New Waves
The Research Newsletter of the Texas Water Resources Institute
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UT Researchers Use Artificial Rainfall to Simulate Highway Runoff

Imagine this. You're driving on the Mopac highway near Austin early in the morning on a typical dry, hot, summer day. It hasn't rained in two months and there isn't a cloud anywhere in the sky. Suddenly, water starts splattering on your windshield and you turn on your windshield wipers. Then, after driving for a few hundred yards in the precipitation, you drive off and don't see rain again until the fall.

What just happened? Did you just return from a trip into the Twilight Zone? Probably not. Instead, you just wandered into an artificial rain-making machine that's part of a cooperative research project by scientists at the University of Texas at Austin, the Texas Department of Transportation, and the Barton Springs-Edwards Aquifer Water Conservation District.

The project is being conducted as part of a larger study to measure the effects of highway construction over the Edwards Aquifer recharge zone near Austin. UT researchers working on the study include Joseph Malina, Randall Charbeneau, and George Ward of the Center for Research in Water Resources.

The researchers hope that, by using the artificial rain maker, they can control the conditions which determine the types and amounts of pollutants (everything from oil, gas and antifreeze to metals, brake linings and

This rainfall simulator sprays precipitation onto Loop 1 in Austin. This was part of a research project at the Center for Research in Water Resources (CRWR) at UT Austin. The goal was to provide insights into the amount of pollutants carried by highway runoff and ways to treat that pollution.

rubber) that run off from traffic during rains and may end up polluting storm water. The simulator can be used to generate "typical" Central Texas showers with a given length, intensity, or time of day. The simulations began in May and will last for roughly a year.

To make it rain, scientists mounted sprinkler heads on top of 14 foot tripods. In a typical simulation, the rain extends for 750 feet. Water is supplied to the simulator with a system of pipes and hoses from City of Austin fire hydrants. During the first five minutes of each simulated storm, the researchers collect water samples to learn more about the "first flush" of runoff pollutants. During the rest of the hour-long studies, samples are gathered every 10 minutes. All samples are analyzed for pollutants such as suspended solids, oxygen demanding chemicals, nutrients, oil and grease and metals.

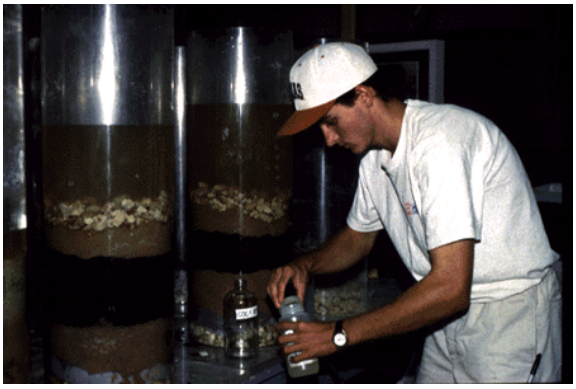
What have the researchers found out so far? Preliminary results show that many of the contaminants in the first flush are nutrients, copper, zinc and suspended solids. More suspended solids have been measured from the artificial rainfall than by "natural" precipitation. The researchers also learned not to schedule the simulations during rush hour. They tend to tie up traffic and test the patience of even the travelers who want rain the most.

For details, call Mike Barrett of the CRWR at (512) 471-0935.

UT student Ty Lehman checks the performance of this geotextile fence that is designed to trap sediments.

UT student Jeff Peters and UT CRWR research assistant Hanne Nielsen collect this water quality sample from Loop 1. These samples often contained oil and gas products and other automotive wastes.

UT student Jeff Peters collects this water quality sample from Loop 1.



This UT student prepares a "runoff" cocktail that contains different elements that are commonly found in highway runoff. It was then applied over typical geologic surfaces found in the region in these lab studies.

Relationships Between Radon 222 Levels in Groundwater and Households in Robstown, Texas

Researchers: Norma Castaneda and Thomas McGehee, Geosciences Department, Texas A&l University, Kingsville, TX.

Problem: Radon is a radioactive gas that forms when radium 226 and uranium 238 decay naturally. Radon commonly enters homes that are sited near uranium-bearing rocks. Health risks increase when radon "daughter" by-products like Polonium 218 and 214 are ingested. The Environmental Protection Agency (EPA) has developed a safe limit for radon in public drinking water of 400 picocuries per liter. High levels of radon were found in two homes that pumped groundwater for drinking water near uranium deposits at Panna Maria, TX. The EPA recommended that more studies be performed to identify the source of the radon gas and to determine if a health risk was present.

Objectives: To conduct a geochemical survey of water and air in homes in the Robstown area for radon 222; to construct maps of subsurface levels of radon 222; to determine if radon 222 is entering homes from domestic wells; and to determine if potential health risks are present.

Methodology: Samples were taken from 60 locations in the Robstown area to determine radon 222 levels in groundwater from the Goliad Aquifer. Testing was performed utilizing a sampling kit developed by EPA. However, this method was limited in that significant amounts of radon were degassed before the samples were placed in vials and some leakage occurred after they were in the vials. Indoor air samples of radon 222 were collected in 21 homes that utilize private wells and four homes that rely on public water supplies. Charcoal canisters were used to obtain indoor airborne radon levels. Other sources that contribute radon into homes such as natural gas, other sources of drinking water, house foundations, and soils were also examined.

Results: Radon 222 data from water wells and indoor air sampling were gathered and analyzed. Results were displayed on contour maps. The greatest percent of radon 222 levels in wells was between 81 and 160 picocuries per liter (pci/L). Sampling of the air inside homes showed that radon 222 levels ranged from 0 to 1.11 pci/L. Levels of radon 222 in groundwater were highest along the thickest portion of channel fluvial sands in the Goliad Aquifer, where two samples were greater than 200 pci/L. In general, the levels of radon 222 in groundwater are too low to generate enough airborne radon 222 to endanger human health .

Reference: Castaneda, Norma, *Preliminary Investigation of Naturally Occurring Radon 222 Levels in Groundwater and Domiciles in Robstown, Texas and Vicinity,* M.S. Thesis, Texas A&l University, 1990.

Pilot Plant Operations at Rolling Hills Water Treatment Plant

Researcher: Syed Qasim, Civil Engineering Department, University of Texas at Arlington, Arlington, TX.

Problem: Pilot plants are used in water treatment to optimize chemical doses, evaluate the performance of treatment processes, and reduce costs. Pilot plant operational data are also beneficial to expand the main plant in the future.

Objectives: To operate a pilot plant for 12 months to: 1) calibrate the pilot plant and simulate the operation of the City of Fort Worth's Rolling Hills Water Treatment Plant, 2) evaluate filter media, 3) conduct pre-ozonation studies, and 4) conduct training programs for the plant's water treatment operators and laboratory personnel.

Methodology: A pilot plant treating flows of 8,640 gallons per day was operated for 12 months. Numerous studies were conducted to calibrate the pilot plant, evaluate filter media, test pre-ozonation techniques, and train operators.

Results: To calibrate the pilot plant, 14 runs were conducted. Several modifications were needed to improve the performance of the pilot plant so that it could be operated in a mode to be compatible with the main plant. Dual media and deep monomedia filters were evaluated. Both media removed similar amounts of turbidity, but the dual media removed significantly more suspended particles. Neither filter removed 99% of the particles in the 4 to 20 micrometer range, which is necessary to achieve two-log removal to receive credit for disinfection. Pre-ozonation improved the turbidity of coagulated, flocculated, and settled water. The settling velocity of the floc was improved and lower doses of coagulants were required for the same amount of turbidity remaining in the settled water. The pilot plant was also used to provide hands-on training to the plant operators and treatment personnel.

Reference: Qasim, Syed, R. Frederick Stone, and Rex Miller, *Pilot Plant Operation at Rolling Hills Water Treatment Plant*, Department of Civil Engineering, University of Texas at Arlington, Arlington, TX 1992.

Use of Ozone and Biodegradation to Lessen Disinfection By-Products

Researchers: Gerald Speitel Jr. and Alicia Diehl, Civil Engineering Department, University of Texas at Austin; James Symons, and Harvey Sorensen, Civil Engineering Department, University of Houston, and Lora Cipparone, Texas Water Development Board, Austin.

Problem: Halogenated disinfection by-products (DBPs) are often produced when chlorine is used to disinfect drinking water. Because DBPs can cause cancer, they are of great concern to regulatory agencies and cities that treat drinking water. The use of ozone has the potential to replace chlorine to treat drinking water in many cases, but produces biodegradable organic matter which can lead to bacterial regrowth.

Objectives: To evaluate a wide range of ozone dosages needed to treat drinking water to determine if they lower DBP levels, and to evaluate the potential use of biodegradation to destroy DBP precursors.

Methodology: Research was conducted on Lake Austin, which typically has low levels of turbidity and total organic carbon (TOC) and Lake Houston (which usually contains much higher turbidity and TOC concentrations). Treatment plants along both lakes employ similar techniques, except for coagulation where Lake Austin uses lime and Lake Houston utilizes alum. A series of batch experiments utilized water from both lakes and different ozone doses. In the studies, the ozone was applied after coagulation and settling but before filtration. Ozone was measured before, during, and after each run. A method was modified to biodegrade ozonated water and to measure biodegradable organic carbon (BDOC). A biofilm was established on a fine gravel medium by seeding it with raw lake water and feeding it with ozonated lake water over four months. The medium was packed into a glass column and the sample was recirculated. BDOC was calculated as the difference between the TOC levels before and after the samples were recirculated for up to seven days. DBP formation potentials were determined by placing lake water in glass bottles, where it was buffered to a pH of 8 and chlorinated. Levels of trihalomethanes (THM) were determined by liquid extraction methods.

Results: Ozone removed a small fraction of the THM formation potential when low or intermediate doses were applied to water from Lake Austin. Large ozone doses produced significant levels of bromate. THMs shifted from being dominated by bromine to chlorine. Biodegrading THM precursors was somewhat dependent on ozone doses. As the ozone dose increased, THM removal improved from 20 to 30%. When waters from Lake Houston were tested, the removal of THM formation potential ranged from 10 to 15%. The amount removed by biodegradation combined with low and intermediate levels of ozone was about 20%. Unlike Lake Austin, biodegradation increased at larger ozone doses. This might be due to differences in precursor materials, background matrices, and other factors in the two waters.

Reference: Gerald Speitel, James Symons, Alicia Diehl, Harvey Sorensen, Lora Cipparone, "Effect of Ozone Dosage and Subsequent Biodegradation on Removal of DBP Precursors," *American Water Works Association Journal*, May 1993.

Environmentally Sound Alternatives to Tidal Brine Discharges in Nueces Bay

Researchers: Claude D'Unger and Jennifer Prouty, Environmental Science Program, Wes Tunnell, Center for Coastal Studies, and Gary Jeffress, Blucher Institute for Surveying and Science, Texas A&M University at Corpus Christi, Corpus Christi, TX; and Duane Chapman and Scott Carr, U.S. Fish and Wildlife Service, Corpus Christi.

Background information: For many years, the most widely used method to dispose of oilfield brines was "tidal discharge." In general terms, this consists of pumping brines into skimming pits where hydrocarbons and brine are separated. Although tidal discharge has not been prohibited in Texas, it has been banned in many states because of evidence that it leads to spills and leaks that increase the levels of salinity and toxic chemicals in coastal waters. In addition, many regulatory agencies and oil producers contend that such a prohibition is not now economical. An alternative method may be to convert from tidal discharge to salt water injection wells. Salt water disposal wells are used to inject brines

into deep geologic formations from which oil and gas were once pumped. They could improve water quality, because brines that are now being released in the Bay would be injected underground.

Objectives: To assimilate available literature on the effects of oilfield brine discharges on Nueces Bay and to determine if more environmentally acceptable methods to dispose of brines were economical.

Methodology: Tidal brine discharge sites were identified, physically located, and entered into a GIS. Background data on oil and natural gas production in the Bay were collected and analyzed so that revenue estimates could be made. This information was needed to assess whether salt water injections were economically feasible, compared to current tidal discharge practices. Information was also reviewed concerning the water quality of the Bay, the impact of brines on key species, the amount of chronic oil releases into the Bay and other issues.

Results: Review of Coast Guard records showed that more than half of the oil and brine pollution in Nueces Bay probably originates from tidal discharge operations. Study results suggest that brine waters do not mix quickly with Bay waters. This probably increases the amount of time that heavy metals and other pollutants are in contact with Bay waters and sediment. This creates anoxic conditions which cannot support benthic organisms and disrupts the food chain. The inventory of oil and gas wells in the Bay reveals that there are nearly 100 active wells that need to be plugged. Because it would cost roughly $11,000 to plug and clean up each well, the total cost could be more than $1 million. Many of these inactive wells could be converted into economically viable salt water disposal wells. Salt water injection wells should be able to receive 4,000 to 7,500 barrels of water per day.

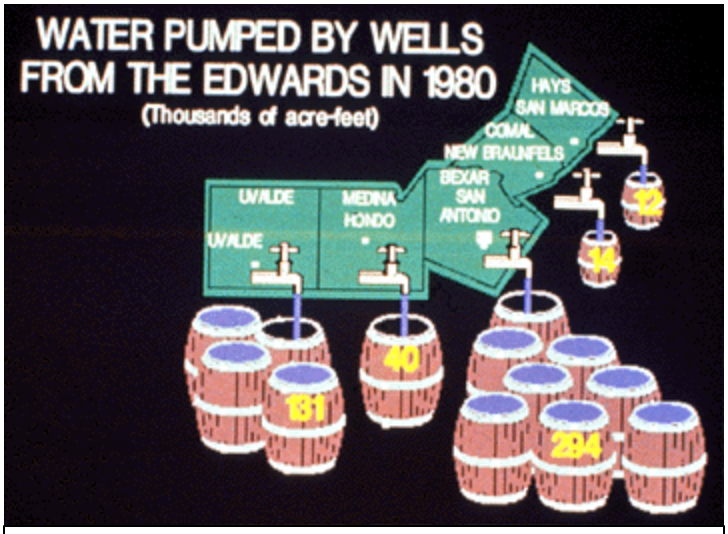
Reference: D'Unger, Claude, *An Alternative to Tidal Discharge in Nueces Bay*, Environmental Science Program Graduate Report, Corpus Christi State University, 1993.

Economic and Hydrologic Implications of Proposed Edwards Aquifer Management Plans

Researchers: Bruce McCarl and Lonnie Jones, Agricultural Economics Dept.; and Wayne Jordan, Texas Water Resources Institute (TWRI), Texas ARM University, College Station, TX; and R. Lynn Williams, Agricultural Business Dept., Sam Houston State Univ. Huntsville, TX; and Carl Dillon, Agricultural Economics Dept., University of Arkansas, Little Rock, AR.

Problem: In 1992, the Texas Water Commission (TWC) proposed plans that would, for the first time, regulate the amount of water pumped from the Edwards Aquifer. The Aquifer provides large amounts of water for irrigation and municipal uses but there were concerns that, unless a management plan were implemented, endangered species living in Comal and San Marcos Springs would be threatened. Analyses are required to define the impact of these and other management plans on groundwater levels, springflows, water prices, and agricultural production.

Objectives: To utilize computer simulation models to assess the hydrologic, economic, and water marketing impact of two plans that were proposed by the TWC to manage the Edwards Aquifer. Background Information: Two management plans were developed by the TWC. The "sector" plan proposed specific cutbacks for different water use categories. For example, when water levels in an index well at San Antonio fell below 649 feet, agricultural water use would be cut by 30% and all other uses would be reduced by 15%. If the levels fell below 633 feet, irrigation use would be cut in half while other uses would be reduced by 30%. The other plan proposed by the TWC was the "total limit" plan. In this case, pumping by all users would have to total less than 450,000 acre feet (AF) annually if aquifer levels fell below 666 feet. If levels at the index well sank to less than 625 feet, total pumping would be cut to 350,000 AF annually.



This graph shows the amount of groundwater pumped from the Edwards Aquifer in 1980.

Methodology: The management plans were analyzed using an aquifer simulation model (EDSIM) that calculated annual economic and hydrologic activity. The model encompasses agricultural, industrial, and municipal use and calculates year-end springflows and aquifer levels. The model also chooses the water use pattern that maximizes the economic value of the region. Significantly, the model "optimizes" water use by assuming that water will be transferred from low value to high value uses (typically from agricultural to urban and industrial). The model simulates the "best" economic outcomes from management plans and accurately simulates the unrestricted pumping environment that has historically existed in the region. The model also incorporates variables associated with rainfall and recharge. In this study, simulations were performed to assess the effect of implementing drought management plans, the sector plan and the total use plan. Other simulations that were performed analyzed the impact of guaranteeing set amounts of water for irrigation, and the potential for water markets.

Results: Modeling runs were conducted using near-term (1988) and long-term (2000) water demands Resultssuggestthat"annual welfare" may be reduced by as much as $1.57 million in the near future, and could decline by $6.6 million over the long-term. By the year 2000, agricultural water use could decline by up to 84%, while net agricultural income could drop by more than a third. Guaranteeing irrigators the same amount of water they used in 1988 would raise agricultural revenues. However, those gains would be less than the losses they would cause for municipal and industrial users. By the year 2000, the value of agricultural water could be as low as $19 per AF, while the value of

municipal use could rise to $109 per AF. This disparity may encourage water marketing. Farmers could make money by selling water for more than it is worth to them, while cities could purchase new water supplies for less than it would cost to develop new supplies. Finally, even though the TWC developed the management plans to protect the springs, simulation results show they will not guarantee springflows during droughts.

Reference: McCarl, Bruce, Wayne Jordan, R. Lynn Williams, Lonnie Jones, and Carl Dillon, *Economic and Hydrologic Implications of Proposed Edwards Aquifer Management Plans* (TR 158), TWRI, Texas A&M University, College Station, TX.

TNRCC Begins Operations; Combines TWC and Air Control Board

The Texas Water Commission and the Texas Air Control Board have been merged into a new state agency titled the Texas Natural Resources Conservation Commission (TNRCC).

The consolidation was required by Texas Senate Bill 2, which was passed in 1991. The TNRCC began operations September 1.

One result of the merger is that joint teams of employees have been formed in such areas as permitting, enforcement, hearings and rule making. The teams identified the "best practices" utilized by either predecessor agency and recommended they be utilized by the TNRCC.

TNRCC officials say that people with water issues should notice few changes when dealing with the new agency. Initially, water issues will be handled by personnel who were previously with the TWC.

The new agency will be temporarily located at the Stephen F. Austin State Office Building at 1700 N. Congress near the Capitol. Eventually, agency staff will be relocated to a five building office complex nine miles north of downtown Austin.

More information about the TNRCC can be obtained by calling (512) 475-2029.

Lubbock Dam Nearly Complete

A reservoir that will provide additional water supplies for the City of Lubbock is 90% complete. The project, which includes the John Monfford Dam and Lake Alan Henry, is located southeast of Lubbock near Justiceburg. The dam will be three-fourths of a mile long at its base and will be 138 feet high at its tallest point. It is designed to store 116,000 acre-feet (AF) of water. The dam will supplement Lubbock's existing water supplies, which include Lake Meredith and groundwater wells near Muleshoe.

Work that still needs to be done includes installing an irrigation system on the downstream side of the dam, and placing soil cement on the upstream portion. Later, pump stations and distribution lines will be developed. The project was built by the Brazos River Authority, which will also operate the dam for the City of Lubbock.

Legislature Passes Bills to Manage Edwards, Increase Research, Boost Xeriscaping

The Texas Legislature passed many significant water-related bills last session.

The major effort was a plan to manage the Edwards Aquifer by creating the Edwards Aquifer Authority (that replaces the old Edwards Underground Water District). That plan sets pumping limits, monitors the amount of water that is pumped, issues permits to pump specific amounts of water and encourages water marketing. The Edwards Legislation is described in detail in the current issue of TWRI's Texas Water Resources newsletter.

Other key water-related bills were also passed. HB2249 includes water conservation research as a new category in the Texas Higher Education Coordinating Board's Advanced Technology and Advanced Research programs. That should create additional opportunities for researchers in those fields. SB 1392 bill designates the Texas Coastal Offshore Observation Network, which is being operated as a joint venture between Texas A&M University at Corpus Christi and Lamar University, as an official agency for gathering coastal water quality data. SB 814 requires that water conserving landscapes called "xeriscapes" be installed along highways and new and renovated state buildings.

EPA Study Shows that 8 Texas Cities Exceed Lead Limit

A new study by the U.S. Environmental Protection Agency shows that eight public water suppliers in Texas have dangerously high levels of lead in their drinking water.

EPA's limit for lead in drinking water is 15 parts per billion (ppb) and 819 public drinking water suppliers exceeded that standard.

Texas drinking water suppliers that exceeded the limit include the Fort Bliss Army Base in El Paso (44 ppb); Port Neches (39 ppb); Fort Sam Houston in San Antonio (37 ppb); Terrell (30 ppb); the CNP Utility District in Harris County (22 ppb); McKinney (19 ppb); Freeport (18 ppb); Rockport (18 ppb), and Palestine (17).

As a result, the EPA ordered them to take steps to correct the hazard. EPA advised utilities that had water with too much lead to conduct extensive public notification and education campaigns. Residents in the affected areas were advised to have their tap water tested.

SW Texas State Acquires Aquarena Springs; May Enhance Research Opportunities

Southwest Texas State University is purchasing a unique recreational attraction that comes complete with a celebrity pig and an ideal site for conducting environmental research.

The University is acquiring the Aquarena Springs resort for $6 million. The 90 acre site includes a nine-hole golf course, an underwater theater where mermaids and the Ralph

the famous swimming pig perform, glass bottom boats, a gondola and observation tower, a hotel, gift shop, and two restaurants.

In 1993, Southwest Texas State University announced it is acquiring the Aquarena Springs resort for $6 million. The 90 acre site includes Spring Lake which is fed by San Marcos springs. The springs are important because they are home to endangered species.

One of the reasons SWTSU was interested in acquiring the site is to be able to preserve its unique environment. San Marcos Springs provides the site with roughly 150,000 gallons per day of unusually clear water. In addition, the water temperature varies only slightly throughout the year. The springs also serve as the headwaters of the San Marcos River. The springs support many unique species including blind salamanders, the San Marcos salamander, the fountain darter, and Texas wild rice.

SWTSU researchers should also benefit by having the University own and manage the property. Scientists at the Edwards Aquifer Research and Data Center and the Aquatic Biology Field Station have conducted numerous studies about the endangered species that live there, the impact of introduced species, ground and surface water interactions in the area, and many other topics.

"Scientists at the university could have the benefit of being able to provide more input into how the site can be used for research projects," said Edwards Center Director Glenn Longley. "We'll be able to work with the university to see that the research potential of the site can be maximized."

New Mexico Agrees to Increase Amount of Water Flowing to Canadian River; Should Benefit Texas High Plains

Cities, farmers, and industries in the Texas High Plainsthat rely on Lake Meredith for water supplies could be seeing increased amounts of water coming from New Mexico in the near future.

Attorneys for Texas, Oklahoma, and New Mexico have agreed on a plan that would substantially boost the amount of water New Mexico releases from the Ute Reservoir near Tucumcari. The agreement still has to be approved by the U.S. Supreme Court.

In general terms, the dispute centered on charges by Texas and Oklahomafiled in 1987 that New Mexico was storing more water in Ute Reservoir than was allowed under the terms of a compact between the three states that divided up the waters of the Canadian River. New Mexico countered that most of the stored water was exempt because it had spilled from an upstream reservoir and because it was part of a pool to offset the buildup of sediments. In 1991, the Supreme Court rejected New Mexico's contention that the spilled water was exempt and referred the question about the sediment pool to a "special master" appointed by the Court for a trial. After the trial, the master urged that the three states work to develop a compromise. That compromise plan was agreed to in June.

The plan will increase the amount of water flowing into the Canadian River and Lake Meredith. Lake Meredith supplies municipal and industrial water to Amarillo, Lubbock, and other cities in the region . The agreement requires New Mexico to release the amount of water stored in the sediment pool of Ute Reservoir and to further reduce the amount of water it stores at Ute Reservoir by 25,000 acre feet (AF) during the next four years. Lesser reductions will be in effect for four additional years. In addition, New Mexico was ordered to pay $200,000 in legal costs to both Texas and Oklahoma.

TPWD Marks Texas-Louisiana Boundary On Caddo Lake

Texas Parks and Wildlife Department officials are coping with a difficult dilemma ‹what do you do when two states that share a lake adopt different fishing regulations?

Caddo Lake straddles the Texas-Louisiana border. For many years, TPWD and the Louisiana Department of Wildlife and Fisheries adopted similar fishing regulations. In part, this was done to make it less confusing for fishermen.

In June, however, Louisiana implemented new rules that differ from those governing the Texas side of the lake. For example, a bass caught on the Louisiana side of the lake could be a legal "keeper" according to their regulations, but would be too small to be kept under Texas rules. Other differences include the daily bag limit and the types of fishing (for example, gill nets, and seines are not allowed in Louisiana).

To help clarify the situation and to make sure Texas rules are enforced, TPWD officials have placed border markers along the state line that runs through the center of the lake. The markers tell fishermen which side of the lake they're fishing in. Just to make sure, TPWD has increased the number of agency personnel that patrol the lake to answer questions and to make sure Texas laws are being applied.

TWRI Issues Call for Proposals

The Texas Water Resources Institute is now accepting pre-proposals for its research program. The project is open to faculty members at Texas universities.

Research priorities are those that were developed at the 1991 workshop, "Water for Texas: Settingthe Research Agenda." A complete list of the Top 10 research areas is available by contacting TWRI.

Researchers should submit brief (three pages or less) pre-proposals by October 30. Pre-proposals will be ranked on their relevance to state and regional needs, scientific merit, and the potential impact of the proposed studies. The pre-proposals will be evaluated by TWRI's Advisory Committee. Researchers who submitted the highest ranking pre-proposals will be asked to develop full proposals. Researchers must provide $2 of matching funds for every $1 provided by the TWRI grant. TWRI anticipates that three or four projects with budgets of $20,000 to $25,000 will be funded. These projects will begin in September 1994 and run through August 1995.

For details, call TWRI at (409) 845-1851.

Rice U. Institute Seeks Proposals to Clean Up DOD Sites

The Rice University Energy and Environmental Systems Institute is seeking research proposals dealing with groundwater and environmental restoration at Department of Defense sites.

The Institute will develop an experimental controlled release site, which will provide scientists with facilities to conduct controlled release experiments. They are requesting pre-proposals that involve controlled tests of mature technologies under the DOD technology development and demonstration program.

Individuals from universities, research laboratories, and private industry are invited to submit proposals. Proposals are due October 15.

Detailed information on how to submit proposals and other information is available by calling the Institute at (713) 285-5438.

TWRI Reports Cover Edwards Aquifer, Salinity

Two new technical reports are available from the Texas Water Resources Institute (TWRI).

Economic and HydroIogic ImpIications of Proposed Edwards Aquifer Management Plans (TR-158) evaluates the impact of four proposed management plans on both the aquifer and the regional economy. The report was written by Bruce McCarl and Lonnie Jones of the Texas A&M University Agricultural Economics Department, TWRI Director Wayne Jordan, Lynn Williams, of the Agricultural Business Department at Sam Houston State University, and Carl Dillon of the Agricultural Economics Department at the University of Arkansas.

Natural Salt Pollution and Water Supply Reliability in the Brazos River Basin (TR-160) was written by Ralph Wurbs, Awes Karama, Ishtiaque Saleh, and Keith Ganze of the Texas A&M University Civil Engineering Department. It summarizes the results of a study to gain better understanding of natural salt pollution in the Brazos River basin.

The report contains information on natural salt sources that flow intothe Brazos (mainly groundwater) . It also evaluates how salinity impacts the yield of reservoirs in the basin.

Finally, TWRI has recently developed the capability to utilize the U.S. Geological Survey's Selected Water Resources Abstracts on CD-ROM disks. The disks contain 260,000 abstracts of water-related research that was conducted nationally from 1967 through 1993. If you need to have a brief search performed on a particulartopic, call the Institute and we can help you. Please make your requests as precise as possible.

For information on any of these items, call TWRI at (409) 845-1851.

UT Reports Focus on Supercritical Water Oxidation

Four technical reports have recently been published by the Center for Research in Water Resources (CRWR) at the University of Texas at Austin.

Behavior of Chromium During Supercritical Water Oxidation (TR240) was written by Sam Rollans and Earnest Gloyna. It summarizes research in the use of supercritical water oxidation (SCWO) to treat water. The process involves subjecting municipal and industrial sludge to temperatures greater than 705° F to destroy organic contaminants. This report addresses the problem of chromium and other metals being converted to soluble forms in the SCWO process.

Supercritical Water Oxidation Model Development for Selected EPA Priority Pollutants (TR 245) was written by Earnest Gloyna and Lixioong Li. It summarizes recent research regarding the potential for using SCWO to destroy five EPA (Environmental Protection Agency) priority pollutants (acetic acid, 2,4-dicholorophenol, pentachlorophenol, pyridine, and 2,4-dichlorophenoxyacetic acid methyl ester). The test compounds were destroyed, and construction of the first commercial SCWO plant is planned for next year.

Performance Assessment for the Texas Low-Level Radioactive Waste Disposal Facility (TR 243) was written by Randall Charbeneau, Nolan Hertel, and Christine Pollard. It summarizes studies on the potential use of Fort Hancock as the Texas low-level radioactive waste disposal facility. The report addresses natural releases of radioactivity, including soil, atmospheric, and groundwater pathways, and accidental releases.

Model for Transport of Floating Debris in the Ocean (TR 236) was written by YuChun Su and Edward Holley. It summarizes a model developed by the authors to simulate the movement of floating debris in the Gulf of Mexico and oceans. The model could be used to predict and control the transport of marine debris.

For more information, call CRWR at (512) 471 -3131.

UT, Rice Researchers Contribute to Update of Handbook of Hydrology

An updated version of the *Handbook of Hydrology*, a practical reference on the theory and practice of hydrology, is now available. The book was edited by David R. Maidment of the Department of Civil Engineering at the University of Texas at Austin. More than 50 specialists in various aspects of hydrology contributed to the 1,400-page book, which will be a valuable resource for professionals in hydrology and related fields.

The book contains chapters on aspects of the hydrologic cycle, the transport of sediment and pollutants, and the use of statistical analysis to understand hydrologic data. It also includes information on technologies that can be used to deal with computational hydrology (including the application of remote sensing and geographic information systems) and the use of computer simulation models to solve both surface and groundwater problems.

Several other researchers from Texas universities took part in writing and reviewing the book. Randall Charbeneau and David Daniel of the Department of Civil Engineering at the Universityof Texas at Austin co-authored a chapter on contaminant transport in unsaturated flow and Philip Bedient and Hanadi Rifai of the Department of Environmental Science and Engineering at Rice University coauthored a chapter on hydrologic design for groundwater pollution control. Roy Dodson of Dodson & Associates, Inc. in Houston authored a chapter on advances in hydrologic computation.

To order the *Handbook of Hydrology*, call (800) 2MCGRAW.

New UT Book Looks at Rio Grande

A book which examines binational water management along the Rio Grande has been published by the LBJ School of Public Affairs at the University of Texas at Austin. *Challenges in the Binational Management of Water Resources in the Rio Grande/Rio Bravo* was written by David Eaton and David Hurlbut of the LBJ School. It provides insights into the environmental, social, and economic problems facing the region today. The book provides detailed information on the physical and institutional characteristics of the river. Chapters include a water basin overview, water use and apportionment, groundwater, water quality conflicts, and institutional solutions. The book is available through the LBJ School at (512) 471-4962.

UT, A&M Studies Show Declining Nutrient Levels May Threaten Galveston Bay Oysters

Oyster populations could decline significantly in Galveston Bay in the next decade if their food supply keeps shrinking, according to new studies at the University of Texas at Austin and Texas A&M University.

George Ward and Neal Armstrong of the Center for Research in Water Resources assembled water quality data about the Bay from many agencies during the past 30 years into a comprehensive, long-term record of water and sediment qualitv. Analysis of that

data suggests that the Bay may be becoming much less productive. This may be because: 1) the level of wastewater treatment has improved, 2) more diversions have been constructed on rivers, and 3) runoff control has improved neighboring watersheds. These factors limit the levels of nutrients and suspended solids that enter the Bay. Nutrients act as a kind of fertilizer that helps spawn the growth of algae and phytoplankton, which are the base of the food chain. Chlorophyll levels, which are a measure of phytoplankton, are also showing downward trends and have been cut in half in the last 20 years. Ward and

Armstrong caution that more detailed analysis needs to be performed to understand how nutrients are transported to and transformed in the Bay. Ward and Armstrong have written a report about the project that was published by the Galveston Bay National Estuary Program. Copies of it can be obtained by calling (713) 337-9932.

In a related project, Eric Powell, a researcher in the Oceanography Department at Texas A&M, has conducted many oyster-related studies concerning Galveston Bay. He recently utilized nutrient data and direct measurements of the phytoplankton that were taken last year as inputs into a computer model. That model determines possible effects on oyster food supplies. His results suggest that oysters may cease growing to a marketable size in three to seven years and could stop reproducing in eight to 12 years if food supplies continue to decline. For details, call Powell at (409) 845-3441.

Texas-Mexico Policy Issues Are Focus of UTEP, NMSU Study

Researchers at the University of Texas at El Paso (UTEP) and New Mexico State University (NMSU) are working to identify key problems and to develop policy recommendations for water management problems along the Texas-Mexico border.

Richard Bath of the UTEP Political Science Department is working with Janet Tanski of the Department of Economics at NMSU in the on-going studies.

So far, they've compiled background information on the history of water rights conflicts, population and economic characteristics of people, water supply and consumption, the administrative, political and legal framework, and many other issues. In particular, they're focusing on the implications of the North American Free Trade Agreement and on Constitutional changes now proposed in Mexico that could lead to more conservation and efficient water use. They are also studying whether the Bellagio Treaty is the best way to manage groundwaters that stretch across parts of Texas, Mexico and New Mexico.

Bath and Tanski recently published a draft report that summarizes these issues titled "Resolving Water Disputes in the El Paso Del Norte Region." For a copy or more information, call Bath at (915) 747-7980.

Baylor, Tarleton State Researchers Help Brazos RA Sample North Bosque River

Scientists from Baylor University and Tarleton State University are working with the Brazos River Authority to test water quality in the North Bosque River.

Dale Pahlmiyer (left) and Tom Conry of the Brazos River Authority collect water quality samples from the Bosque River.

The intensive studies, which are required under the provisions of the Texas Clean Rivers Act, involve monitoring and sampling water quality in the river continuously over a 24-hour period. The goal of the survey is to identify point and non-point sources that contribute large amounts of pollutants to the river.

In May, three sampling teams gathered samples at 16 sites along the river from Stephenville to Waco. This sampling was conducted when flows in the river were normal. In June, another set of samples was taken when stormflows were present.

Larry Hauck from the Institute for Applied Research and Public Policy (IARPP) at Tarleton State University in Stephenville assisted in the sampling efforts and provided some of the needed sampling equipment. Mahamane Mamadou of the Baylor University Department of Environmental Studies tested the river water for giardia, and cryptosporidium bacteria. Analysis for coliform bacteria was carried out by City of Waco personnel. Samples were also analyzed for ammonia, nitrates, chlorophyll, phosphorus, salts, dissolved oxygen, pH, and other parameters.

For more information, contact IARPP at (817) 698-9567 or the Environment Studies Department at (817) 755-3405.

UT Researchers Part of Team Project to Help Augment Flows at Comal, San Marcos Springs

Much of the debate about how best to manage the Edwards Aquifer concerned whether it would be practical to artificially enhance flows at Comal and San Marcos Springs. The idea was that more water could be taken from the Aquifer while still providing endangered species that live in the springs with the flows they need.

That concept had not been widely studied until now. Researchers at the University of Texas at Austin are taking part in a team project to determine if it is feasible to augment springflows in the Edwards Aquifer region.

The first phase of the study, which is now being conducted, will analyze existing data. Information that is now being gathered includes historic hydrological records, the

geochemistry of the region, biological habitats of the springs, sources of water that could be utilized for augmentation, and alternative augmentation sites and methods. This information will be used to analyze the feasibility of augmentation alternatives.

This study will help determine if springflows needed to support endangered species like this blind salamander (above) can be provided more regularly.

The second phase of the project generally involves more detailed studies and primary data collection. For example, that could include developing engineering plans to augment springflows, additional hydrological studies, instream flow analyses, and detailed biological studies. The third phase of the study involves the construction and implementation of a demonstration project at Comal Springs.

UT Scientists involved in the project include UT researchers Daene McKinney and Dean Djokic of the Center for Research in Water Resources, and John Sharp of the Geological Sciences Department. Other principal investigators include Marshall Jennings and Ernest Baker of the Austin office of the U.S. Geological Survey (USGS), Fred Ore of the U.S. Bureau of Reclamation office in Austin, and Doyle Stephens of the USGS office in Salt Lake City.

For details, call the CRWR at (512) 471-3131.

ETSU Project Assesses Sociological Impact of Delay in Building Cooper Dam

Many water planning experts tell us it can take up to 20 years between the time a dam is initially proposed and water finally gushes down its spillways. What are the impacts on local communities, however, when these dams are delayed for long time periods? That question was addressed by Raghu Singh, a researcher in the Sociology Department at East Texas State University.

Singh recently performed a case study of Cooper Dam, which is located north and east of Dallas. Cooper Dam was first proposed in the 1950s and was nearly finished in 1971 when a federal judge halted construction and ordered that environmental impact analysis be performed. The dam wasn't completed until 1992.

He interviewed 97 residents who live near the site about how the delay in building the dam affected them. They said the delays made the cost much higher than originally planned; hurt the local economy (particularly those who had speculated in lakefront real

estate); caused some businesses to leave the area; and lessened the faith of many residents in community leaders.

Singh then developed an "expert scale" that identified 37 subject areas that could be potentially impacted by the delays. "Expert" judges (long-time area residents and Corps of Engineers officials) were interviewed to assess their perception of ramifications of the long delay. While the local experts felt strongly that the delay in building the dam caused many negative impacts, Corps officials felt the effect was minimal.

For details, call Singh at (903) 886-5324.

Texas A&M Researchers Work With TPWD to Restore Prehistoric Paddlefish to Texas Waters

Restoring the population of a prehistoric fish in east Texas waters is the goal of a cooperative research program between Texas A&M University and the Texas Parks and Wildlife Department (TPWD).

Brian Murphy and Bill Neill of Texas A&M's Wildlife and Fisheries Sciences Department are two of the major collaborators in the program to increase the numbers of paddlefish in Texas waters. In the study, Murphy is leading an effort to evaluate habitats and water quality characteristics that may be suitable for the fish. Part of Murphy's work includes identifying which types of zooplankton (tiny microscopic organisms) the paddlefish prefer to feed on and where the largest sources of it are located. Paddlefish like to feed in slow-moving waters, but they also need areas with rising waters and fast flows to spawn. Neill has been studying what salinity levels paddlefish can tolerate and thrive in. Early results suggest that the fish may be able to tolerate salinity levels of up to 9 parts per million (ppm) but probably thrive in salinity concentrations of 4 to 5 ppm.

Paddlefish have been listed as an endangered species in Texas since 1977 because their numbers were so low. TPWD hopes to correct that situation by raising large numbers of young paddlefish and releasing them into the Trinity, Neches, Sabine, and Sulphur rivers. The fingerlings are reared at a TPWD hatchery in San Marcos.

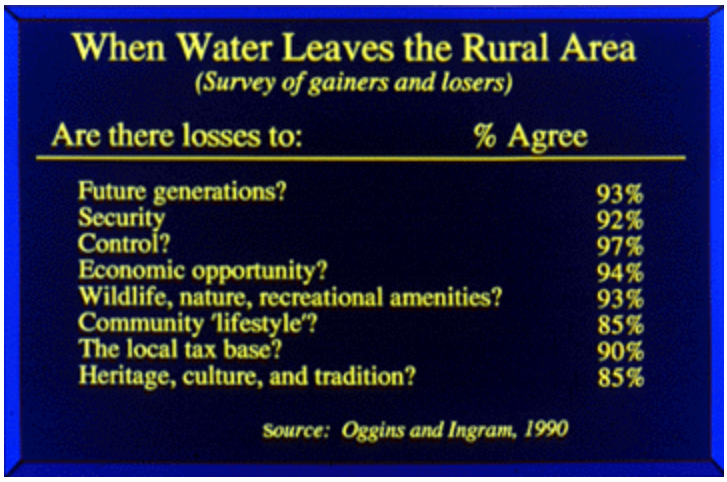
For details, call Murphy at (409) 845-5785.

UH Researchers Survey Attitudes of Edwards Aquifer Voters

While the Texas Legislature debated what to do about the Edwards Aquifer this summer, the Edwards Underground Water District wanted to find out what people in the region thought.

As a result, the District awarded a grant to Richard Murray and Kent Tedin, researchers in the Political Science Department at the University of Houston, to conduct a telephone survey with 401 area residents. The survey was conducted in May.

What did they find? Roughly 30% of the people anticipated that the area was likely to experience a severe water shortage during the next 10 years. Nearly three-fourths expected a moderate water shortage would likely occur during that time. Individuals were also asked to choose which of five agencies they would prefer to regulate the Edwards Aquifer. A management district that included the six counties in the region was the most preferred choice (34%), followed by the Texas Water Commission (22%), and single-county water districts (14%).



Other results show that people overwhelmingly preferred an elected versus an appointed Board of Directors to manage the aquifer (79% versus 12%), and nearly 80% said they supported surface water development as opposed to continued reliance on the Edwards Aquifer.

For details, call Murray or Tedin at (713) 743-3890.

UT-Arlington Biologists Try to Find if Fish Can Control Spread of Pesky Freshwater Clam

The freshwater clam *(Corbicula fluminea)* is known for its ability to reproduce quickly and densely populate warm-water lakes. To water managers, it's a full-fledged pest. The shells of living and dead clams build up in distribution pipes, pumps and valves and can reduce the flow of even the best-engineered system to a slow trickle.

The most efficient way to control the clams is by using chlorine to poison them. However, the federal government limits the use of chlorine because it could harm other aquatic species. A less environmentally threatening way to limit the clams populations would be to find natural methods to control them. That prompted Ellen McCrady, a graduate student at the University of Texas at Arlington, to study Lake Fairfield and identify which fish (if any) eat the most clams and what impact they exert on the number of clams in the lake.

One early clue that fish may eat large amounts of clams came from earlier studies. That research showed that these clams were 30 times more likely to be found in cages that fish were excluded from than in cages where the fish and clams could co-exist. She inventoried the fish that live in the lake and developed a list of seven fish species that are known to eat the clams. Then, she began sampling fish in the lake and analyzed whether partially eaten clams were in their guts. Finally, fish that prefer clams were placed in aquariums and offered a range of different sizes of clams to dine on.

Unfortunately, McCrady found clam fragments in only six out of 367 fish that were caught. This is because many fish that eat the clams crunch them up into small pieces that can't be identified and others digest the clams so quickly that no recognizable remains are left. However, McCrady did find that carp and long-eared sunfish are the species most likely to eat the clams. Both probe muddy bottom sediments with long, especially developed noses and eat by suction . Their teeth are particularly suited for crunching food once it's in their mouth. She also learned that, when the clams are small, they defend themselves by burrowing into the mud. After they reach a larger size, they can rest safely on top of the mud because they're too large for fish to easily swallow and too hard to crush.

McCrady worked under the supervision of James Robinson and Robert McMahon of UT-A Biology Department. They can be reached at (817) 273-2412.

A&M Researchers to Demonstrate Drip Irrigation and Rainfall Harvesting at Uvalde Farm

A study by researchers with the Texas Agricultural Extension Service (TAEX) will utilize an existing irrigated farm near Uvalde to demonstrate to water conservation techniques to farmers.

The project is being led by horticulturist Frank Dainello, agricultural engineer Guy Fipps, economist Charles Hall, horticulturist Larry Stein, and soil chemist Dale Pennington.

There are three main components to the study: 1) how to conserve irrigation water with drip irrigation under a plastic mulch; 2) techniques for harvesting rain water, and 3) methods to minimize fertilizer losses and possible nitrate pollution of groundwater. The study will be conducted at McFadden Farms near Uvalde.

First, the researchers will construct a mobile "drip trailer" to demonstrate the use of drip tubing for irrigating under plastic mulch *(drip under plastic)*. Drip irrigation is a very efficient way to provide water at low pressure and low volumes. The plastic mulch will help reduces evaporative losses and maintain a higher soil temperature. The drip tubes will be installed just beneath the soil surface and the system will operate at 10 to 25 pounds per square inch of pressure.

This researchers hope to demonstrate that drip trailers can reduce the total conversion and equipment costs. Drip trailers, which are already being used in Starr County, consist of a pump, engine, filters, fertilizer injector, and other pipes and connections that can be attached to existing water delivery valves. The water is pumped from the underground pipeline, and then pressurized, filtered and discharged into the plastic tubing which delivers water to each furrow's drip tape. Preliminary results from comparisons of drip irrigation under plastic versus furrow systems in Starr County suggest that drip irrigation may increase production by 60%, while using only one-third the amount of water and half the pesticides.

Drip trailers aren't cheap; a fully equipped trailer can cost in the range of $15,000 to $30,000 depending on the capacity needed. However, the same trailer can be used to irrigate several different fields, and portable drip trailers are less expensive than installing a permanent pumping plant and distribution system for each field. The drip trailers can be moved from field to field to accommodate higher valued crops.

Conserving irrigation water is important for many reasons. It saves growers money by reducing pumping costs and lowers groundwater use. Conservation may also lessen the risk that pesticides and nitrate may pollute groundwater, because it lowers runoff and percolation.

Research and demonstration in rainfall harvesting will be another part of the study. The researchers will construct a system of small furrows and catchment basins lined with perforated plastic. Water that runs off into the furrows will flow into these basins and recharge the root zone. The plastic liners will help prevent evaporative losses.

Results from the studies will be relayed to farmers through a series of field days at the farm where the portable drip and the rainfall harvesting systems will be demonstrated. A short course on drip irrigation will be conducted at the Texas A&M University Research Center at Uvalde. The researchers will also work closely with crop specialists and scientists in other areas of the state to set up similar programs.

For details, call Dainello at (409)845-7341.

TAES Study Will Determine if Conservation, Reuse, Are Practical in Rice Production

Capturing and reusing irrigation water and rainfall in rice production systems is the focus of a new study being conducted by researchers with the Texas Agricultural Experiment Station in Beaumont.

Leading the project are soil scientist Fred Turner and agricultural engineer Garry McCauley.

Rice is produced along much the Texas Gulf Coast and can require as much as 28 inches of water in a growing season. Although many of Texas' rice growing areas receive up to 50 inches of rain a year, supplemental irrigation can still be needed at key times of the growing season.

The goal of this study is to design methods to capture irrigation and runoff from rice fields that can later be reused. This could make rice production much more water efficient. The research team will also evaluate the quality of the "reuse" water to determine if salts or other pollutants could build up in the recycled water and pose a threat to the crops. In the study, rice fields will be leveled to drain to a low place, where runoff will be captured and pumped into a reservoir.

During the early part of growing season, the plants need to be irrigated in Flushes," which are short-term, rapid irrigations. Currently, little of this water remains on the field and most is lost to runoff. After the plants emerge, rice fields are "flooded" with standing water that is in tended to remain on the field.

The researchers hope to capture the flush water for reuse. Flushing constitutes 8 of the 28 inches of water that rice crops need. The researchers hope that they will be able to capture and reuse at least 4 inches of the flush water, a 20% overall water savings.

Rainfall run-off will also be captured by the new system. The rainfall and flush irrigation runoff will be pumped to a holding reservoir.

Traditionally, capturing and reusing irrigation water from any crop has been difficult because salts can build up. This can reduce the quality of the water and make it unusable for irrigation. The researchers believe rainfall will dilute the irrigation water and keep salt levels low.

The researchers also hope to show that the system will be economically viable. They believe the expense of installing and operating the pumping system will be offset by higher yields.

For details, call McCauley at (409) 752-2741.

SMU Researchers, Consultants,Will Assess Effectiveness of Sump Pumps to Improve Stormwater Quality

A study by researchers at Southern Methodist University and private consultants in Dallas will determine how well temporary stormwater capturing systems known as sumps," work to clean sediment and pollutants from runoff.

The study is being conducted by Edward Smith of the Department of Civil and Mechanical Engineering at Southem Methodist University, and by Albert Halff and Walter Skipwith of Albert H. Halff Associates, an engineering firm in Dallas.

Stormwater sumps are widely used in urban watersheds and are built and operated by cities and industries. Although sumps are designed and operated for flood control, they may also help treat stormwater and improve its quality.

In the study, the researchers will evaluate the water treatment efficiency of stormwater sumps in the Dallas area. The City of Dallas operates 10 major sump systems which have varying designs, operation requirements, and drainage areas. The goal is to document the degree of treatment that occurs in the sumps, to establish standards and procedures for the use of sumps in a dual role as flood control devices and treatment systems, and to develop optimal design and operational strategies.

The researchers will collect water samples from sump systems in the area during storm events, and will sample bottom sediments to determine which pollutants they contain.

The sumps that are sampled will represent different land uses, watershed characteristics and detention times. The water samples will be analyzed for such parameters as total suspended solids, biochemical and chemical oxygen demand, phosphorous, nitrogen, nitrate, and metals. The project will also involve hydraulic and hydrologic modeling.

If the researchers show that existing sump systems can provide significant treatment of stormwater pollutants, then these can be included in the best management practice program for stormwater water quality control, and Texas cities can save time and money in complying with stormwater quality discharge requirements.

Interest in documenting the water treatment capabilities of these systems stems from Environmental Protection Agency rules to control non-point source (NPS) pollution by treating stormwater discharges. Although stormwater sumps were not designed to treat runoff, the researchers believe that some water quality improvement occurs as sediments and pollutants settle to the bottom after they remain in the sumps for extended time periods.

Typically, there have been no "standard" designs for sumps or detention ponds . As a result, the size, design, placement, and detention times of these systems varies. While the ability of detention ponds to treat stormwater is recognized, there have been few attempts to quantify the treatment provided by stormwater sumps.

Most cities rely on either stormwater sumps or detention ponds. New EPA rules may force cities and industries to construct detention ponds, even if they already have sumps. The researchers hope they can show that sumps are effective at treating stormwater so that Texas cities can save time and money in complying with NPS regulations.

For details, call Smith at (214) 768-3122.