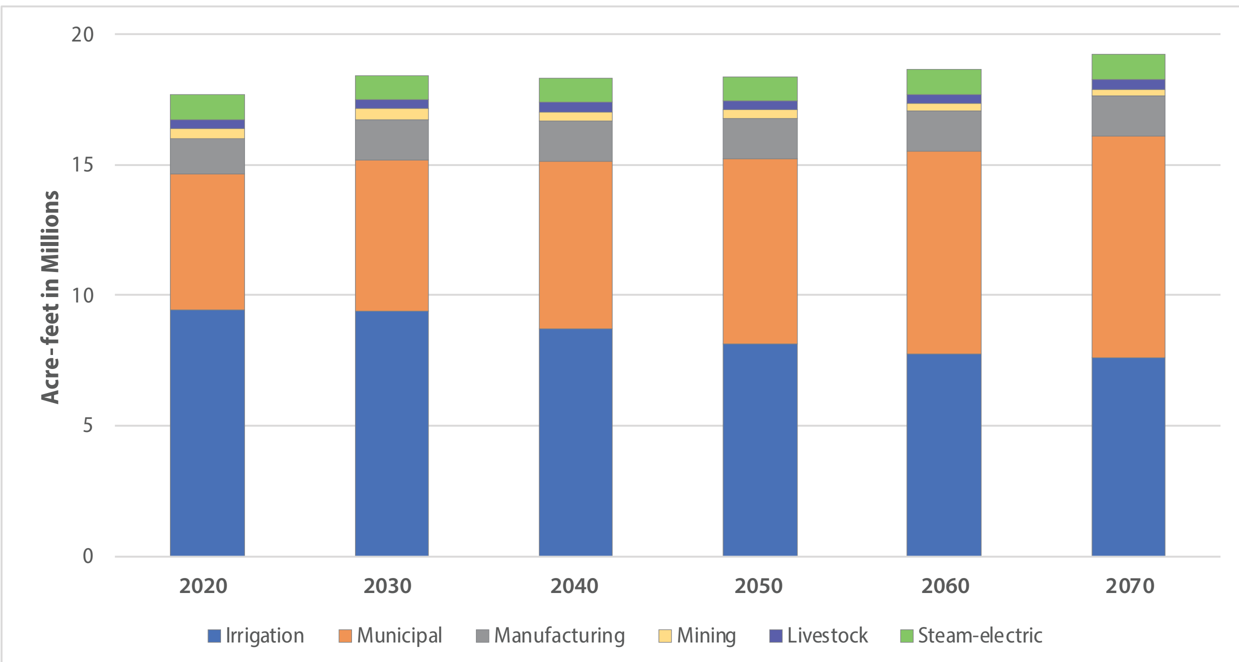
EXHIBIT 2
Annual Existing and Projected Water Supplies in Texas, 2020 and 2070

SOURCE	2020 (ACRE-FEET)	2070 (ACRE-FEET)	PERCENT CHANGE
Surface Water	7,232,000	7,080,000	-2.1%
Groundwater	8,912,000	6,023,000	-32.4%
Reuse	620,000	714,000	15.2%
Total	16,764,000	13,817,000	-17.6%

Source: TWDB, Texas Comptroller of Public Accounts

The SWP identifies six primary water use categories: municipal, irrigation, steam-electric, manufacturing, mining and livestock. Irrigation accounted for more than half of the state's water use in 2020. Water use for irrigation is expected to fall by about 20 percent between 2020 and 2070 – from 9.4 million acre-feet to 7.6 million acre-feet. Meanwhile, water use for municipal needs is projected to rise from 5.2 million acre-feet in 2020 to 8.5 million acre-feet in 2070 – a 63 percent increase – and this sector will account for 44 percent of total water use by 2070. Water usage for mining is expected to fall steadily from 2020 levels, as usage for livestock and manufacturing needs rises slightly (**Exhibit 3**).

EXHIBIT 3
Projected Annual Water Demand by Water Use Category (millions of acre-feet), 2020-2070



Source: TWDB

EXHIBIT 4

Projected Population and Water Use Demand by Texas Water Planning Regions, 2020-2070

	POPULATION PROJECTIONS				WATER DEMAND PROJECTIONS (IN ACRE-FEET)			
REGION	2020	2070	TOTAL CHANGE	PERCENT CHANGE	2020	2070	TOTAL CHANGE	PERCENT CHANGE
Region A Panhandle	418,345	637,412	219,067	52.40%	2,130,529	1,598,115	-532,414	-25.00%
Region B	206,307	228,973	22,666	11.00%	156,489	154,535	-1,954	-1.20%
Region C	7,637,764	14,684,790	7,047,026	92.30%	1,733,893	2,898,540	1,164,647	67.20%
Region D North East Texas	831,469	1,370,438	538,969	64.80%	401,419	479,321	77,902	19.40%
Region E Far West Texas	954,035	1,551,438	597,403	62.60%	480,424	559,976	79,552	16.60%
Region F	715,773	1,039,502	323,729	45.20%	765,150	744,366	-20,784	-2.70%
Region G Brazos	2,371,064	4,351,042	1,979,978	83.50%	1,121,088	1,421,583	300,495	26.80%
Region H	7,325,314	11,743,278	4,417,964	60.30%	2,336,763	3,076,799	740,036	31.70%
Region I East Texas	1,151,556	1,553,652	402,096	34.90%	738,081	839,601	101,520	13.80%
Region J Plateau	141,476	184,595	43,119	30.50%	37,337	43,155	5,818	15.60%
Region K Lower Colorado	1,762,591	3,290,477	1,527,886	86.70%	1,116,839	1,307,643	190,804	17.10%
Region L South Central Texas	3,013,139	5,219,393	2,206,254	73.20%	1,050,964	1,320,128	269,164	25.60%
Region M Rio Grande	1,960,738	4,029,338	2,068,600	105.50%	1,783,993	1,853,358	69,365	3.90%
Region N Coastal Bend	614,790	744,544	129,754	21.10%	253,218	276,492	23,274	9.20%
Region O Llano Estacado	540,495	801,719	261,224	48.30%	3,367,953	2,452,931	-915,022	-27.20%
Region P Lavaca	50,489	55,522	5,033	10.00%	206,304	204,333	-1,971	-1.00%
TEXAS	29,695,345	51,486,113	21,790,768	73.40%	17,680,444	19,230,876	1,550,432	8.80%

Source: TWDB and Texas Comptroller of Public Accounts

Total Texas water usage is projected to rise by 8.8 percent between 2020 and 2070, but changes in water use demands will vary widely by region. Regions A and O, for example, are projected to experience declines in water use of at least 25 percent during this period; Region C – home to the Dallas-Fort Worth Metroplex – will see a projected 67 percent increase in water usage **(Exhibit 4)**.

Planning for Future Needs

There are several types of water management strategies the state can use to help meet the projected increase in demand, including water reuse, conservation, groundwater wells, desalination and incorporating additional water supplies from new reservoirs.

As previously noted, Texas' water demands are expected to increase while overall supplies are predicted to decrease, and planning has become a focus for state and local government entities. In 1997, the Texas Legislature established 16 regional water planning groups to coordinate a "bottom-up" water planning process.[5] These planning groups support the TWDB by developing consensus-based plans every five years that advise on how to meet regional water needs during droughts based on the state's drought of record.[6] A drought of record is defined by the TWDB as "a period when historical records indicate that natural hydrological conditions provided the least amount of water supply." The drought of the 1950s is the benchmark for statewide water planning.[7] Most recently, state leaders have passed legislation enabling regional water planning groups that help develop the SWP to plan for drought conditions worse than the drought of record.[8]

The 2022 SWP recommended more than 2,400 water management strategy projects with a total projected cost of $80 billion, much lower than estimated annual economic losses of a severe drought, which the SWP projects could reach potential costs of $153 billion by 2070. With each water plan comes new ideas for water management and improvements that aim to ensure adequate water supplies for all Texans in times of drought..

Water Governance

Water governance provides the structure, regulation and accountability necessary for the use and management of water, making it an important aspect of monitoring the current and future water needs of a country, state or water region.

The TWDB plays an important role in water governance, with responsibilities that extend beyond the SWP:

- Collecting and disseminating water-related data.
- Assisting with regional water supply and flood planning as part of preparing the state water and flood plans.
- Administering cost-effective financial programs for constructing water supply, wastewater treatment, flood control and agricultural water conservation projects.[9]

The creation and funding of TWDB represented a significant chapter in Texas water history as it allowed the legislature to address the water supply and conservation needs of the state. Other milestones in the Texas water timeline include:

- **1949**—Passage of legislation allowing for the creation of underground water conservation districts. [10]
- **1957**—Creation of TWDB by Texas constitutional amendment.
- **1977**—The combining and reorganizing of water agencies in the state creating a new agency —the Texas Department of Water Resources — responsible for developing the state's water resources, maintaining water quality and managing the distribution of water rights. The new agency was created from the predecessors of the TWDB and the Texas Commission on Environmental Quality (TCEQ).
- **1985**—Passage of a constitutional amendment authorizing the issuance of additional dollars of Texas Water Development Bonds for water conservation, water development, water quality enhancement and several other water-related advancements.
- **1985**—The dissolution of the Department of Water Resources and the transferring of its responsibilities back to a recreated Texas Water Commission (predecessor of the TCEQ) and a recreated TWDB.
- **2013**—Passage of a constitutional amendment to fund the State Water Implementation Fund for Texas (SWIFT) to provide affordable, ongoing state financial assistance for projects in the SWP.[11]
- **2023**—Passage of legislation relating to financial assistance provided and administered by the TWDB to develop water supply projects that create new water sources in the state. A constitutional amendment creating the Texas Water Fund will be decided by voters.[12]

Additionally, the TCEQ is charged with maintaining water quality and availability for municipalities, businesses and homeowners in the state. At the federal level, the U.S. Environmental Protection Agency (EPA) sets standards and regulations for the quality of drinking water and enforces national drinking water regulations, including the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). The CWA regulates discharges of pollutants into waterways and sets surface water quality standards, while the SDWA protects the quality of drinking water in the U.S.[13] The federal Clean Water State Revolving Fund was created by amendments to the CWA to help finance water infrastructure projects.[14] Similarly, the Drinking Water State Revolving Fund (DWSRF) was established by amendments to the SDWA to help water systems and states to achieve the health protection objectives of the SDWA.

Water Rights

Texas law divides water into two categories: groundwater and surface water. Groundwater is defined in the Texas Water Code as water percolating below the surface of the earth and is owned by the landowner.[15] The state adopted the Rule of Capture following a Texas Supreme Court ruling in 1904, which allows landowners to pump as much water as they choose, without liability to surrounding landowners who might claim that the pumping has depleted their wells. To conserve and protect groundwater resources, many areas of the state are subject to policy decisions made by groundwater conservation districts (GCDs). GCDs can be created either by the Texas Legislature or by the TCEQ through a local petition process and are required to develop and implement a comprehensive plan for effective management of groundwater resources within their jurisdictions.[16] The TCEQ can also create a GCD in a priority groundwater management area.

Surface water in Texas, on the other hand, is owned by the state and held in trust for the citizens of the state.[17] Surface water consists of "water of the ordinary flow, underflow and tides of every flowing river, natural stream and lake and of every bay or arm of the Gulf of Mexico and the storm water, floodwater and rainwater of every river, natural stream, canyon, ravine, depression and watershed in the state."[18] The state grants the right to use surface water to different entities, such as farmers or ranchers, cities, industries, businesses, and other public and private interests. The use of surface water in Texas is regulated through a system of water rights that are evaluated by the TCEQ.[19] Ownership of this vital resource can be cause for much political debate and intense legal battles.[20]

Water Issues in Texas

Texas regional water planning groups recommend water management strategies — specific plans and associated projects — to meet projected water needs by either providing additional water supply or by reducing water demand. Weather extremes and rapid population growth are subjects of interest for current and future Texans.

Urgent concerns regarding water infrastructure statewide include an increasing number of boil water notices, aging systems that will need replacement and an absence of acceptable water systems (as is the case with some colonias statewide).

> *Colonias in Texas are residential subdivisions, usually in unincorporated areas of a county, which often lack all or some of the basic services such as drinking water and sewage treatment, paved roads, electricity and drainage systems.[21] A 2015 Federal Reserve Bank of Dallas study reports that an estimated 500,000 people live in Texas' 2,294 colonias, primarily concentrated in El Paso, Maverick, Webb, Starr, Hidalgo and Cameron counties.[22] The Economically Distressed Areas Program (EDAP) provides financial assistance for areas where water or sewer systems do not exist or do not meet minimum state standards, which include colonias.[23]*

Aging Water Infrastructure

In 2021, Texas received a ranking of C minus for drinking water infrastructure and flood risk mitigation from the Texas Section of the American Society of Civil Engineers (ASCE) *Infrastructure Texas Report Card*, toeing the line between "mediocre, requires attention" and "poor, at risk."[24] Aging water infrastructure can lead to both small leaks and catastrophic main breaks which significantly threatens water supply throughout the state and diminishes the conservation efforts of Texans statewide.

According to a 2022 *Texas Living Waters Report*, Texas water distribution systems are composed of more than 165,000 miles of pipes.[25] Unfortunately, pipes degrade over time due to a host of forces, leading to various types of fractures and leaks. The ages of pipes within the state's water system vary. Some water utilities are still equipped with pipes that were installed in the 1800s while others have pipes from the early to mid-20th century that have a 75- to 100-year lifespan, according to the Texas Water Resources Institute.[26] A 2022 survey from the Texas Rural Water Association found that the average year of installation for small- to medium-sized water utilities across Texas was 1966, indicating that many water systems in the state have not adapted to meet the needs of today.[27]

Broken pipes and water leaks in Texas have led to thousands of gallons of water being wasted every year – more than 30 billion gallons of water lost in 2021 alone. An additional 100 billion gallons of water were lost due to infrastructure issues, resulting in a cost to Texas utilities of $266 million – and experts believe the actual water lost is greater.[28] The EPA estimates that the average American household uses 300 gallons of water per day, meaning water lost due to infrastructure deficiencies is enough water to supply nearly 1.19 million Texas homes annually.[29]

To track water loss the Texas legislature requires that all retail public water utilities with more than 3,300 connections or with a financial obligation to the TWDB to complete and submit an annual water loss audit to TWDB. All other public retail utilities are required to file a water loss audit with the TWDB every five years. For public retail utilities, a water loss audit is a reliable way to measure water loss and implement changes to mitigate water loss.

Water loss varies throughout Texas water planning regions, but some areas may experience substantially more loss than others – in part because of the significant cost associated with replacing aging infrastructure. While funding for water projects may be available, the *Sunset Advisory Commission staff report* for the Texas Water Development Board, State Water Implementation Fund for Texas Advisory Committee finds that rural Texas communities often lack the resources, technical experience or ability to pursue available funds.[30] According to the TWDB's *Water Loss Audits Summary Report*, a repository of water loss data collected, 2021 data illustrate that the East Texas Water

Planning Region (I) and the Region F Water Planning Region that includes cities such as Midland, Odessa and San Angelo lead all other regions with a reported water loss average of 79.87 and 78.54 gallons per connection per day, respectively. That same year, the statewide water loss average was 54.68 gallons per connection per day **(Exhibit 5)**.

EXHIBIT 5
Average Reported Water Loss in Gallons per Connection per Day (GCD), 2011-2021

YEAR	AVERAGE STATEWIDE WATER LOSS GCD	NUMBER OF AUDITS SUBMITTED
2011	72.30	117
2012	65.34	334
2013	53.46	472
2014	58.50	591
2015	51.21	1,729
2016	58.24	743
2017	56.87	642
2018	62.13	689
2019	54.39	901
2020	55.02	1,776
2021	54.68	828

Source: TWDB

Aging water infrastructure and pipes are also the biggest contributors to boil water notices in Texas. A boil water notice occurs when a water pipe breaks or leaks and results in water supply being exposed to contaminants and therefore leads to safety concerns. Both rural and urban areas have experienced chronic boil water notices, leaving residents without clean water for significant periods of time. Local municipalities and their residents bear the costs of repair and water loss.

According to the TCEQ, there were 3,143 boil water notices across Texas in 2022 compared to 1,993 notices in 2018. Texans living in rural areas are most impacted by boil water notices, although densely populated cities like Houston and Austin are not exempt. In addition to aging infrastructure, droughts exacerbate other water infrastructure issues. Under dry and hot drought conditions, soil expands and contracts, placing additional pressure on pipes that are already deteriorating.

Additionally, aging pipes pose health concerns due to the prevalence and corrosion of lead-based water lines across the state. As of 2023, the EPA estimates that more than 647,000 water lines in Texas are lead-based — about 7 percent of water pipes — placing the state among those with the most projected lead service lines **(Exhibit 6)**.[31] Lead enters water when plumbing materials that contain lead corrode, and it's especially harmful to children. TWDB has taken an essential role in providing Lead Service Line replacement funding. In 2023, the state agency applied for $222 million from the EPA for DWSRF lead Service Line replacement funding.

EXHIBIT 6
Top Ten States with Greatest Number of Lead-Based Service Lines, 2023

STATE	NUMBER	PERCENT OF TOTAL SERVICE LINES
Florida	1,159,300	12.62%
Illinois	1,043,294	11.35%
Ohio	745,061	8.11%
Pennsylvania	688,697	7.50%
Texas	647,640	7.05%
New York	494,007	5.38%
Tennessee	381,342	4.15%
North Carolina	369,715	4.02%
New Jersey	349,357	3.80%
Wisconsin	341,023	3.71%

Source: EPA

Funding Texas Water Needs

The variability in water supply and aging infrastructure throughout natural regions in the state requires investments in the use, quality and impact of water. TWDB offers a variety of loan and grant programs providing approximately $33.6 billion in funding as of April 2023 for the planning, acquisition, design and construction of water-related infrastructure and other water quality improvements since its inception in 1957.[32] While there are gaps in infrastructure funding, Texas has made great strides in addressing some of its infrastructure needs. According to TWDB's Water Supply and Infrastructure Division, since 2013 alone the TWDB has provided more than $12 billion to water infrastructure in Texas through the DWSRF program and the State Water Implementation Fund for Texas (SWIFT) program.

SWIFT, established by the Texas Legislature and maintained by the Texas Treasury Safekeeping Trust Company (a special purpose entity in which the Texas Comptroller of Public Accounts is the sole shareholder and director), is administered through TWDB. SWIFT provides financial assistance for water projects that are designed to conserve the existing water supplies in Texas. Eligible projects include those for conservation and reuse, desalinating groundwater and seawater, building new pipelines and other water strategies.[33]

The actual dollar amount of SWIFT funds available each year is expected to fluctuate based on capacity set by the policies directed by board members but the initial legislative directive was the financing of $27 billion in SWP projects. The TWDB solicits SWIFT abridged applications for financial assistance up to twice a year and prioritizes projects based on a ranking system found in the Texas Administrative Code. If two projects receive the same ranking, the project with the highest water conservation score is prioritized; in the case of another tie, funding goes to the project with the highest emergency need score.[34] The loan application is a separate process and occurs after priority is established.

Other TWDB programs such as the Economically Distressed Areas Program (EDAP) and the Texas Water Development Fund (WDF) have provided additional funding for water infrastructure needs, according to TWDB. The four programs illustrated in the table below represent only some of the financial assistance programs administered by TWDB **(Exhibit 7).**

For projects that address aging infrastructure (outside the DWSRF and SWIFT programs), the Texas Water Development Fund has increased funding for these purposes. According to TWDB, $20 million is committed toward addressing aging infrastructure needs in 2022, up from $4.5 million in 2018.

Additionally, the federal Infrastructure Investment and Jobs Act (IIJA), signed into law in 2021, appropriates more than $50 billion to the EPA to improve drinking water, wastewater and stormwater infrastructure nationwide.[35] Over the next five years, Texas expects to receive approximately $2.5 billion through the IIJA to improve water and wastewater infrastructure in the state.[36] The TWDB received $222,340,000 this year [2023] from IIJA, of which 49 percent must be committed to projects in the form of principal forgiveness, according to the TWDB.

Aside from the TWDB, the Texas Department of Agriculture (TDA) has several financial programs to assist water and wastewater providers. Additional sources of available funding programs include Communities Unlimited, the United States Department of Agriculture (USDA) and the North American Development Bank.[37]

Population growth in many areas of Texas will result in the construction of new developments and a need for infrastructure expansion. Water and wastewater impact fees help pay for various infrastructure needs such as treatment and distribution facilities, pump stations and storage tanks. Impact fees are charges or assessments imposed by a political subdivision against new development to generate revenue for funding or recouping the costs of capital improvements or facility expansions.[38] Impact fees enable municipalities to support their water infrastructure in a way that does not harm existing residents and ratepayers.

EXHIBIT 7
TWDB Financial Assistance for Water Projects

PROGRAM	CUMULATIVE COMMITMENTS THROUGH APRIL 2023	NUMBER OF PROJECTS	COMMITMENTS SINCE SEPTEMBER 2013	NUMBER OF PROJECTS SINCE SEPTEMBER 2013	PROJECT TYPE
State Water Implementation Fund for Texas (SWIFT)	$9,923,555,000	58	$9,923,555,000	58	Water Supply
Drinking Water State Revolving Fund (DWSRF)	$3,689,430,817	504	$2,251,758,199	296	Water Only
Texas Water Development Fund (WDF)	$2,935,953,405	580	$639,200,000	58	Water and Wastewater
Economically Distressed Areas Program (EDAP)	$511,145,793	160	$164,168,742	20	Water and Wastewater

Source: TWDB

Weather Extremes: Droughts and Floods

Texas is the second largest state in the U.S. by area with more than 261,267 square miles of land and 3,359 miles of shoreline along the Gulf Coast.[39] As a result, Texas natural regions have varying water needs and varying weather extremes, including droughts, floods, hurricanes, ice storms and more. According to the 2021 report, *Assessment of Historic and Future Trends of Extreme Weather in Texas, 1900-2036*, from the Office of the Texas State Climatologist at Texas A&M University, extreme weather is predicted to become more frequent in the future. Temperatures in both the winter and summer months are expected to rise. Additionally, precipitation in East Texas is anticipated to increase while droughts in West Texas are expected to continue.[40] TWDB uses the best available data, projections, and models to develop and tailor the state water plan and the state water flood plan to proactively prepare the state to be resilient to droughts and floods. In addition to managing funding programs that support this work, the agency is also expanding the state's hydrometeorological monitoring network, TexMesonet, to enhance real-time monitoring of weather phenomena and to collect data to improve forecasts of droughts, floods, and wildfires.

Impact of Drought

According to the National Integrated Drought Information System, a drought is generally defined as a deficiency of precipitation during an extended period of time (usually a season or more), resulting in a water shortage.[41] The U.S. Drought Monitor, produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, classifies droughts by six different levels of severity:

- None
- D0 (abnormally dry)
- D1 (moderate drought)
- D2 (severe drought)
- D3 (extreme drought)
- D4 (exceptional drought)

D0 (abnormally dry) is not considered a drought level but rather an indicator that an area may be recovering from or entering a drought. U.S. Drought Monitor data are updated weekly, and as of August 29, 2023, about 76 percent of Texas was experiencing some stage of drought, ranging from moderate drought to exceptional drought. An estimated 23.7 million Texans reside in areas experiencing some stage of drought **(Exhibit 8)**. Drought levels in Texas do vary throughout the year; in 2023, the share of Texas area experiencing some form of drought has ranged from a low of 23 percent for the week ending June 13 to a high of 79 percent for the week ending August 22.[42]

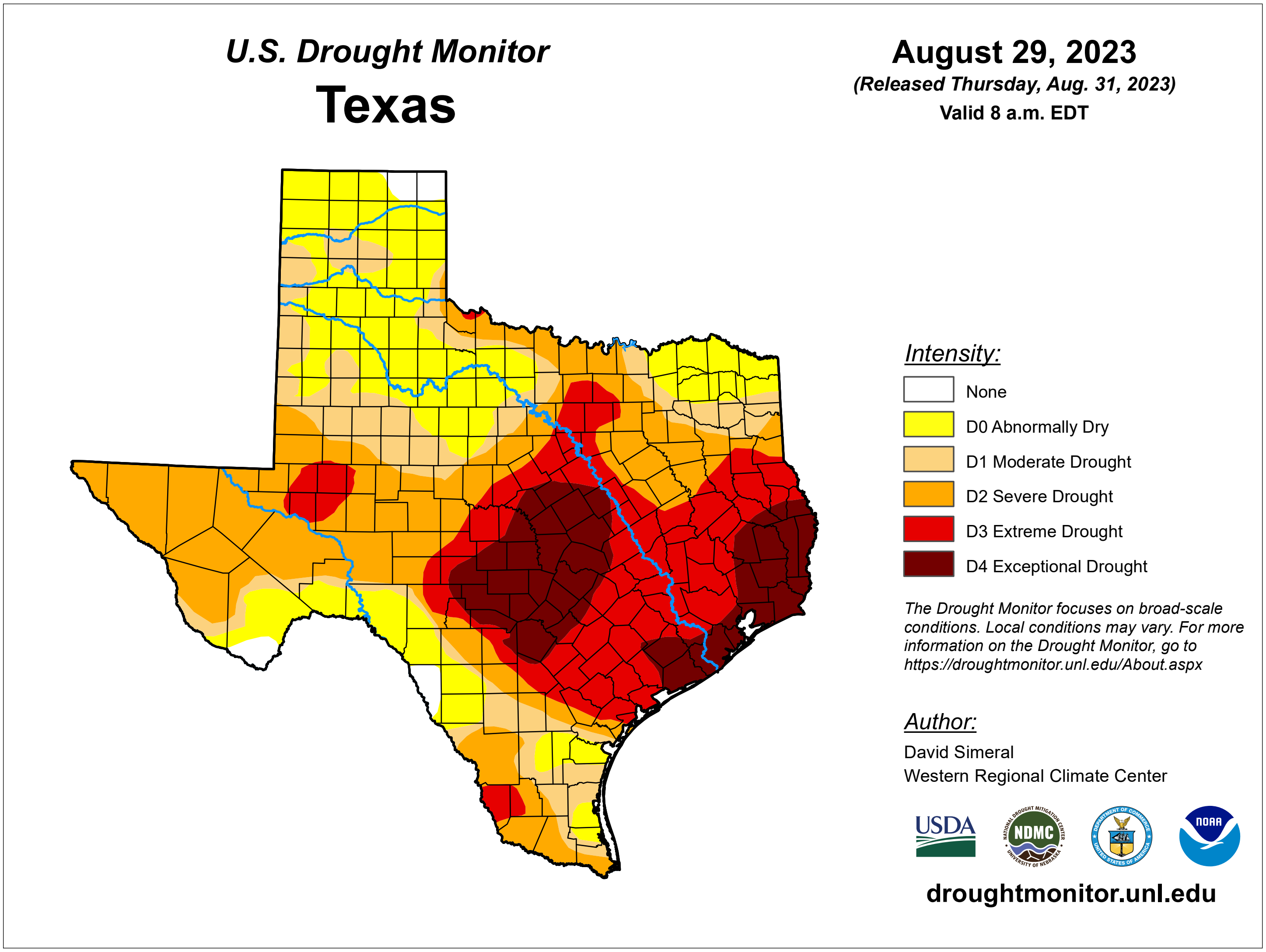
The drought of record in Texas occurred between 1950 and 1957. During this period, economic losses due to crop damage were estimated at more than $3 billion, or $27 billion when adjusted for inflation in 2017 dollars, according to the 2022 TWDB report, *Drought in Texas: A Comparison of the 1950-1957 and 2010-2015 Droughts*.[43] When adjusted for inflation in 2023 dollars, economic losses due to crop damage for the drought of record would be $34 billion. To compensate for the economic losses of agricultural products during the 1950 to 1957 drought, the USDA distributed more than $61 million in aid and provided other federal resources such as livestock feed, emergency loans and more.

Between 2010 and 2014, the second longest drought in Texas history impacted 100 percent of the state. The economic toll according to TWDB in their 2022 report *Drought in Texas: A Comparison of the 1950-1957 and 2010-2015 Droughts* cost the state's agricultural industry an estimated $10 billion to $14 billion in losses, while the total economic impact on the state during 2011 alone was estimated to be nearly $17 billion.[44] Commodity insurance, a standard need for agricultural business owners to financially protect themselves against instances of drought and other natural disasters, amounted to $6.4 billion dollars in relief between 2010 and 2014.[45]

To address the impact of droughts, financial assistance is made available through various state and federal programs. Texas communities experiencing drought may be eligible for grant funding if they meet certain requirements, such as declaring that their community water supplies are diminished to fewer than 180 days of use. Additionally, the Drinking Water State Revolving Fund provides financial relief up to $500,000 to communities that experience loss of water supply due to droughts or other eligible situations such as broken water pipes.[46] Communities experiencing water loss that are considered "disadvantaged" are eligible to receive up to $800,000 for urgent need projects.[47] According to TWDB, without the implementation of projects and grant funding to assist communities in need, the next severe drought could cost Texas $153 billion per year in economic damages by 2070.[48]

EXHIBIT 8

Drought Levels in Texas as of August 29, 2023



Note: Data are current as of August 29, 2023.

Sources: National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA)

TWDB anticipates that by 2070, water use categories such as irrigation, livestock, manufacturing, mining, municipal and steam-electric across all 16 water planning group regions may experience both income losses and job losses due to water loss from droughts should none of the water management strategies in the SWP be implemented, or in the event of another drought of record. Notably, the largest estimated job loss is anticipated to occur in the municipal use category with a loss of more than 671,000 jobs.

Additionally, most water use categories apart from irrigation and steam-electric may anticipated to experience significant tax loss from an estimated decline in production and imports within the next few decades. **(Exhibit 9)**.

EXHIBIT 9

Estimated Economic Impact from Droughts Between 2020 and 2070

WATER USE CATEGORY	ECONOMIC IMPACT	2020	2030	2040	2050	2060	2070
Irrigation	Income Loss (millions)	$843.90	$1,356.90	$1,319.00	$1,287.60	$1,258.80	$1,244.20
	Job loss	13,107.50	19,484.30	18,909.30	18,440.50	18,012.70	17,791.40
	Tax Loss on Production and Imports (millions)	$0	$0	$0	$0	$0	$0
Livestock	Income Loss (millions)	$2,196.20	$2,416.40	$2,679.70	$3,031.90	$3,452.60	$3,606.40
	Job loss	46,399.60	49,843.60	53,736.20	58,536.70	64,300.70	66,300.40
	Tax Loss on Production and Imports (millions)	$114.20	$125.00	$137.90	$155.50	$176.50	$184.60
Manufacturing	Income Loss (millions)	$19,192.40	$30,449.70	$35,692.90	$43,552.20	$50,379.70	$55,495.80
	Job Loss	156,431.40	244,190.70	278,375.40	331,938.70	379,571.10	414,976.70
	Tax Loss on Production and Imports (millions)	$1,329.00	$2,117.80	$2,403.80	$2,859.20	$3,256.10	$3,544.50
Mining	Income Loss (millions)	$67,239.00	$62,450.50	$48,627.10	$38,495.00	$27,513.10	$25,367.90
	Job Loss	348,111.00	325,175.50	255,386.40	205,624.50	151,326.30	142,973.20
	Tax Loss on Production and Imports (millions)	$8,308.60	$7,650.70	$5,866.90	$4,525.40	$3,051.20	$2,697.00
Municipal	Income Loss (millions)	$1,814.80	$7,165.50	$15,186.00	$23,348.20	$32,612.40	$42,027.60
	Job Loss	34,159.70	117,943.20	244,065.20	373,512.50	520,802.90	671,445.90
	Tax Loss on Production and Imports (millions)	$178.30	$626.50	$1,302.40	$1,998.90	$2,790.70	$3,597.70
Steam-Electric	Income Loss (millions)	$6,878.20	$7,298.00	$7,627.70	$7,896.60	$8,125.30	$8,338.50
	Job Loss	0.00	0.00	0.00	0.00	0.00	0.00
	Tax Loss on Production and Imports (millions)	$0	$0	$0	$0	$0	$0

Source: TWDB

Impact of Drought on Agriculture

Within the agricultural sector, water usage types such as livestock and irrigation – as well as the state's overall economy – have been negatively impacted by droughts. As agriculture has become more mechanized and agricultural employment has declined, the economic impact of drought looks different now than in the past.

Drought conditions have made farming increasingly challenging, resulting in Texas farmers planting and harvesting fewer crops. Cotton, the largest produced crop in Texas, has not fared well during drought. The crop that once brought in billions of dollars to the Texas economy is estimated to experience $2 billion in losses in the High Plains region of Texas alone, according to the International Center for Agricultural Competitiveness at Texas Tech University.[49] In 2022, Texas farmers were anticipated to harvest just 2.9 million bales of cotton – the smallest cotton crop since 2009 and 63 percent less than the cotton harvested in 2021, which was 7.7 million bales, according to the Texas Farm Bureau.[50]

Because cotton requires significant water usage, farmers have begun shifting away from it, opting for more drought-tolerant crops such as sorghum.

Drought conditions have worsened so significantly that farmers are anticipated to abandon two-thirds of acres planted in 2023. This has the potential to bring historically high abandonment rates, according to the USDA.[51] According to the National Cotton Council, to combat lost income due to high rates of crop abandonment, Texas farmers are expected to plant 20 percent less cotton than they did in 2022.[52]

Impact of Floods

In addition to droughts, flooding can occur even in areas of the state experiencing drought conditions. Flooding can also be the result of natural phenomena, such as hurricanes. The drought of the 1950s ended with much-needed rainfall in the spring of 1957. However, this rainfall caused flooding all the way from west Texas to east Texas. Additionally, historic flooding occurred in central Texas between San Antonio and San Marcos in October 1998, when nearly 30 inches of rain fell over two days.

Besides excessive rain, floods most commonly occur following hurricanes, which have the biggest impact along the Gulf of Mexico. According to the National Park Service, the deadliest hurricane and subsequent flood to occur in U.S. history happened in Galveston, Texas, in September of 1900. The Category 4 hurricane brought waves up to 15 feet tall that engulfed the city, which had an average elevation at the time of roughly 8.7 feet. This hurricane is estimated to have resulted in between 6,000 and 8,000 deaths and a financial impact estimated to be between $20 million and $30 million by contemporary figures. [53]

In 2017, Hurricane Harvey was the first major hurricane to hit the state since 1999. Storm surge levels were recorded at 12 feet above ground in certain areas of the Texas coast, with some areas receiving 40 to 50 inches of rain in less than 48 hours.[54] Almost 780,000 people along the Gulf Coast were evacuated. According to a 2019 report from the Legislative Budget Board, *Fiscal Impact of Hurricane Harvey on State Agencies,* the estimated cost of damages from Hurricane Harvey was $125 billion, making this the second most costly hurricane in U.S. history after Hurricane Katrina in 2005.[55]

Flood Relief

According to the Federal Emergency Management Agency, just one inch of flooding in a home can cost a homeowner up to $25,000 in damages. To compensate Texans for the economic impact of natural disasters such as floods and hurricanes, the Texas General Land Office has distributed more than $14 billion of federal funding for recovery and mitigation following events such as Hurricanes Rita (2005), Dolly (2008), Ike (2008) and Harvey (2017), as well as following other floods in areas like Central Texas (2015), Houston (2016) and the Llano River (2018). This funding came from Community Development Block Grant Disaster Recovery (CDBG-DR) and Mitigation (CSBD-MIT), both funded by the U.S. Department of Housing and Urban Development (HUD) for purposes including housing redevelopment, infrastructure repair and long-term planning.[56]

In 2019, the 86th Texas Legislature authorized the transfer of $793 million dollars to the Flood Infrastructure Fund (FIF), approved by Texas voters, to assist TWDB in the financing of drainage, flood control, and flood mitigation projects across the state. That same year, Texas lawmakers approved legislation relating to state and regional flood planning with the passage of SB 8. From the fund's inception to 2023, 138 projects and commitments totaling $514 million in funding have been created across the state.[57] There are four categories of FIF projects and commitments:

- **Category 1:** flood protection planning for watersheds.
- **Category 2:** planning, acquisition, design, construction and rehabilitation.
- **Category 3:** federal award matching funds.
- **Category 4:** measures immediately effective in protecting life and property.

Category 2 projects account for about 57 percent of active FIF projects and 84 percent of the committed funding as of August 2023 **(Exhibit 10).**

EXHIBIT 10
Flood Infrastructure Fund Active Projects and Committed Funding, August 2023

CATEGORY	CATEGORY DESCRIPTION	NUMBER OF ACTIVE PROJECTS	AMOUNT COMMITTED
1	Flood Protection Planning for Watersheds	46	$72,491,660
2	Planning, Acquisition, Design, Construction and Rehabilitation	78	$433,812,385
3	Federal Award Matching Funds	7	$5,967,628
4	Measures Immediately Effective in Protecting Life and Property	7	$1,710,954
	Total	138	$513,982,627

Source: TWDB

In 2023, the 88th legislature appropriated nearly $625 million dollars from the general revenue fund to TWDB to supplement existing FIF funds and continue providing flood mitigation projects across the state.

Conserving With Care

To manage the need for additional water and to meet the demand of a rapidly growing population, anticipated to increase by more than 70 percent by 2070, long-term conservation strategies are an essential part of the SWP. According to the 2022 SWP, conservation represents 30 percent of the recommended water management strategy supplies in 2070, with 13 percent from municipal use; 16 percent from agricultural irrigation use; and another 1 percent from mining, manufacturing and power generation uses. Conservation is defined in the Texas Water Code as the development of water resources, and those practices, techniques and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses.[58]

Water conservation efforts are complicated by water loss, which falls under two categories: real loss and apparent loss. According to a 2022 report by the Texas Water Conservation Advisory Council, real losses are physical water losses (leakage) from the water distribution system, which can range from small yet constant leaks throughout a water distribution system to the losses from catastrophic main breaks. Apparent losses are nonphysical losses: water that is consumed but not properly tabulated or billed. These losses are the result of meter inaccuracies, billing system errors and water theft (unauthorized consumption).[59]

Every five years, as part of the effort to encourage water conservation and ensure water is being used efficiently, entities must submit a water conservation plan to the TWDB and TCEQ, which includes a schedule for achieving conservation targets and goals. Entities include organizations who apply for more than $500,000 in financial assistance from the TWDB, or provide potable water service to 3,300 or more connections, or have certain TCEQ surface water rights. Water conservation plans must also contain ongoing education activities, universal metering, water accounting and water savings from reuse/recycling activities, leak detection and repair, and other conservation-related activities.[60]

Innovative Water Practices

According to the EPA, water availability and variability issues can lead to higher costs, loss of revenue, difficulties meeting customer needs, and challenges to the treatment and distribution of safe drinking water for public water systems.[61] Innovative practices that reduce water consumption and improve efficiency to meet future demand such as those highlighted by the *ASCE's Report Card For America's Infrastructure* — technology relating to leak detection, seismic resilient pipes, smart water quality monitoring and real-time data sensors — may be employed to target specific water users.[62] The ASCE suggests that these innovative practices improve resilience of water systems by allowing utilities to respond to changing climate conditions, improve efficiency of operations by reducing water losses and deliver real-time data that allow for interactive decision-making.

Conservation efforts may range from a practice as common as a radio, online or billboard campaign with water conservation messaging to much more complex technologies and projects requiring long-term financial commitments including:

- Aquifer Storage and Recovery (ASR) — Aquifers are underground areas made up of porous rock or sediment that hold groundwater. An aquifer can be replenished through recharge from rainfall, surrounding streams, lakes, or inflow from other aquifers. ASR is an innovative technique to store water for future use. These projects capture excess water from wet years and use wells to inject and store in an aquifer for later recovery and beneficial use.[63] Aquifer recharge projects use surface structures such as infiltration basins or other means to intentionally recharge aquifers for uses other than recovery. There are currently three ASR systems in Texas:
    - Fred Hervey Water Reclamation Plant, El Paso Water.
    - Surface Water Treatment Plant, City of Kerrville.
    - H2Oaks, San Antonio Water System.
- Rainwater Harvesting — Rainwater harvesting is the capture, storage and use of rainwater for a suitable purpose. Texas is one of only a few states that has devoted a considerable amount of attention to rainwater harvesting and has enacted many laws regulating the practice of collecting rainwater, such as a state sales tax exemption on rainwater harvesting equipment and requiring rainwater harvesting system technology to be incorporated into the design of new state buildings.[64]
- Water Reclamation and Reuse — Water reclamation and reuse refers to the process of using treated wastewater (reclaimed water) from a variety of sources for beneficial purposes such as agriculture and irrigation, groundwater replenishment, industrial processes and environmental restoration. Texas is home to many successful water reuse infrastructure projects, including:
    - Dallas-Fort Worth Metropolitan Wetlands.
    - Bob Derrington Water Reclamation Plant, Odessa.
    - Brazos Research Wetlands.
- Desalination of Seawater, Brackish Groundwater and Brackish Surface water — Desalination refers to the removal of excess salt and other minerals from available water sources to create fresh water — making otherwise unusable water suitable for human consumption, industrial applications and other purposes. The process of desalination can be more expensive compared to conventional water sources because of the amount of energy required to remove the salt and the technology used.
    - Texas currently has 53 municipal desalination facilities.
- Soil Moisture Monitoring Sensors — Soil moisture sensor technology that measures or estimates the amount of water in the soil to improve irrigation efficiency.
    - Along with sensors, TexMesonet (a statewide earth observation data collection network capturing real-time data on soil conditions and meteorological events) can improve irrigation efficiency using meteorological, hydrological and soil data to monitor, understand and respond to weather patterns.
    - The 88th Texas Legislature established the TexMesonet Hydrometeorology Network and the creation of the TexMesonet Advisory Committee to advise and make recommendations on ensuring data quality and optimizing the efficiency and effectiveness of hydrometeorological data collection, product development, and dissemination of data and information.
- Low Pressure Center Pivot (LPCP) Sprinkler Irrigation Systems — These low-pressure sprinkler systems use fixed sprinkler applicators or nozzles, drop tubes, or a combination of both to apply water crop irrigation.[65]
    - Low Energy Precision Application (LEPA).
    - Low Pressure In-Canopy (LPIC).
    - Low Elevation Spray Application (LESA).
    - Medium Elevation Spray Application (MESA).

Precision agricultural technology, coupled with expanded access to broadband connection, can help farmers reduce fuel and water usage. High speed internet connectivity is necessary for digital technologies in agriculture to reach their full potential and substantially increase crop and animal yields, improve distribution, and reduce input costs.[66] Irrigation conservation represents the state's best opportunity to achieve significant water use savings because agriculture uses an estimated 53 percent of all water in the state, representing Texas' greatest usage, according to a 2022 report by the Texas Water Conservation Advisory Council to the 88th Texas Legislature.[67]

Influence of Water Rates on Use and Revenue

Water providers, including municipality owned utilities, retail public utilities, and wholesale water or sewer service providers have a financial incentive to make money through the sale of water to continue to serve the customers that rely on its services. As such, it is to their benefit to ensure that the natural resource remains available. Water rates and financial policies may serve as a conservation tool through water conservation pricing – implementing rate structures that discourage the inefficient use of water.[68] Water conservation pricing, according to TWDB's best management practices for municipal water providers, is only effective if accompanied by consumer education on utility rate structure and monthly water use feedback on a consumer's water bill.

Water systems consider many factors when setting their rates and selecting a rate structure: a set of fees and rates used to charge customers for water. There are five common rate structures, according to the EPA: [69]

- Flat rate or fixed fee — the amount customers pay remains the same regardless of water usage. A drawback to this rate structure is that during times of high water use, the water system will not generate the additional revenue needed to keep up with high demand. Additionally, this rate structure does not offer incentives for customers to conserve water.
- Uniform block rate — based on customers' water consumption and often includes a fixed service charge or "base rate" that ensures revenue stability for water systems. This rate structure can help encourage water conservation.
- Decreasing block rate — customers are charged lower rates per unit of water for successive blocks. Water systems may charge a fixed fee in addition to decreasing block rates. For example, water systems may charge $8 per 1,000 gallons for the first 5000 gallons and $4 per thousand gallons for all subsequent usage. This rate structure offers little incentive for customers to conserve water.
- Increasing block rate — customers are charged higher rates per unit of water for successive blocks. Water systems may charge a fixed fee in addition to increasing block rates. For example, water systems may charge $4.00 per 1,000 gallons for the first 5000 gallons and $8.00 per thousand gallons for all subsequent usage This rate structure can offer an incentive for customers to conserve water if priced appropriately.
- Seasonal rate — accounts for changes in water use patterns from season to season based on weather changes (charging higher rates during peak seasons). Seasonal rates can encourage conservation, reducing usage during peak periods.

Rate structures enable water systems the flexibility to set different rates for different categories of customers, such as residential users and agricultural users, while ensuring that adequate revenue is collected for the system to provide safe drinking water.

In addition to ensuring adequate revenue is collected, the EPA sets out the following factors water systems may want to consider in selecting a rate structure:

- Rate stability: Rates will have to increase to meet the ever-increasing total annual cost of business, to maintain full cost pricing and to avoid affordability issues.
- Revenue predictability: Knowing how much revenue to expect. Generating and keeping sufficient reserves in the event of short-term decrease in revenue.
- Customer classes: Some systems may serve only residential customers, while others also serve industrial, commercial or agricultural customers. Residential, industrial, commercial and agricultural customers may have very different patterns of water use.
- Billing Period: Frequency for which customers are billed (monthly, bi-monthly, quarterly or less frequently).
- Affordability: Questions of customer equity and rates within a customer class (low-income household verses higher-

income household) or business type (low or no profit entities such as schools versus for-profit entities).

- Conservation: Structuring rates so that they send a "price signal" to customers that encourages efficient water use.

Conclusion

Increasingly frequent extreme weather patterns, aging infrastructure and Texas' daily net migration of 1,000 people necessitates increased attention to the state's water supply. The SWP sets forth actionable strategies and projects that clearly demonstrate how Texas will withstand future droughts and, if implemented, will ensure a more secure water future for Texas.

During the 88th Texas Legislative session in 2023, lawmakers worked to support Texas water at the state and local levels to ensure water needs are met. Senate Bill 28 was passed to support the financial assistance provided by TWDB and the programs administered by the agency to fund water supply projects that create new water sources for the state, including desalination projects, produced water treatment projects, ASR projects, and the development of infrastructure to transport water that is made available by the new water supply projects.

In November 2023, Texas voters will weigh in on a proposed constitutional amendment to create the Texas Water Fund to help finance water projects in the state. This fund will only be established if Texas voters approve Proposition 6 in November 2023.

Through planning efforts and funding programs, the state continues to make considerable progress in addressing present and future water supply needs, but sustained efforts will be necessary to ensure there is enough water supply for Texans today and tomorrow.

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