BEST BETS for TEXAS WATER

It's true that nobody knows what the future holds – but looking toward Texas' future, two things are clear: there will be more people. There will not be more water. In fact, there will be less.

The good news is that many strategies exist for Texas communities to prepare for a future with more people and less water. But when it comes to implementing these strategies, the stakes are high. If water supply projects aren't examined closely and done carefully, water could be wasted, rivers could be depleted, and wildlife could be harmed – all while Texans foot the costly bill.

This guidebook explores the strategies in Texas' water security toolbox, good and bad. By using this tool to make informed and forward-thinking decisions about where to invest Texans' money, communities can prepare for both flood and drought without sacrificing wildlife and the environment.

Learn more and take action online:
www.texaslivingwaters.org/bestbets

Texas Living Waters Project

Texas, we have a problem.

Water is everything. But between growing populations, heat waves and severe droughts, it's becoming scarce.

If we're going to have enough fresh water for every living thing, Texas needs to make wise water choices – we can't wait any longer.

This project is a guide to charting Texas' water future.

In order to design a wise way forward, our decision-makers and community members must have a shared understanding of how our decisions might impact our state's environment, economy and long-term resilience. Read on as we explore the strategies in Texas' water security toolbox, good and bad.

Why should I be concerned?

When water never fails to fill our sinks, showers and hoses, it's hard to grapple with the idea that one day there really might not be enough. But if Texas doesn't start making informed, deliberate and innovative decisions today to plan for its water future, that could be our reality sooner than we think.

How could this happen?

Simply put: water shortages are an issue of demand exceeding supply. Texas has only a limited amount of water. Even in wet years, it's possible for Texas to use more water than it gets; in times of drought, it's all too easy to dry up our aquifers, rivers and streams. The consequences can be tragic – not just for people, but for our natural heritage and wildlife, too.

That's where water supply strategies come in.

It's not possible to create more water, but it is possible to help communities become more resilient by planning wisely for a future that very likely includes a much larger population, deeper droughts, and more severe storms. By making informed and forward-thinking decisions about where to invest Texans' money, communities can prepare for both flood and drought, without sacrificing wildlife and the environment.

Where does Texas water come from? Where does it go?

First things first: we can't make a plan for Texas water if we don't understand its path. 191,000 miles of named streams and major rivers snake across Texas, carrying the gift of fresh water to people and wildlife. Of these streams and rivers, the ones that begin in Texas share similar origins: they are often spring-fed, which means water bubbles up from underneath the land's surface and flows onward in the form of a river or stream.

The majority of the waterways that thread the state make their winding way to the Texas coast, where they bring life to an incredible network of bays and estuaries that support wildlife like oysters, blue crabs, redhead ducks, whooping cranes and our legendary game fish. These bays and the wildlife that call them home couldn't exist without the freshwater inflows that come from rivers – their entire ecosystem depends on a healthy mix of salty and fresh water.

Just like the trees, birds, fish and oysters that call Texas home, you need this fresh water to survive.

The water we use every day can come from any point along Texas water's path. Usually, we extract it from underneath the ground (aptly named "groundwater") or we pull it from rivers ("surface water") through a series of dams, pipelines and other large-scale pieces of infrastructure. Much of where a community gets its water depends on the region's climate and water availability; each unique part of Texas has its own challenges and opportunities, and what makes sense for one community doesn't always make sense for others.

Do you know where your water comes from? If you don't, it's time to find out.

Knowing the source of your water will help you identify ways to protect it and make sure it is safe and clean. Understanding how drinking water gets to your home and water faucets is also an important step to becoming an advocate for fresh water for every living thing.

How to use this guide

We've assigned each water strategy grades based on three criteria:

Environment: How does this strategy impact rivers, springs, bays and wildlife?

True costs: This criterion looks beyond dollar signs to the big picture. How does this strategy affect the Texas economy (and water customers whose wallets foot the bill for water supply projects)?

Longterm viability: Decades from now, will this strategy have been worth the investment? Looking forward, are there any opportunities and concerns that we already know to expect?

Here's how to interpret our grades:

Relative to other strategies, this is as good as it gets – however, even a good strategy can be done poorly if it is not carefully implemented.

This strategy is promising on some fronts, but there are some real concerns.

When compared to other strategies, it's hard to see the benefit of this one.

Disclaimer: We have evaluated these strategies relative to one another, based on currently available information and observations. We acknowledge that the water supply landscape is vast and nuanced, and that each strategy must also be evaluated in the context of community size and type, region, geology and more. We also recognize that there are concerns involved with any new water supply project that removes water from its natural sources for human use, leaving less available water for downstream people, fish, bays and wildlife.

Some terms you should know

Aquifer

A below-ground area of permeable rock where water collects over time, almost like a groundwater reservoir.

Bay / estuary

Bays are bodies of water that are partially enclosed by land and open up into the ocean. Many Texas bays are also estuaries, which are life-filled bodies of water where fresh water and salty ocean water mix.

Watershed

An area of land where water falls to the ground as rain or snow and then drains into a body of water such as a stream.

River basin

Includes all of the water that flows into a major river. There are multiple watersheds within a single basin.

Environmental flows

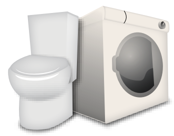
A measurement of both *how much* water flow is needed in a river for it to stay healthy, and *when* different levels of high and low flow should occur to sustain natural life cycles.

WATER CONSERVATION STRATEGIES

Conserving water means using the water we already have more wisely. Other ways of thinking about water conservation include using water more efficiently, doing the same activities with less water, or reducing our water demands.

Education is an important part of water conservation; people need to be given tools and knowledge to make water-wise decisions.

Common water conservation examples

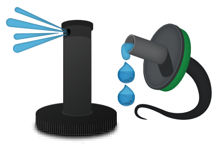


Installing water-efficient technology

- In industry: Using air-cooled equipment instead of water-cooled equipment when possible, or redesigning manufacturing or refining processes to use less water.
- In communities: Installing metering technology that monitors water use so that excessive use and leaks can be quickly identified.
- In businesses: Investing in technologies that use both energy and water more efficiently, because using less energy saves water and vice versa.
- In homes: Upgrading to water-efficient appliances and fixtures, including washing machines, dishwashers, low-flow sinks, toilet and shower fixtures, and drip irrigation systems outside the home.

Adopting water-wise policies

- Incentivizing water-efficient appliances and landscaping practices that use native plants and less water.
- Structuring water rates so that low water users pay less per gallon for their water.
- Offering free leak repairs for low-income water customers.



Rethinking landscaping

- Installing drought-tolerant native and adapted grasses and landscapes.
- Limiting landscape irrigation to no more than twice per week (once is better), and refraining from watering during the heat of the day (when water is quickly lost to evaporation).
- Converting small gardens or landscaped areas to drip irrigation, rather than sprinkler systems that don't deliver water as efficiently.

Capturing rainwater

- Installing rain barrels and cisterns to collect rainwater so that it can be used to water gardens, wash cars, top off swimming pools, flush toilets and more.

Eagle Nest Creek near Langtry, Texas.
Photo by Charles Kruvand

Environment:
When Texas communities use less water, they don't have to take as much away from the environment.

True costs:
The cheapest water supply is the water you already have. Additionally, many water conservation strategies do not require expensive investments or maintenance costs.

Long-term viability:
Reducing per-person water use allows communities to meet the needs of more people with the same amount of water (or less, which is important during drought years). Texas is growing rapidly, which means using water more efficiently is the most viable long-term strategy available.

Environmental impacts

Positive

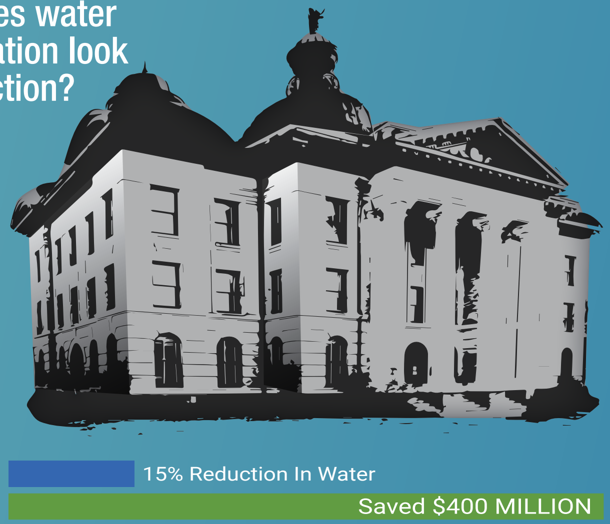
Water conservation programs reduce the total amount of water a community uses, which frees up valuable fresh water that can stay in rivers, recharge aquifers and flow down into the bays, giving wildlife across Texas a chance to survive and even thrive.

Communities that increase their water supplies by conserving water are less likely to need water supply projects that are environmentally destructive.

Negative

None

What does water conservation look like in action?



North Fort Bend Water Authority found that by reducing water demands by 15%, it can eliminate $400 million in future infrastructure costs. Their water conservation strategy includes financial incentives for residents to repair leaky irrigation systems, alerting high-water users of their water use levels, tiered water rates, rain barrel rebates, conservation education, and more.

True costs

Water conservation is the most cost-effective water supply strategy available. It involves getting more benefit out of the same amount of water that has already been treated and transported at very high cost.

There are some costs associated with implementing water conservation strategies and programs, with the cost-efficiency of specific measures varying between different communities and industries. These are more than made up for by the costs that water conservation allows communities and industries to avoid, such as acquiring expensive new water supplies.

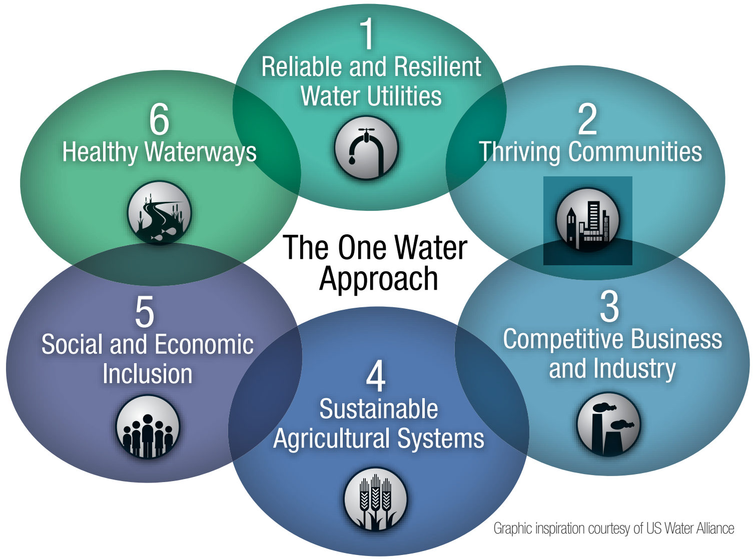
Long-term viability

Water is a finite resource; this means using less of it is the single-most reliable strategy available to us. Finding ways to reduce water demand is especially important as populations grow and weather patterns become more unpredictable.

ONE WATER

One Water is a collaborative water planning and operational approach that uses many diverse and connected strategies to manage limited water resources. Its goal is for both communities and ecosystems to be healthy and resilient.

Because One Water is a water management approach, rather than a prescribed set of tasks and check boxes, it looks different for every community. It can begin by bringing various new stakeholders into the planning process, which allows communities to take a bigger-picture approach as they take inventory of and address different challenges and opportunities. It also allows communities to map out how water fits into other key venues, such as parks, industry, development and business growth, and to create opportunities for water to move seamlessly and efficiently through these different aspects of community living.



Graphic inspiration courtesy of US Water Alliance

Differences in management approaches

Traditional water management

Water management is siloed in different departments that don't necessarily collaborate, even though all water sources are part of the same water cycle. Other municipal departments that have an impact on how water moves through a community, including parks management and city planners, are not typically brought in as collaborators.

One Water

A community manages its water comprehensively, cost-effectively and sustainably. Collaboration, which is a key One Water tenet, makes innovation and efficiency easier, and the entire community is brought into the planning and implementation process.

What does One Water look like in practice?

- Increasing urban greenspace to help reduce stormwater runoff, mitigate flooding and slow water flow to recharge aquifers.
- Incentivizing various forms of "green" infrastructure, such as permeable pavement, rooftop gardens, and connected wildlife habitats.
- Collecting and using water, such as air conditioning condensate and rainwater, for things like landscape irrigation and flushing toilets.
- Involving residents as stakeholders, leading to greater equity within the community.
- Protecting wildlife, rivers and bays by using water efficiently and intentionally setting aside enough water to replenish watersheds.
- **See it in action** in St. James County, Florida; Los Angeles, California; San Francisco, California; Philadelphia, Pennsylvania; and Austin, Texas (Austin is currently drafting a 100-year water supply plan with One Water principles).

Environmental impacts

Positive

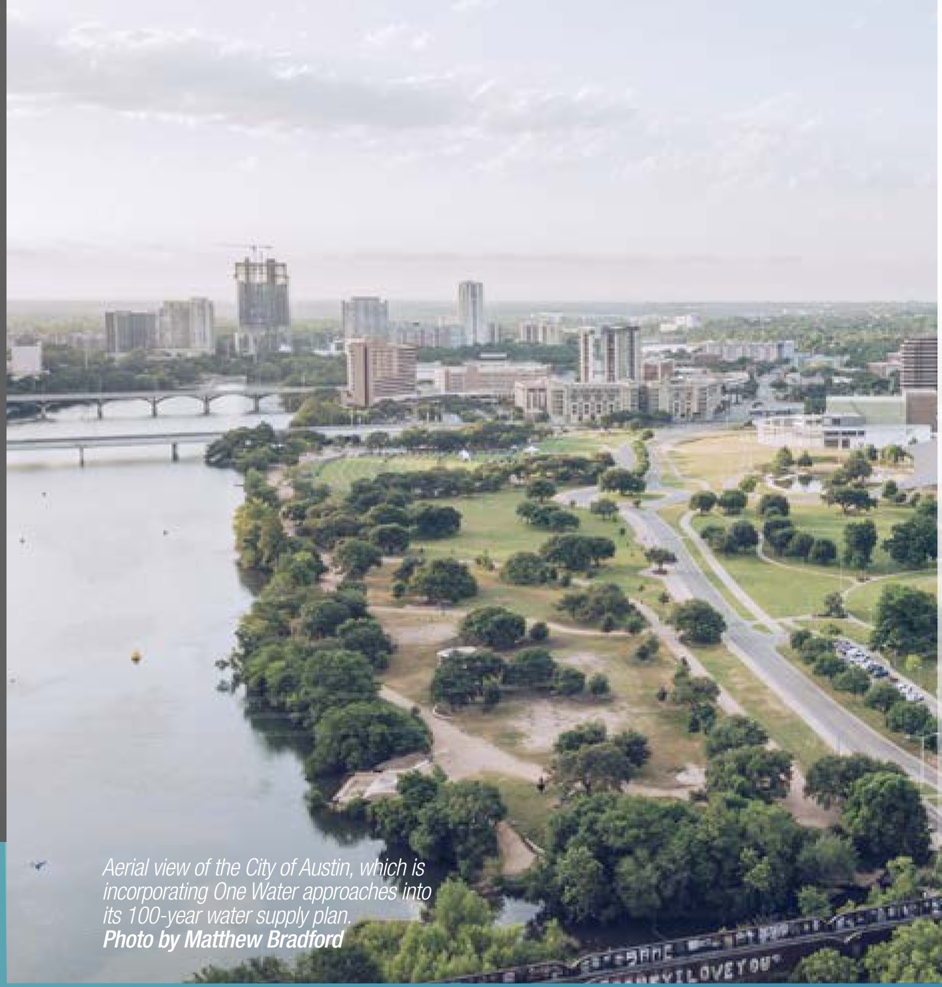
Rather than taking more water than the environment can afford to give, One Water communities use innovation, education and planning to work with the water they have. This means understanding how much water the environment needs, and leaving enough water in Texas watersheds to protect and replenish springs, rivers, bays and wildlife.

Water conservation and nature-based development are both key One Water components; their environmental impacts also apply to One Water. Learn more on pages 4 and 8.

The One Water approach emphasizes using many smaller-scale, diverse, local water sources, which allows communities to avoid large, environmentally-damaging water supply projects.

Negative

None, if One Water is adopted in a way that provides downstream communities, rivers and wildlife with enough fresh water.



Aerial view of the City of Austin, which is incorporating One Water approaches into its 100-year water supply plan.
Photo by Matthew Bradford

Environment:
One Water earns a positive recommendation – but only if communities that adopt it intentionally leave enough water in their watersheds to support healthy springs, rivers and wildlife.

True costs:
One Water costs will be different for every community. Adopting One Water can help avoid many costs common to community living, has numerous societal and economic benefits, and can help communities delay or avoid the need for more costly infrastructure.

Long-term viability:
One Water helps communities stay flexible and resilient by reducing water demands and diversifying water supplies.

True costs

One Water costs vary widely depending on a community's size, growth, and unique portfolio of One Water strategies. Bringing One Water to a community can be a time-intensive process, and there are upfront costs involved in rolling out new water management, infrastructure, development and urban planning initiatives.

One Water's numerous co-benefits can transform a community, which means it is essential to consider the "big picture" when analyzing One Water costs. Common One Water components, such as green space, restored urban waterways, stormwater capture and reuse, and more efficient water use, can lead to:

- Desirable urban spaces
- Healthier residents
- Drought preparedness and flood resilience
- Reduced water treatment costs and less water pollution
- Stronger community ties
- New funding opportunities
- *Learn more about these benefits on our online guide (texaslivingwaters.org/bestbets)*

One Water may also help bolster local economies by reducing major expenses such as flood damage, human health costs related to the urban heat island effect and a lack of open community spaces, drought-related agricultural losses, and expensive billion-dollar projects like reservoirs.

Long-term viability

Adopting a One Water approach means incorporating a broad portfolio of water conservation, demand management, and supply options, rather than automatically locking into large-scale projects that are less responsive to changing populations, climates and technologies. This portfolio-based approach encourages innovation and future-oriented, flexible growth, and helps communities stay resilient by diversifying their water supply.

By treating water like the single, connected resource that it is, rather than managing it in silos, communities can use water more efficiently. As populations grow, temperatures climb, and extreme weather becomes more common, One Water strengthens a community's long-term resiliency; it does this by reducing water waste, increasing local water supplies and availability, protecting the environment, and mitigating flooding.

NATURE-BASED SOLUTIONS

Nature-based solutions proactively use nature's forms and functions to address societal and environmental challenges, including water scarcity, pollution, and flooding. Many nature-based solutions help protect local water supplies by allowing communities to capture more water, whether through rainfall collection systems or landscaping techniques that replenish groundwater supplies and slow rain runoff for healthier river flows.

For example, landscapes that use solutions such as rain gardens or berms and swales (contoured ditches and small hills) mimic designs that already exist in nature, taking advantage of their proven water-capturing benefits.

In urban settings, these solutions frequently involve increasing the amount of greenspace or other surfaces that allow water to seep into the ground. Some examples include parks, urban meadows and forests, habitat restoration and permeable pavement. Other solutions involve capturing rainwater through strategies like rooftop catchment systems and rain barrels.

In rural settings, nature-based solutions typically aim to improve soil and land health so that agricultural processes consume less water (and allow more water to soak into the ground). This approach is sometimes also called "conservation agriculture," and employs strategies like fully covering the land with vegetation and letting it "rest" and regrow for a time before it is grazed again.

To learn more about the differences nature-based solutions can make in a community, visit our online guide *(texaslivingwaters.org/bestbets)*

Making Connections

Does this strategy sound familiar? That may be because nature-based solutions are an important part of a robust One Water plan (see page 6). Some of these solutions also help conserve water (see page 4).

This structure at Confluence Park in San Antonio collects rainwater and stores it underground for later use.
Photo by Charles Kruvand

Environment:
By replicating water collection methods that exist in nature, these solutions work with the environment, rather than against it, to efficiently capture water supplies.

True costs:
Nature-based solutions can have fairly high front-loaded costs, but these are recouped over the long-term as communities benefit from the ability to both better capture water and increase the area's quality of life.

Long-term viability:
Nature-based solutions include strategies that capture water in retention facilities that mimic nature, which increases the amount of locally-available water. These onsite water supplies help communities become more self-reliant and resilient.

Environmental impacts

Positive

Many nature-based solutions help rainfall absorb into our artificially-altered local watersheds, which replenishes springs and rivers and helps maintain healthy levels of fresh water for downstream fish, wildlife and plants.

Nature-based solutions that capture and use concentrated rainwater runoff help reduce the demand for water diverted from sources like rivers, which helps protect healthy fresh water levels in rivers and bays in periods between rainfall events.

Many nature-based solutions increase green spaces and wildlife-friendly habitat, which give wildlife a better chance of thriving alongside humans.

In rural spaces, nature-based solutions that increase soil's health and ability to hold rainwater can lead to more productive crops and grazing lands with diverse vegetation. These crops and fields need fewer pesticides and less water for irrigation.

Nature-based solutions that involve wetland restoration or riparian habitat improvement naturally filter pollutants from water and slow rainwater runoff, which improves a watershed's water quality and decreases flooding and erosion.

Negative

None

True costs

Costs can vary widely depending on the nature-based solution(s) that a community implements. While some projects may have high construction and/or maintenance costs, the long-term economic and water supply benefits are numerous.

One way in which nature-based solutions pay off is in the form of avoided costs. Many nature-based solutions strengthen a community's water supplies by introducing rainwater as a new supply. By using rainwater more effectively and creating healthier soil, communities also don't need to use as much additional water to irrigate their landscapes, which is often a huge drain on water supply. These benefits lessen the need for expensive new infrastructure projects.

In addition to the financial water supply benefits that come with nature-based solutions, there are many "bonus" economic benefits, including community amenities, increased quality of life, and higher crop yields. Learn more about these "bonus" benefits in the online version of our guide (texaslivingwaters.org/bestbets).

Long-term viability

By adopting solutions that continuously recharge local watersheds, communities can improve their water supply resiliency in the face of more frequent and intense dry periods, growing populations, and more of the accompanying manmade surfaces that don't absorb water.

As rainfall and natural disasters become more powerful, nature-based development and restoration can help to mitigate storm impacts, especially flooding and erosion.

Creating on-site water sources lessens the need for communities to import water from far distances, and gives communities more control over their water.

AQUIFER STORAGE AND RECOVERY

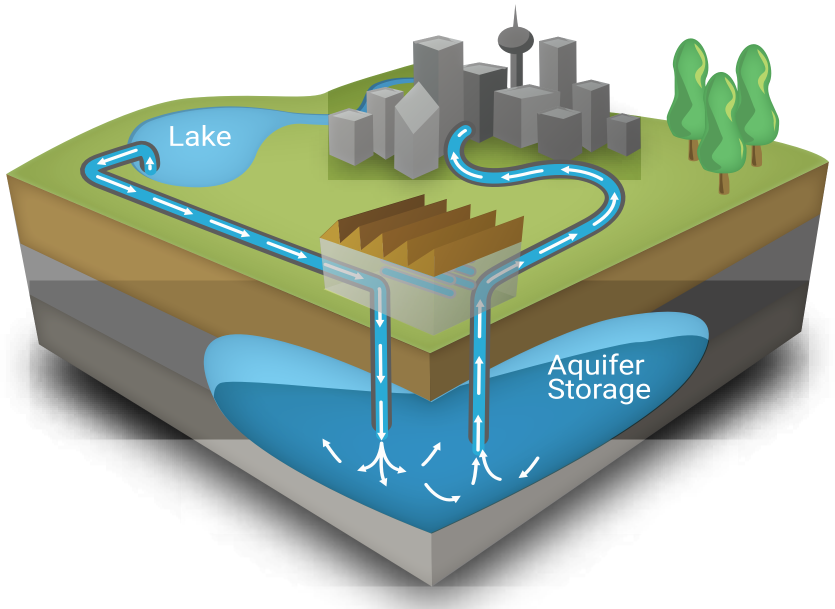
Aquifer storage and recovery, or ASR, is the process of injecting or pumping treated water into an underground aquifer, where it is stored so that it can be used at a later time. In some locations, water can be directed to natural recharge zones instead of mechanically injected.

Where is ASR being done?

11 countries, with 95 facilities in the U.S.A. The largest ASR injection system in the world is in Las Vegas, Nevada.

Three major facilities in Texas:
El Paso, Kerrville and San Antonio

ASR is likely to become more common in Texas. The most recent (2017) State Water Plan recommends ASR projects to provide 1.8 percent of Texas' water supply in coming years – still a small percentage, but double what it was in the 2012 Water Plan.



During times of plenty, extra water can be stored underground so that it can be used during drought or other similar circumstances. The supply source for ASR can be surface water from rivers, treated wastewater, groundwater from other aquifers, or even captured stormwater runoff.

At the H2Oaks ASR facility near San Antonio, this aerator removes iron from Carrizo Aquifer water.
Photo courtesy of San Antonio Water System

Environment:
When done carefully and coupled with water conservation, ASR can be one of the more environmentally-friendly forms of new water supply.

True costs:
ASR costs include large, ongoing energy expenses and significant infrastructure costs. However, ASR can help communities avoid many of the financial and ecological costs, including significant evaporative water losses, associated with new reservoirs.

Long-term viability:
With reasonable restrictions on when water is allowed to be taken from its source and injected underground, ASR can be a reliable water supply strategy that minimizes evaporation for Texas' hotter, drier future. It can also help communities prepare for drought by "banking" water for later use.

Environmental impacts

Positive

When a community invests in ASR, they can offset the need for more environmentally-destructive water supply projects like reservoirs.

ASR has better water retention than reservoirs, which lose an immense amount of water to evaporation. Water that evaporates is wasted, leaving less water for human use and less water in streams and rivers for wildlife.

Depending on the rate of withdrawal, injecting water into aquifers can help replenish groundwater levels, which can prevent – but not reverse – subsidence (sinking land, often caused by withdrawing too much groundwater) and help maintain springflows.

In theory, ASR could also be used to release water into rivers when their flows become too low to sustain healthy fish and wildlife. However, cost and energy requirements may limit its usefulness for this purpose.

Negative

Water stored through ASR still has to come from somewhere; if too much water is taken out of rivers or other sources for ASR, it can threaten fish and wildlife that need healthy amounts of fresh water to survive.

ASR is usually very energy-intensive; water must be pumped, as well as treated before injection and after withdrawal.

True costs

Initial costs typically include constructing intake, transmission and treatment facilities, as well as acquiring the land above the aquifer or achieving some kind of enforceable legal protections to prevent other landowners from pulling the stored water from the aquifer.

There are ongoing operations and maintenance costs over the project's lifetime. Because of various treatment and pumping needs, ASR projects have substantial energy costs. Energy costs continue throughout the life of the project so that water can be pumped and treated.

Communities that invest in ASR instead of a reservoir, which is the other primary water storage option, save money by avoiding costs associated with significant water evaporation and with the more extensive land acquisition required for reservoirs.

Long-term viability

Unlike reservoirs, ASR doesn't suffer from large amounts of evaporative water loss and typically does not involve large-scale habitat destruction.

This means that in the long-term, there are fewer financial and environmental costs with ASR than there are with reservoirs.

As with any water supply or storage option, communities must take into account the health of their water sources. If communities withdraw too much water for ASR or do so during dry times, rivers and groundwater could be depleted.

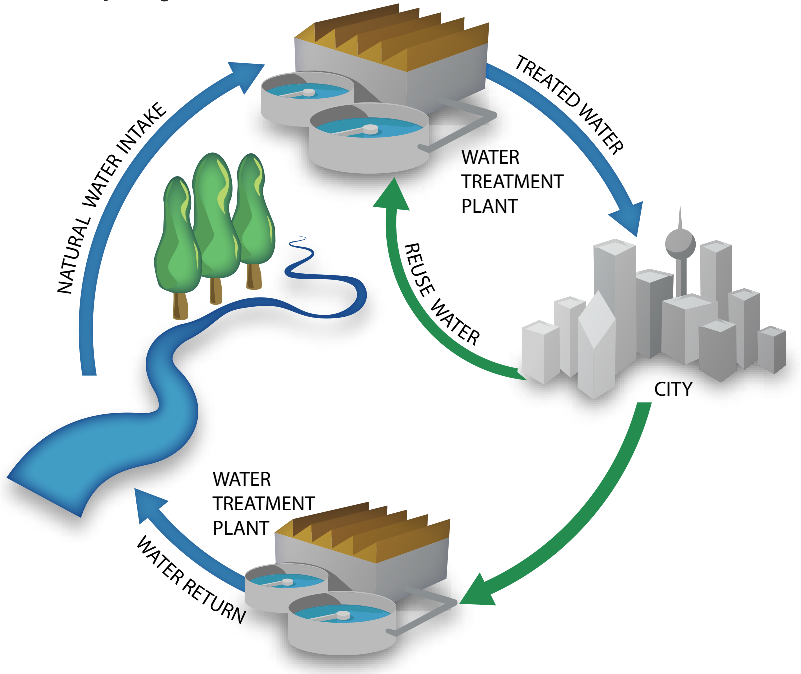
Because groundwater is owned by whoever owns the land above it but can travel across property lines, careful long-term planning is important to avoid future legal issues. Neighboring wells could potentially draw water away from community water supply aquifers, and vice versa.

Inadequately treated water could also cause problems with this strategy's effectiveness over the long-term. These issues are not well understood and will require continued study.

ASR allows communities to "bank" water for later use, which can help them become more resilient during drought. If managed carefully, ASR could be used to reduce demands on rivers during times of drought.

WATER REUSE

Traditionally, after a community uses water it is treated to reduce levels of harmful pollutants and then it is released into downstream rivers or other water bodies. One way to increase a community's water supply is to reuse this wastewater. This is also known as water recycling.



Reuse and conservation: What's the difference?

Although reuse is included in Texas' legal definition of water conservation – a decision that was strongly contested – water reuse is not the same as traditional water conservation. Unlike traditional water conservation, reuse does not reduce how much water a community uses; the community is still consuming the same total amount of water.

Reuse and water conservation can (and should) be used together, but reuse is still a way to make more water available for use, not a substitute for strong water conservation programs that reduce usage.

Reuse is increasingly common in Texas. Wholesale water suppliers in North Texas cities like Fort Worth, Plano and Frisco all use indirect potable reuse. Big Spring is credited as having the first direct potable reuse project in the country, and Wichita Falls used direct potable reuse as an emergency measure during the severe 2011 drought. Although most direct reuse projects focus on nonpotable reuse, potable reuse is becoming more common.

Terms to know

1. **Wastewater:** Water that has been used by humans. "Graywater" is wastewater that does not include toilet waste; "blackwater" refers to wastewater that includes toilet water.

2. **Return flows:** Wastewater that is treated and then released into a downstream river. Because of how much water has been diverted and pumped for human use across the state, many Texas rivers now depend on this wastewater to maintain flow, especially during droughts. Conditions vary from one river to another and in a few places, such as the Trinity River below Dallas, wastewater discharges (arising in part from imported surfaced water) are large enough to have an artificially high amount of water flowing in the river during times of drought.

3. **Potable reuse:** Wastewater is treated to drinking water standards and then reused in a potable (drinkable) water system.

4. **Nonpotable reuse:** Wastewater is treated, though not to drinking water standards, and is used for non-drinking water purposes (such as landscape irrigation and flushing toilets).

5. **Indirect reuse:** Wastewater is treated, discharged into an aquifer or surface water reservoir and then captured and used again. Some communities have constructed wetlands to hold and naturally filter wastewater as part of the reuse process.

6. **Direct reuse:** Wastewater is treated and then reused directly without first being discharged into a body of water.

Indirect and direct reuse can both include either potable or nonpotable reuse, depending on the purpose of the water reuse project. Indirect and direct reuse require different permitting processes.

A pipeline from Wichita Falls, a North Texas city that has used both direct and indirect potable reuse.
Photo courtesy of City of Wichita Falls

Environment:
As long as enough water is returned to rivers for fish and wildlife, reuse is a promising way to avoid more destructive projects.

True costs:
Reuse is less expensive and less ecologically damaging than most other water supply projects. Centralized reuse systems in particular can be less expensive, but these costs are often subsidized.

Long-term viability:
Reuse is a reliable long-term strategy. Whether it is the best choice for water supply in a given case requires a careful evaluation of reuse vs. other alternatives, to make sure there is enough water flowing downstream to sustain rivers, bays and wildlife.

Environmental impacts

Positive

When done responsibly and with due consideration of the water flows needed downstream, water reuse is a reliable water supply source that helps communities avoid more expensive and environmentally-damaging water supply options.

Negative

If too much water is reused consumptively (such as for watering lawns), return flows will be lessened. Some rivers may run dry, threatening the health of the river and wildlife, including the health of coastal bays.

True costs

There are various infrastructure (treatment, piping) costs for reuse. Studies have shown, however, that reuse is often less expensive, and less environmentally-damaging, than developing an entirely new water supply and/or moving water from a long distance.

Reuse water may often be provided at subsidized rates to encourage users to participate. As a result, reuse projects may not fully pay their way, at least until there is broader acceptance of the practice.

If return flows provide a substantial part of a specific river's flows during dry periods, then reusing too much of that water can harm the river's health, as well as its related recreational, tourism and fishing economies, and any affected bay system. Careful judgement is needed to determine which does more damage – reusing return flows or developing a new source of water.

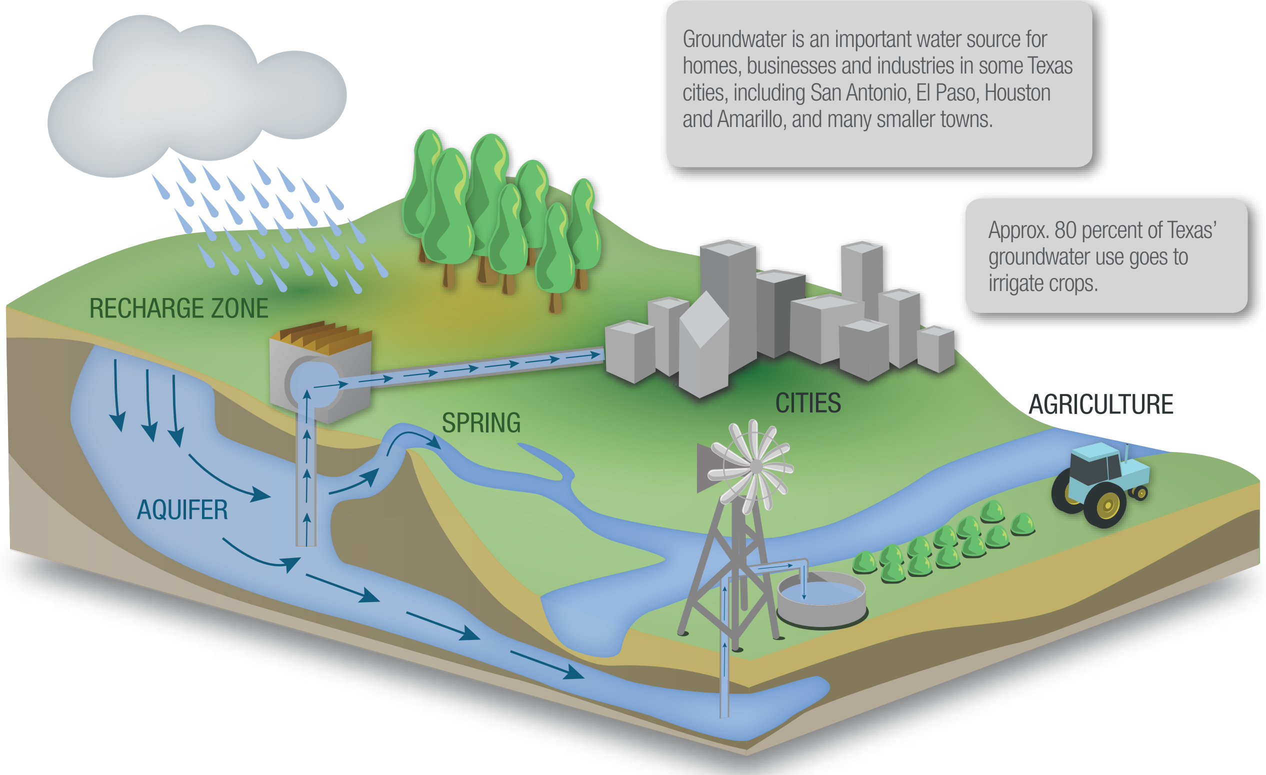
Long-term viability

Because it allows communities to recapture water locally instead of depending on water from other new sources, reuse can be a sustainable and cost-effective long-term strategy.

As with any water supply project, for water reuse to be truly viable in the long term, a community must consider the river (and any bay) downstream and make sure to release enough return flows to maintain its health.

GROUNDWATER WITHDRAWAL

More than 55 percent of Texas' water supply comes from beneath its surface. This water, called groundwater, generally moves slowly through the Earth's rocks and soil; the below-ground areas where it collects are called aquifers.



Spring Lake Falls at the headwaters of the spring-fed San Marcos River.
Photo by Charles Kruvand

Texas groundwater law 101

Texas groundwater law is complicated, but it primarily relies on the *rule of capture*, which says that landowners have the right to capture any water that exists below their property. This also means that a landowner's neighbor has the same right, even if their groundwater usage pulls water away from another landowner's property.

Groundwater conservation districts, which exist across much of Texas, are tasked with the difficult job of managing groundwater levels in a way that protects the rights of all property owners when some owners seek to pump very large amounts. *Learn more about Texas groundwater management online (texaslivingwaters.org/bestbets)*

Environmental Impacts

Positive

If communities were to switch between using surface water and groundwater in a way that is sensitive to the conditions of each water source and allows each time to replenish, this intermittent groundwater withdrawal (also known as conjunctive use) could help relieve pressure on surface water sources, especially during dry times, without depleting groundwater supplies.

Withdrawing groundwater in careful moderation may help communities to avoid constructing reservoirs and inflicting related adverse impacts on the environment, such as inundating croplands, pasture and forest.

Negative

Pumping too much groundwater can lead to subsidence, or sinking land, in some areas of the state (this is a big issue in the Houston-Galveston region, where it contributes to flooding. Parts of West Texas are also at high risk). Subsidence occurs because groundwater is a natural part of the below-ground landscape, and helps to hold the ground up; without it, underground layers contract and the land's surface falls inward. Subsidence likely is largely irreversible.

Many Texas rivers get a portion of their water flow from springs and seeps (small openings), which form where groundwater rises to the surface. Pumping too much groundwater can rob rivers of the fresh water they need to sustain healthy fish, wildlife and bays. This is a big problem during drought, when rivers receive very little water from rain and runoff and often depend on groundwater contributions to keep them flowing.

Groundwater pumping can be energy-intensive, especially as water levels in aquifers get lower and lower.

Springs are important habitats for unique wildlife, including lots of threatened and endangered species. Overpumping can harm these already-struggling species.

True costs

Groundwater withdrawal costs vary greatly depending on the aquifer's geology, water depth, how far the groundwater will be transported, and whether the water has naturally-occurring contaminants. All pumping systems will require maintenance in the long term.

In some areas of the state, such as the Houston-Galveston region, groundwater withdrawal-related subsidence can worsen the reach and impacts of flooding.

If groundwater is not carefully withdrawn and aquifers are depleted, this can lead to habitat loss and can deprive surface water of needed spring flows. These ecological costs lead to societal costs in the forms of habitat loss, and limited commercial and recreational opportunities on rivers, streams and bays.

The deeper the water level, the more expensive it is to withdraw the water. This means that over time as water is withdrawn and water levels sink, pumping water from the same area becomes more expensive. In some cases, it can become prohibitively so, especially for individual homeowners and small farmers.

Long-term viability

Different aquifers recharge, or fill back up with water, at different rates. Many Texas aquifers contain "fossil water" — the water has taken thousands of years to accumulate and could take a comparable amount of time to refill after being depleted. In many cases, the current rates of groundwater withdrawal are not sustainable in the long run because we are using the water faster than it is naturally replenishing. For example, all of Central Texas' Hill Country aquifers, except for the Edwards Aquifer, are being depleted faster than they can recharge.

One way to potentially use groundwater as a reliable water source for the future is through conjunctive use. In theory, communities could switch back and forth between using groundwater and using surface water, informed by climate conditions and water availability, to protect each water source when it is most vulnerable.

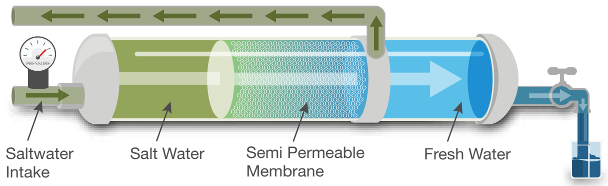
Learn more about long-term viability prospects and concerns online (texaslivingwaters.org/bestbets).

DESALINATION

Desalination involves removing salt and other dissolved solids from water that is otherwise not suitable for the intended use. This process can be used to turn saline water into fresh water for drinking and other purposes.

Desalination can be used for both brackish water and seawater.

Brackish water is less salty than seawater. Brackish desalination in Texas usually draws from aquifers, where water is found underground, but sometimes also pulls from certain salty rivers like stretches of the Brazos River. Desalinating water from rivers and bays could become more common in Texas in the future.



Reverse osmosis, one of the most common desalination processes, uses high pressure to propel water through a membrane that separates out salt and other minerals.

El Paso's brackish water desalination plant is the largest in Texas and can produce up to 27.5 million gallons of water per day (mgd), though on average it produces only 4.2 mgd. For context, in 2013 El Paso used an average of 99,781 mgd.

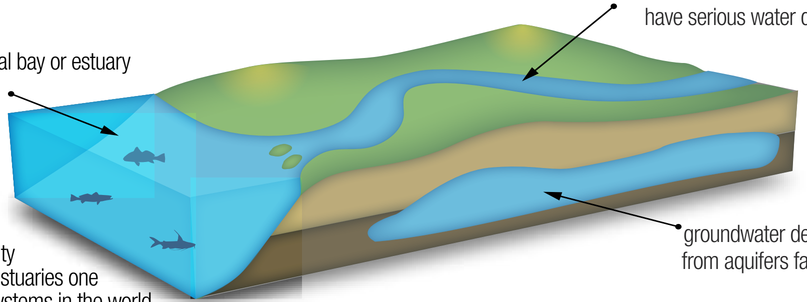
This adds up to only

.004%

of El Paso's water demands

The majority of desalination plants in Texas produce less than 1 mgd. Larger-volume plants are uncommon because of the high expenses involved.

Location matters for desalination



Bay

Pulling water from a coastal bay or estuary can suck up and kill juvenile shrimp, crabs and other fish, as well as their eggs. It can also capture the less-salty water needed to dilute saltier ocean water, disrupting the critical salinity balance that helps make estuaries one of the most life-filled ecosystems in the world.

When brine is disposed into bays, it can change salinity levels and stress or kill aquatic wildlife. (Diverting water from and disposing brine into the open ocean may minimize these impacts.)

River

When disposed of into fresh surface water, brine increases the water's salinity, as well as its levels of other chemicals. This can have serious water quality consequences.

Aquifer

Just like any other groundwater withdrawal, it is important that brackish groundwater desalination doesn't pull water from aquifers faster than they can recharge.

Brine can be injected into the ground, but if this is not done carefully, it can contaminate freshwater aquifers.

Environmental impacts

Positive

Desalination allows communities to diversify their water supply mix, which lessens the need to withdraw fresh water from rivers and aquifers and leaves more water for wildlife.

Negative

Water often moves between adjacent aquifers. Because of this connectivity, pumping brackish groundwater for desalination could impact aquifers in ways that we don't yet entirely understand.

Desalination plants, because of their high energy usage, cause additional air pollution and emissions.

Depending on where desalination plants are located, there are different potential environment impacts. One important thing to consider is that brine, which is the salt and other minerals removed from the water, must be disposed of. *See Location matters for desalination graphic (above) to learn more about potential impacts.*

A heron wades in estuary waters near Aransas Pass, where a desalination plant has been proposed, as of 2018.
Photo by Lizzie Jespersen

Environment:
Different impacts exist depending on the water's source and where brine is disposed; for example, there are many concerns associated with desalinating coastal waters. Less problematic alternatives may include locating desal plants further offshore or using brackish groundwater instead of surface water. In general, extreme caution and care need to be taken in locating and designing desalination plants to make sure they do not harm rivers, bays, aquifers and wildlife.

True costs:
There are different true cost considerations depending on how salty the source water is and how much of it is being desalinated. With current technology, there is often a notably high price tag attached to desalination. This is due in large part to its energy needs and the costs of appropriately disposing of brine.

Long-term viability:
Desalination has intensive energy needs, which pose numerous long-term viability issues, including increased carbon emissions. However, it can be a lifeline for communities impacted by serious drought or with no other viable options.

True costs

Desalination costs vary depending on the volume of water being desalinated and how much salt and other minerals are in the water. In addition to construction costs, maintenance and operations costs include intensive energy production and regularly cleaning membranes. These costs are passed on to residents through higher water rates.

If energy becomes more expensive and associated carbon emissions become more regulated, both of which are expected to happen, this will drive desalination costs higher.

When desalination plants pull water out of bays and estuaries, this may disrupt nurseries for economically-vital commercial fish species. It may also harm oyster reefs, which act as important storm surge barriers for coastal communities. Likewise, if brine is disposed of into sensitive habitats, this could have similar impacts.

Long-term viability

Desalination is an energy-intensive supply option, which ultimately requires fresh water for energy production. This means that even though it frees up new water sources, this strategy isn't without continuing long-term water needs.

Carbon emissions from electrical energy generation are a global concern for many reasons, including their impacts on health, quality of life and the economy. Whether this concern applies to a particular desalination plant depends on its source of energy generation.

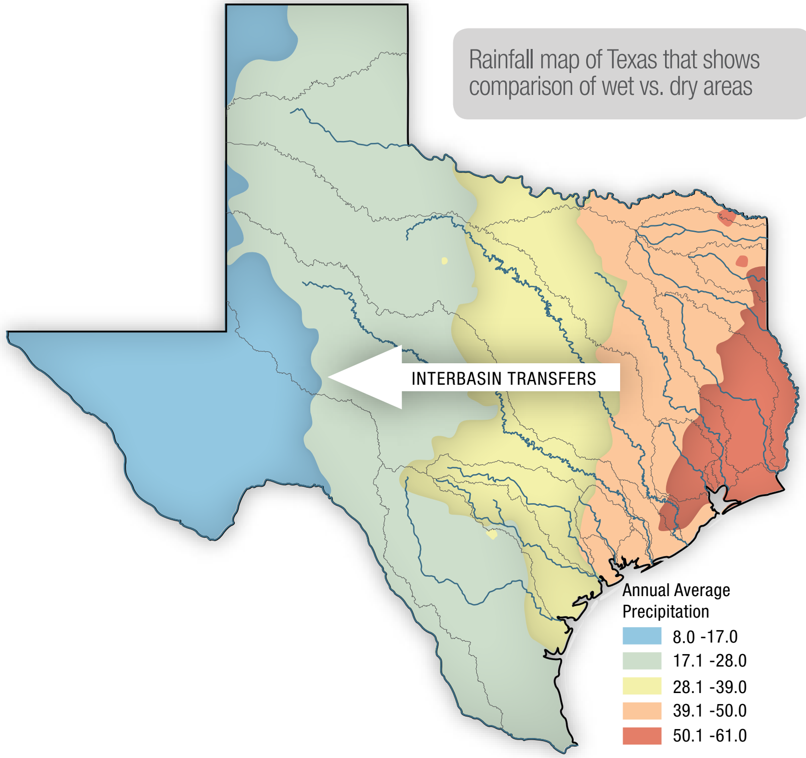
Droughts are predicted to become more frequent and intense in Texas, which threatens freshwater availability across the state. On a small scale and as a part of a larger portfolio of water supply solutions, desalination can be a much-needed supplement to other supply sources during dry times when there is not enough fresh water to support communities and the environment.

INTERBASIN TRANSFERS

In an interbasin water transfer, surface water is taken from one river basin and conveyed into another river basin for use there.

Within the large state of Texas and its different climate zones, there are very wet areas and very dry areas. Interbasin transfers are used to bring water from wetter areas to places where the demand for water exceeds readily available local water supplies.

As of 2014, there are more than 150 active interbasin transfer projects in Texas. The Dallas metroplex is one of several areas in Texas that receive a lot of interbasin transfers. Houston also receives significant amounts of water from interbasin transfers and is currently working on a project that would increase that amount.



Rainfall map of Texas that shows comparison of wet vs. dry areas

There are various regulatory requirements that are intended to prevent people from withdrawing too much water from rivers for interbasin transfers. However, there have been attempts to weaken these regulations, and these attempts will likely continue. *To learn more, visit our online guide (texaslivingwaters.org/bestbets)*

Environmental impacts

Positive

Transfers from a basin with more available water to a basin that is already very water-short could potentially improve river flows in the receiving basin; however, this depends on how the receiving basin manages the water and what the water availability and river flow situations are like in the basin of origin.

Negative

Just because some areas have water that isn't being consumed doesn't mean rivers and wildlife won't be adversely impacted when water is taken away and transferred to a different basin. When water is moved out of a basin it is completely lost to that basin, which may rob fish, wildlife and plants of the fresh water they need and deprive communities of a valued recreational resource and future water supply.

The standards set by Texas' regulatory water agency, Texas Commission on Environmental Quality (TCEQ), for how much river flow needs to be protected for the environment are not strong enough to truly sustain healthy rivers and wildlife. This means interbasin transfer permits likely won't be adequately limited, and may not leave enough fresh water in the basin of origin for healthy rivers, bays and wildlife.

Constructing pipeline or canal systems requires cutting through many different environments and land types, which can seriously damage wildlife habitat.

When water is moved from one basin to another, tiny aquatic species and organisms may come with it, depending on how the water is transferred. This can introduce non-native species to a new basin, which can become invasive and threaten the area's plants, wildlife and water supply infrastructure.

The Neches River in East Texas is one waterway that could be impacted by large-scale interbasin transfers.
Photo by Charles Kruvand

Environment:
These water transfers to date have not been subjected to strong river flow protections for the basins of origin. Theoretically, transferred water could help struggling rivers and wildlife in dry areas of the state. *Note: If a transfer requires a new reservoir rather than using an existing one, the project would receive an "empty water drop" grade.*

True costs:
Interbasin transfers are usually expensive on their own, with extensive infrastructure and energy costs, and they may often require a new reservoir to be constructed as well.

Long-term viability:
Interbasin transfers could help sustain struggling dry areas of the state. However, without careful balancing, this could be to the detriment of the basins that supply the water. High energy needs are also a long-term concern. This strategy is only viable when the basin receiving a water transfer already has strong water conservation measures and will use the new water wisely.

True costs

Initial costs typically include acquiring land for pipelines or canals, constructing pipeline systems and treatment plants, and disturbing land to build canals or bury pipes. Interbasin transfer projects often also require a new reservoir to be constructed to capture the water and make it available for transfer; reservoirs are costly and have their own true costs associated.

Energy is a big cost throughout the life of the transfer. This is especially true when the pipeline does not run naturally downhill, which is usually the case for transfers in Texas.

Interbasin transfers may introduce invasive species from basins of origin to the receiving basins. Dealing with invasive species is costly and incredibly time-intensive, and invasive species have been known to seriously threaten the survival of native species and damage water management infrastructure.

Long-term viability

As water supplies become scarcer and droughts become more frequent and intense, dry areas can benefit from piping in water supplies that likely aren't available to them locally.

At the same time, basins where water is being removed from will likely have greater needs for this fresh water over time. It may rapidly become unsustainable to continue removing it from the rivers due to impacts on wildlife as well as the recreational and economic activities in the basin of origin.

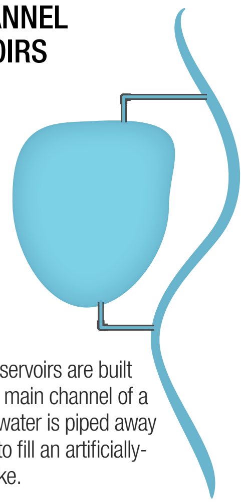
Infrastructure wears out over time, and interbasin transfers require a lot of it; already, Texas is having to replace piping from the 1950s. Although these kinds of water infrastructure projects use more durable materials now, it is still expensive and burdensome to replace.

If not designed sustainably, interbasin transfers can allow and even encourage growth and unsound water use practices in areas that cannot otherwise sustain the population; meanwhile, the basin that the water is removed from has less available water because it is supporting another basin's unsustainable growth.

DAMS & RESERVOIRS

In Texas, reservoirs are large man-made lakes used as a source of water supply. There is only one natural lake in the state, though even that lake has been modified with a dam; the rest are artificially constructed. There are 200 man-made major reservoirs in Texas, as well as various smaller ones.

OFF-CHANNEL RESERVOIRS



Off-channel reservoirs are built away from the main channel of a river; instead, water is piped away from the river to fill an artificially-constructed lake.

Some “off-channel” reservoirs are hybrids that are built on the channel of a small stream but also hold water pumped from a nearby river.

ON-CHANNEL RESERVOIRS

On-channel reservoirs are built by damming rivers, flooding riverside habitat and cutting off much of the flow of water downstream to create a large and controlled lake.

There are hundreds of reservoirs in Texas, many of which were constructed during a reservoir-building frenzy in the 60s and 70s. Construction rates have since slowed down, partially because there aren’t many locations left that could be viable sites for new large reservoirs. Even so, the most recent (2017) state water plan for Texas recommends building 26 new major reservoirs. In many cases, **greater water conservation and drought response measures, along with other more environmentally-friendly supply options, could avoid these multi-billion dollar projects.**

Mansfield Dam is one of six dams that form the Highland Lakes in Austin, Texas.
Photo by Matthew Bradford

Environment:
Reservoirs cannot be created without destroying large amounts of wildlife habitat. After they are created, reservoirs capture flows needed to support downstream fish and wildlife.

True costs:
Reservoirs are one of the most expensive water supply strategies available, and residents shoulder these costs through higher water rates. Reservoir construction also involves societal costs implicit in taking economically-valuable and/or family-owned land out of production, often through means of eminent domain.

Long-term viability:
Reservoirs become less effective over time as sediment builds up and as evaporation rates increase, which is already happening as a result of climate change.

Environmental impacts

Positive

None

Negative

Reservoirs are created by permanently flooding land, which irreversibly destroys wildlife habitat. On-channel reservoirs flood economically- and environmentally-valuable riverside woodlands, and, like off-channel reservoirs, can destroy valuable land like prairies, farmland and wetlands.

Dams used for on-channel reservoirs block fish and wildlife from moving freely upstream and downstream, which can interfere with their natural feeding and spawning lifecycles, as well as destroy species diversity, which is important for healthy wildlife populations.

Dams used for on-channel reservoirs trap sand and silt above the dam, rather than allowing it to move naturally downstream through a river. Without these sediments, the river channel downstream often gets deeper and the banks cave in, leading to tree loss. Without trees, habitat is lost, and without the shade they provide, water temperatures may rise and create an inhospitable home for fish and wildlife. In addition, coastal bays and beaches may be deprived of sediment and sand needed to keep them healthy.

Reservoirs divert water away from rivers downstream; without enough flowing water from natural river flows, many plants, fish, birds and other wildlife struggle to survive. Water quality can also become a bigger issue: without healthy river flows, rivers cannot dilute pollution as well.

True costs

The lifetime costs of a reservoir and its water delivery system include construction and ongoing operation and management (such as intensive energy needs) for the reservoir itself, as well as for water treatment facilities and delivery pipelines and pumps. Eventually, reservoir infrastructure will wear out and will need to be replaced or repaired.

Revenue-generating farm, ranch and forest lands are often flooded and destroyed in the reservoir-creation process. When this land is privately owned and the family is uninterested in selling, the city or river authority may use eminent domain to take the land, regardless of whether the land is their source of livelihood or it has been in their family for generations.

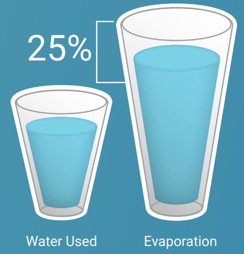
When rivers are dammed to create reservoirs, wildlife communities are destroyed. This can necessitate costly wildlife management measures, such as the money currently being used to study threatened blue suckers in the Colorado River. And if already-threatened mussel species were to be further harmed because of reservoirs, water quality benefits could suffer because of lost services when mussels naturally filter water and remove pollution. Expensive mitigation efforts likely would be required.

Reservoirs divert water from Texas rivers; without enough fresh water flowing through rivers into Texas bays to provide essential nutrients, sediments, and salinity moderation, fish and wildlife suffer, harming fishing and tourism-based economies.

Over time, sediment builds up in reservoirs, limiting their storage capacity and leading to diminishing returns. Reservoirs greatly increase evaporation rates, which also leads to diminishing returns.

Long-term viability

Reservoirs lose massive amounts of water each year to evaporation. As drought and weather patterns become more extreme, we can expect evaporation rates to be even higher. When water evaporates, it is lost to the watershed in large amounts. (While it will fall as rain somewhere else, that may not be in Texas.)



In 2011, the Highland Lakes reservoirs lost 25% more water to evaporation than the entire City of Austin used in the same time.

Higher temperatures are becoming increasingly common in Texas, leading to higher water temperatures, less frequent rainfall, and more evaporation, which are water chemistry changes that make toxic algae blooms more common in reservoirs.

Sedimentation that builds up in reservoirs over time dramatically decreases water storage space, which means these projects become less useful and may need to be dredged. Dredging is a time- and cost-heavy process.

For a city to use water from a reservoir, the water has to be piped or moved to the city. Because the majority of prime reservoir locations have already been used, reservoirs must be built increasingly far away from the communities they are supplying.

What's next for Texas water?

Our recommendations for a thriving Texas future.

As you have seen, there are many different water supply strategies and approaches in Texas' "toolbox." Some of these strategies make more sense than others when evaluated for cost, long-term viability and environmental impact. The reality is, Texas will need to depend on a mix of these different strategies. Sometimes, this could mean making tough decisions and using strategies that our team wouldn't otherwise recommend.

However, our hope is that if Texans understand the full range of impacts that their water management decisions can have, they will plan for the future in a way that prioritizes sustainable projects with multiple benefits, and puts aside more destructive and expensive projects as last resorts.

We owe our love of this state to its vastness and its diversity in customs, physical topography and climate zones. Because each region has its own unique water stories, opportunities and limitations, the "right" water management investments will look different for every community. In addition to planning for drought and water scarcity, some regions must also plan for flooding and storm-wrought destruction. Across the entire state, Texans must plan for how the weather extremes that accompany a changing planet will uniquely impact their community's water future.

That said, our team believes the following recommendations provide a reliable compass for mapping Texas' water future:

1. **Reducing demand.** Before anything else, communities must engage mightily in water conservation. Using water more efficiently is the only way to truly mitigate water scarcity.

2. **Collaborating.** Texas communities must bring more stakeholders to the table to plan for their water future. Whether or not a community implements a One Water management approach, Texans can all benefit from thinking more comprehensively about how time-tested strategies like stormwater collection can be used alongside innovations that utilize new developments, parks and community spaces to manage water more efficiently and effectively.

3. **Embracing innovation.** Communities must be willing to think beyond traditional approaches to embrace and incentivize the adoption of newer, more innovative solutions. Nature-based approaches to development and land restoration have incredible benefits for communities, including preparing them to be more resilient when faced with both droughts and storms.

4. **Thinking big picture.** Communities must remember that when the Texas environment suffers, so does the rest of Texas. Water supply strategies must be implemented responsibly, in a way that allows enough fresh water to flow in rivers and all the way to Texas bays.

5. **Planning for drought.** Community drought management protocols typically kick in when water supplies drop to a certain level or water treatment facilities begin to reach capacity – but often, this ignores earlier signs of real drought. Instead of waiting for supplies to stretch thin, our communities should develop multi-faceted drought response plans that also consider whether the region is in a climatic drought. By doing so, communities can become more nimble and proactive in stretching water supplies in the face of drought.

6. **Diversifying.** No strategy is sufficient or reliable on its own; Texas communities must stay flexible and resilient by investing in a diverse mix of strategies. By implementing a host of smaller-scale strategies, communities may even be able to avoid larger, more destructive water supply projects.

7. **Remaining diligent.** Technology has been, and will continue to be, a boon for water conservation and supply. Still, as new technologies become available, communities must continue to fully evaluate strategies to ensure they are the right fit for them and the environment. Water utilities should invest in research and development and be willing to test and give feedback on new strategies.

Help us make Texas' future one every Texan can be proud of.

Show your fellow community members and decision-makers that you support wise water decisions and fresh water for every living thing — endorse our recommendations by visiting *http://texaslivingwaters.org/bestbets and clicking* **"Take Action."**

Brought to you by
Texas Living Waters Project

Fresh water for every living thing

Texas Living Waters Project

SIERRA CLUB

GALVESTON BAY FOUNDATION

Texas Living Waters Project is a coalition of National Wildlife Federation, Sierra Club Lone Star Chapter and Galveston Bay Foundation
texaslivingwaters.org

Have questions?
Want to learn more?
Looking to get involved?

Our team of legal, policy, science and water conservation experts is available to you as a resource for your Texas water needs. Please contact us at *info@texaslivingwaters.org* or by reaching out to our staff directly: *texaslivingwaters.org/meet-our-team*

The San Marcos River near, Staples Texas.
***Photo courtesy of Mike Mulry, XCEL**ARTS*