7

Water management strategies and projects

QUICK FACTS

More than 5,800 recommended water management strategies would provide about 7.7 million acre-feet per year in additional water supplies to water user groups in 2070.

The cost of implementing the more than 2,400 recommended water management strategy projects by 2070 is $80 billion in 2018 dollars, without accounting for future inflation.

Conservation strategies represent approximately 29 percent, or 2.2 million acre-feet per year, of all recommended water management strategy volumes in 2070 and were recommended for more than half of the water user groups in the plan.

Planning groups recommended 23 new major reservoirs that, if implemented, would provide 866,000 acre-feet per year in additional supplies by 2070.

Approximately 37 percent of the recommended new water supplies in 2070 are based on surface water, 15 percent on reuse, and 12 percent on groundwater.

A water management *strategy* is a plan to meet a water need (potential shortage) of a water user group. After identifying water surpluses and potential water shortages for water user groups in their regions, regional water planning groups identify, evaluate, and recommend water management strategies to avoid potential shortages, including to be protective of public health, safety and welfare during a repeat of the drought of record over the next 50 years.

Water management strategies allocate water supply (in acre-feet per year) to specific water user groups, often through an intermediate regional or wholesale water provider. In the same manner that projected water demands, existing water supplies, and water needs in this plan are associated with water user groups, recommended water management strategy water volumes are also generally associated directly with water user groups.

Strategies may or may not require new water infrastructure—referred to as "water management strategy *projects*." Construction of most new water infrastructure projects requires long-term financing of the capital costs. The TWDB may provide financial assistance to support the implementation of water supply projects only if the needs to be addressed by the project are consistent with the regional water plans and the state water plan. This same provision applies to the Texas Commission on Environmental Quality's granting of water right permits, although the governing bodies of these agencies may grant waivers to the consistency requirement. The TWDB financial program that specifically targets implementation of state water plan projects, the State Water Implementation Fund for Texas (SWIFT) program, further requires that projects, including their capital costs, must be recommended water management strategy projects in the most recently adopted state water plan to be eligible for that financial assistance.

7.1 Selecting water management strategies

Each planning group identifies and evaluates feasible water management strategies for consideration to be included as a recommended final set of strategies. In selecting strategies, planning groups are required to consider certain factors, including

- quantity of supply provided by a strategy;
- reliability of the supply under drought of record conditions;
- cost of the supply (including borrowing and mitigation costs); and
- impacts of the strategy on water quality and on water, agricultural, and natural resources.

Evaluations of water management strategies are based on drought of record conditions and must honor all existing water rights, which are the same benchmark conditions used in the water demand and water supply evaluations. Planning groups are also required to consider conservation and drought management strategies for all water user groups that have identified water needs.

The types of strategies recommended depend upon the size and nature of identified water needs, geographic location, available water resources, associated strategy impacts, and costs of implementation. Some water management strategies do not require infrastructure projects with capital costs to implement while others may require significant capital investments, including various combinations of pipelines, wells, pump stations, river diversion facilities, or water treatment plants. For example, certain types of conservation may be supported by annual program budgets, and many water purchase strategies will rely on existing infrastructure capacity to convey increased water deliveries. Other strategies, such as new reservoirs and seawater desalination plants, require significant upfront investment in infrastructure to implement. However, the significance of any infrastructure investment is relative and varies by community and entity. For example, installing a single new groundwater well can be a more major investment for a small community than a large city.

The complexity of recommended strategies and the projects supporting them varies greatly. Some strategies, such as a new groundwater well, may serve and be implemented by a single water provider from a single water source. Other large regional projects, such as conveyances from reservoirs, may encompass a mixture of water sources from one or more wholesale water providers; may require a variety of infrastructure including intakes, major pipelines, and pump stations; and ultimately serve numerous retail water providers.

Just over 5,800 water management strategies were recommended by the 16 regional planning groups. If all were implemented, they would provide almost 1.7 million acre-feet per year, including in the form of conservation savings, to water user groups in 2020 and nearly 7.7 million acre-feet per year in 2070 (Table 7-1). The total capital cost of the approximately 2,400 recommended water management strategy projects associated with these 5,800 strategies is $80 billion (Table 7-2). Detailed lists of the recommended water management strategies, including projects, may be found on the 2022 State Water Plan webpage at www.twdb.texas.gov/waterplanning/swp/2022/index.asp and the interactive state water plan website at 2022.texasstatewaterplan.org.

7.2 Water resources for recommended strategies

Recommended water management strategies may be considered from different perspectives, including

- by the water resources on which they rely; or

Table 7-1. Annual volume of recommended water management strategies by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070
A	155,000	295,000	529,000	616,000	618,000	658,000
B	10,000	14,000	38,000	43,000	45,000	49,000
C	129,000	361,000	588,000	830,000	1,075,000	1,336,000
D	83,000	149,000	161,000	175,000	192,000	221,000
E	82,000	118,000	130,000	146,000	150,000	156,000
F	79,000	141,000	166,000	171,000	176,000	182,000
G	119,000	291,000	353,000	396,000	443,000	492,000
H	251,000	978,000	1,412,000	1,725,000	1,845,000	1,942,000
I	24,000	251,000	272,000	285,000	295,000	279,000
J	13,000	26,000	26,000	26,000	26,000	26,000
K	251,000	297,000	373,000	418,000	476,000	565,000
L	199,000	429,000	551,000	596,000	692,000	737,000
M	141,000	219,000	296,000	372,000	440,000	508,000
N	24,000	255,000	266,000	271,000	278,000	282,000
O	119,000	199,000	249,000	236,000	239,000	242,000
P	16,000	17,000	17,000	17,000	17,000	17,000
Texas[a]	**1,695,000**	**4,040,000**	**5,427,000**	**6,323,000**	**7,007,000**	**7,692,000**

[a] *Statewide totals may vary between tables due to rounding.*

- by the combination of specific water resource(s), projects, and/or technology required for implementation.

Recommended water management strategies will rely on both future demand management (reducing the demand for water) and a variety of Texas' water resources (Figures 7-1 and 7-2). If implemented, all recommended water management strategies would provide approximately 7.7 million acre-feet per year in additional water supplies to water user groups in 2070.

Surface water is the most significant water resource on which strategies are based, providing over 2.8 million acre-feet per year to water user groups, which is approximately 37 percent of the total recommended strategy supplies in 2070.

Demand management, mostly in the form of conservation savings but also including drought management, will address almost 2.4 million acre-feet per year in water user group water demands, which is approximately 31 percent of the recommended strategy volume in 2070.

Reuse provides 1.2 million acre-feet per year to water user groups, which is approximately 15 percent of the total recommended strategy supplies in 2070.

Groundwater resources provide just over 920,000 acre-feet per year to water user groups, which is approximately 12 percent of the total recommended strategy supplies in 2070.

Seawater provides nearly 190,000 acre-feet per year to water user groups, which is approximately 3 percent of the total recommended strategy supplies in 2070.

Aquifer storage and recovery, which can use a variety of water source types that are then stored underground, provides over 190,000 acre-feet per year to water user groups, or approximately 3 percent of the total recommended strategy supplies in 2070.

Table 7-2. Capital costs, by required online decade, of all recommended water management strategy projects by region (in millions)

Region	2020	2030	2040	2050	2060	2070	Total capital cost[a]	Number of projects[b]
A	$308	$584	$88	$49	$5	$113	$1,147	65
B	$212	$1	$443	$0	$0	$0	$656	20
C	$4,363	$5,482	$4,796	$7,437	$4,061	$3,793	$29,932	506
D	$157	$295	$39	$118	$31	$90	$730	103
E	$371	$243	$569	$320	$0	$0	$1,503	39
F	$439	$954	$66	$171	$6	$0	$1,636	111
G	$2,169	$2,377	$426	$496	$5	$13	$5,486	221
H	$4,124	$9,166	$4,125	$1,279	$907	$451	$20,052	818
I	$871	$1,466	$726	$11	$31	$6	$3,111	59
J	$70	$150	$0	$0	$0	$0	$220	45
K	$1,539	$1,484	$873	$173	$15	$510	$4,594	162
L	$1,176	$1,592	$1,019	$132	$203	$0	$4,122	57
M	$1,033	$449	$124	$165	$39	$25	$1,835	131
N	$166	$3,110	$0	$0	$0	$0	$3,276	64
O	$184	$118	$275	$1	$104	$126	$808	26
P	$26	$56	$340	$0	$0	$0	$422	12
Texas	**$17,208**	**$27,527**	**$13,909**	**$10,352**	**$5,407**	**$5,127**	**$79,530**	**2,439**

[a] *Capital costs represent approximations based on anticipated online dates. Projects with capital costs that would occur over multiple decades are reported as a single, total capital cost in the project's online decade and may therefore differ from those presented in the regional water plans.*

[b] *Some projects are associated with multiple sponsors.*

Figure 7-1. Share of recommended water management strategy volume by water resource in 2070 (percent)

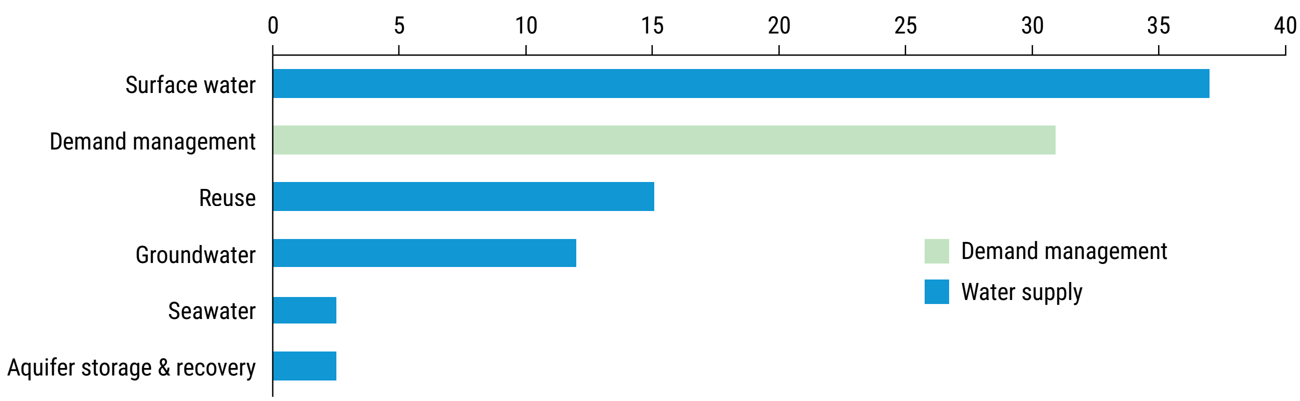
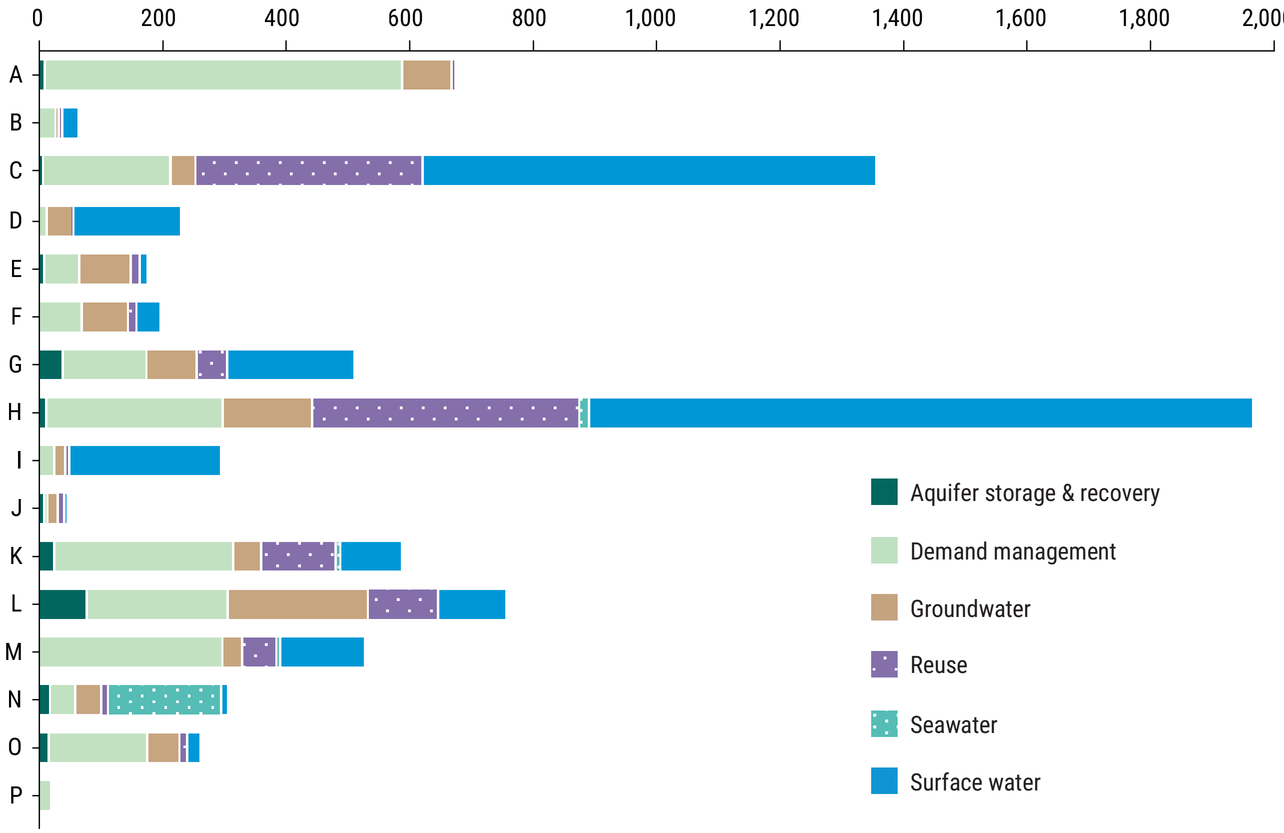


*Figure 7-2. Annual volume of recommended water management strategies by region and water resource in 2070 (thousands of acre-feet)**



** Strategy types are presented left to right in the order listed in the legend.*

7.3 Strategy types

Planning groups recommended a wide variety of water management strategies to serve water user groups, each of which relies on a specific combination of water source(s), infrastructure, and technology (Figure 7-3, Table 7-3).

7.3.1 Conservation

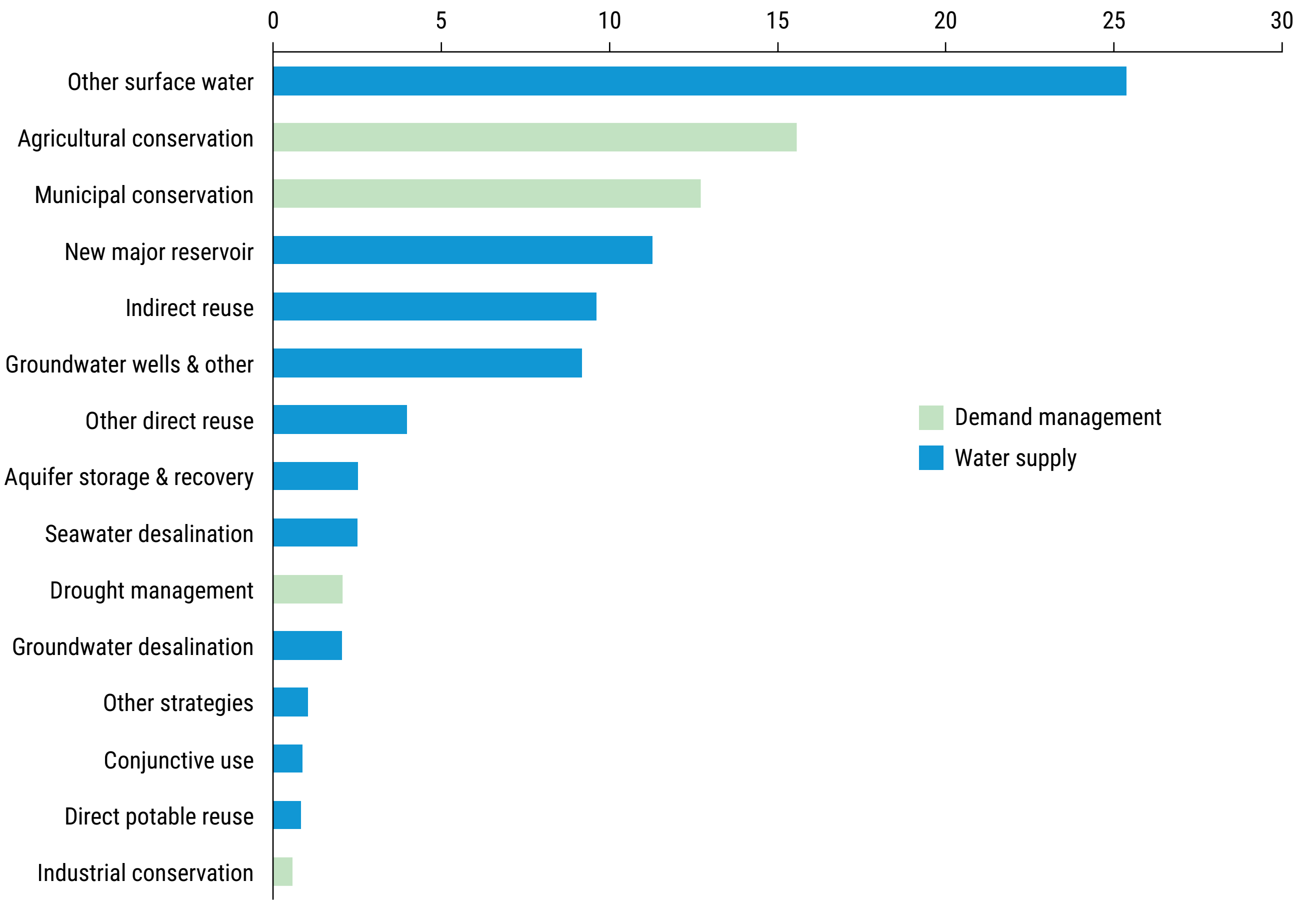
Conservation includes a variety of activities that either reduce everyday water consumption or increase water use efficiency, allowing more to be done with the same amount of water. Conservation occurs throughout both wet and dry weather and maintains all normal economic and domestic activities. Conservation strategies are divided into several types, including municipal; agricultural, which includes strategies predominantly for irrigation and some livestock water users; and industrial, which includes conservation strategies for steam-electric, manufacturing, and mining water users.

Conservation is a recommended strategy in all 16 regional water plans and is associated with over 1,500 water user groups (Table 7-4). About 778,000 acre-feet per year in conservation strategy volume is recommended in 2020, and 2.2 million acre-feet per year is recommended in 2070. Additional information on conservation strategies, planning, and programs is provided in Chapter 8.

7.3.2 Drought management

Drought management reduces water use during times of drought by temporarily restricting certain economic and domestic activities such as car washing and landscape irrigation. These measures vary and are generally implemented by local

Figure 7-3. Share of total recommended water management strategies volume by strategy type in 2070 (percent)



water providers. Planning groups recommended drought management strategies for certain water user groups and in limited instances to address, for example, near-term shortages that will eventually be met in future decades from other water supply strategies. It is important to recognize that in the absence of sufficient water, restricting water use through drought management is likely the primary, and often the only, means by which water providers will be able to successfully navigate their way through a severe drought. About 87,000 acre-feet per year in drought management strategies is recommended in 2020, and 158,000 acre-feet per year is recommended in 2070.

7.3.3 Reuse

Reuse takes many forms and is broadly categorized as either direct or indirect. Either type of reuse may be used for potable or non-potable purposes.

Direct potable reuse involves further treating of wastewater effluent at an advanced water treatment plant and then either introducing it ahead of the water treatment plant or directly into the potable water distribution system. About 12,000 acre-feet per year in direct potable reuse strategies is recommended in 2020, and 62,000 acre-feet per year is recommended in 2070.

Other direct reuse strategies generally convey treated wastewater directly from a treatment plant to non-potable uses such as landscape irrigation or industrial processes. About 51,000 acre-feet per year in other direct reuse (as opposed to direct potable reuse) strategies is recommended

Table 7-3. Annual volume of recommended water management strategies by online decade and strategy type (acre-feet)

Water management strategy type	2020	2030	2040	2050	2060	2070
Agricultural conservation	535,000	757,000	1,066,000	1,142,000	1,151,000	1,197,000
Aquifer storage & recovery	19,000	132,000	155,000	162,000	180,000	193,000
Conjunctive use	5,000	57,000	65,000	64,000	64,000	67,000
Direct potable reuse	12,000	34,000	44,000	57,000	61,000	62,000
Drought management	87,000	110,000	129,000	140,000	149,000	158,000
Groundwater desalination	19,000	97,000	123,000	124,000	154,000	157,000
Groundwater wells & other	255,000	418,000	543,000	604,000	665,000	705,000
Indirect reuse	58,000	209,000	510,000	560,000	648,000	739,000
Industrial conservation	23,000	32,000	35,000	37,000	39,000	44,000
Municipal conservation	220,000	395,000	530,000	675,000	822,000	977,000
New major reservoir	60,000	324,000	468,000	658,000	793,000	866,000
Other direct reuse	51,000	179,000	202,000	232,000	265,000	305,000
Other strategies	8,000	44,000	52,000	57,000	67,000	78,000
Other surface water	345,000	1,071,000	1,314,000	1,620,000	1,757,000	1,951,000
Seawater desalination	0	179,000	190,000	192,000	192,000	192,000
Texas[a]	**1,697,000**	**4,038,000**	**5,426,000**	**6,324,000**	**7,007,000**	**7,691,000**

[a] *Statewide totals may vary between tables due to rounding.*

in 2020, and 305,000 acre-feet per year is recommended in 2070.

Indirect reuse generally involves discharging wastewater into a natural water body and diverting that water for subsequent potable or non-potable use. About 58,000 acre-feet per year in indirect reuse strategies is recommended in 2020, and 739,000 acre-feet per year is recommended in 2070.

7.3.4 Conjunctive use

Conjunctive use strategies combine multiple water sources, usually surface water and groundwater, to optimize the beneficial characteristics of each source, yielding additional firm water supplies. For example, a strategy may be to rely intermittently on groundwater to supplement surface water supplies that are not fully available under drought of record conditions. About 5,000 acre-feet per year in conjunctive use strategies is recommended in 2020, and 67,000 acre-feet per year is recommended in 2070.

7.3.5 Aquifer storage and recovery

Aquifer storage and recovery refers to the practice of injecting water, when available, into an aquifer where it is stored for later use. This strategy is feasible only in certain geologic formations and in areas where only the project sponsor may retrieve the stored water. About 19,000 acre-feet per year in aquifer storage and recovery strategies is recommended in 2020, and 193,000 acre-feet per year is recommended in 2070.

Aquifer storage and recovery strategies can be associated with a variety of water source types that are stored underground. Recommended aquifer storage and recovery strategies are categorized under their own water resource type in this plan (Figure 7-1) but may be associated with one or a combination of initial surface water, groundwater, and reuse sources. Approximately 60 percent of 2070 aquifer storage and recovery strategy supplies are associated with stored surface water sources, while 30 percent are associated with a combination of groundwater and surface water sources. The remaining 10 percent are associated with groundwater or a combination

*Table 7-4. Number of water user groups relying on different types of water management strategies by region**

Water management strategy type	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Texas
Agricultural conservation	21	3	4	0	2	30	20	8	0	3	6	0	8	5	18	1	**129**
Aquifer storage & recovery	2	0	111	1	1	0	20	1	0	3	7	9	0	1	5	0	**161**
Conjunctive use	0	0	0	0	1	0	30	95	0	0	0	0	0	0	0	0	**126**
Direct potable reuse	1	0	0	0	0	1	1	0	0	1	4	1	9	0	0	0	**18**
Drought management	0	0	0	0	0	0	0	0	0	1	118	39	40	1	0	8	**207**
Groundwater desalination	0	0	0	0	4	1	2	1	0	1	1	5	11	3	0	0	**29**
Groundwater wells & other	32	8	150	49	13	19	77	28	23	17	31	64	11	24	26	0	**572**
Indirect reuse	0	5	240	10	0	7	11	9	5	0	7	0	0	0	0	0	**294**
Industrial conservation	0	12	2	3	0	32	40	0	0	0	5	0	17	13	12	3	**139**
Municipal conservation	40	23	283	9	10	68	114	345	58	9	70	106	58	23	38	6	**1260**
New major reservoir	0	18	246	9	0	0	30	10	15	0	18	4	0	0	1	0	**351**
Other direct reuse	0	0	10	0	2	2	18	18	0	2	14	11	5	2	2	0	**86**
Other strategies	0	0	36	0	1	11	0	1	0	1	8	0	7	0	0	0	**65**
Other surface water	0	5	277	40	2	41	91	132	28	2	11	5	47	4	1	0	**686**
Seawater desalination	0	0	0	0	0	0	0	1	0	0	0	0	1	3	0	0	**5**

** Water user groups associated with more than one planning region may be counted more than once with different region and strategy type combinations.*

of surface water and reuse or groundwater and reuse supplies.

As planning groups considered and evaluated water management strategies, House Bill 807 from the 86th Legislative Session required that they also provide a specific assessment of the potential for aquifer storage and recovery projects to meet any identified significant water needs. Each planning group defined its own threshold of significant water need. Most regions defined a quantitative threshold for significant water need. Quantitative thresholds ranged from water needs greater than 800 acre-feet (Region B) to greater than 25,000 acre-feet (Region H) in any decade and were generally determined by evaluating needs across a planning region or comparing needs to demands. In some regions, quantitative thresholds were limited to municipal water users. Two regions utilized categorical thresholds to define significant water need. Region C defined significant need as any major water provider need, and Region O defined significant need as any non-irrigation water need. Assessments of the potential for aquifer storage and recovery projects to meet significant water needs also varied by region but generally considered available water sources, suitable geology, and interested project sponsors.

Ten regions recommended aquifer storage and recovery strategies. Associated with these strategies are 27 recommended projects that would establish aquifer storage and recovery systems or pilot projects. More than 160 water user groups could benefit from these projects. Regions not recommending aquifer storage and recovery strategies (Regions B, D, F, I, M, and P) cited reasons such as the lack of suitable geology in proximity to needs, cost constraints, or a lack of interested project sponsors. Although Region D does not have project sponsors recommending aquifer storage and recovery, there are beneficiaries within Region D of an aquifer storage and recovery project sponsored in Region C. This information is reflected in Tables 7-4 and 7-5.

7.3.6 New major reservoirs

A major reservoir has a storage capacity of 5,000 acre-feet or more. Regional planning groups recommended 23 new major reservoirs during this planning cycle (Figure 7-4). About 60,000 acre-feet per year from new major reservoir strategies, including some that rely on indirect reuse, is recommended in 2020, and 866,000 acre-feet per year is recommended in 2070. Several of these reservoir sites are off-channel, meaning they would not be built on the main stem of the river, although they might rely on the main stem flows.

Because Senate Bill 1511, 85th Texas Legislature, now requires planning groups to amend their regional water plans if recommended water management strategies or projects become infeasible prior to adopting the next plan, including "infeasible in time,"[8] the TWDB emphasized in contract guidance and at planning group meetings the need to ensure realistic reservoir development timelines. Fourteen of the recommended new major reservoirs in this plan are anticipated to be online and providing water supply by 2030 (Figure 7-5). An additional eight new major reservoirs are planned to be online by 2050. Planning groups with new major reservoir strategies recommended for the 2020 decade were required to provide the specific basis on which the planning group anticipates that it is feasible for these major strategies to be online and providing water supply by January 5, 2023. Partly in response to this feasibility review, online decades for six recommended new major reservoir strategies were shifted from 2020 in the draft regional plans to 2030 in the final, adopted regional water plans.

7.3.7 Other surface water

Other surface water supplies include strategies that are not associated with new major reservoirs, surface water desalination, conjunctive use, or aquifer storage and recovery. The other surface water category includes minor reservoirs (less than 5,000 acre-feet of storage) and the subordination of surface water rights as well as a wide variety of other strategies that convey, treat, reassign, or otherwise make accessible additional surface water supplies to users—with or without additional infrastructure.

Some of these strategies are based on building pipelines to convey previously developed surface water supplies over long distances to either wholesale or retail water providers, for example, from an existing reservoir. These strategies generally do not require further development of surface water resources and new water right permits but simply convey previously developed and permitted surface water to users. In addition to pipelines, the types of projects associated with these strategies may include, but are not limited to, constructing pump stations, adding water treatment capacity, or lowering the elevation of a reservoir intake to allow a water provider to continue to draw water when lake levels are low.

Another portion of these strategies is based on reassigning existing surplus water supplies or more fully utilizing the capacity of existing infrastructure to deliver additional surface water to wholesale and/or retail water providers. Many of these strategies are based on transactions (such as sales, contracts, or purchases) between

[8] Although all projects recommended in the plan are considered technically feasible, a project may become infeasible on its projected timeline, meaning that obstacles and related delays to implementation might make it impractical to build the project quickly enough to meet water needs intended to be met in an early decade. Thus, the project would need to be shown as meeting needs later on.

Table 7-5. Weight-averaged unit costs (dollars per acre-foot)* of strategy water supplies by region and strategy type in 2070 *– continued on next page*

Water management strategy type	A	B	C	D	E	F	G	H	I
Agricultural conservation	$66	$83	$307	na	$39	$0	$1,330	$132	na
Aquifer storage & recovery	$391	na	$99	$99	$212	na	$418	$3,256	na
Conjunctive use	na	na	na	na	$251	na	$235	$1,060	na
Direct potable reuse	$1,228	na	na	na	na	$2,443	$606	na	na
Drought management**	na	na	na	na	na	na	na	na	na
Groundwater desalination	na	na	na	na	$818	$403	$1,540	$4,927	na
Groundwater wells & other	$355	$396	$408	$383	$710	$340	$407	$481	$173
Indirect reuse	na	$698	$273	$1,032	na	$269	$275	$326	$435
Industrial conservation	na	$385	$147	$0	na	$0	$0	na	na
Municipal conservation	$779	$356	$103	$679	$92	$663	$546	$584	$398
New major reservoir	na	$384	$625	$540	na	na	$659	$411	$281
Other direct reuse	na	na	$278	na	$479	$201	$384	$525	na
Other strategies	na	na	$899	na	$307	$10	na	$1,560	na
Other surface water	na	$828	$527	$199	$290	$80	$521	$273	$475
Seawater desalination	na	na	na	na	na	na	na	$1,293	na

** Unit costs include a mixture of projects, some of which will be beyond their debt service period by 2070.*

*** Unit costs for drought management strategies represent possible costs to municipal water users from foregone consumer surplus of imposed reduced water use rather than capital expended to produce water supply.*

na = not applicable or not available.

wholesale and/or retail water providers involving previously developed supplies. These transactions may include voluntary reallocations of existing supplies, for example, to support an emergency connection between water providers. Delivery and treatment of these additional water supplies may or may not require new or expanded water infrastructure.

The remaining other surface water strategies increase supplies simply by removing infrastructure bottlenecks, which limit the volume of supplies that could otherwise be delivered. Expanding the capacity of a water treatment plant to better align with the larger capacity of a conveyance pipeline that already delivers water to the plant is an example of this type of strategy.

About 345,000 acre-feet of water supply per year from other surface water strategies is recommended in 2020, and almost 2 million acre-feet per year is recommended in 2070.

7.3.8 Groundwater wells and other

All but one of the planning groups recommended the development of at least some additional groundwater. This includes single wells or multiple wells, which may be part of the development of new well fields or expansions of existing well fields. New wells are often the only economically feasible strategy to meet the water needs of rural municipal water users.

Other groundwater strategies do not involve installing new wells but instead convey, reassign, or otherwise make accessible previously developed groundwater supplies to users with or without additional conveyance and/or treatment infrastructure. These strategies may include, for example, maximizing the use of existing facilities by increasing production from existing groundwater wells and conveying groundwater supplies from one provider to another through a purchase.

Table 7-5. Weight-averaged unit costs (dollars per acre-foot) of strategy water supplies by region and strategy type in 2070 – continued*

Water management strategy type	J	K	L	M	N	O	P	Texas
Agricultural conservation	$0	$151	na	$315	$3,597	$450	$200	$181
Aquifer storage & recovery	$148	$2,109	$221	na	$171	$824	na	$664
Conjunctive use	na	na	na	na	na	na	na	$814
Direct potable reuse	$6	$1,961	$1,980	$1,709	na	na	na	$1,505
Drought management**	$0	$66	$358	$55	$0	na	$100	$169
Groundwater desalination	$294	$2,995	$1,227	$1,085	$1,088	na	na	$1,080
Groundwater wells & other	$154	$523	$435	$85	$93	$174	na	$402
Indirect reuse	na	$214	na	na	na	na	na	$297
Industrial conservation	na	$109	na	$2,983	$0	$0	$0	$292
Municipal conservation	$408	$999	$625	$582	$502	$332	$1,990	$515
New major reservoir	na	$715	$97	na	na	$518	na	$511
Other direct reuse	$56	$1,036	$625	$354	$157	$1,407	na	$630
Other strategies	$0	$1,618	na	$10	na	na	na	$1,066
Other surface water	$244	$143	$621	$2,890	$229	$783	na	$523
Seawater desalination	na	na	na	$3,188	$1,364	na	na	$1,371

** Unit costs include a mixture of projects, some of which will be beyond their debt service period by 2070.*

*** Unit costs for drought management strategies represent possible costs to municipal water users from foregone consumer surplus of imposed reduced water use rather than capital expended to produce water supply.*

na = not applicable or not available.

About 255,000 acre-feet per year of supply from groundwater development strategies (not associated with groundwater desalination, conjunctive use, or aquifer storage and recovery strategies) is recommended in 2020, and 705,000 acre-feet per year is recommended in 2070.

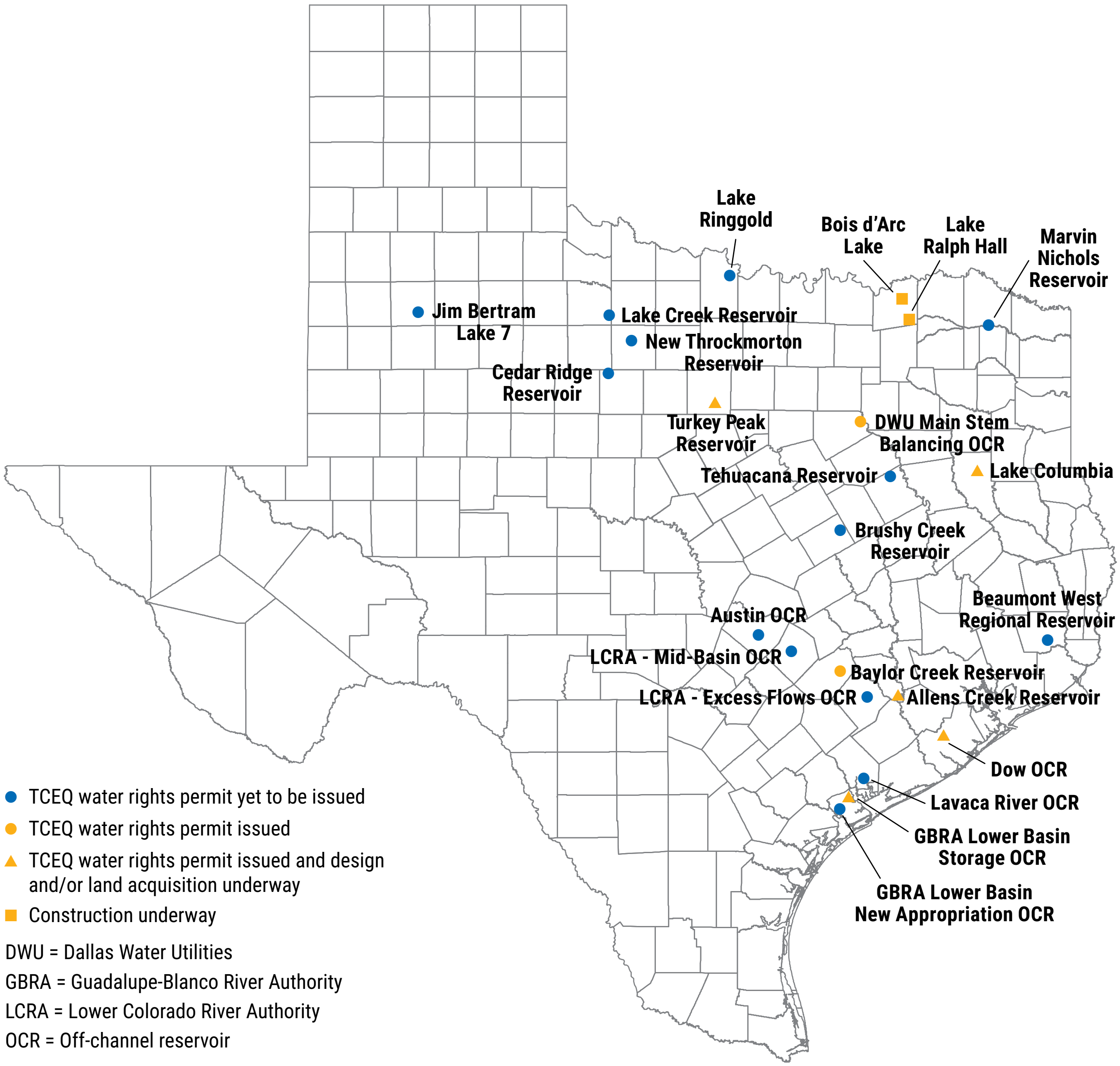
7.3.9 Desalination of groundwater and seawater

Desalination is the process of removing dissolved solids from seawater or brackish groundwater, often by forcing the source water through membranes under high pressure. The specific process used to desalinate water varies depending upon the amount of total dissolved solids, temperature, and other physical characteristics of the source water but always requires disposal of concentrate that has a higher total dissolved content than the source water. Disposal may take the form of an injection well, evaporation ponds, discharge to surface water, or an ocean outfall diffuser.

About 19,000 acre-feet per year of supply from groundwater desalination strategies is recommended in 2020, and 157,000 acre-feet per year is recommended in 2070. For seawater desalination strategies, no additional supply is recommended by 2020; however, 179,000 acre-feet per year of supply is recommended to be online by 2030, and 192,000 acre-feet per year is recommended in 2070.

Nine planning groups recommended groundwater desalination strategies and three recommended seawater desalination strategies. Planning groups cited the cost of desalination treatment and infrastructure, a lack of interested project sponsors, and the existing availability of non-brackish water sources as reasons for not recommending groundwater desalination strategies. Finding qualified operators in rural areas to operate these sophisticated systems is an implementation issue that has been raised on these projects. The primary reason for not recommending seawater

Figure 7-4. Recommended new major reservoirs



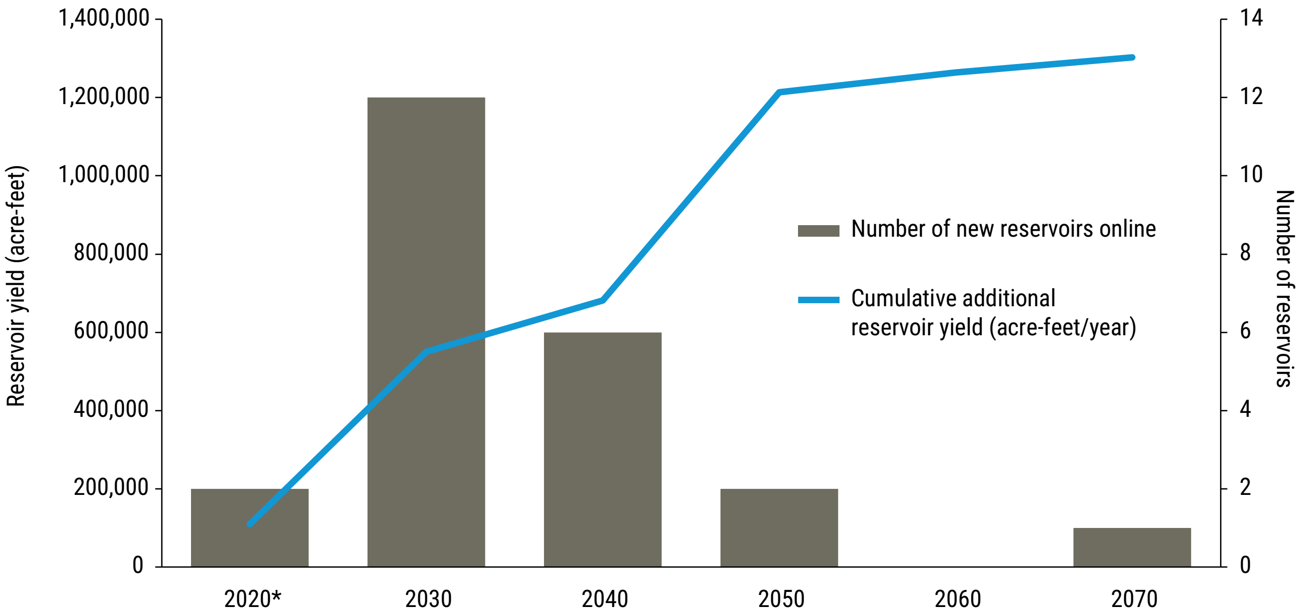
desalination strategies was based on cost, particularly as related to the distance supplies would have to be conveyed from the Gulf of Mexico.

7.3.10 Other strategies

Four remaining strategy types complete the portfolio of recommended water management strategies. Each individually provides approximately 1 percent of the total recommended strategy supplies in 2070. For two of these, weather modification and brush control, it is difficult to quantify the reliable supplies they are capable of providing under extended drought of record conditions when there is less cloud cover, precipitation, runoff, and infiltration of precipitation into the soil. For this reason, they are not often recommended as strategies to meet needs.

Surface water desalination is the process of removing dissolved solids from brackish surface water, often by forcing the source water through membranes under high pressure. About 63,000 acre-feet per year of supply from surface water desalination strategies is recommended in 2070.

Figure 7-5. Online decade count and cumulative yield of recommended new major reservoirs



** Reservoirs shown as online in 2020 are anticipated to have construction completed by January 2023.*

Weather modification, sometimes referred to as cloud seeding, is the application of technology to enhance precipitation from clouds. About 5,000 acre-feet per year of supply from weather modification strategies is recommended in 2070 to address needs for select irrigation water users that also have recommended irrigation conservation strategies.

Brush control is a land stewardship technique that involves removal of species, such as ashe juniper, that may reduce runoff to streams and rivers and recharge to aquifers. About 5,000 acre-feet per year of supply from brush control strategies is recommended in 2070 to address needs for select non-municipal water users that also have other recommended strategies.

Rainwater harvesting involves capturing, diverting, and storing rainwater for landscape irrigation, drinking and domestic use, aquifer recharge, and stormwater abatement. Rainwater harvesting can reduce municipal outdoor irrigation demand on potable systems. Building-scale level of rainwater harvesting, as was generally considered by planning groups and which meets planning rules, requires active management by each system owner to economically develop it to a scale that is large and productive enough to ensure a meaningful supply sustainable through a drought of record. About 5,000 acre-feet per year of supply from rainwater harvesting strategies is recommended in 2070 to address needs for select water users that have multiple additional recommended strategies.

7.4 Assignment of strategy and project supply volumes

The volume of water associated with all recommended water management strategy projects may, in some cases, be greater than an identified need or what was actually assigned to specific water user groups. Differences in water volumes may occur between the yield developed by certain projects at the source and the volume that would actually be conveyed to wholesalers or water user groups, the volume assigned to wholesale water providers and retail water providers, and/or the identified water user needs and strategy volume assigned to a specific water user. Depending on the project and provider, these differences in water volumes generally represent

- anticipated water losses in conveyance and/or treatment;
- a management supply or safety factor to address uncertainties such as whether recommended projects will be implemented, unanticipated water supply reductions, or greater-than-anticipated water demand for wholesale and retail water system operations;
- a planning buffer against a future drought worse than the drought of record;
- water supply available to a wholesale provider that could eventually be distributed to meet the needs of its customer water user groups; and/or
- a portion of the capacity of larger, optimally sized regional projects, such as major reservoirs, that come online later in the planning decades and that may not be fully connected to or utilized by water user groups, for example, until after 2070.

In some cases, additional water may be developed at the source only, while in other instances the water may be delivered to a wholesale provider but may not have been assigned to any specific water user group in a particular decade. Future delivery of unassigned water volumes may require additional water infrastructure that may not be included in this plan.

The full capacities of all recommended projects and strategies that are included in the approved regional water plans, including any of their associated capacities or volumes of water that may not be assigned to specific water user groups, are also considered to be part of the state water plan. There are 22 recommended projects that are associated with only unassigned strategy supplies, meaning the supplies from these projects have not yet been allocated to a specific water user group. Approximately 210,000 acre-feet per year of unassigned strategy supply is recommended in 2020, and 1.1 million acre-feet per year is included in the recommended strategies in 2070. Unassigned strategy supplies account for 11 percent of the total supply share in 2020 and 13 percent in 2070. Assigned and unassigned strategy supplies recommended in 2070 are presented by region in Figure 7-6.

7.5 Costs of recommended strategies

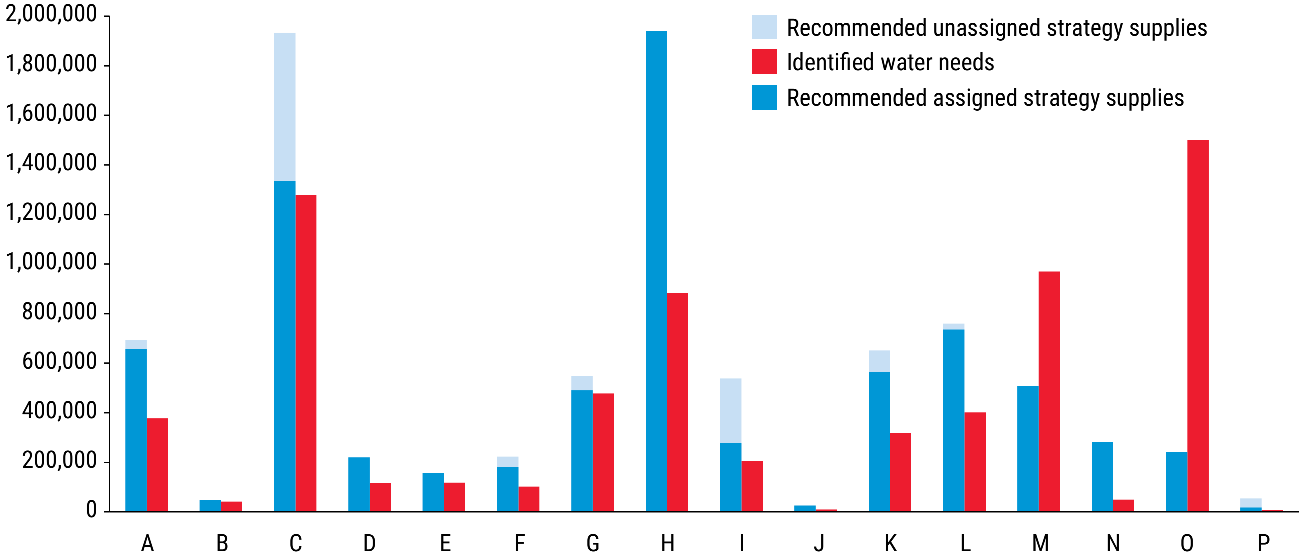
Planning groups estimated the costs of their recommended water management strategy projects using common cost elements and methodologies. This is the second cycle of regional plans in which planning groups utilized a cost estimation tool that was developed under a TWDB-funded research study and the first in which a cost estimation tool for drought management strategies was made available.[9] Extensive use of the spreadsheet-based tool introduced greater consistency in the cost estimates and helped planning groups ensure that all required cost considerations were included in the estimates.

In accordance with planning rules and guidance, this state water plan is intended to include only those recommended projects and costs necessary to conserve, develop, deliver, or treat additional water supply volumes. It specifically excludes the cost for maintaining or replacing existing infrastructure as well as retail distribution projects, such as expanding internal distribution infrastructure to serve a new subdivision, other than those directly associated with recommended conservation strategies.

The total capital cost required to implement all recommended water management strategy projects is $80 billion in 2018 dollars, without

[9] The costing of drought management strategies is a significantly different cost concept (economic cost) than the explicit capital cost of implementing other strategy types. Additional detail on lost consumer surplus appears in the user guide for the Drought Management Tool at www.twdb.texas.gov/waterplanning/rwp/planningdocu/2021/doc/current_docs/project_docs/TWDB_Drought_Management_Costing_Tool_User_Manual_2019.pdf.

Figure 7-6. Recommended assigned and unassigned strategy supplies and needs by region in 2070 (acre-feet)



accounting for future inflation. This includes approximately 2,400 projects that would be built and completed at various times over the next five planning decades.

The estimated unit cost of water (dollars per acre-foot of water delivered to water user groups in each year) varies greatly depending on the type of strategy, location, water source, and infrastructure required to convey and treat the water. Statewide, based on a weighted average cost,[10] the least expensive recommended water management strategy type in the year 2070 is drought management followed by irrigation conservation. The most expensive is direct potable reuse followed by seawater desalination (Table 7-5). There can be a substantial range in unit cost even within a single type of strategy depending on the source water quality, geographic distances, and whether the unit cost includes debt service in the later decades; this is true between regions as well. For example, if a seawater desalination strategy requires a 100-mile pipeline inland, the costs of that strategy will likely be substantially greater than a seawater desalination plant built to serve an entity located on the coast.

Similarly, unit costs of water were estimated by strategy type at a statewide level for each decade in the planning horizon (Table 7-6). Statewide weight-averaged unit costs are higher than the 2017 State Water Plan for every strategy type except groundwater well development, seawater desalination, and the grouped category Other strategies, which includes such strategies as rainwater harvesting (Section 7.3.10).

7.6 Strategies benefiting multiple regions

Several wholesale and major water providers in this plan serve customers in multiple planning regions. Additionally, regional water planning groups coordinate with each other throughout each cycle to identify and consider potential regionalized projects during the development of their plans. In this plan, 35 recommended strategies recommended by 7 planning groups benefit water user groups in more than those 7 primary regions. This regionalization provides shared water supplies to 10 of the 16 regions across the

[10] The weighted average is the average of values scaled by the relative volume of each strategy.

Table 7-6. Statewide weight-averaged unit costs (dollars per acre-foot) of strategy water supplies by strategy type 2020–2070*

Water management strategy type	2020	2030	2040	2050	2060	2070
Agricultural conservation	$284	$273	$202	$188	$186	$181
Aquifer storage & recovery	$437	$666	$904	$609	$509	$664
Conjunctive use	$1,724	$1,729	$1,986	$1,147	$903	$814
Direct potable reuse	$1,321	$1,456	$1,402	$1,587	$1,590	$1,504
Drought management**	$70	$119	$168	$168	$169	$169
Groundwater desalination	$920	$1,618	$1,430	$899	$994	$1,080
Groundwater wells & other	$599	$659	$592	$523	$439	$402
Indirect reuse	$391	$697	$541	$391	$266	$297
Industrial conservation	$680	$597	$513	$339	$311	$292
Municipal conservation	$675	$607	$503	$498	$519	$515
New major reservoir	$114	$598	$818	$678	$521	$511
Other direct reuse	$962	$892	$865	$483	$559	$630
Other strategies	$10	$2,128	$2,016	$1,073	$1,055	$1,066
Other surface water	$744	$1,037	$986	$581	$550	$523
Seawater desalination	na	$2,402	$2,394	$1,440	$1,383	$1,371

** Unit costs include a mixture of projects, some of which will be beyond their debt service period by 2070.*

*** Unit costs for drought management strategies represent possible costs to municipal water users from foregone consumer surplus of imposed reduced water use rather than capital expended to produce water supply.*

na = not applicable or not available.

state. The volume of water from these regionalized strategies represents 13 percent of the total recommended strategy water supply volume in 2070 that includes groundwater development, transfers of existing water supplies, development of new major reservoirs, direct and indirect reuse, and aquifer storage and recovery projects. Planning groups also assessed progress toward regionalization, a new requirement in this plan from House Bill 807, 86th Legislative Session. This discussion is included with other implementation results in Chapter 10.

7.7 Impacts of recommended strategies

The process of developing regional water plans requires that planning groups describe the major impacts on key water quality parameters and how the plans are consistent with the long-term protection of water, agricultural, and natural resources.

7.7.1 Potential impacts on water quality

To assess how water management strategies could potentially affect water quality, planning groups identified key water quality parameters within their regions. These parameters were generally based on surface and groundwater quality standards, the list of impaired waters developed by the Texas Commission on Environmental Quality, and input from local and regional water management entities and the public.

Planning groups presented high-level assessments of how implementing strategies could potentially affect the water quality of surface water and groundwater sources. Regions used different approaches, including categorical assessments (such as low, moderate, high) or numerical impact classifications (such as 1, 2, 3, 4, 5).

To evaluate the potential impacts of the recommended water management strategies on surface water quality, the planning groups commonly used the Texas Surface Water Quality Standards, which include the following:

- **Total dissolved solids (salinity)**: For most purposes, total dissolved solids is a direct measure of salinity. Salinity concentration determines whether water is acceptable for drinking water, livestock, or irrigation.
- **Nutrients**: Nutrients are chemical constituents, most commonly as a form of nitrogen or phosphorus, that can occur in high concentrations, contributing to the overgrowth of aquatic vegetation and impacting water uses.
- **Dissolved oxygen**: Dissolved oxygen concentrations must be sufficient to support existing, designated, presumed, and attainable aquatic life uses in classified water body segments.
- **Bacteria**: Some bacteria, although not generally harmful themselves, indicate potential contamination by feces of warm-blooded animals.
- **Toxicity**: Toxicity is the occurrence of adverse effects to living organisms due to exposure to a wide range of toxic materials.

The water quality indicators that planning groups commonly used to evaluate groundwater quality impacts of the recommended water management strategies include the following:

- **Total dissolved solids (salinity)**: As noted above, total dissolved solids is a measure of the salinity of water and represents the amount of minerals dissolved in water.
- **Nitrates**: Although nitrates are naturally occurring nutrients, elevated levels generally result from human activities, such as overuse of fertilizer and improper disposal of human and animal waste.
- **Arsenic**: Although arsenic can occur both naturally and through human contamination, most arsenic in Texas groundwater is naturally occurring.
- **Radionuclides**: A radionuclide is an atom with an unstable nucleus that emits radiation; this occurs naturally in several Texas aquifers.

Water management strategies for water supply are subject to the Texas Commission on Environmental Quality's Public Drinking Water and Water Quality standards, permitting, monitoring, assessment, treatment, sampling, and other requirements or methods used by that agency to address water quality problems related to water supply.

7.7.2 Protecting the state's water, agricultural, and natural resources

In developing the regional plans, planning groups honored all existing water rights and contracts and considered conservation strategies based on identified best management practices for all water user groups with a water supply need or that relied on an interbasin transfer. Planning groups also accounted for environmental flow standards adopted by the Texas Commission on Environmental Quality, Consensus Criteria for Environmental Flow Needs, or, when available, site-specific studies. Regional plans do not include any recommended strategies incompatible with the desired future conditions of aquifers or that divert greater-than-permitted surface water volumes.

Planning groups quantified and considered the impacts of water management strategies to agricultural resources. In developing the plans, planning groups were also required to consider and, when feasible, recommend water management strategies to meet the water supply needs of irrigated agriculture and livestock production. Recommended strategies involving conversion or transfer of water associated with existing water right permits either being used for agricultural purposes or from rural areas were based on future voluntary transactions between willing buyers and willing sellers.

In considering the protection of natural resources, planning groups included estimated costs of anticipated mitigation requirements for project construction and quantified the potential impacts of water management strategies related to environmental factors. These factors were quantified and summarized primarily based on existing data and the potential to avoid or mitigate impacts. Some categorized assessments as “high,” “moderate,” or “low” based on underlying quantified impacts or quantified ranges of impacts. For example, a “low” impact rating indicated that impacts could generally be avoided or mitigated relatively easily. In contrast, an impact rated as “high” generally indicated that impacts would be significant with the potential for substantial mitigation requirements.

In their environmental reviews, planning groups also considered a variety of factors, including the volume of discharge a strategy would produce, the number of acres of habitat potentially affected, changes to streamflows, and changes to bay and estuary inflow patterns. The groups also relied on identifying the number of endangered or threatened species or cultural sites occurring within the vicinity of the recommended projects.

The emphasis of these evaluations varied by region based on the type of project under consideration and the relevant resources affected. Evaluations included project-by-project evaluations as well as cumulative, region-wide impact analyses. In general, most planning groups relied on existing information and data generated as part of the technical evaluations of strategies, such as flow frequency data, land cover, and habitat maps, to evaluate the impacts of water management strategies on agricultural and natural resources.

7.8 Needs met by recommended strategies

Planning groups were required to consider all identified water needs (potential shortages) and identify possible strategies to meet them, when feasible. Two planning groups (Regions N and P) were able to recommend water management strategies that, if implemented, can meet the needs for all their water user groups. The remaining 14 planning groups were unable to identify sufficient feasible strategies that could meet both Texas’ planning requirements and all the needs in their regions (Figure 7-7).

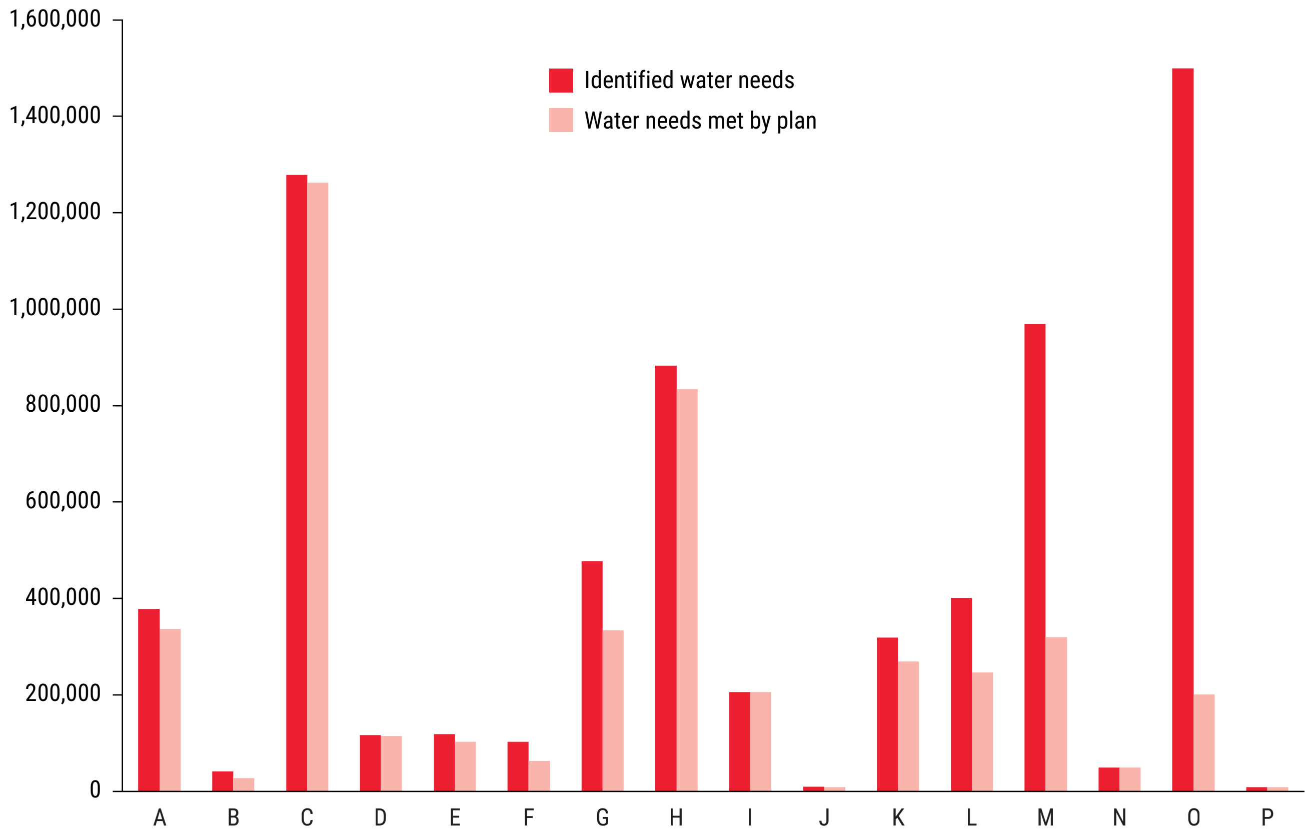
Statewide, most water needs associated with municipal, manufacturing, livestock, and mining water user groups are met by the plan in 2070 (Figure 7-8). However, at least some unmet water supply needs occur for all categories of water user groups, with irrigation water user groups accounting for the majority of unmet water needs. The inability to meet a water user group’s need in the plan is usually due to the lack of an economically feasible water management strategy. The significant unmet irrigation water needs are largely due to managed depletion of aquifers and a lack of economically feasible alternatives to meet agricultural needs. An unmet need does not prevent an associated entity from pursuing development of additional water supply.

7.9 Comparison to the 2017 State Water Plan

The volumes and relative mix of recommended water management strategies change between each state water plan for a variety of reasons. Some strategies recommended in the previous plan will have been implemented by the adoption of the next water plan, at which time those “new” supplies are then accounted for as existing water supplies (Chapter 5) and thereby reduce the resulting water needs.

Counts of recommended strategies in this plan vary from the 2017 State Water Plan partly due to both the transition to utility-based planning and a shift by some planning regions toward grouping strategies under project sponsors. Such strategy grouping by sponsors has occurred as projects get further defined over time, serving multiple customers with interrelated needs, such as meeting groundwater reduction requirements by regional water authorities around the

Figure 7-7. Annual water supply needs and needs met by the plan by region in 2070 (acre-feet)

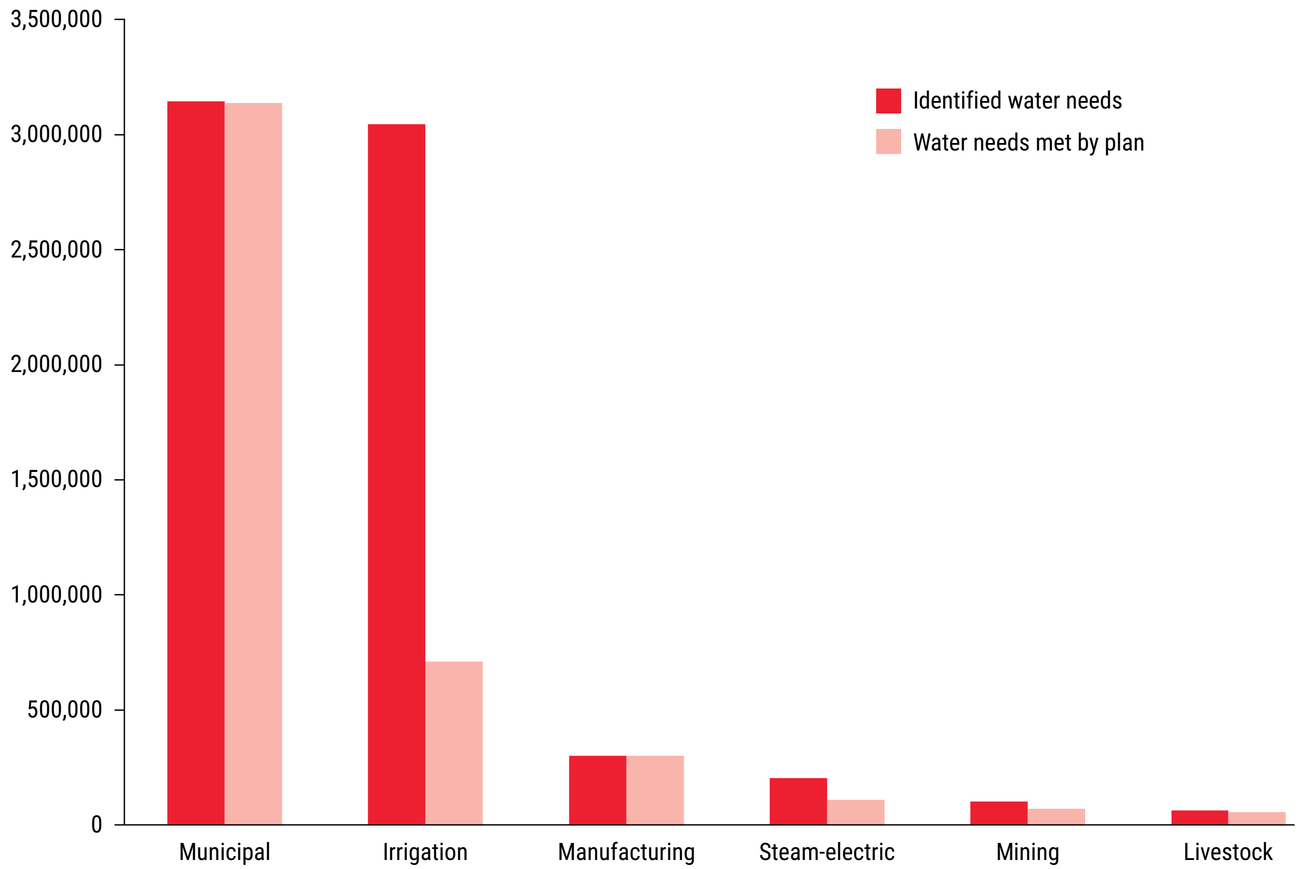


Houston area. There are approximately 5,800 recommended strategies described in this plan that represent the total number of recommended strategies assigned to water user groups and account for individual and grouped strategies. This represents a net increase of approximately 500 in the count of recommended strategies over the count in the 2017 plan, some of which is the result of the transition to utility-based planning.

As is the case with this plan, the 2017 State Water Plan also included a varying mixture of water supply volumes not directly associated with water user groups. However, the associated volumes and project sponsors differ, which makes comparisons between plans difficult. The recommended water management supplies, as presented here, are those supply volumes that planning groups associated with specific water user groups. In addition to the shift in timing of several major reservoirs previously discussed, notable changes from the 2017 State Water Plan include the following:

- The anticipated total strategy supplies directly associated with water user groups in the 2070 decade decreased from 8.5 million acre-feet per year in the 2017 State Water Plan to 7.7 million acre-feet per year in this plan, primarily due to a lower volume of needs to address in 2070 than in the 2017 State Water Plan.
- The total capital costs of all recommended strategies increased significantly from $63 billion in the previous plan to $80 billion, due to many factors but largely because of increased construction costs, refinement of projects through the planning phases, increased engagement of water providers and communities in the planning process, and a more comprehensive effort to include all projects that will conserve water or increase treated water supply volumes.

Figure 7-8. Annual water supply needs and needs met by the plan by water use category in 2070 (acre-feet)



- The number of water user groups benefiting from recommended aquifer storage and recovery strategies increased significantly from the previous plan.
- Capital-intensive conservation strategies increased to $7.4 billion—$2.7 billion more than in the previous plan.
- The volume of recommended municipal conservation savings of 977,000 acre-feet per year in 2070 is greater than the 811,000 acre-feet per year recommended in the 2017 plan.
- The volume of recommended direct potable reuse strategies in 2070 decreased from approximately 87,000 acre-feet per year in the 2017 plan to 62,000 acre-feet per year.
- The volume of recommended desalination strategies in 2070 nearly doubled, from approximately 229,000 acre-feet per year in the 2017 plan to almost 412,000 acre-feet per year.
- The volume of recommended aquifer storage and recovery strategies in 2070 increased from approximately 123,000 acre-feet per year in the 2017 plan to 193,000 acre-feet per year.

7.10 Uncertainty of future strategies

Implementation of any given recommended water management strategy or project is not a certainty, and project sponsors are ultimately responsible for implementing water management strategies. Many of the more significant projects will require obtaining a surface water right or groundwater permit from a regulatory entity. Some projects, such as large reservoirs, will require extensive and time-intensive studies, including additional environmental permitting from the U.S. Army Corps of Engineers and the National Environmental Policy Act process, which involves wide-ranging information collection, study, and public input.

Comal Springs flow from the limestone rocks, New Braunfels, Texas

Implementing all water supply projects also remains subject to political and financial processes associated with project sponsors and communities. Eventually, some recommended projects may become politically or financially infeasible and, therefore, will be shelved or abandoned.

To account for uncertainties, including the possibility of projects being downsized or not being implemented at all, planning groups sometimes recommended a combination of water management strategies that, if implemented, would provide more water supplies than are required to meet needs. Planning groups also included alternative water management strategies, which are fully evaluated strategies that can be substituted at a future date if a recommended strategy becomes infeasible. The further into the 50-year planning horizon, the greater the uncertainty of implementing any given strategy. Regulations may change or technological advances may make some strategies more affordable. Water planning in Texas is an adaptive process in which regional and state water plans are developed every five years to reflect these and many other changes.