tx H2O

A Publication of the Texas Water Resources Institute

Summer 2025

NEXT GENERATION

Meet the leaders and programs building future Texas water professionals

Inside: Texas 4-H Water Ambassadors, produced water research, and state water planning explained

Texas A&M AgriLife Research | Texas A&M AgriLife Extension Service | Texas A&M University College of Agriculture and Life Sciences

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Published by
Texas Water Resources Institute

Editor
Leslie Lee
Texas Water Resources Institute

Art Direction
Sarah Dormire
Texas Water Resources Institute

Assistant Editors
Cameron Castilaw
Danielle Kalisek
Sarah Dormire
Texas Water Resources Institute

Student Editor
Sadie Kammlah
Texas Water Resources Institute

On the Cover
In 2023, Texas 4-H Water Ambassador high school students in the Tier III Academy toured Canyon Lake Gorge, which is managed by the Guadalupe-Blanco River Authority. Photo courtesy of 4-H Water Ambassadors.

For more information and to subscribe to *txH$_2$O,* visit
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Working to make every drop count

I am honored to welcome you to the 37th issue of *txH$_2$O,* my first issue as director of the Texas Water Resources Institute. After joining TWRI in 2024, I have taken every opportunity to connect with colleagues around the state and at other universities, Texas A&M AgriLife centers and offices, research labs, organizations, extension offices and many more.

I have traveled to visit with teams of scientists addressing the pressing worldwide issue of water scarcity. Numerous outstanding teams are working to ensure safe and available water for our communities, agriculture and industry, not only in Texas but around the world, and TWRI is proud to collaborate with so many of you.

In this issue, I summarize my vision for TWRI on pages 4-5. That vision drives me to continually meet with leaders to recognize the significance of the water challenges ahead and promote the achievement of impactful results.

The rapid surge in population and industrial expansion is driving an unprecedented demand for water, creating a critical imbalance as our water supply struggles to keep pace. Aging infrastructure is also failing to keep pace, raising urgent concerns about the sustainability of our most vital resource. The situation is reaching a tipping point, and immediate action is essential to avert a potential crisis. The Texas Water Development Board predicts that with no changes in water sources, if another drought-of-record occurs in 2070, according to population growth predictions, Texas will be short 6.9 million acre-feet of water. There would not be enough water for every need in Texas.

And so, innovation is the name of the game. Researchers are testing water-efficient strategies and technologies and then getting those proven best practices to producers and professionals as fast as possible. Texas' resilient farmers and ranchers innovate and use those research-backed best practices to provide needed food and fiber, support rural economies, increase profits and decrease water use. Water providers are aiming to diversify their portfolios to protect communities' water reliability.

In this edition of *txH$_2$O,* you'll meet many of these professionals, educators and researchers working for Texas' water future. We provide an explainer on the State Water Plan; spotlight Texas A&M scientists testing, filtering and using produced water from oil and gas production; and introduce the numerous Texas A&M AgriLife centers around the state and their water-related research areas. We also highlight the 4-H Water Ambassadors program, advanced wetlands in North Texas, and TWRI's long-running Watershed Planning Short Course.

I hope you enjoy reading, and as always, please join us in making every drop count.

Giovanni Piccinni, Ph.D.
TWRI Director and Professor of Soil and Crop Sciences, Texas A&M University

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make every drop count

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The George W. Shannon Wetlands Water Reuse Project located at the East end of Richland and Chambers Reservoir. Photo courtesy of Darrel Andrews, Tarrant Regional Water District.

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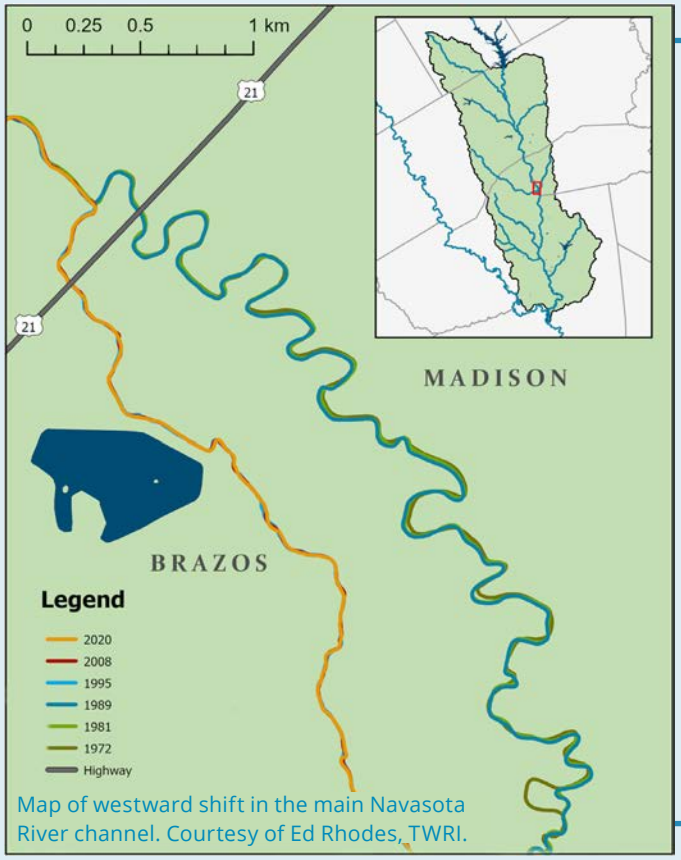
Water Research and News

Recent water science news from around the state



Map of westward shift in the main Navasota River channel. Courtesy of Ed Rhodes, TWRI.

Shifting Navasota River examined in TWRI-led research

Rivers change over time, and natural erosion, severe weather events and human intervention all contribute to rivers' changing landscapes. The Navasota River is no exception to this, and recent research led by Texas Water Resources Institute (TWRI) Research Specialist Ed Rhodes, titled "A changing river: Long-term changes of sinuosity and land cover in the Navasota River Watershed," examined its shifts over time.

Flowing 125 miles from Mount Calm in East Texas, the Navasota eventually joins the Brazos River and is dammed in six places to form manmade lakes. These natural and unnatural changes can cause degraded water quality, altered or destroyed habitats, flash-flooding and more.

Rhodes and coauthors, Jackson State University Assistant Professor Rocky Talchabhadel, Ph.D., and former TWRI Graduate Research Assistant Taylor Jordan, used historical images and records to better understand the Navasota River's changes over the last 50 years and how those have potentially caused more flooding in the watershed's southern portion.

Read more ⇨ tx.ag/water25

Texas Water Journal covers Texas' water research spectrum

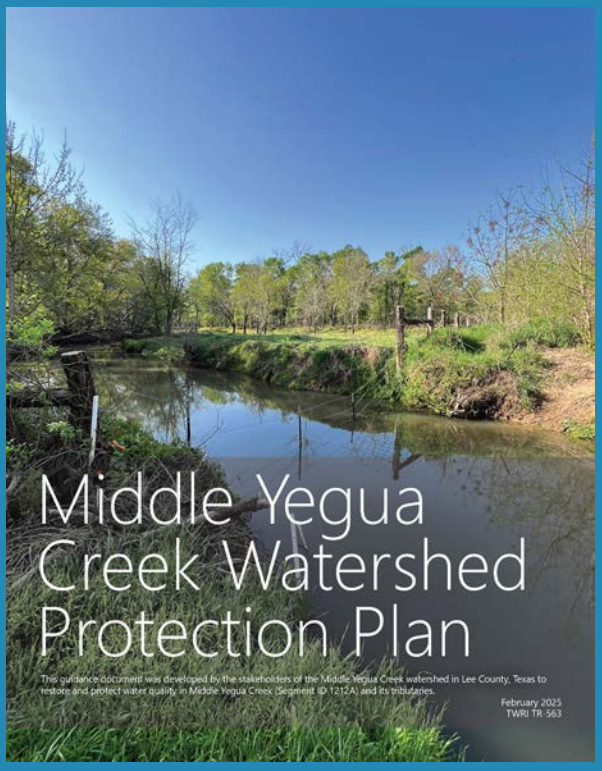
The 2024 volume of the *Texas Water Journal* has published articles covering much of Texas' water research spectrum, from groundwater and water policy to infrastructure and surface water.

- "A Hydro-Economic Approach for Quantifying Well Performance Thresholds and Recoverable Groundwater Yields in Texas" by Justin C. Thompson, Ph.D., and co-author
- "Case Study of Emerging Groundwater Management Issues at the Forefront of Large-scale Production from a Confined Aquifer: The Vista Ridge Project" by Steve Young, Ph.D., and co-authors
- "Water Reuse in the Hill Country: Lessons from Existing Reuse Facilities in Texas and Opportunities to Advance Reuse in Comal County" by Rachel Hanes
- "Differences in the Hydration State of Riparian Pecan Trees Between Rural and Urban Settings" by Michael Snook and co-authors
- "Addressing Challenges to Ensuring Justice and Sustainability in Policy and Infrastructure for Texas Water Resources in the 21st Century" by Margaret Cook, Ph.D., and co-authors
- "Best Management Practices to Mitigate Inadvertent Transport of Contaminants to Karstic Aquifers in Runoff During Emergency Fire Control" by Rudolph A. Rosen, Ph.D., and co-authors

Read more ⇨ tx.ag/water25

Middle Yegua Creek Watershed Protection Plan published

TWRI recently published the Middle Yegua Creek Watershed Protection Plan, which presents prioritized voluntary strategies and best management practices to restore and protect local water quality. The plan was accepted by the U.S. Environmental Protection Agency in February, a major accomplishment for the coalition of local stakeholders and state officials who collaboratively created the science-based plan, led by TWRI.



TWRI engaged local stakeholders and led them in the process to develop the voluntary plan through informational meetings, educational programs, and focused discussions regarding the current state of water quality, their concerns for future water resource issues, and what could be done to mitigate these issues.

The effort was funded through a State Nonpoint Source grant from the Texas State Soil and Water Conservation Board. The plan is available at middleyegua.twri.tamu.edu.

Keep reading about this water news at tx.ag/water25

(Top left) Shay Postma, TWRI research specialist, and Nicholas Stillwell, TWRI intern; (top right) Claire Leffingwell, TWRI intern, (bottom left) Kaiya Haines, TWRI intern; (bottom right) Saboor Rahmany, TWRI research specialist, and Leen Maknojia, TWRI intern.

TWRI water internship program wraps up first year

The Texas Water Resources Institute's water internship program, created in partnership with Texas A&M University's College of Arts and Sciences, aims to provide students with hands-on experiences in the water profession.

During the program's first full year, eight students have benefited from the internship, with more beginning this summer.

"We have had the great pleasure of working with many bright and enthusiastic young water professionals," said TWRI Research Specialist Ed Rhodes. "Working with these eight amazing interns over the past year has been a great experience for us as professionals and for them as budding professionals."

Interns assist TWRI's water team with regular water quality monitoring, learning to collect and analyze data.

"The feedback I've gotten from every intern has been that the experience opened up a whole new kind of set of understandings related to water management, water quality monitoring, working on teams, going out in the field and water quality analysis," said Wendy Jepson, Ph.D., director of the college's Environmental Programs and Environment and Sustainability Initiative and a previous associate director at TWRI.

The water internship program allows students to build on knowledge they've gained in class and apply it in real-time, learning how to work in a professional environment.

Read more ⇨ tx.ag/water25

Q&A with Giovanni Piccinni

Get to know the director of the Texas Water Resources Institute

For more than seven decades, the Texas Water Resources Institute (TWRI) has helped Texans solve critically important water problems. The institute welcomed a new leader in 2024, Giovanni Piccinni, Ph.D., now TWRI director and a professor in Texas A&M University's Department of Soil and Crop Sciences.

Piccinni previously served as the global lead for field and plant production optimization and sustainability at Bayer Crop Science in St. Louis. Before that, he served in research and leadership roles at Texas A&M AgriLife Research in Amarillo, Bushland and Uvalde from 1994 to 2008. Learn about his vision for the institute in this question and answer with *txH$_2$O*.

Photos (from the top, clockwise): Giovanni Piccinni, TWRI director, photo by Michael Miller, Texas A&M AgriLife Marketing and Communications; TWRI leadership visits with leadership and researchers at the Polytechnic University of Bari, Italy; Allen Berthold, Ph.D., TWRI interim director from 2022 – 2024, welcoming Piccinni to TWRI in August 2024; Brent Auvermann, Ph.D., Berthold and Piccinni view construction progress at the future Texas A&M AgriLife Research and Extension Center at West Texas A&M University in November 2024; Piccinni visiting researchers and wildlife at the Texas A&M AgriLife Research and Extension Center at Uvalde; and Texas A&M AgriLife Research and Extension Center at Uvalde Director Daniel Leskovar, Ph.D., with Piccinni at the center.

txH$_2$O: What were you most looking forward to about leading TWRI?

Piccinni: The institute boasts a rich legacy of conducting extensive research and providing education on the sustainable utilization of water resources. I look forward to continuing TWRI's work of building teams that leverage the research, extension and education expertise in the Texas A&M University System and at TWRI to provide premier water resources research and programs that ultimately improve communities and lives.

Last fall, I began visiting all the AgriLife centers and getting together with all the departments that work in water resource management, and I have greatly enjoyed those visits.

We have so much technical expertise in water research and extension in the Texas A&M System, and TWRI is poised to continue bringing together experts from across the system and beyond to solve water problems.

txH$_2$O: Your early career research centered on agronomy and crop physiology. What did you enjoy most about those fields and leading research programs in those areas?

Piccinni: The first part of my career was full of research opportunities that all involved crops, soil, water resources, water conservation and water management. I was able to study agricultural systems ranging from tomatoes to wheat, sugar beets, corn and other crops. What really motivated me to eventually lead my own lab at the Uvalde Center was looking at water resource management for sustainable cropping systems.

Establishing the plant stress physiology program at Uvalde was an amazing opportunity. We researched the water-use efficiency of crops under stress, prediction models for irrigation management, precision agriculture techniques using remote sensing evaluation of plant stress and irrigation management under limited water availability.

We were always looking for opportunities for farmers to use water resources in the best way possible, in the most sustainable way, but also in the most profitable way.

txH$_2$O: In 2008, you began working at the Monsanto Company in St. Louis, Missouri, conducting biotechnology research and agronomic trials studying gene responses in corn and soybeans. What are you most proud of from your time at Bayer Crop Science, formerly Monsanto?

Piccinni: I am very proud to have served on the teams that helped develop a new variety of drought-tolerant corn, saving producers both water and money.

Serving as Bayer's global lead for field and plant production optimization and sustainability beginning in 2018 was an honor and opportunity I deeply enjoyed. As a scientist, I thrive in a diverse environment. That role allowed me to meet with our international teams and experience so many different teams and places all around the world. I greatly enjoy working with people from different cultural and scientific backgrounds.

I'm also very proud that we always prioritized sustainability, even when I was on the production side, or biotechnology, or supply chain — we always looked at ways to help grow more and consume less.

txH$_2$O: What is your vision for leadership at TWRI and for the institute's future?

Piccinni: As a leader, collaborative and strong teams are my core philosophy, both internally and externally. Empowering and building interdisciplinary teams of researchers is a top priority for us.

Building consensus among stakeholders, explaining the value of cutting-edge technologies and empowering research excellence to improve the lives of the people we serve, the communities where we live, the state, the nation and ultimately the world — that is the vision I plan to lead at TWRI.

txH$_2$O: Texas is facing interconnected and compounding problems with both water quality and supply. After leading TWRI for several months, in what water issues do you see TWRI and Texas A&M AgriLife especially poised to serve the state and residents?

Piccinni: After extensive travel across the state, it is evident that many regions that faced significant water resource challenges 16 years ago, when I relocated from Texas, continue to experience these issues. The severity of these challenges has worsened over time, with some areas now facing even more dire circumstances.

Given this, it is clear that current efforts focused on water conservation must be supplemented by the exploration of alternative water sources. We are actively supporting research initiatives that examine the viability of using saline water for crop irrigation, as well as projects investigating the potential of utilizing produced water from oil and gas. After appropriate treatment, this alternative water source could provide a viable solution for some irrigation needs. There is substantial opportunity for progress in this area, but the critical issue remains the speed at which we can implement effective solutions to address the ongoing water scarcity crisis.

The key to success will be achieving tangible results and fostering rapid innovation.

txH$_2$O: Besides your new role as TWRI director, what else have you looked forward to about returning to Texas?

Piccinni: Texas holds a special place in my heart, filled with memories I treasure every single day. It is where both of my kids, who are now young adults, were born, where I began my career as a scientist and where I purchased my first home — each of these moments still brings me joy. But what I hold most dear are the people of this incredible state. The farmers and ranchers have always welcomed my family and me with warmth and kindness. The friendships I formed in Texas have had a lasting impact on me, shaping my passion for agriculture and deep love for the land. I have been thrilled to reconnect with old friends, spend quality time together, and, of course, enjoy some delicious Texas steak!

MISSION CRITICAL:

The State Water Plan, Explained

To prevent water supply shortfalls during future extreme droughts, new water supply strategies must be funded and implemented — and this plan is Texas' official path forward

"Failure is not an option," says NASA Flight Director Gene Krantz in the film Apollo 13, a fictionalized quote portraying the real mission's determination to save its three astronauts.

The same could be said by Texans staring down the inescapable truth of Texas water planning: our population is growing while our water supplies are not.

The Texas Water Development Board (TWDB) estimates that if Texas does not develop more water supplies and supply strategies, Texas would face a potential water shortage of 6.9 million acre-feet per year in 2070 if drought of record conditions occurred.

And that potential failure — failure to provide adequate water for all Texans in the event of another extraordinary drought — state leaders say that failure is not an option.

But, it's going to take all hands on deck to prepare for the worst.

Planning for worst-case scenarios

The state's demographer and TWDB demographic researchers project that Texas' population is anticipated to increase 73% between 2020 and 2070, from 29.7 million to 51.5 million. As water users increase, water demand is also projected to increase, from 17.7 million to 19.2 million acre-feet per year, and Texas' existing water supplies are projected by TWDB to decline by approximately 18% between 2020 and 2070, primarily due to aquifer depletion.

With those demands on the horizon, the state has invested significant resources and statewide collaboration into developing the state water plan.

"TWDB is tasked by statute to develop a plan that identifies water supply needs and how those needs would be met in a recurrence of the drought of record," said Temple McKinnon, director of the Water Supply Planning Division in TWDB's Office of Planning. The division is responsible for developing the state water plan.

"That drought of record distinction is important," she said. "This is a plan to meet or address needs during a recurrence of drought — it's not the same as what utilities typically do, which is average condition planning."

The drought of record for most Texas counties is the 1950s drought, or the 2011 drought for some.

The state water plan is not about everyday water supply planning, McKinnon said. This plan is focused on how to keep Texas afloat when extreme hydrological and meteorological drought conditions persist.

How will Texas bridge the gaps?

Preventing a 6.9 million acre-foot water deficit in a future drought of record will only be possible if new water conservation and water supply strategies are funded and implemented, TWDB planners say.

"The state water plan identifies the potential needs and effective strategies to address them, but it is up to individual project sponsors to implement those strategies," McKinnon said. Project sponsors are usually municipal water utilities, river authorities, cities or local governments.

TWDB plans on a 5-year cycle, and a new state water plan is published every 5 years.

"The state is producing a plan and everybody's bringing their local planning efforts to the table, and it will address anticipated water needs over the next 50 years if it is implemented."

The strategies identified by the 2022 State Water Plan to bridge the water deficit include, but are not limited to:

- Surface water: creating new reservoirs and other new projects, including surface water pipelines.
- Conservation and drought management: saving water through technology, programs and drought condition-based restrictions.
- Reuse: building new water reuse facilities and infrastructure.
- Groundwater: using treated brackish groundwater and other new groundwater sources.
- Seawater: building additional desalination facilities to treat and use seawater.
- Aquifer storage and recovery: storing water in aquifers for later use.

Two of thoses categories account for 67.9% of the additional water supplies: surface water, and demand reduction (conservation and drought management).
(See infographic.)

Surface water strategies

In the 2022 plan, regional planning groups recommended 23 new major reservoirs be built by 2070, providing 866,000 acre-feet of water per year. The status of those proposed lakes as of spring 2025 was:

- 2 reservoirs have completed construction.
- 5 have received TCEQ water rights permits, and design and/or land acquisition is underway.
- 3 have received a TCEQ water rights permit.
- 13 have yet to be issued a TCEQ water rights permit.

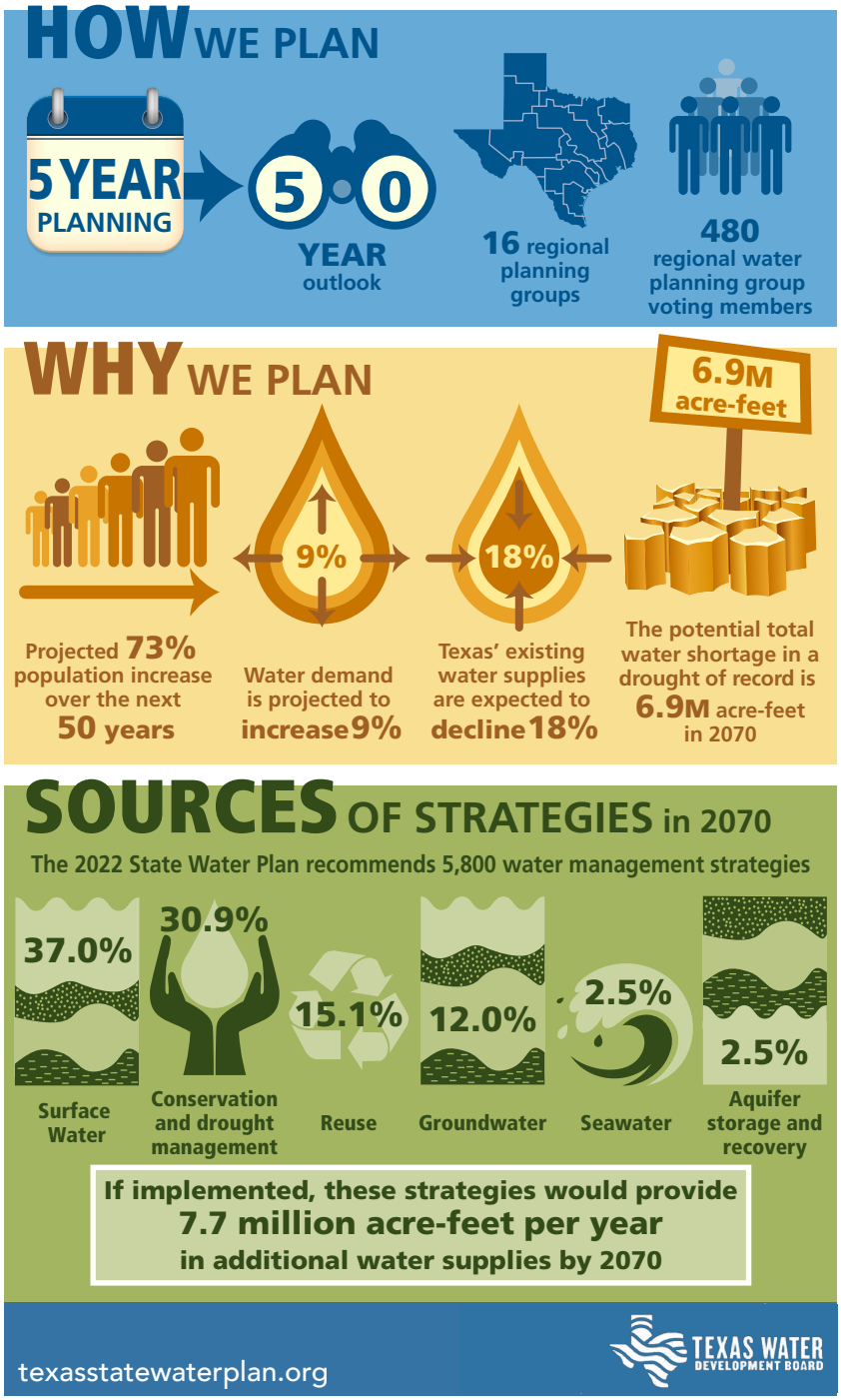
Over the past century in Texas, reservoir construction has slowed. This is "due, in part, to the fact that there remain very few viable sites for new major reservoirs, permits are much more difficult to obtain due primarily to environmental concerns, and the cost of construction has gone up faster than the rate of inflation," according to the TWDB website.

Water conservation strategies

The 2022 State Water Plan detailed water conservation and drought management strategies for municipal, agricultural and industrial water users.

Municipal conservation includes water-loss prevention by utilities; state policies require water-loss audits and state programs help fund water-loss prevention. Municipal conservation strategies in the regional plans included:

- Metering of all new connections and retrofitting existing connections.
- System water audits, water-loss controls, and rapid leak detection and repair.



Texas' state water planning process runs on 5-year cycle. Infographic courtesy of the Texas Water Development Board.

- Public education and incentives for water conservation indoors and on landscaping.
- Water-efficient plumbing fixtures and rebates for purchasing them.
- Stronger water conservation pricing structures that discourage waste.
- Year-round landscape irrigation restrictions that also support healthy landscapes. ⇨

To support agricultural water conservation, TWDB's Agricultural Water Conservation Grants Program supports the implementation of agricultural irrigation strategies. Agricultural water conservation best management strategies in the plans included:

- Efficiency-based changes to irrigation methods, equipment and crops.
- Conversion to Low Energy Precision Application systems.
- Irrigation scheduling.

Industrial water conservation strategies in the plans included:

- More efficient cooling and process-water practices.
- Water audits.
- Submetering.

Challenges of implementation

Implementing water infrastructure projects is complicated in a massive state that is 93% privately owned land and historically frequented by prolonged drought conditions and sudden floods. The local and regional entities implementing new strategies also face:

- Reservoir evaporation rates.
- Rising infrastructure costs.
- Texas' extreme weather events and preparing with resilient infrastructure.
- High energy costs associated with desalination and treating produced water.
- Environmental impacts of desalination brine output.
- Private land acquisition delays and environmental impacts of reservoir construction.

Not only that, but ultimately, implementing these strategies requires funding. And funding water infrastructure is only getting costlier by the day.

Funding the plan

In 2013, two new funding sources for the plan were created when the 83rd Texas Legislature and then statewide voters authorized a one-time, $2 billion investment from the Economic Stabilization Fund, or the Rainy Day Fund, to the State Water Implementation Fund for Texas (SWIFT) and the State Water Implementation Revenue Fund for Texas (SWIRFT).

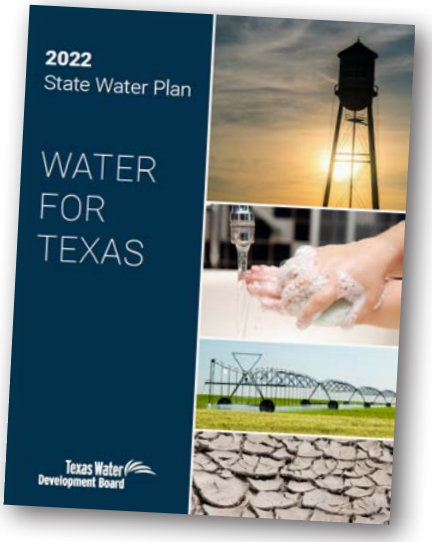
SWIFT was designed to provide financial assistance specifically to projects listed in the state water plan, and the original $2 billion would be leveraged with revenue bonds over the next 50 years to finance approximately $27 billion in water supply projects, according to TWDB.

Then, in 2023 the 88th Texas Legislature passed legislation creating the Texas Water Fund and providing a one-time $1 billion appropriation to it, and voters approved it later that year. The Texas Water Fund is a special fund in the state treasury outside the general revenue fund. It is administered by TWDB to fund projects through existing financial assistance programs managed by TWDB, and through the New Water Supply for Texas Fund, also created by the 88th Legislature.

Recipients of these funds include municipal water utilities, rural counties and communities, river authorities, city governments, rural water supply corporations, irrigation districts and regional water authorities.

This year, the 89th Texas Legislature passed Senate Bill 7 and House Joint Resolution 7, both focused on water funding. SB 7 works in conjunction with HJR 7 to dedicate $1 billion in sales tax revenues to the Texas Water Fund, administered by TWDB. If HJR 7 is approved by Texas voters in the Nov. 4 election, then up to $20 billion over the next 20 years will be allocated for water infrastructure projects.

2027 plan in development



The next planning cycle is underway. Strategies from the 2022 plan are being implemented, and the next plan is in development, for 2026 publication.

"The plan is updated every 5 years, and this process begins with the 16 regional water planning groups," McKinnon said. "According to statute, every regional group must include certain interest groups and then each planning group can add members as they decide. Draft regional plans were received this March and are now under agency and public review."

The draft regional plans are published online, along with an interactive platform to facilitate public review: 2027.texasstatewaterplan.org. Following the review period, TWDB provides feedback to each planning group based on agency requirements, and then the planning groups address those comments and public input, and resubmit the final plans.

"We then compile that information into a state water plan and provide it for public review," McKinnon said. "And then it is considered by our board for adoption."

By Cameron Castilaw

Cleaning Produced Water

Creating new possibilities for water reuse, this Texas A&M professor's lab is perfecting techniques for treating water byproduct from oil and gas production

Hydraulic fracturing for oil and gas extraction produces water laced with high levels of salt and chemicals. This byproduct is old news in Texas, the top oil-producing state in the United States.

What is a newer concept is cleaning and treating that water from the hydraulic fracturing process and the possibilities it opens for water reuse in the oil industry, nonconsumptive agriculture and more.

Shankar Chellam, Ph.D., a professor in Texas A&M University's Zachry Department of Civil and Environmental Engineering, and his students are at the forefront of the produced water research field, expanding on and refining the process of cleaning the toxic water byproduct.

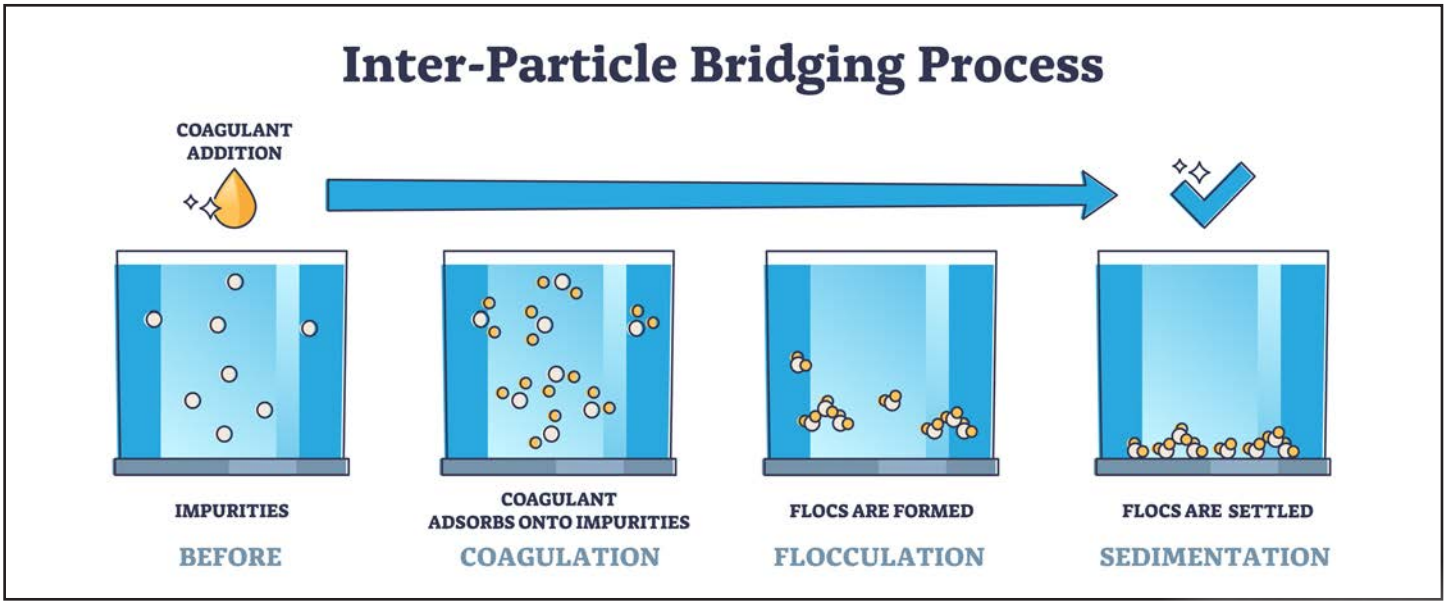
Solving an underground problem

What exactly is produced water?

"Produced water is the wastewater that comes out of oil exploration and production activities," Chellam said. "A long time ago, there used to be only 'conventional' produced water before the increase in hydraulic fracturing, or fracking. In the Permian Basin, which is the world's largest site for unconventional shale oil production, the quality and quantity of produced water are different."

The process of hydraulic fracturing uses many unknown chemicals, he explained, making the wastewater produced unsuitable for any direct use and difficult to clean. It is also highly saline because the Permian Basin is an ancient seabed at least 250 million years old. ⇨

Water illustration from Adobe Stock.



Inter-particle bridging process used by student researchers to treat produced water in Chellam's lab. Illustration from Adobe Stock, edited by Sarah Dormire, TWRI.

"We don't know exactly what's in it, and so treatment and purification of that water is that much more complicated," Chellam said. "I'm told that in the Permian Basin, the amount of produced water that comes out is maybe four times the amount of oil that is produced. And we make a lot of oil, so we make four times larger amounts of water than oil, and this water is extremely saline. We have done experiments with produced water that is around six times more saline than seawater."

With many unknowns and an abundance of produced water to work with, that's where Chellam and his lab of undergraduates, graduate students and postdoctoral researchers get involved, working to develop a treatment process that's as effective as possible.

"A lot of what my research focuses on is three areas, primarily coagulation, flocculation and sedimentation," said Allison Hughes, a senior environmental engineering student in Chellam's lab. "In very simple terms, you're aggregating these particles that you want removed with an additive, which is a coagulant, and then they're going to flocculate and just get bigger and bigger so that they're a little bit heavier and can settle. And then we filter that water to remove remaining flocs and have a relatively clear supernatant, and then we do desalination."

"We use aluminum chlorohydrate, or ACH, as our coagulant, that's the chemical that we first inject into the water when it's mixing, and then after a rapid mix, we add an anionic polymer, and that helps make the flocs even bigger than it would have been," said Nicole Giovannetti, another senior environmental engineering student in the lab.

The process by which the polymer works is called inter-particle bridging, which makes the particles larger and helps them settle to the bottom of the container faster. The lab is developing ways to complete this treatment and remove solids in ultrashort times, only about five to 10 minutes, to reduce system footprint.

After removing these larger particles, the team can then filter and desalinate the water, which is the final step of their treatment process.

While the treated water is much cleaner, it may still be unsuitable for human use, Chellam said. Potential uses for the treated water include additional hydraulic fracturing, dust suppression, steam generation and irrigation for agricultural crops not for consumption, such as cotton.

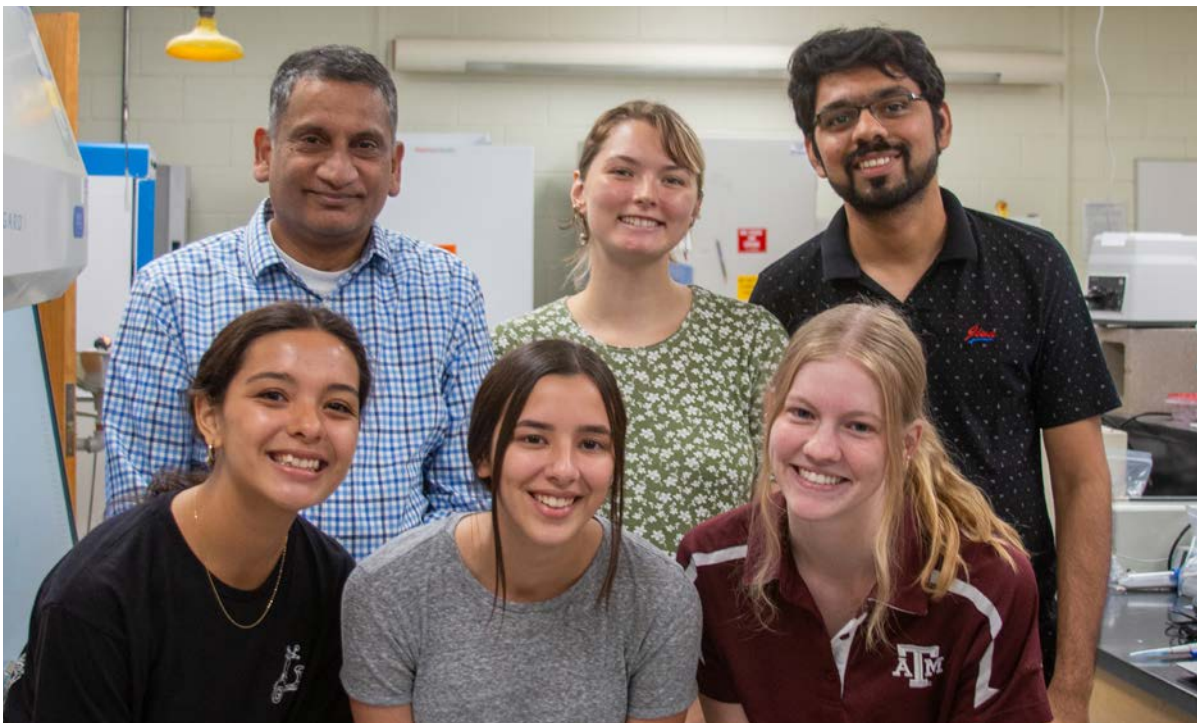
"All this is brand new because I don't think there is a one-stop solution for treating produced water," said Sanket Joag, environmental engineering Ph.D. student. "So, we are making improvements. First of all, we can remove solids to use it for hydraulic fracturing. After that, we can remove some parts of it and see if that can be used for some kind of beneficial reuse such as for agricultural purposes."

Reuse it or lose it

Currently, oil companies largely dispose of produced water through deep well injection. The process injects the water far into the earth, below aquifers and other groundwater sources, Chellam said.

Subsurface injection voids the possibility of beneficially reusing the water, he said, and this raises some concerns as water supplies experience greater demand, particularly in arid and semi-arid regions.

Concerns have also been raised that the underground pore space could run out and injection wells could lead to potential contamination of groundwater resources and induce seismicity,



Chellam with his students in the lab. (From the top, clockwise) Chellam, Megan Geerts, Sanket Joag, Allison Hughes, Nichole Giovanneth, Deztenie Garcia. Photo by Cameron Castilaw, TWRI.

Chellam explains. Some companies are looking into research, such as his lab's work, for solutions to reduce disposal volumes.

"They are trying to do a better and better job in water management," Chellam said. "They want us to develop robust processes that can handle variations in the water quality so that, at the very least, they don't need to source new water for fracking, like before. If they reuse at least one part, it is saving groundwater, surface water or another source."

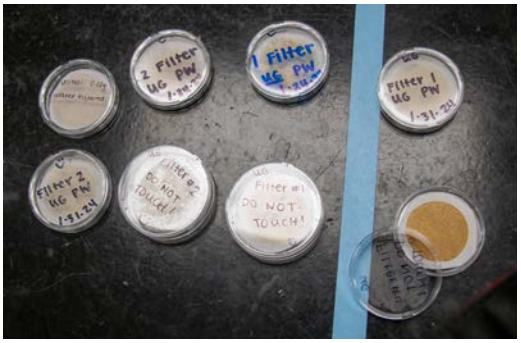
Partnering with the oil and gas industry, Chellam's lab obtains samples of the raw produced water and tries various treatment methods. Their results are then shared with the partners, who scale up the processes to treat larger amounts of water in the field. Chellam emphasized that his research is truly a partnership with industry engineers and many of his grants and publications are written collaboratively with them.

"The way we design and communicate our results has to be robust," he said. "People do not know how much chemical to add, what chemical to add and when to add. The things that we study, these students have figured out that an anionic polymer is better than a nonionic polymer, and that a certain dose works better than a different dose, and a certain time is better than some other time.

"We tell the collaborators and companies that these conditions will work, and then they test it in the field, and so far, they tell me that our data are very good, and they can scale it."

Ultimately, the oil and gas industry and scientists like Chellam and his students are working towards reuse of produced water. Creating additional water from their process instead of removing even more from the hydrological cycle.

"If we really want oil, we should also be responsible for whatever byproducts we are getting with the oil, because we are consuming it," Joag said. "If we can't well-inject it, if we can't discharge it on the surface, what are we going to do? What if we can reuse it? We are solving the problem of disposal, and we are also reusing it for a beneficial use."



(From left to right) A clean filter the lab will use to remove particles, various used filters showing cleaning process, and a beaker of filtered water going through the desalination process. Photos by Cameron Castilaw, TWRI.

Can Treated Produced Water Safely Irrigate Crops?

Texas A&M AgriLife Research scientists study the impacts of using treated water produced by oil and gas operations for irrigating non-consumptive crops

Cotton growing on the Texas A&M AgriLife Farm in Snook. Photo by Sam Craft, Texas A&M AgriLife Marketing and Communications.

There is one type of water currently in abundance in West Texas and Far West Texas: produced water resulting from the oil and gas industry.

Texas annually generates up to 500,000 acre-feet of treated produced water, experts say.

Market factors and governmental policies make it likely that produced water will be available in the region for some time. Still, more research is needed around a key question: Could this water be safely used for beneficial purposes instead of being pumped back below ground in injection wells?

Limited water resources

In semi-arid West Texas, regional agricultural production has decreased over the last two decades due to limited water quantity and quality, said Katie Lewis, Ph.D., Texas A&M AgriLife associate professor of soil fertility and chemistry in Lubbock.

Could reusing produced water that's been treated help local agricultural economies survive?

Step one of answering these questions is, can the water be successfully treated and cleared of all industrial chemical levels that could be harmful to ecosystems or humans?

As a byproduct of oil and gas extraction, produced water is high in organic materials, salt, and minerals, making it unsuitable for consumption. Companies currently use treatment processes to filter the water to remove any additional hydrocarbons before reinjecting it into the ground.

Texas A&M Engineering experts are researching the best methods for successfully cleaning the water to a standard suitable for agricultural use; see page 9.

Step two is, if that water can be successfully treated, could it then be used to irrigate nonconsumptive crops, such as cotton and forage grains?

And, how will that irrigation application affect the surrounding soil, air and water?

Texas A&M AgriLife Research is conducting multiscale research projects to answer this, Lewis said.

"We're evaluating annual and perennial cropping systems irrigated with treated produced water, and a research site has been established in the Trans-Pecos Region to observe these effects," she said.

AgriLife researchers start investigating

A few years ago, Lewis and collaborator Joseph Burke, Ph.D., AgriLife Research and Extension Service assistant professor of cropping systems agronomy, jumped feet-first into answering these questions.

Burke and Lewis are using their soil science expertise to test produced water possibilities in the High Plains. Photo by Hector Valencia, Lewis and Burke Laboratory.

When a research opportunity sponsored by Anadarko and Energy Water Solutions became available, Lewis' lab began studying land applications of treated produced water to fields using drip irrigation.

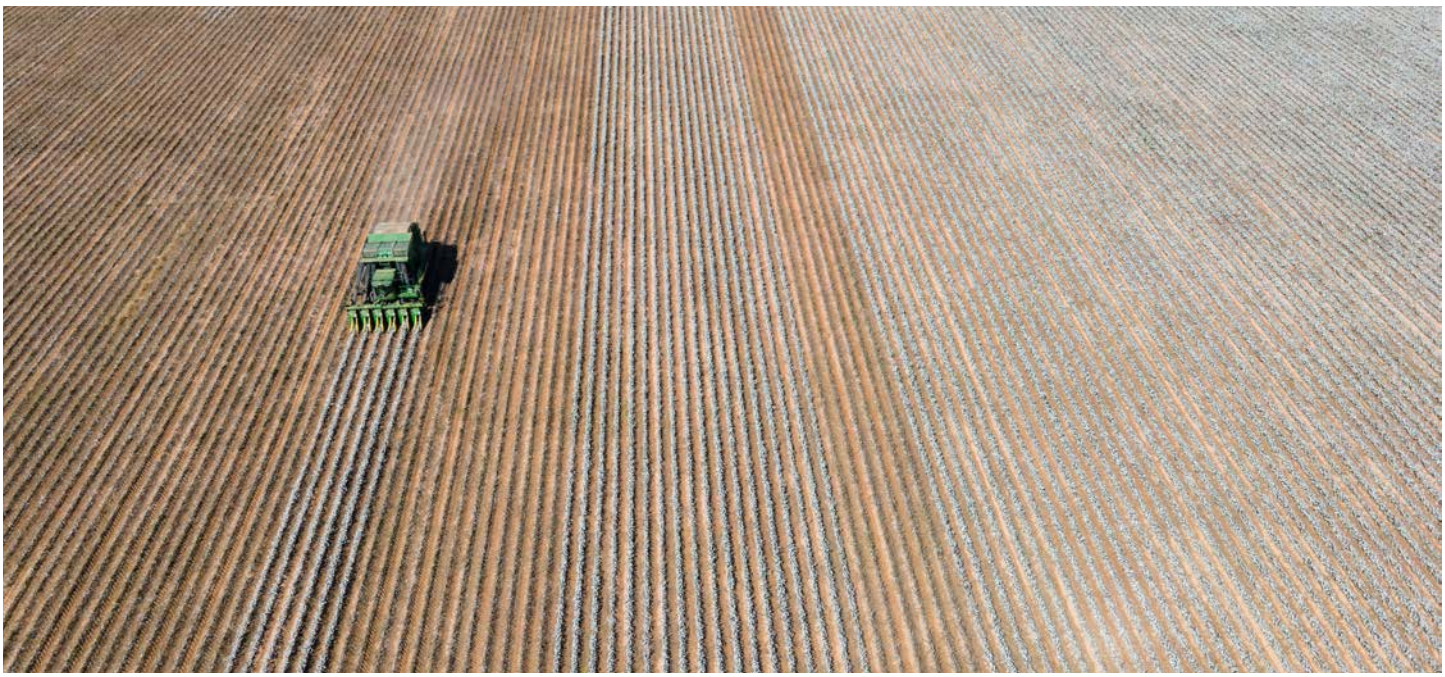
"My research group jumped all in," she said. They collaborated with state and federal agencies to ensure that the water complied with regulations and then began field research.

Their results showed that irrigating with treated produced water blended with groundwater did not reduce cotton yield or lint quality, but did reduce soil salinity, she said.

In another study, the research team focused on the soil's reactions to produced water.

"We monitored the chemical, physical and biological aspects of the soil that are being influenced potentially by the produced water," Lewis said. "Three different irrigation waters were used: traditional groundwater, simulated produced water that we created in our lab, and clean produced water filtered by Texas A&M University's Dr. Shankar Chellam."

This study was funded by Solaris Water. Lewis and Burkes' team found that produced water had minimal detrimental effects on plant development and mineral uptake, and it enhanced soil carbon, pH, and micronutrient availability. ⇨



Cotton harvest. Photo by Courtney Sacco, Texas A&M AgriLife Marketing and Communications.

New frontiers

Lewis and Burke are now studying additional treatment strategies for produced water and the long-term effects on soil and plant productivity, in research funded by WaterBridge Operating, LLC.

"This study will begin with the produced water getting treated in a novel three-step process by one of the water industry partners in the study — using absorption, regeneration and membranes," Burke said. "And then our portion of the research will be studying if forages and row crops can potentially thrive with produced water."

The team will monitor the impact of produced water on soil parameters, water quality, plant growth, and greenhouse gas emissions. "We'll do a complete ecological assessment of these crops," he said.

In another study, sponsored by the U.S. Department of Energy, Lewis and Burke are partnering with ARIS Water and New Mexico State University to analyze the feasibility of cost-effective beneficial reuse of treated produced water.

They are studying crop irrigation with treated produced water, growing non-consumptive crops: cotton, bioenergy sorghum and bioenergy peanuts. New Mexico State is leading the engineering and water filtration portion of the project, and Lewis and Burke are leading the agricultural work.

"This will be the largest-scale pilot study of produced water applications we've been a part of so far," Burke said.

The project will be growing forage, for hay production, and forage breeders and agronomists are also collaborators in the effort.

"These forages are going to be able to accumulate and withstand the high salinity that this water will add to the soil, but then we're going to cut and bale it, and so it will be removed off the field, hopefully maintaining and improving soil quality, because we are removing those salts," Lewis explained.

Revitalizing agricultural industries

The Trans-Pecos region once produced renowned crops, including Pecos cantaloupe and watermelon, Burke said, and he and his colleagues are curious to see if treated produced water could help revitalize those farming communities.

"Could this water source bring some agricultural production back to the region, specifically growing nonconsumptive crops right now, like cotton, bioenergy peanuts or sorghum?" he said. Growing edible crops with cleaned produced water is a far-off question, Lewis said, but nonconsumptive crops are a near-future possibility.

"Both Joseph and I are highly devoted to agricultural production not just in the High Plains, but across the state, both professionally and personally," Lewis said.

"And we know that inevitably, and I would say even currently, but inevitably, water is going to be the reason that agricultural production declines in areas like the High Plains and West Texas, regions that are dependent on groundwater resources or surface water resources. And so, if we can have an alternative source to continue to grow our crops, we're going to better sustain the level of productivity that we're at now."

By Cameron Castilaw

Empowering the Next Generation

Texas 4-H Water Ambassadors Program helps high school students learn about water issues and careers

High school can be a time of discovery for many teens as they figure out their interests and decide what career to pursue. However, students' choices can be limited when they aren't aware of different career paths.

One Texas group is working to change that when it comes to students seeing career opportunities in water.

Since 2017, the Texas 4-H Water Ambassadors Program has supported 218 high school students as they get hands-on knowledge about water in Texas, connect with professionals in the field and use that knowledge to educate others.

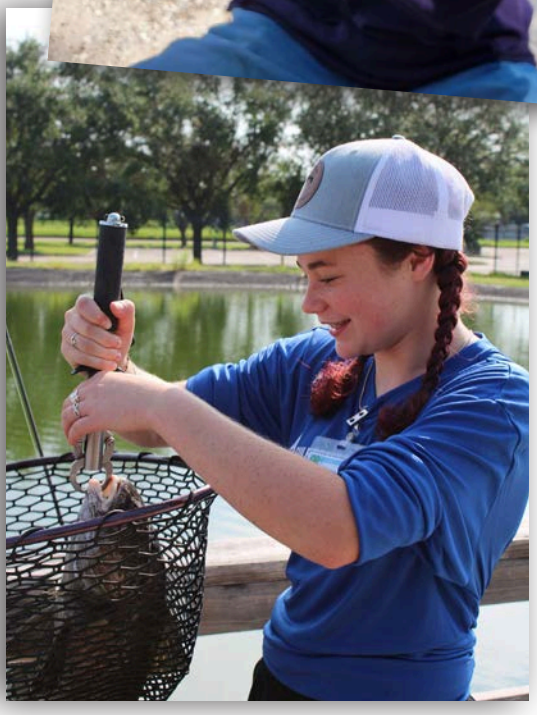
New challenges, new solutions

The concept started with Dirk Aaron, a former Texas A&M AgriLife Extension Service agent now serving as general manager for Clearwater Underground Water Conservation District. David Smith leads the program and has been involved since the beginning.

"Within 4-H, there are different programs for high school youth that are aimed at career exploration, leadership and service; there's probably seven or eight other similar types of ambassador programs," said Smith, an extension program specialist in the Texas A&M University Department of Biological and Agricultural Engineering. "In 2016, Dirk talked to the state 4-H program director at the time about the idea of starting a Water Ambassadors Program."

Aaron felt that the water industry would support the program and help provide opportunities and sponsors. He sees it as "planting a seed" to grow the next generation of water leaders, Smith said.

That's where Smith got involved; he had recently started youth water education and was contacted by Aaron to lead the program. ⇨



(Top) Texas 4-H Water Ambassador J.D. Haines completing his monthly Stream Team monitoring on Greens Bayou in Houston.

(Bottom) 4-H Water Ambassador Ocean Landreneau helped with the Gulf Coast 4-H Angler Day for kids at Sea Center Texas, assisting with hatchery tour, aquarium scavenger hunt, angler education, and fish habitat education.

All photos courtesy of Texas 4-H Water Ambassadors.

(Left to right) Lilly Haddox, 4-H water ambassador, presenting an "Edible Aquifer" activity and explaining aquifer science to the Waller County Brazos Valley Project Club.

4-H water ambassador Jack Luckey leading water and aquifer education activities at the Milam County 4-H FriYAY Summer Day Camp.

"He said, 'Hey, we have this idea. Would you be willing to take it on and build it?'" Smith recalls.

After agreeing to lead the program, Smith and Aaron met with the Texas 4-H Youth Development Foundation and groups of water industry professionals, attorneys, hydrologists and organizations, and pitched the program to them. "All of them bought into it," Smith said.

There is a big need for youth interest in the water industry, he said, because many professionals are nearing retirement. Finding driven students interested in the water field can be challenging, Smith said. That's where the Water Ambassadors Program comes in.

"Water folks are interested in developing the next generation of water decision makers, leaders, and people in the industry," he said.2017 saw the first group of ambassadors begin their journey. Now in their eighth year of existence, their mission stays the same.

"Our purpose is to get high school youth who are considering what they are going to do, if they're going to college or not, with their future or career and show them what a career in water looks like," Smith said.

Finding a place to belong

Each spring, the program accepts applications for admittance. Promoted through Texas 4-H and Texas A&M AgriLife Extension agents, any interested youth from across Texas who will be in high school the next academic year are eligible to apply.

"I've enjoyed natural resources my entire life and was looking for something more engaging to do in that area," said J.D. Haines, a water ambassador in Montgomery County. "I have really enjoyed learning about water; it's very hands-on and interesting for me."

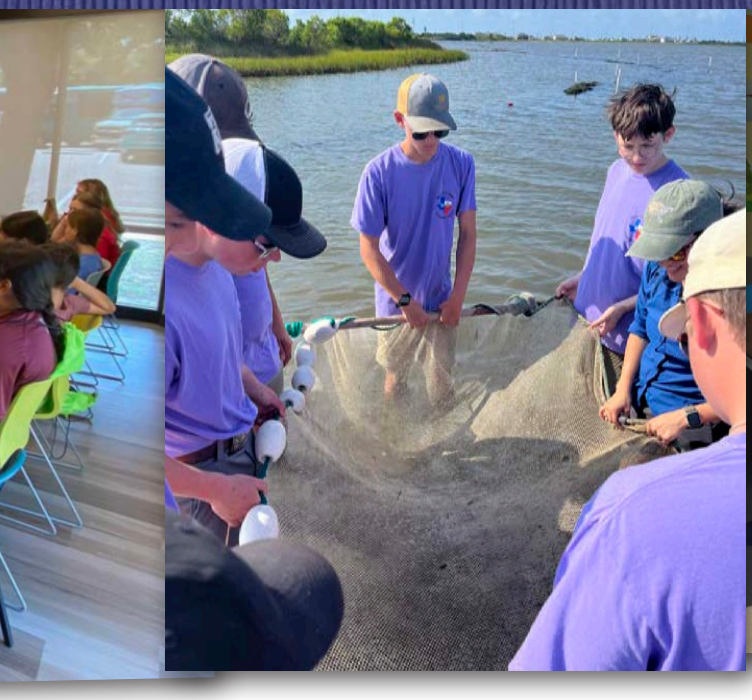
Students are able to apply any year they are in high school and commit to being in the program for an entire year.

"It's year-long, continued education," Smith said. "And in exchange for that, they're required to commit to a minimum of 40 hours of education and service in their communities."

For some students like Riley Calk from Denver City, who joined the program in its second year of existence, this education was personal. Calk said she learned more about water issues her family faces as the fifth generation on their ranches in Uvalde and Brewster counties, within the Edwards Aquifer region.

Neighboring ranchland-owners are facing economic pressure to sell their water rights to municipalities, Calk mentioned, and she learned more about that in the 4-H Water Ambassador Program.

"That really brought up my interest in natural resources and water when I was in high school, so I joined the Water Ambassador Program and it was awesome," Calk said. "The first year of the program is really focused on groundwater and then throughout the next years and rivers and water reuse, it really opened my eyes to so much, and you realize that no more water is being made, so you need to conserve as much as you can when reasonable."



Students in the 4-H water ambassadors Tier II Academy learning about bay seining, water testing and oysters with the Galveston Bay Foundation.

Ambassador Sarah Wood assisting the Clearwater Underground Water Conservation District in teaching local homeschool groups about watersheds and groundwater.

The program's required education and service hours can be fulfilled by: presenting to 4-H clubs, educating students at local schools and volunteering with other educators like water educators and groundwater conservation district education coordinators. Students report their work to Smith to keep track of service opportunities completed.

Another part of the program is the 4-H2O Leadership Academy. These summer programs help further educate students about how water is managed in different parts of the state and introduce them to the people doing that work. The level, or year, of the program a student is in decides which academy trip they attend in the summer.

"The first-year group starts generally somewhere in the center of the state, and we end up in the Panhandle and then come back around over seven days," Smith said. "They learn a lot about aquifers, agricultural irrigation, water wells, and water law and policy, especially since that area of the state is groundwater focused."

Level two students focus on the coastal area of Texas, while level three travels to the Rio Grande Valley and level four, the final one for students who were in the program for all four years, heads out to Southwest Texas.

With Texas being such a large state, these trips help bring together students from across the state and meet face to face. Ambassadors also come together during the school year for retreats and to lead educational camps for younger students.

"Water ambassadors are charged with leading the spring Lone Star 4-H Splash Camp, which is a camp that they lead over the course of a weekend," Smith said. "They're teaching younger students what they've learned and leading activities."

Along with helping others learn about water, Smith helps his students continue learning through monthly assignments and Zoom seminars to stay in touch with each other and hear from water industry professionals.

The program's leaders are regularly invited to exhibit at water industry conferences throughout the state to promote their work.

"That's an opportunity for me to invite the students in that region, or those who want to make the trip, to come and man the booth, promote the program and look for sponsors to support the program," he said. "There's a lot of face-to-face time that our students have with people in the water industry."

Ambassadors also assist county extension agents and groundwater conservation districts with running educational events.

"I think it's good that the students get to interact with other educators and see how they're teaching and all the different types of activities and educational models and things like that that they could use," Smith said.

These events help ambassadors build their skills in speaking and educating.

"Before this, I was not so much of a public speaker, but through this, I've grown much more confident speaking to others and educating them," Haines said. "I've started to really enjoy, especially with the younger groups, educating them and teaching them." ⇨

As the program has grown, Smith said, more invitations to attend events and scholarship opportunities from the water industry have become available for ambassadors.

"As the sponsorships have grown each year, we get more visibility, and we're asked to participate in more programs," he said.

The goal of all these opportunities, Smith explained, is to encourage the students to get involved in their community and connect them with local water professionals. Those connections lead to having a local mentor and possible internships.

Making connections does not end with high school graduation for some students. The two student workers who currently assist Smith are former water ambassadors, along with many of his former student workers like Calk.

"I enjoyed the program so much that when I decided to go to Texas A&M and major in ag systems management, I continued to work for the program for my four years there," Calk said. "That was really fun to be able to continue that and learn more over the years."

Justin Hill, current student worker, said that the program helped him decide his major.

"I wanted to do plant soil science, but then Mr. David had a recruiter of the ag systems management major come and talk to us about it, and that changed my major; I even changed my college for that," Hill said.

These former students being a part of the planning helps Smith ensure that the program stays relevant and interesting for ambassadors.

"They're a lot of help because they've been through the experience," he said. "They help me better connect with what the kids are looking for and what will resonate with them, especially when it comes to planning our retreats and activities."

Looking to the future

"As former ambassadors find their way into the workforce, Smith is interested to see what paths they decide to follow, water related or not.

"We're in our eighth year, so we're starting to see the first group graduating college and we're trying to see, where did they go? What program did they join? What impact did the program have on their choice of careers?" he said.

Calk is one student who found her way into the world of agriculture and uses the knowledge she learned through all her years involved with the program to connect with farmers as a program analyst for the United States Department of Agriculture Farm Service Agency.

(Top, left to right) Olivia and Abigail Clifton, 4-H water ambassadors, demonstrating the Texas A&M AgriLife Stream Trailer at Hallsville Elementary, teaching about streams and rivers, the water cycle, runoff and pollution;

Kyson Bunch and Randal Coffman assisting Michelle Cooper of the Southern Ogallala Conservation and Outreach Program at a public event;

J.D. Haines and Clay Workman at the Brazos County Water Field Day, where they led the Pipe Game Activity, showing how water towers work and the importance of pipes in transporting water to homes;

Tier II 4-H2O Leadership Academy learning about water treatment;

Roxy Islas, 4-H water ambassador, leading the "How much water is in your pizza?" activity for students at an educational event in Abilene.

"Getting a broad overview of water and agriculture in Texas helped me in my next journey," she said. "I get to see farmers every day who are utilizing conservation practices because that is their livelihood. So, it's really fun to get to see everything I've learned throughout the program be applied practically."

While not every student may want to join the water field, Smith enjoys the chance to show them the different opportunities.

"It's a lot of work, but it's pretty rewarding because kids at that age are impressionable and most of them don't know anything about the water industry and what they do," he said. "It's fun to see them broaden their perspectives and be made aware of the opportunities and things they could do after college."

As the program continues to help educate students from across the state, Smith remembers those who helped elevate the program to the success it is today.

"It's the water industry support that allows the program to happen," Smith said. "Without their support, the program wouldn't be possible. It's not just the funding they provide. They host us during the summer academies, mentor our students throughout the year, provide opportunities to get visibility out there, and get students involved in their education programs and more."

When thinking of the future of both the program and youth water education in the state, Smith hopes that people will understand the importance of programs like this and the potential youth programs hold for the betterment of everyone.

"Our youth are getting more disconnected from the origins of where their water is coming from," Smith said. "That's why people should care. Because they need the people who are making decisions and laws governing how our water is used to be educated about water."

(Bottom, left to right) Tier I 4-H water ambassadors learn about playa lakes at the Ogallala Commons Outdoor Classroom in Nazareth;

Ambassador Layla Howton leading water education presentations at a San Jacinto County Ag in the Classroom event;

Ambassador Ocean Landreneau with water samples from her monthly water testing at Bastrop Bayou;

Tier I 4-H2O Academy water ambassadors touring the San Marcos River with the San Marcos River Foundation to learn about riparian protection;

4-H water ambassador Isaiah Atoe working with his local inland fisheries office to sample a lake using electro fishing and dip nets, netting and measuring all species caught.

AgriLife Water Experts serve Texas

From east to west, Texas A&M AgriLife water professionals serve all Texans

Texas A&M AgriLife Research and the Texas A&M AgriLife Extension Service are two sides of the same coin. For more than 100 years, AgriLife Research and AgriLife Extension have improved lives in communities across Texas by delivering innovative science-based solutions and education at the intersection of health, agriculture and the environment.

From irrigation technology advancement and urban conservation to drought-tolerant crops and water-efficient turfgrasses, AgriLife Research scientists help solve water-related issues every day locally and regionally.

AgriLife Research teams and labs partner with local, state and federal agencies to move new research advances to consumer-accessible solutions as quickly as possible. They help protect rivers, streams, lakes, bays, oceans and aquifers.

In tandem with AgriLife Research's work, AgriLife Extension professionals connect agricultural producers and all Texans to research-backed solutions through educational programming on water conservation, water management, irrigation and water quality.

These research and extension teams have made it their mission to learn, test and share knowledge about agriculture and the life sciences to nourish health, strengthen communities, protect natural resources and support economies.

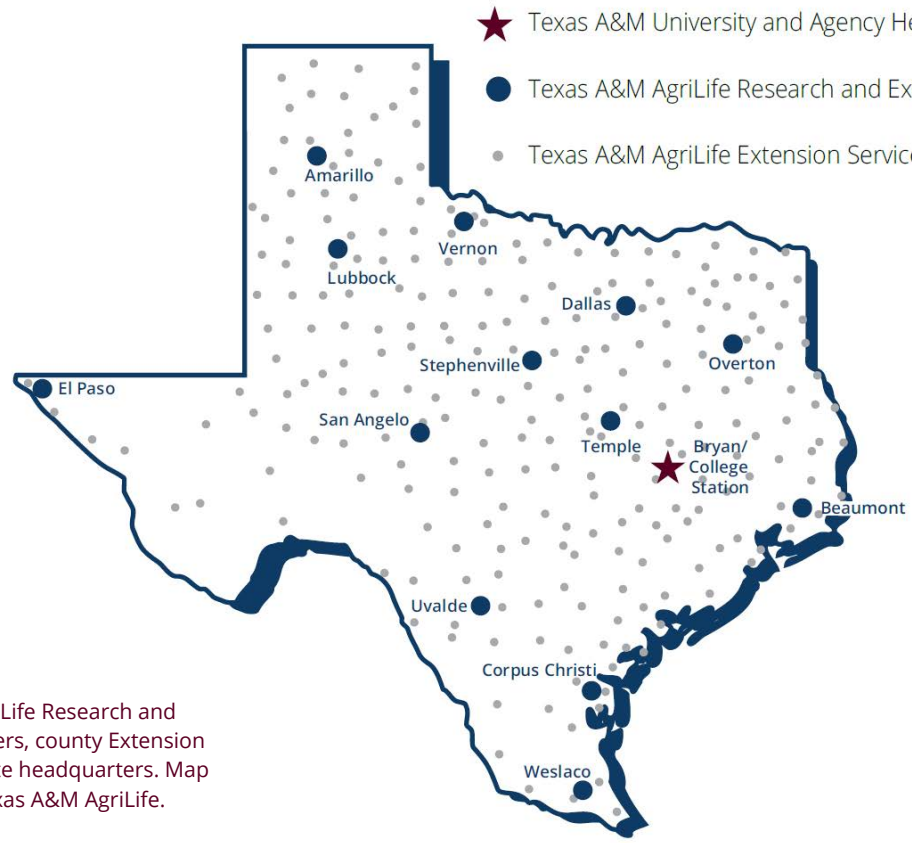
Centers help AgriLife serve the entire state

There are 13 Texas A&M AgriLife Research and Extension Centers located throughout the state. Together, the centers support a statewide network of researchers, extension agents, educators, specialists, volunteers and county officials. In addition, AgriLife Extension serves every Texas county, with offices in 250 out of 254 counties in Texas.

AgriLife researchers dedicate their careers to solving the unique agriculture and natural resources challenges facing each region. AgriLife Research and Extension also support communities when disasters strike.

Local AgriLife teams are built from the very communities they serve. This grassroots structure means Texans anywhere in the state can contact a Texas A&M AgriLife expert who is intimately familiar with emerging needs and solutions specific to their locality.

This vast network of professionals stands ready to serve all Texans right where they are, adapting to meet the needs of the citizens and the land.



Texas A&M AgriLife Research and Extension Centers, county Extension offices, and state headquarters. Map provided by Texas A&M AgriLife.

Texas A&M AgriLife water programs at centers across Texas

The Panhandle

Texas A&M AgriLife Research and Extension Center at Amarillo

In Amarillo, water programs focus on irrigation water management and water-limited forage production.

With declining groundwater availability from the Ogallala Aquifer, researchers at Amarillo emphasize best practices for reliable crop production in dry climates using limited irrigation or rain-fed conditions.

In the Panhandle, scientists evaluate cropping system contributions to the carbon, water, and ecological footprints of regionally adapted agricultural systems. They also evaluate the region's potential for high-value specialty crops, where limited irrigation water can be focused on smaller acreages that preserve or increase farm profitability.

Amarillo's Cropping Systems for Semi-Arid Climates research program includes water-related goals such as: advancing the water-use efficiency of irrigated crops, advancing the sustainability of dryland and rain-fed crops, evaluating strategies to improve soil health under agricultural production, advancing the profitability of forage crops for regional beef and dairy production, and expanding the applicability of controlled-environment agriculture.

South Plains Region

Texas A&M AgriLife Research and Extension Center at Lubbock

For more than 100 years, the center at Lubbock and its satellite research stations have addressed key issues for Southern High Plains producers. Today the center's scientists focus on crop production, plant breeding, and water-use practices.

Researchers at Lubbock work with other Texas A&M AgriLife units and federal, state, and international collaborators to conduct research in sensor and digital imaging-based data for specific crop variety-soil-water interactions. They are optimizing the use of water in crop production, evaluating regenerative agriculture, studying produced water uses for agricultural production and evaluating water-conserving irrigation systems. Lubbock scientists are working to develop or improve irrigation software tools, and they are also using combinations of soil, plant, UAV, and environmental-based sensors for the development of irrigation management tools for specific crop varieties and hybrids, soil health and water management.

Lubbock scientists work to meet the regional need of improving water use efficiency for sustainable crop production and rural economic development. They are developing high-yielding and disease-resistant corn, cotton, grain sorghum, and peanut germplasm that are also drought, heat and salt-tolerant. They anticipate regional producers' need for science-based guidance on transitioning farmland from irrigated to rainfed row-crop agricultural production. ⇨

Rolling Plains Region

Texas A&M AgriLife Research and Extension Center at Vernon

In Vernon, researchers develop and evaluate climate-resilient, regenerative agricultural strategies for conserving soil and water. They aim to enhance crop water productivity and protect soil and water quality in diverse agroecosystems. Scientists use hydrologic, ecosystem, and crop growth models and data analysis approaches to achieve their research goals.

Major focus areas in crop and rangeland settings include: assessing hydrologic and environmental impacts of changes in land use and management; improving crop water use efficiency and development of irrigation decision support tools; assessing climate change impacts on crop production and evaluation of adaptation strategies; improving soil health and enhancing ecosystem services; and characterization of groundwater quantity and quality.

The Environmental Soil Science Program at Vernon contributes expansive and diverse research experience evaluating the impact of climate-smart agricultural approaches on soil improvement, water quality, carbon sequestration, greenhouse gas emissions and overall soil and environmental health.

The goal of the Environmental Soil Science Program is to cultivate best management practices that improve overall soil health and function. This creates a resilient agricultural production system that protects water resources while maintaining agronomic and economic viability under changing climatic conditions.

North Region

Texas A&M AgriLife Research and Extension Center at Dallas

More than 80 percent of Texas' residents live in urban environments. The Texas A&M AgriLife Research and Extension Center at Dallas, located in the heart of the Dallas–Fort Worth Metroplex, focuses on increasing the sustainability of urban living through its internationally recognized research and outreach initiatives.

The center's programs address the preservation and wise use of critical resources through the development of urban food production through controlled environment systems or controlled environment agriculture (CEA), water-efficient turfgrasses, technologies for low-impact development, stormwater management, water conservation, and healthy human living. The turfgrass breeding team continues to develop new cultivars aimed at increasing water use efficiency and heat tolerance. The center's water and land resource team leads the nation in developing water use management strategies, increasing sustainability and ensuring water availability for the next generation of Texans.

East Region

Texas A&M AgriLife Research and Extension Center at Overton

In Overton, research focuses on Forage-Based Beef Cattle Production Systems and Horticultural Production. Researchers conduct their work on agricultural topics pertinent to the East Texas ecosystem.

The center at Overton includes an AgriLife Extension Pond Management Program to provide educational programming and address questions, comments, and concerns from communities managing ponds, fish, pond plants and anything else pond- or lake-related.

Far West Region

Texas A&M AgriLife Research Center at El Paso

The Texas Water Resources Institute and scientists of the center at El Paso study transboundary aquifers alongside water institutes in New Mexico, the U.S. Geological Survey and the International Boundary and Water Commission. El Paso also shares aquifers with New Mexico across the state line and is planning to transfer groundwater from other basins in Far West Texas. Such complex configurations of shared water resources create opportunities for scientific research, technical innovation, and institutional reform.

El Paso is a rapidly growing city of 900,000, the 5th largest in Texas. Located in the Chihuahuan Desert, the region receives an average of 8 inches of precipitation each year. Just across the border is Ciudad Juarez, with a population of 1.4 million, making it one of the largest border cities in the world. Water is the most important resource needed to sustain the region's economy, population, quality of life and environment. Tremendous and justified concern surrounds the availability, quality, allocation, and cost of local water resources. Both cities rely upon the same two aquifers for water.

Scientists at El Paso lead research in integrated water resources management; water and soil salinity management; watershed hydrology; river operations and aquifer development; district delivery and irrigation efficiency; water value, pricing and water-use efficacy; reclaimed water use; urban landscape water conservation; and public health nutrition.

The Far West Region is unique in climate, water resources, demographics and institutional jurisdictions, and it shares many issues that will challenge other regions of Texas and the world in the future.

West Central Region

Texas A&M AgriLife Research and Extension Center at San Angelo

In the West Central Region, Texas A&M AgriLife Research's mission is to develop ranching solutions. To accomplish this mission, scientists develop technologies to improve the efficiency of livestock and wildlife production and the ecological condition of rangelands. Research takes place at the center in San Angelo and its satellite stations near Sonora, Ozona, Menard and Carlsbad.

The center at San Angelo leads West Central Texas producers through innovative research and technology transfer to optimize regionally specific agricultural practices, enhance natural resources, and improve environmental, economic, and social networks. Research at San Angelo will continue to improve native rangeland health, understand and mitigate climate change, sustain agricultural productivity, and enhance wildlife habitats. Rangeland research programs focus on long-term rangeland health, environmental impact, and sustaining agricultural production within energy production sites like solar and wind farms.

The research staff's responsibility is to develop new technology and strategies to improve the management of range livestock, wildlife and the native range itself. Research under the scope of the center at San Angelo takes place at the Sonora Research Station in Sutton and Edwards counties, the Read Ranch in Crockett County, and the Carl & Bina-Sue Martin Research Ranch in Menard County. Researchers collaborate with Angelo State University and with landowners on area ranches.

Central Region

Texas A&M AgriLife Blackland Research and Extension Center at Temple and Texas A&M AgriLife Research and Extension Center at Stephenville

Local watersheds have been impacted by microbes and nutrients used intensively in agricultural production. Texas A&M AgriLife scientists respond by developing sustainable production systems to decrease contaminants or eliminate agricultural inputs of nitrogen, phosphorus, microbes and pharmaceutical products in local rivers and streams. Researchers are also developing new methods for microbial detection to identify and quantify microbial pathogens in waterways rapidly, potentially saving time and expense for regulatory agencies that monitor biological pollutants.

Scientists at the Blackland center at Temple are improving the region's water and soil quality with research and new technologies that enable improved decision-making regarding land and water management.

Agricultural, municipal, industrial, and private users all compete for limited water resources in the region. As populations grow and water sources shrink, addressing how water resources are developed and protected exerts dramatic environmental and economic consequences. Detrimental effects must be minimized through efficiency and innovation to provide both water quality and quantity for future generations. The Water Science Laboratory (WSL) at Temple develops and applies new technologies to improve water management systems.

The center at Temple shares research facilities with the Grassland, Soil and Water Research Laboratory (GSWRL) of the United States Department of Agriculture Agricultural Research Service (USDA-ARS). AgriLife Research and ARS scientists have worked cooperatively in Temple for over 80 years. Regional research programs also include scientists from the USDA Natural Resources Conservation Service (NRCS), who are co-located at GSWRL with ARS.

In Stephenville, center researchers are studying best practices for restoring native grassland plant species, cultivating dual-purpose forage and growing bioenergy crops. Experts also study dairy industry production and environmental impacts extensively, as well as organic fruit and vegetable production.

The Riesel Research Center in the Riesel Watershed in the Texas Blackland Prairie has provided valuable information to the water resource community for more than 70 years, making it the longest continuously monitored hydrologic research site in the country. Research programs include hydrologic systems computer modeling and water quality monitoring.

Southeast Region

Texas A&M AgriLife Research and Extension Center at Beaumont

In Beaumont, scientists' goal is to develop and implement production and management approaches and innovations that enhance rice production's economic, environmental, and social sustainability at a local, national and international level. They're ultimately working to improve national and international food security.

The center at Beaumont works to quantify the impact of water and fertility management practices in rice, study climate-smart rice production, and evaluate alternative wetting and drying (AWD) irrigation practices.

Southwest Region

Texas A&M AgriLife Research and Extension Center at Uvalde

This area of South Texas is also known as the Wintergarden due to a mild climate that allows year-round agricultural production. Characterized by a historically stable and diverse agricultural economy dominated by irrigated high-value specialty crops, rotational systems with field and vegetable crops, and ranching and wildlife enterprises, the research goals at Uvalde encompass important water-related elements. Projects at Uvalde focus on developing and testing emerging technologies for environmental pathogen detection and improving soil productivity and quality with optimized irrigation volume and timing.

Uvalde scientists are optimizing water use in crop production by quantifying root water uptake of current cotton varieties and updating cotton crop coefficients for the Wintergarden Region. They are also working to determine seasonal water use of sesame cultivars in southwest Texas, and researchers are utilizing high-throughput data from the ground-based sensing system to characterize drought tolerance in cotton, wheat, corn, and sorghum genotypes. Monitoring soil water status in onions, another research team is improving water-use efficiency and reducing root disease.

Coastal Bend Region

Texas A&M AgriLife Research and Extension Center at Corpus Christi

The vision of AgriLife Research at the center at Corpus Christi is to excel in the creation of novel technologies in plant and animal agriculture, aquaculture and natural resources to benefit stakeholders in the Coastal Bend region of Texas and beyond. Corpus Christi researchers are achieving their goals using advanced technology, such as remote sensing tools, to characterize crop performance and grasslands as affected by biotic and abiotic stresses. They employ data-driven tools for precision crop management systems using remote sensing data. This includes both unmanned aerial systems, or drones, and satellites, digital twins, and artificial intelligence; state-of-the-art tools for genotyping and phenotyping species relevant to Texas aquaculture; satellite-based in-season prescription management systems; and assessing crop health using remote sensing images.

South Region

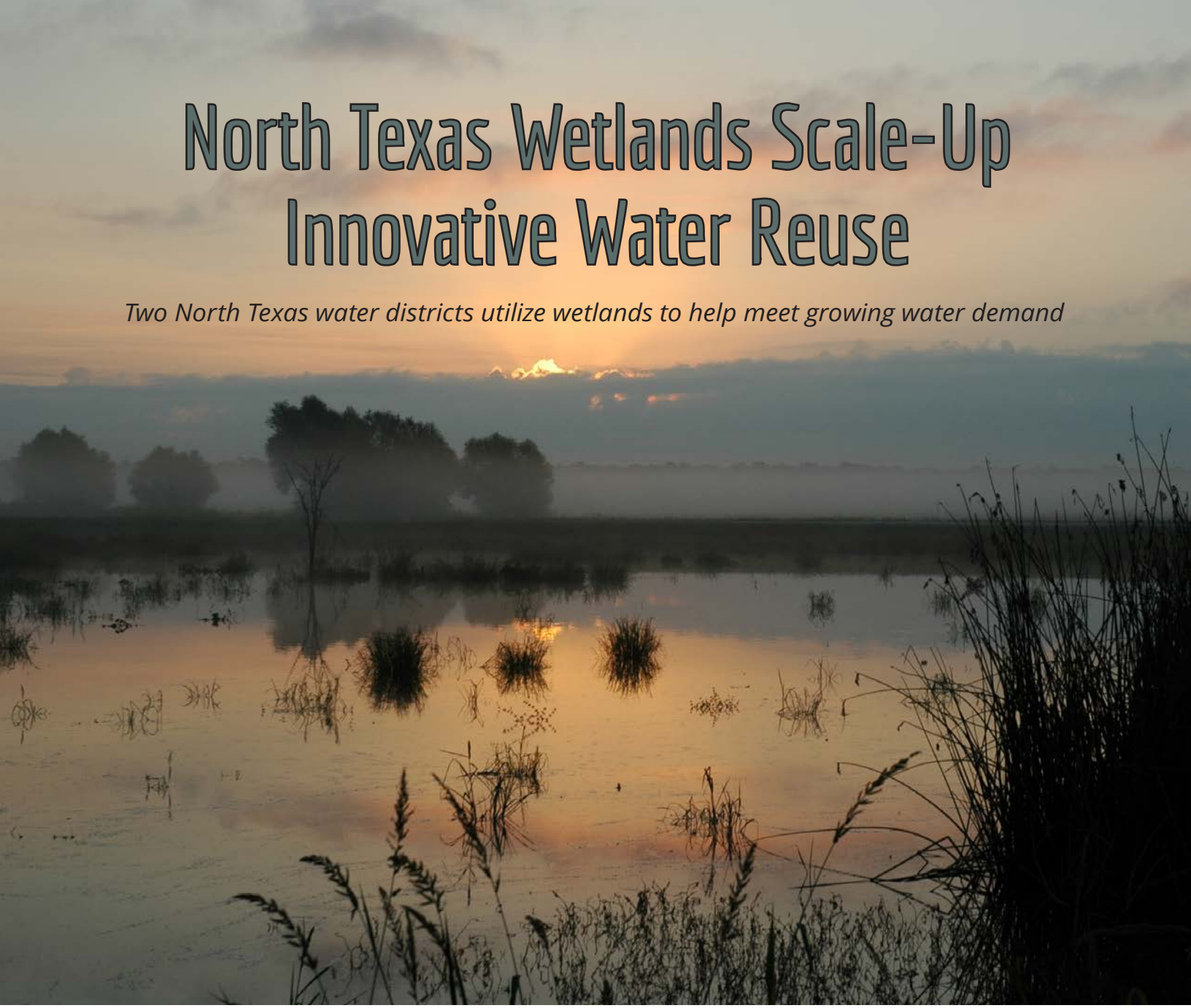
Texas A&M AgriLife Research and Extension Center at Weslaco

Weslaco researchers work to develop improved plants, plant products, and production systems that enable sustainable use of limited resources to optimize productivity and enhance the health, economic well-being, and quality of life of constituents throughout the Lower Rio Grande Valley. Research projects include the development of irrigation management and fertigation tools; studies using limited water supplies, saline, and wastewater to sustain crop productivity; combining crop simulation models and remote sensing tools to improve management strategies using saline water, wastewater, and deficit irrigation strategies; and evaluating the use of satellites and UAS applications to select best management practices in different cropping systems.

For almost 20 years, the Arroyo Colorado Watershed Partnership has improved water quality in the South Region. An innovative gathering of federal, state, and private organizations, the partnership works to improve watershed health and integrate watershed management in the Arroyo Colorado Watershed. Their goals include the interrelated issues of water quantity (supply), water excess (flooding and drainage), habitat, and water quality, particularly concerning runoff pollution.

North Texas Wetlands Scale-Up Innovative Water Reuse

Two North Texas water districts utilize wetlands to help meet growing water demand



As Texas grows in population, the need for alternate water supply sources grows with it. The Dallas-Fort Worth metroplex has experienced a large increase in new residents and is projected to gain even more in the next decades.

For the North Texas Municipal Water District (NTMWD) and Tarrant Regional Water District (TRWD), part of the solution to meeting these increased water demands is manmade wetlands.

TRWD operates the George W. Shannon Wetlands Water Reuse Project in partnership with the Texas Parks and Wildlife Department (TPWD). At 2,200 acres, the facility is located at the East end of Richland-Chambers Reservoir.

76 miles to the northwest, the East Fork Water Reuse Project is operated by NTMWD on the East Fork Wetlands.

"For us, one of the key things is that the river is dependable because you're always going to have people using water that then goes into the river," said Darrel Andrews, director of the Environmental Services Division at TRWD. "Unlike reservoirs that are dependent on rainfall, water is always going to be coming down the river, so its resiliency is of the utmost importance for us."

These wetlands are part of the water reuse cycle, the practice of reclaiming water from a variety of sources, treating it and reusing it for beneficial purposes, according to the EPA.

The George W. Shannon Wetlands at Richland-Chambers Reservoir. Photo courtesy of Darrel Andrews, Tarrant Regional Water District.

How the system works

Both water districts use the Trinity River as their wetlands' source.

"TRWD captures the water that hits these watersheds and pumps that water back upstream, uphill into the metroplex and it gets used." Andrews explained, "It gets sent to a wastewater treatment plant and cleaned, and then it goes back to the river, then flows all the way back down close to the two reservoirs and the wetlands."

The wetlands play a crucial role by cleaning out high sediment and nutrient loads from the river that could pose issues to the health of the reservoirs.

"High sentiment loads are going to fill the reservoirs up faster," Andrews said. "The quality issue is called unification; it's the process of the reservoir getting older and things like algae blooms make it harder to treat the water for our customers."

Being able to reliably pull water from the Trinity River also helps ease the stress from potential drought conditions.

"In the water world, we plan for a drought of record scenario when we plan for water supply," said Galen Roberts, NTMWD director of water resources. "We use the term reliable supply when referring to the volume of run-of-the-river supplies we can reliably divert in a drought of record scenario."

NTMWD estimates that they can divert around 45 million gallons per day out of the Trinity's East Fork in a drought of record scenario, he mentioned.

History of the George W. Shannon Wetlands

"We began to look at wetlands in 1992, and it was really an unknown technology," Andrews said.

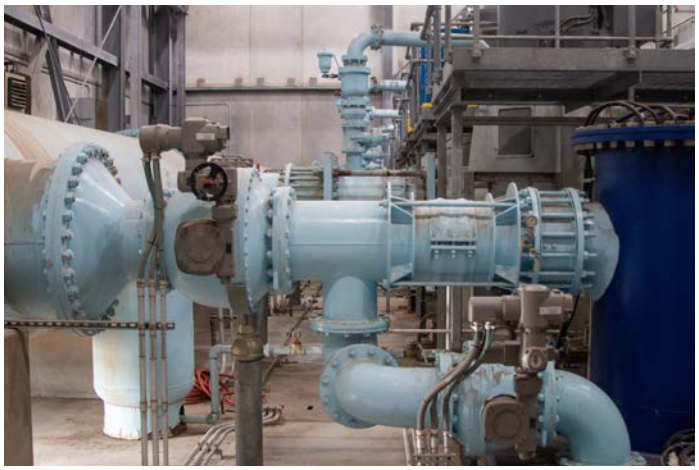
An ibis at the George W. Shannon Wetlands. Photo courtesy of Darrel Andrews, TRWD.

TRWD tested the proposed wetland-based water reuse system on a smaller, two-and-a-half-acre property for eight years to ensure that it would work. Once the wetlands proved a success, they went to the TPWD to collaborate and scale up the project.

"We went to them and said, 'Hey, we want to do this on a bigger scale. We'd have room on your wildlife management area. Could we enter into an agreement with you guys that would benefit both of us?'" Andrews said.

Using the 5,000-acre property that TPWD operates next to Richland-Chambers Reservoir, construction began on creating the manmade wetlands system, and it was completed in 2013. The project now produces around 190 million gallons of water a day. TRWD plans to develop a new manmade wetlands water reuse system in Cedar Creek, Andrews said. ⇨

A sedge of egrets in the George W. Shannon Wetlands. Photo courtesy of Darrel Andrews, TRWD



(Top) Stages of the water reuse cycle at the East Forks Water Reuse Project. Photos by Cameron Castilaw, TWRI.

(Bottom) The East Forks Wetlands. Photo by Cameron Castilaw, TWRI.

Origins of the East Fork Water Reuse Project

The vision for NTMWD's manmade wetlands took shape over the course of decades, starting in the 1980s with the original landowner, John Bunker Sands. He envisioned a wetland system with the complementary goals of providing nesting and wintering habitat for migratory birds and conserving water.

The East Fork Water Reuse Project eventually began in 2004 through a public-private partnership between NTMWD and John Bunker Sands (i.e. the Rosewood Corporation). The project opened for operation in 2009 and is now the largest manmade wetland in the United States.

"We the district were, in the years leading up to that, looking for additional water supplies; we were growing quickly," Roberts said.

A common contact brought the namesake of the wetlands, John Bunker and NTMWD together to create and design the wetland system. The partnership also led to the establishment of the John Bunker Sands Wetland Center; an independent non-profit organization located in the heart of the East Fork Wetlands.

"NTMWD ultimately purchased the property outright, but as part of the design process and conceptualizing, we not only thought about water supply and the function of the wetlands but also having it to leverage it for education and outreach purposes," Roberts explained. "That's what led to the creation of the John Bunker Sands Wetland Center."

The system pumps water from the East Fork of the Trinity River into the wetlands, and after water makes its way through the wetlands, it is pumped through a 42-mile pipeline to Lavon Lake.

"It takes approximately 11 days for the water to travel through the wetlands," Roberts said. "During that time, plants, sunlight and natural processes treat the water and improve the quality of the water before it is pumped to Lavon Lake and subsequently used for drinking water supply."

Why manmade wetlands matter

Conservation and education are important parts of both wetlands, with different approaches.

"Because the property that we built the wetland on is owned and managed by Parks and Wildlife, of course, they're going to allow hunting and other types of recreation on the property," Andrews said.

The public is also able to visit the John Bunker wetland, and its visitor center offers outreach and education. Having access to these properties and hands-on learning experiences with wetlands helps people understand the importance of such projects for ensuring future water resources.

"People turn on the tap, and it's just there," Andrews said. "And so, it's a resource that is really important, but until you understand where it's from, and you really get an idea that it's a limited resource, it's easy to take for granted."

As Texas continues to grow, manmade wetlands and water reuse projects like these offer one way to meet growing water demand in creative, environmentally beneficial ways.

"There's no silver bullet strategy out there," Roberts said. "It's going to take a combination of strategies to continue to meet the needs of the state and the needs of North Texas in terms of our supply, and reuse is a critical part of that strategy. Innovative strategies like reuse and conservation are going to continue to be a cornerstone of the water supply strategies for North Texas Municipal Water District and increasingly for others around the state."

10 Big Water Problems, 10 Big Teams

These 10 state-funded research projects are advancing Texas water

The water problems facing Texas are as diverse as the state's vast landscape, and many involve information gaps and research questions difficult for singular academic departments or research labs to solve.

That's where multidisciplinary teams come in.

In early 2023, Texas A&M AgriLife Research and the Texas Water Resources Institute (TWRI) released a call for research proposals from dynamic teams tackling future-minded Texas water problems. Each project team was required to include at least one representative from each of these Texas A&M University System agencies: Texas A&M AgriLife Research, the Texas A&M AgriLife Extension Service, and the Texas A&M Engineering Experiment Station (TEES).

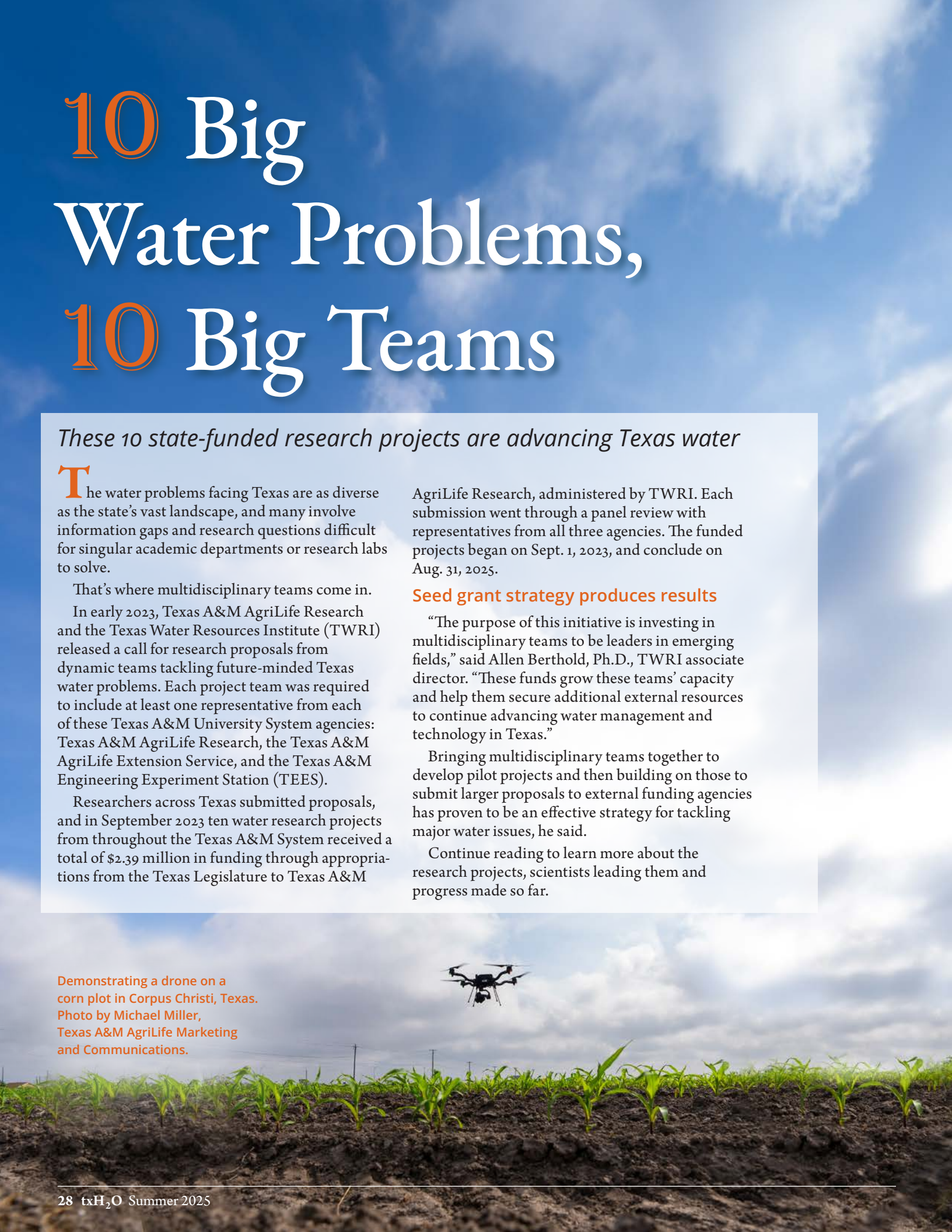
Researchers across Texas submitted proposals, and in September 2023 ten water research projects from throughout the Texas A&M System received a total of $2.39 million in funding through appropriations from the Texas Legislature to Texas A&M AgriLife Research, administered by TWRI. Each submission went through a panel review with representatives from all three agencies. The funded projects began on Sept. 1, 2023, and conclude on Aug. 31, 2025.

Seed grant strategy produces results

"The purpose of this initiative is investing in multidisciplinary teams to be leaders in emerging fields," said Allen Berthold, Ph.D., TWRI associate director. "These funds grow these teams' capacity and help them secure additional external resources to continue advancing water management and technology in Texas."

Bringing multidisciplinary teams together to develop pilot projects and then building on those to submit larger proposals to external funding agencies has proven to be an effective strategy for tackling major water issues, he said.

Continue reading to learn more about the research projects, scientists leading them and progress made so far.



Demonstrating a drone on a corn plot in Corpus Christi, Texas. Photo by Michael Miller, Texas A&M AgriLife Marketing and Communications.

1 Enhancing corn water-use efficiency through integration of sensor, crop model and machine learning-based approaches

Principal investigator (PI): Srinivasulu Ale, Ph.D., AgriLife Research, Vernon.

Co-PIs: Qingwu Xue, Ph.D., AgriLife Research; Thomas Marek, Ph.D., AgriLife Research; Chukwuzubelu Ufodike, Ph.D., TEES; Jourdan Bell, Ph.D., AgriLife Extension.

In Texas' Northern High Plains, corn is a key crop, and enhancing corn water-use efficiency is increasingly important, Ale said. The region faces declining Ogallala Aquifer groundwater levels, recurring droughts, and anticipated warmer and drier weather conditions. This research team is pursuing an integrated approach, combining sensor technology, a crop model, and machine learning to optimize irrigation management and increase corn yield while conserving water resources.

By developing a deep learning machine model that utilizes crop sensor data, unmanned aerial vehicle data, and Decision Support System for Agrotechnology Transfer cropping system model outputs, the team aims to increase regional water-use efficiency and crop productivity. They use wired and wireless sensors that monitor sap flow, plant health, canopy temperature and soil moisture.

The corn field experiment at Bushland is collecting planned sensor output and performance data, plant growth performance measurements, and irrigation event monitoring. The data from ongoing and past corn field experiments will be used to develop crop-growth-stage-based efficient irrigation strategies for the study region.

2 Advanced irrigation management system guided by remote sensing and artificial intelligence

PI: Craig Bednarz, Ph.D., AgriLife Research, Amarillo.

Co-PIs: Nick Duffield, Ph.D., TEES; Mahendra Bhandari, Ph.D., AgriLife Research; David Parker, Ph.D., AgriLife Extension.

Scheduling and managing irrigation decisions in Texas can be incredibly complicated. Bednarz and team are developing an unmanned aerial system (UAS)-based crop monitoring system that calculates crop water use for irrigation scheduling and increased water-use efficiency. They're using big data analytics and artificial intelligence on the UAS-derived phenotypic data and infield weather data to calculate actual crop evapotranspiration, biomass accumulation, and determine the timing and quantity of irrigation water needed.

They hypothesize that quantifying crop canopy cover accurately and in a timely manner should significantly improve irrigation efficiency.

The researchers are working to establish an empirical relationship between remote sensing-derived canopy features and crop coefficient, and then identify the remote sensing-based canopy vegetation index that provides the best efficiency. They'll then develop and validate an irrigation scheduling approach that uses those crop coefficients and canopy efficiency estimates. To make their results publicly accessible, they plan to develop a web-based digital portal called "AIMS" integrating imagery and models for use as an irrigation scheduling system.

Conducting field studies in Corpus Christi, Lubbock and Bushland, they are measuring crop water use, biomass accumulation, and a suite of drone-derived crop data. In 2024 the team was collecting UAS, yield, irrigation and soil moisture data from the Bushland and Lubbock locations.

3 A risk-based approach to mobilize South Texas communities for groundwater management and water quality

PI: Susie Dai, Ph.D., formerly AgriLife Research, College Station.

Co-PIs: Garrett McKay, Ph.D., TEES; Joel Pigg, AgriLife Extension; Omar Montemayor, AgriLife Extension.

**Note: This project's proposal was for a smaller support grant, for 1 year of funds.*

Groundwater arsenic contamination in the Southern Gulf Coast Aquifer presents a critical public health concern. Estimates show that about 4 million Texans rely on the public water supply that contains more than 5 parts per billion (ppb) arsenic, Dai said, and approximately 180,000 people drink water containing more than 10 ppb arsenic, the maximum containment level in Texas.

This team is conducting arsenic groundwater contamination testing, modeling, human biomonitoring, education and outreach in the Texas-Mexico border region. Combining risk-based arsenic sampling, testing and citizen science strategies, they are mobilizing communities, promoting drinking water quality awareness and providing filters.

Texas A&M AgriLife Extension Service agents and specialists have established local networks in these communities. At events for AgriLife Extension's Texas Well Owner Network program and Healthy South Texas program, Dai's team recruits participants and then sends them water sample kits. If the kit analysis results show high arsenic levels, the team helps residents access personal arsenic exposure testing.

The project screened 429 residential water samples in 2022-2023. Arsenic does not present uniformly across the region but instead in specific hotspots, and in 2023, they identified high-risk regions in Starr County. In 2024, the team tested commercially available filters to identify those most effective at removing arsenic and then began distributing filter pitchers to households needing them. The team also conducted a community-based survey measuring water quality perceptions, water treatment and testing options.

"We want to give these residents solutions, not just leave them hanging," Dai said. "Forming local coalitions with AgriLife Extension on the ground is proving very effective." ⇨

4 Climate-smart alternate wetting and drying rice production

Principal investigator (PI): Fugen Dou, Ph.D., AgriLife Research, Beaumont.

Co-principal investigators (Co-PIs): Xingmao Ma, Ph.D., TEES; Jake Mowrer, Ph.D., AgriLife Extension; Terry Gentry, Ph.D., AgriLife Research.

Rice is critically important to the global food supply chain and is the staple crop for most people on Earth. Texas A&M System scientists are working to find more sustainable rice production techniques.

Alternate wetting and drying, or AWD, is one of the emerging water management practices for rice production, but AWD has not yet been extensively researched in Texas. Based in Beaumont, Dou and his research team are developing a climate-smart AWD rice production system by experimenting with various degrees of AWD application, on different soils, in multiple growing seasons. They are also measuring the effect of AWD on arsenic and cadmium uptake in rice production. "For paddy rice, flooded soil conditions favor arsenic update more than in upland crop conditions," Dou said. "Not all arsenic has a health concern; currently only inorganic arsenic does."

In the fall of 2024, the AWD rice trials continued to show promise, and the research team shared the preliminary results with rice producers during the annual rice field days at the Eagle Lake Station and Texas A&M AgriLife Beaumont Center. They measure rice yields from AWD fields and control fields, extract soil samples for RNA sequencing and soil health analysis and collect weekly greenhouse gas samples.

5 Projection of hydrologic intensity duration frequency parameters and their uncertainties based on climate projections for 21st century in the state of Texas

PI: Bardia Heidari, Ph.D., AgriLife Research, Dallas.

Co-PIs: Fouad H. Jaber, Ph.D., AgriLife Research; Nicholas G. Duffield, Ph.D., TEES.

The frequency and intensity of extreme precipitation have been changing globally, including in the United States and in Texas. Heidari and his team are developing an array of traditional statistical methods and machine learning models to update the intensity-duration-frequency (IDF) curves for modeling predicted precipitation in Texas for the next 80 years. They are working to downscale, bias-correct, disaggregate the projected precipitation values, and quantify uncertainties, for the next 80 years.

The significant ecoregion variability across Texas also makes precipitation modeling extremely difficult.

The results from this study will improve flood planning and disaster response for the state. They also plan for the method to be scalable and transferable to other locations, enabling the scientific community and engineers to better adapt to future rainfall patterns.

Without bias-correction, the intensity of extreme precipitation value would be heavily underestimated, Heidari said, and the team made major progress processing such data in fall 2024. So far, as the team has tested and compared models, they have found that the Prophet model, an open-source software that is a procedure for forecasting time series data based on an additive model where non-linear trends are fit with yearly, weekly and daily seasonality, has outperformed the other tested time-series methods, Heidari said.

6 Satellite remote sensing for agricultural water system management in Texas

PI: Zong Liu, Ph.D., AgriLife Research, College Station.

Co-PIs: Huilin Gao, Ph.D., TEES; Jennifer Spencer, Ph.D., AgriLife Extension.

Texas is currently the 4th-most-dairy-producing state in the country. Dairy producers contribute both economically and environmentally, managing major amounts of manure and working to protect local water quality.

Because manure management does contribute to greenhouse gas emissions and can be a source of water quality impairment, Liu said, researchers are using emerging technology to improve management tools. His team is testing satellite remote sensing for animal wastewater monitoring and automatic pond mapping using satellite imagery.

Analyzing lagoons' color-change data from satellite imagery can help predict water quality issues. Satellite remote sensing data is already used by many scientists tackling diverse water issues, including co-PI Gao, currently leading three NASA-funded research projects monitoring reservoirs at regional and global scales.

The team is working to develop a satellite-observing framework to identify, characterize, and monitor farm lagoons in Texas; understand the relationship between satellite remote sensing data to lagoon water quality and greenhouse gas emissions; and develop a national initiative for holistic assessment of agricultural wastewater management.

They are also producing educational videos on the Texas Manure YouTube channel and providing in-person training events for producers.

7 On-site wastewater monitoring using miniaturized optical-sensing chips

PI: Pao Tai Lin, Ph.D., TEES, College Station.

Co-PIs: Anish Jantrania, Ph.D., AgriLife Extension; June Wolfe, Ph.D., AgriLife Research.

More than 6.2 million Texans rely on on-site sewage facilities (OSSF), or septic systems, of which more than 10% use aerobic treatment systems. To maintain these systems, disinfection is needed, most commonly using chlorine, and most owners rely on service providers for maintenance, typically 2-4 times per year. Malfunctioning chlorine disinfection systems may go months without detection and repair, potentially harming residents and neighbors.

Lin and his collaborators see the potential for real-time detection of inadequate OSSF discharge disinfection being improved through low-cost, in-line, accurate and compact chlorine sensors. They are developing a chip-scale water sensor to enable real-time chemical detection. Using these chlorine-specific optical sensors could lower the cost of aerobic system operation and maintenance while also protecting environmental health. The miniaturized sensors will be fabricated by semiconductor processes that enable low-cost, high-volume production, and long-term operation, he said. So far, the team has made major progress in fabricating these sensors and evaluating their performance in chlorine detection.

This project is conducting testing at the Texas A&M Mid-Infrared Integrated Photonics and Remote Sensing (MiPRoS) Laboratory and Texas A&M OSSF Research Center at the RELLIS Campus.

8 Optimizing agricultural water management: A climate-smart approach to reduce carbon intensity and harness carbon market opportunities

PI: Nithya Rajan, Ph.D., AgriLife Research, College Station.

Co-PIs: Salvatore Calabrese, Ph.D., AgriLife Research; Francisco (Pancho) Abello, Ph.D., AgriLife Extension; Nick Duffield, Ph.D., TEES.

What if we could incentivize farmers through financial compensation for implementing water conservation practices by using emerging carbon markets? Rajan and collaborators are studying the relationship between optimal irrigation practices, carbon intensity, and financial benefits.

Today in Texas, there is a significant variation in the application efficiency of different irrigation methods, Rajan said. In Texas, sprinkler irrigation covers approximately 78% of the irrigated land, and application efficiency ranges from 60-95%.

This project aims to answer critical questions about the impact of different irrigation systems' impacts on greenhouse gas emissions from large-scale crop production, such as cotton in Texas. For an irrigation practice to be climate-smart, overall greenhouse gas emissions need to decrease, Rajan said.

Rajan is currently leading several other multimillion-dollar climate-smart agriculture research initiatives, and this pilot project complements those efforts. "Generating data through this seed grant project will enable us to demonstrate that irrigation management could also be eligible for these climate-based markets, providing additional income to farmers," she said. "However, currently, there is no existing data to support this claim. To position ourselves to advance water management in Texas, seed grants like this are necessary to test innovative ideas and generate preliminary data, establishing a successful track record of research at Texas A&M."

"This work has the potential to transform irrigation practices, benefiting farmers across Texas," she said.

9 Next generation sustainable water treatment system using engineered nano materials

PI: Velumani Subramaniam, Ph.D., TEES, College Station.

Co-PIs: Guillermo Aguilar, Ph.D., TEES; Anish Jantrania, Ph.D., AgriLife Extension; June Wolfe, Ph.D., AgriLife Research.

Subramaniam and his team are pioneering the development of a lab-scale prototype and a pilot field-scale water treatment plant designed to address critical wastewater challenges. Their approach combines advanced photocatalysis and adsorption technologies to clean and reuse wastewater effectively.

"This innovative system is envisioned to be self-sustaining, capable of operating with minimal external inputs while meeting stringent water quality standards," he said.

The targeted contaminants include heavy toxic metals, metalloids, non-metals, microorganisms, and persistent organic pollutants, such as per- and polyfluoroalkyl substances (PFAS). By leveraging nanotechnology, the project aims to deliver a cutting-edge, portable, and scalable solution to combat water pollution, Subramaniam said.

"The significance of such a system is particularly acute in Texas, where extreme weather conditions and aging infrastructure have heightened vulnerabilities in wastewater treatment," he said. "These challenges underscore the urgent need for resilient and adaptive wastewater treatment solutions, particularly in regions facing similar environmental and infrastructural stressors.

This team is exploring a variety of nanomaterials with unique properties that enhance the efficiency of PFAS remediation. Preliminary results have shown promise, demonstrating the potential of these materials to not only degrade PFAS but also to remove other pollutants effectively.

10 Scalable anti-fouling MXene quantum dots membrane-based energy-efficient water desalination

PI: Shiren Wang, Ph.D., TEES, College Station.

Co-PIs: Jingjing Qiu, Ph.D., TEES; Murthy Girisha Ganjegunte Keshava, Ph.D., AgriLife Research; Anish Jantrania, Ph.D., AgriLife Extension.

Reverse osmosis (RO) is the most common method for desalination worldwide, but its energy consumption is very high, Wang said. His research team is developing a desalination process that uses nanostructures and consumes much less energy.

"It is crucial to make significant advancements in reducing operational pressure for achieving energy-efficient desalination while maintaining optimal performance," Wang said.

This team is developing energy-efficient water desalination through a new class of anti-fouling membranes made from the crosslinked MXene quantum dots, or MQDs, which could minimize the water flow resistance for high flux while maintaining high rejection of salt, he said. So far, they have begun the computational design of MQD membranes, and this year they are manufacturing RO membranes using MQDs, characterizing the anti-fouling properties of the as-manufactured membrane, and evaluating the desalination performance, energy consumption, and cost analysis of the proposed water purification.

Attendees learn about best practices and water monitoring tools during indoor and outdoor presentations at the Mayan Dude Ranch and along the Medina River. Photos by Cameron Castilaw, TWRI.

Short Course, LONG IMPACT

TWRI's Texas Watershed Planning Short Course teaches water professionals how to develop effective watershed protection plans

A watershed protection plan can be a daunting task, both to create and implement. With many moving parts and considerations involved in creating a plan – water quality data, stakeholder involvement, regional land use, local history, population growth, agricultural needs, regulatory limitations, local cultures and traditions – not to mention implementing it, professionals new to the process may be unsure where to even start.

For 17 years, the Texas Water Resources Institute (TWRI) has helped these water professionals learn to develop plans at the Texas Watershed Planning Short Course and through numerous other supporting events throughout the year.

The short course is part of TWRI's Texas Watershed Planning Program and was conceptualized in 2006 by former TWRI Associate Director Kevin Wagner, Ph.D., who now leads the Oklahoma Water Resources Center at Oklahoma State University.

Nikki Dictson, a former TWRI specialist, and TWRI Associate Director Lucas Gregory, Ph.D., helped Wagner develop the program, with cooperation from the Texas Commission on Environmental Quality and Texas State Soil and Water Conservation Board, which fund the program through limited U.S. Environmental Protection Agency (EPA) Nonpoint Source grants.

Creating the course

Wagner brought together a team of experts from both Texas and the United States to develop the content that became the short course.

"This was developed on the heels of EPA, who held a two-week-long watershed planning training program," Gregory said. "It was intense, but the EPA closed that program down. So, there was a big void in training availability for watershed short courses or watershed planning in general."

TWRI's class was first offered in 2008, with 43 people attending the now four-day course. Since then, the course has hosted almost 400 professionals in 14 classes.

"We've kept the content mostly the same but have refined it over the years," Gregory said. "We've taken students' feedback and trimmed some parts down, retooled things, combined presentations. We really hit the heart of what this program needs to be."

The course works through the EPA's defined six-step watershed planning process:

1. Build partnerships.
2. Characterize the watershed.
3. Set goals and identify solutions.
4. Design implementation programs.
5. Implement the watershed plan.
6. Measure and adjust.

Benefits of the course

"The short course itself focuses primarily on those first four steps and touches lightly on the last two," Gregory said. "Most content that we stripped out of the short course itself is now included in standalone training programs. Those are typically day-long events essentially just focusing on that topic."

The short course and broader watershed planning program are both focused on providing the basic tools and resources that a watershed planning professional needs to effectively develop a WPP.

Continuously evaluating and improving the course is part of what helps keep the program beneficial to those new water professionals, he said.

Bringing in professionals to share their experiences also makes the short course uniquely helpful. One of those, Tina Hendon, is now a TWRI program specialist and former EPA technical reviewer for all non-point source pollution remediation-related proposals from Texas to EPA.

"I first started giving presentations at the short course when I was at the EPA," she said. "At that time, the agency would send several nonpoint source team members to the TWRI training to meet new water professionals and deliver presentations."

Another benefit of the program is networking. The short course is offered in-person only, a deliberate choice made to encourage attendees to form connections.

"Most people stay and visit in the evenings and have the chance to really get to know each other," Gregory said. "You can have those side conversations to dig deeper into specific topics or other things."

Looking to the future

As the course nears 20 years of serving water professionals from across the United States, Gregory and Hendon work hard to keep it relevant and address emerging needs.

Educating watershed professionals new to the job is one such need. When experienced water industry professionals retire and new people are hired to fill those roles, they might lack a mentor or support system to help them learn the role and requirements. The short course meets those foundational training and mentorship needs for new water professionals.

"New professionals may not know how to actually implement a watershed planning program because they don't have those mentors," Hendon said. "When planning this most recent short course, we decided to add back in some of the more basic program aspects of water quality standards to provide that foundation for everybody."

The course also adjusts its content to new guidelines from the EPA and other agencies as needed.

"We're always adjusting, kind of reading the room, on what's being looked at and talked about at the national level," Gregory said. "And we integrate bits and pieces of that here in Texas."

That hard work was recognized in 2024 when the program received the Universities Council on Water Resources' Education and Public Service Award.

"It's nice to be recognized as having a solid program that's done a lot of good over the years," Gregory said. "It has impacted watersheds beyond just Texas, since we've had people from other states come and participate in the course and take the knowledge back."

The resulting watershed protection plans have the potential to improve water resources for all.

"Everybody benefits because everybody lives in a watershed," said Mike Bira, a retired EPA nonpoint source program manager.

"So, there's a public benefit and the wildlife benefit or nature benefit or whatever you want to call it for healthy streams and watersheds, and there is also the educational standpoint that people who understand how they live impacts water quality tend to improve their behavior, and there's less of a negative effect on water quality."

Texas Watershed Planning Short Course

2008-Present

One-of-a-kind

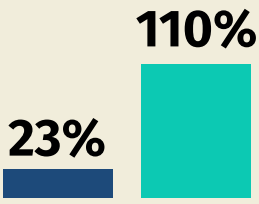
The only watershed planning educational program in the state.

Texas water contribution

In Texas alone, at least 62 watersheds have directly benefited from this course.

Knowledge transfer

Pre- and post-tests are administered to measure knowledge transfer during the course, and results indicate that students' knowledge increased between 23% and 110%.



Continued success

In **17 years**, **14 courses** have been held, training **399 students**.

Nation-wide impacts

Roughly **15%** of students to date are from outside Texas. Most are from surrounding states within EPA Region 6, and some students have come from as far away as Pennsylvania and Washington.

Texas A&M AgriLife Extension Service

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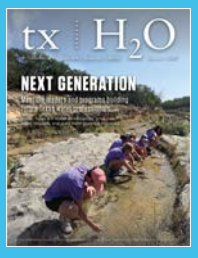

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