



UNITED

How one computer model makes Texas surface water management possible

Managing surface water supplies in Texas is complex, to say the least. Multiple state agencies work together to ensure that the thousands of miles of rivers and streams in Texas can meet both human and environmental needs, now and in the future. This daunting task would be exponentially more complicated if all parties involved couldn't speak the same language.

In Texas, that common language is a computer modeling system called WRAP, the Water Rights Analysis Package.

Developed by Dr. Ralph Wurbs, Arthur McFarland professor in the Zachry Department of Civil Engineering at Texas A&M University, WRAP is a set of computer programs that processes hydrology and water rights input files for Texas' 23 river basins and simulates the amount of water in a river and reservoir system under a given set of conditions. WRAP enables surface water managers throughout Texas to allocate water resources, plan for the future and ensure there is enough water for environmental as well as human needs.

A statewide surface water permitting system is born

Prior to the 1950s drought, different types of water rights had evolved over hundreds of years in Texas, and eventually this reached an unmanageable point, Wurbs said. State water authorities realized something had to be done. The Texas Legislature passed the Water Rights Adjudication Act in 1967, consolidating all surface water rights into one coordinated system by transforming previously held Spanish and Mexican riparian water rights and state of Texas appropriative rights into certificates of adjudication.

Of the more than 6,000 water rights in Texas, all water rights outside of the Middle and Lower Rio Grande are determined by seniority, chronologically; older permits have priority access to surface water diversions. The Texas Commission on Environmental Quality (TCEQ) now manages water rights permitting and appropriations.

"In Texas, it's 'first in time, first in right,'" said Dr. Richard Hoffpauir, engineering research associate at the Texas A&M Engineering Experiment Station, who has helped Wurbs with WRAP development for the last decade.

TCEQ is responsible for protecting water rights and ensuring that water is only diverted according to permitted levels, based on the priority date of individual water rights. ➡

Photo by Kathleen Phillips, Texas A&M AgriLife



Water must be quantified before being allocated

The unified permitting system required an integrated way to quantify and predict surface water supplies.

“The basic premise is this: To manage water resources, you need to know how much water you’re managing,” Wurbs said. “And when you look at it, you figure out it’s not just quantities, it’s reliabilities. And so, that led to the modeling system.”

“WRAP is about better understanding the water resources that are available,” Wurbs said. “If you better understand through the computer modeling system what is available, then you can better manage.”

Development of the model, first called TAMUWRAP, began in 1986 as part of a research project led by Wurbs, funded by the U.S. Geological Survey through the Texas Water Resources Institute (TWRI), with the Brazos River Authority serving as the nonfederal sponsor. Over the years, Wurbs and his team would grow WRAP into a robust set of programs able to wholly simulate development, management, control, allocation and use of the water resources of river basins.

After a major drought in the 1990s, the Texas Legislature passed Senate Bill 1 in 1997, which called for a comprehensive water management planning process and a water availability modeling system to make effective management of the surface water permit system possible.

TCEQ and other state agencies began working with Wurbs to develop the Water Availability Modeling (WAM) system, which consists of WRAP and WRAP input datasets for every river basin in Texas. The WRAP-based WAM system is maintained by TCEQ as the state’s official surface water modeling platform.

“Around 2001, I joined the hydrology team at TCEQ, and in that role, I began working with WRAP model development. The WAM datasets were being developed for river basins around the state,” said Dr. Kathy Alexander, technical specialist for the Water Rights Permitting and Availability section of TCEQ.

“In the early development of WRAP, from the early 90s through the point at which TCEQ adopted WRAP as the model that we’d use for the state, there was an incredible amount of background research involved,” she said. “That aspect, all of the research involved, Dr. Wurbs was instrumental in making it all happen.”

Although WRAP is now used for multiple purposes and at multiple agencies, such as for regional water planning at the Texas Water

Development Board (TWDB), at TCEQ it is used to process water rights permit applications. This entails determining how much water is available for a new permit, Alexander said, as well as any possible impacts it might have on existing water rights in the basin.

“If someone applies for a new water right, we have many requirements, one of which is that we have to find that the water is available, after we look at all existing water rights,” Alexander said. “A new permit can have what’s left over. And so, determining what’s left over is what we use WRAP and WAM for. It kind of is that simple, but it’s also not. There are multiple levels of complexities to the modeling.”

Part of that complex system is the prior appropriations aspect of Texas surface water management policy.

“WRAP and WAM accurately model the prior appropriations system of water rights in Texas, in which the older right gets to go first in its diversion of water,” Hoffpauir said. “Water rights created after that right are not to injure the availability of water to the older water rights. So, WRAP is very good in that it precisely models that system.”

Helping water planners speak the same language

State agencies aren’t the only ones using WRAP. River authorities, private consultants, permit applicants, attorneys — anyone and everyone who deals with water allocations in Texas uses WRAP, creating an agreed-upon, even, reliable playing field for surface water management.

While the state uses the software to permit and plan, water-minded landowners hire engineering firms or consultants to employ the predictive aspects of WRAP.

“Most people want to know about ‘what if’ scenarios — what if we have a drought, or what if I change my water rights and move them here, or what if I add some other component to my portfolio of water supplies,” Hoffpauir said. “So, just as with any modeling system, that’s what you’re trying to do: ask ‘what if’ questions and then evaluate how the system responds when you make those changes.”

“In my mind, the state of Texas is somewhat unique, somewhat of a leading example for water management nationwide, and that in itself is a contribution — to have a statewide modeling system that’s used with consistency,” Wurbs said.

“With WRAP, everyone can speak a common language,” Hoffpauir said. “It’s a common language that the technical people, the engineers and the scientists can all use to get down to the real questions that need to be answered.” ➡

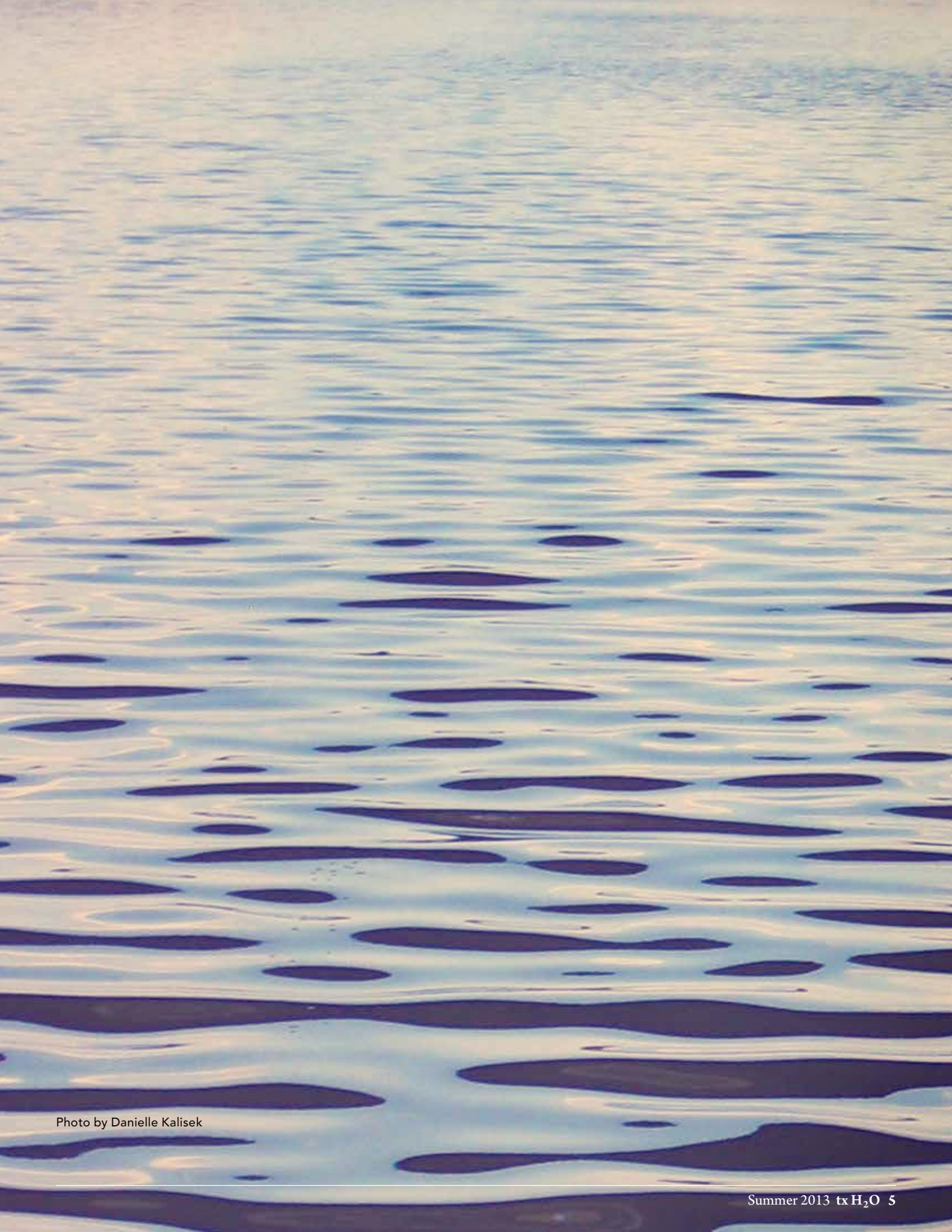


Photo by Danielle Kalisek



Uniquely transparent

“There are several aspects of WRAP that are unique,” Hoffpauir said. “For one, it is public domain — you don’t see that in a lot of other modeling efforts in other places. What you see in a lot of other places is proprietary modeling.”

Through TCEQ’s, TWRI’s and Wurbs’ websites, all components of WRAP and WAM can be accessed and downloaded for free — everything from the actual software and input datasets to years of technical reports and user manuals.

The architecture of WRAP, the way the WAM datasets are open-sourced, how anyone can modify them for their purposes, and how simple the system is to use all combine to make the WRAP/WAM system ideal for users, Alexander said.

“With WRAP, everybody is dealing with a publicly available and transparent modeling system. When you get engineers or technical folks all in a room, they don’t have to argue about the model — they can just talk about the results,” Hoffpauir said.

Collaboration fuels continual improvements

The varied users of WRAP — statewide permitting officials, regional water planning groups and individual water management entities such as river authorities — form a wider water management community in Texas that has seen greater collaboration and consistency because of WRAP.

“There is a consistency, and the advantage of the water modeling system is that it helps tie the water management community together,” Wurbs said. “The different water management functions, the coordination, the interconnection of regulatory, planning and operational functions have been tied together perhaps better than they would have been otherwise, because of the modeling system.”

Through the years, Texas A&M has housed research development of WRAP, funded in large part by TCEQ. Wurbs’ team and TCEQ have consistently listened to public and private groups who use the software, facilitating collaborative progress with WRAP.

“With WRAP, it’s a very collaborative effort, and we see the public sector and private sector and academia all coming together to evolve and improve the modeling system over all,” Hoffpauir said.

New daily model supports environmental flows efforts

In recent years, WRAP has been instrumental in enabling the state to regulate the surface water flows needed to maintain healthy river and stream ecosystems.

The Texas Instream Flow Program, mandated in 2001 by Senate Bill 2, directed state agencies to conduct scientific studies to determine how much water should flow in each river or stream to ensure

To model environmental and instream flow requirements, researchers have developed a version of WRAP that would operate on a daily time step instead of a monthly time step.
Photo by Danielle Kalisek.

a healthy environment. Passed in 2007, Senate Bill 3 created a process for the state to establish environmental flow standards, considering the best available science and future human water needs for Texas' river basin and bay systems.

Based on recommendations from stakeholders and scientists, TCEQ will adopt environmental flow standards for each of the basin and bay systems named in the legislation. TCEQ has adopted environmental flow standards for the Sabine and Neches rivers and Sabine Lake Bay; the Trinity and San Jacinto rivers and Galveston Bay; the Colorado and Lavaca rivers and Matagorda and Lavaca bays; and the Guadalupe, San Antonio, Mission and Aransas rivers and Mission, Copano, Aransas and San Antonio bays.

"Some of the stakeholder teams used WRAP," Hoffpauir said. "And what they were doing was answering those 'what if' questions — what if we adopted this level of environmental flows protection that the science team recommended, what if we adopted that, then how much water would be left over for a new permit?"

WRAP is used in the initial development of environmental flows recommendations, and once TCEQ decides on final regulations, those regulations are incorporated into WAM. Effective modeling of environmental flow requirements has necessitated various additions to the WRAP/WAM system, Wurbs said, including capabilities for modeling at a smaller computational time step.

In recent years, Wurbs' research team has tackled the huge task of developing a version of WRAP that would operate on a daily time step instead of a monthly time step, as the original version had. This meant more data, more programming and more research. Hoffpauir's doctoral dissertation research provided the foundation for the daily modeling system, Wurbs said.

"One of the major reasons for the daily time step is modeling environmental and instream flow requirements," Wurbs said. "The previous version was monthly, and it's not that one version is better than the other — the intent is not to replace the monthly model with a daily model, they're just different. One of the things that the daily model can do quite well is environmental flows."

TCEQ's adopted environmental flow standards include flow regimes consisting of a variety of flows: subsistence flows, base flows and high flow pulses.

"Pulse flows are when there is a rainfall event, so we're talking about hours and days," Wurbs said. "But at a monthly time step you lose this, you really need a daily time step, and the complexities that go along with a daily time step."

"To accommodate the new environmental flows processes, we've done a lot of work within WRAP to be able to model individual pulse flow events on a daily basis," Hoffpauir said. "It's difficult, although not impossible, to model pulse flow events on a monthly basis, primarily because many of the recommendations are for pulse flow events that occur on the order of a few days to less than a few weeks."

"Simplifying assumptions are required to model pulse flow events with a monthly look," he said. "To refine the modeling results, we had to use a daily simulation while preserving all of the capabilities built originally for monthly modeling."

"It is a tremendous amount of work," Alexander said. "Texas is a really big state, so you're looking at daily flows for thousands of points and making sure that you're accurately modeling the complexities of water rights. It's a pretty daunting task, but Dr. Wurbs' team is up to the task."

In August 2012, the new, daily version of WRAP was released to the public, along with extensive new user manuals and technical reports.

WRAP keeps evolving

"The work we've been doing to get these daily time step methodologies worked out, to get the computer programs ready to implement them — it never ends," Wurbs said. "You keep making it better. And that's what was significant about August 2012 — that was when we were close enough to make it available to the water management community."

Wurbs and his team are currently working with TCEQ to develop daily flow datasets incorporating new environmental flow standards for various river basins in Texas. Research efforts for the Brazos River dataset have been completed, and they are now working on the Trinity and Colorado. TCEQ is in the process of reviewing the new daily datasets and will continue to use the monthly model in water rights permitting.

"WRAP keeps evolving," Wurbs said. "Currently the focus is environmental flows. And that's going to continue to be the focus for a while."

"Water is very important to the economic development of the state, and at the political level and the technical level, and at the agencies, people recognize that and work together. The Texas Legislature has supported it. Texas has moved out on it. The Senate Bill 1 planning process is a major step in dealing with water, and the water availability modeling system is a unique system."

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