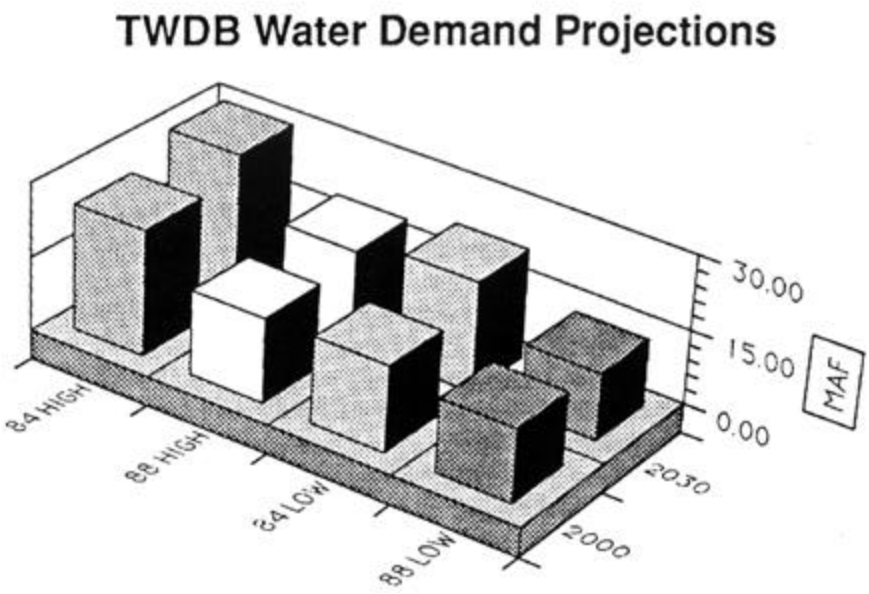
New Waves
The Research Newsletter of the Texas Water Resources Institute
Volume 2, Number 2, July 1989

## *TWDB Revising State Water Demand Projections*

The Texas Water Development Board (TWDB) is now in the process of updating and revising its projections of statewide water use, and early results suggest the state may use less water in the future than was previously thought.

TWDB projected water demands for each decade for each type of use (irrigation, municipal, manufacturing, steam-electric power, and mining). Estimates were generated for 752 cities and each Texas county. University researchers working with TWDB to develop the estimates include Lonnie Jones and Ron Griffin of Texas A&M University, Ray Perryman of the Baylor University Forecasting Service, and Don Ethridge of Texas Tech University.




The new water demand projections show that conservation and efficient water use (both in the agricultural and municipal sectors) may significantly reduce total statewide water demands (see figure above). In 1984, TWDB estimated that state water demands in the year 2000 would range from roughly 17 to 25 million acre-feet (MAF). Now, preliminary estimates indicate that water demands in the year 2000 will be roughly 15 to 17 MAF. Estimates for the years 2020 and beyond show similar savings.

A major difference between 1984 estimates and the current projections is an anticipated reduction in irrigation demand. In 1984, TWDB estimated that agricultural water use would be 9.9 to 16 MAF in the year 2000, and 10.9 to 14.8 MAF in the year 2030. The

current projections are much lower. If conservation is implemented, TWDB projects that irrigation water use will range from 6.1 to 7.5 MAF in the year 2000, and from 5.1 to 6.8 MAF in the year 2030. If conservation is not considered, agricultural water use is expected to be only 7.8 to 9 MAF in the year 2000 and 7.1 to 8.75 MAF in the year 2030. Implementation of more water-efficient technologies and management strategies and a slowed rate of growth in irrigated acreage are two key reasons for the decline.

Municipal and residential conservation practices for both residential and commercial uses were also incorporated into the new projections. If conservation practices are implemented, TWDB projects that savings of as much as 389,000 acre-feet (AF) of water could be realized by the year 2000. By the year 2040, that amount could climb to more than 1.3 MAF.

Even if conservation practices are implemented and water use efficiency increases, TWDB projections show that water demands could be slightly greater than supplies by the year 2000. Demands in the year 2000 could be as high as 16.7 MAF, while dependable water supplies would be only about 16.3 MAF (these projections do not include the development of new water supplies). Unless new water supplies are developed, the gap between demand and supplies could widen to roughly 2.5 MAF by the year 2020 and to as much as 5 MAF by the year 2040.

Later, TWDB will publish its preliminary estimates of water supplies and needed facilities such as dams, water supply projects, and wastewater treatment plants.

TWDB welcomes comments and suggestions about the new estimates. For more information about the water demand projections, contact: Texas Water Development Board, PO Box 13231, Capitol Station, Austin, TX 78711 3231. The phone number is (512) 463-7940.

## *Editor's Note*

Readers:

Articles published in our "Abstracts" section and reports referenced in our "Publications" section are generally not available from the Texas Water Resources Institute (TWRI). The only exceptions would be when TWRI is the publisher of the article. We will also always list a related publication at the bottom of each abstract we print. The articles will usually be in a journal or book that's available at a local library. If you can't find the original article, contact us and we will provide you with a phone number or address for the reference in question. We also list addresses and phone numbers of reports in our "Publications" section. Please contact them directly.

Also, *New Waves is* always looking for information to publish regarding university research news, abstracts, reports, meetings and conferences and other information. Please contact us if you have any information you might like to see included in *New Waves.* Finally, we hope you like the new look of *New Waves.* Additional changes will be made in the future. Let us know of your comments and suggestions.

Thanks,
Ric Jensen
Editor, *New Waves*

## *An Analysis of the Effects of Sociodemographic Factors on Daily Per Capita Residential Water Use in Texas Cities*

**Authors:** Steve Murdock, Don Albrecht, Rita Hamm, Kenneth Backman, and Banoo Parpia, Rural Sociology Department, Texas A&M University, College Station, TX.

**Funded by:** Texas Water Resources Institute, Texas A&M University, College Station, TX.

**Problem:** Texas, like most other states, currently uses daily per capita water use to project water demands for the state. However, per capita water use varies significantly in different regions of Texas. Understanding the effects of differences in economic, social and demographic characteristics on per capita water use could lead to more accurate water demand projections.

**Objectives:** To determine relationships between key demographic, social, and cultural variables and water use in Texas, and to analyze the implications of the relationships between these factors and water use and demand in Texas.

**Methodology:** The study utilized Texas Water Development Board (TWDB) data on per capita water use in 677 Texas cities from 1964-1983. Demographic and social data were taken from the 1980 U.S. Census. Telephone surveys were conducted to collect information on attitudes toward water use and conservation; water costs; and water use for such activities as bathing, swimming pools, lawn care, and washing clothes, dishes and cars. The cities of El Paso, Sonora, Rocksprings, Waco, Hearne, Longview, Mathis, and Alice were selected for the telephone interviews. Actual water use data was gathered from local water utilities to supplement the survey information.

**Results and Discussion:** Results from analyzing the TWDB and census data suggest that older cities with larger minority populations, cities specializing in recreation and entertainment, and those with a majority of their citizens connected to public water systems are likely to consume more water per capita than other cities. The researchers were able to simulate water use more accurately for urban areas than for rural areas. Results from the telephone survey indicate that larger households use less water per capita than smaller households, and that white households with higher levels of education and higher incomes tend to have the highest levels of per capita water use. The researchers also simulated statewide water demands for 1980 using models which included: 1) Only total population and 2) Other sociodemographic characteristics. In analyses based solely on population, projections differed from actual water use by more than 400 million gallons per day (MGD). When sociodemographic factors were included, that difference was narrowed to roughly 70 MGD. The inclusion of sociodemographic factors may improve water demand forecasting.

**Publications:** Murdock, Steve, Don Albrecht, Rita Hamm, Kenneth Backman, and Banoo Parpia, *An Analysis of the Effects of Sociodemographic Factors on Daily Per Capita Residential Water Use in Texas Cities (TR- 143),* Texas Water Resources Institute, Texas A&M University, College Station,TX, 1988.

## *Wet Weather Water Quality Monitoring*

**Authors:** John J. Warwick and J. D. Edgmon, University of Texas at Dallas.

**Problem:** Combined sewer overflow discharges pose a serious threat to water quality in receiving waters in many urban drainage basins. The impact of these overflows on water quality needs to be quantified.

**Objectives:** To develop a satisfactory methodology to assess the impact of wet weather on combined sewer overflow discharges, and to estimate how often dissolved oxygen (DO) standards were violated.

**Methodology:** Research was based on an analysis of data from Altoona, PA. However, the methodology should be applicable to Texas. The study utilized the STORM model developed by the U.S. Army Corps of Engineers to simulate combined sewer overflows. Data required by STORM include information on hourly precipitation, area hydrology, land use, dry weather flow characteristics, sewage treatment capacity in the watershed, and storage capacity for containing combined sewer overflows. A receiving water quality model was developed to compute instream DO levels in response to the data generated by STORM.

**Results and Discussion:** Results indicate that DO standards of 4 mg/l were violated by 42% of all storms in this watershed. Sludge deposits were resuspended when high flow events (velocities greater than 2.25 feet per second) occurred. Similar studies are currently being conducted in the Bachman Creek watershed in Dallas.

**Publications:** Warwick, John J., and J.D. Edgmon, "Wet Weather Water Quality Modeling," *Journal of Water Resources Planning and Management Division,* ASCE, New York, NY, May 1988.

## *Modeling the Effects of Urbanization on Basin Water Yield and Reservoir Sedimentation*

**Authors:** Jeff Arnold, M.D. Bircket, Jimmy Williams, W.F. Smith and H.N. McGill, U.S. Department of Agriculture/Agricultural Research Service (USDA/ARS), Temple, TX.

**Problem:** White Rock Lake is located northeast of Dallas on White Rock Creek, a tributary of the Trinity River. When the reservoir and dam were built in 1910, the area was entirely rural. Today, however, land use is nearly 80% urban. It is necessary to

determine how urbanization is affecting the amount of sediment transported and delivered to the reservoir.

**Methodology:** The Soil Conservation Service (SCS) has conducted five sedimentation studies on the reservoir from 1935-1984. Since that time, erosion was studied using the Universal Soil Loss Equation (USLE). Sediment delivery ratios were developed by comparing total erosion in the watershed to measured levels of sediment in the reservoir. A mathematical model called SWRRB (Simulator for Water Resources in Rural Basins) was utilized to determine the effect of urbanization on water and sediment entering the lake. SWRRB allows simultaneous computations on several subbasins of a watershed and simulates sediment movement through ponds, reservoirs, streams and valleys along with other factors. Water and sediment yields were validated utilizing SWRRB and a modified version of USLE. Sediment delivery ratios were computed for both historical and future conditions.

**Results and Discussion:** Results suggest that streams carry a smaller sediment load as urbanization increases. However, greater surface runoff from urban areas gives the streams a larger carrying capacity. Three scenarios providing alternate rates of urbanization in the watershed were also projected through the year 2050. Results suggest that the useful life of the reservoir would increase as urbanization grows because of lessened sedimentation. A slowing of the rate of urbanization and failure to implement changes in agricultural land use management would result in the highest rates of sedimentation in the lake.

**Publications:** Arnold, J.G., M.D. Bircket, J.R. Williams, W.F. Smith, and H.N. McGill, "Modeling the Effects of Urbanization on Basin Water Yield and Reservoir Sedimentation," *Water Resources Bulletin,* Bethesda, MD, December,1987.

## *HAZMAP - A Computerized Storm Surge Model: A Galveston Bay Area Test*

**Authors:** Kenneth White, Center for Engineering Geosciences, and Earl Hoskins, Geophysics Department, Texas A&M University, College Station, TX; and Lora Schornick, Digital Equipment Corporation, Marlborough, MA.

**Funded By:** Synercom University Grant Program.

**Problem:** Accurately predicting natural hazards such as hurricanes is critical to reducing risks from those disasters. Currently, most emergency planning efforts estimate damages from a specific, unflexible, set of conditions like a "project storm." HAZMAP is an integrated computer package that facilitates real time planning, allowing decision makers to prepare for actual storm events.

**Objectives:** To verify the ability of HAZMAP to accurately simulate hurricane Carla (1961) and hurricane Allen (1980).

**Model Description:** HAZMAP merges geographic data bases and satellite imagery with MIMS (Mapping Information Management Systems) to produce maps displaying elevations, roads and highways, population centers, and other vital locations. Real-time weather observations and storm data were integrated into the MIMS software to produce maps of current and projected storm conditions. Variables such as hurricane landfall, storm surges, flood elevations and hazard potentials were utilized to develop alternative "what if?" scenarios.

**Methodology:** Hurricanes Carla (1961) and Allen (1980) were selected to illustrate storm surges in the Galveston Bay area and to evaluate the HAZMAP package. Carla made landfall near Port Lavaca, created a storm surge of 22 feet, and produced more than 16 inches of rainfall. Allen made landfall near Brownsville, created a storm surge of only 4.4 feet, and resulted in little rainfall. Historical data from both storms was processed to simulate storm surges and tidal heights. Simulated and actual data were compared graphically using the MIMS.

**Results and Discussion:** HAZMAP accurately predicted the storm surge of Hurricane Carla on Galveston. However, the model predicted that Carla would arrive eight hours earlier than it did, and that Allen would arrive four hours earlier than it actually did. Results also indicate that more water is entering Galveston Bay than is leaving, both during hurricanes and normal conditions. Additional tide gauge stations and more detailed descriptions of the geography of Galveston Bay are needed to make the system more accurate.

**Publications:** White, Kenneth, Lora Schornick, and Earl Hoskins, "HAZMAP - A Computerized Storm Surge Model: A Galveston Bay Area Test," in *Geography Information Systems/Land Information Systems 1988 Proceedings,* American Society of Photogrammetry and Remote Sensing, Falls Church, VA, 1988.

## *Factors Affecting the Benthic Community Structure of a Discontinuous Stream in Guadalupe Mountains National Park, Texas*

**Authors:** Owen Lind, Biology Department, Baylor University, Waco, TX, and Richard Meyerhoff, Entomology Department, Oregon State University, Corvallis, OR.

**Problem:** In free-flowing streams, upstream waters play a major role in determining the nature of downstream benthic (plant and animal) communities. However, in some areas, streams are discontinuous and are separated by underground flows. In these streams, upstream waters have little influence on downstream habitats. Few studies have been performed that examine the factors that affect benthic structures in discontinuous streams.

**Study Area:** South McKittrick Creek in the Guadalupe Mountains National Park in Hudspeth and Culberson counties in west Texas was selected for analysis. The creek is shallow with alternating pools and riffles and is separated by dry reaches where the stream flows underground. The creek is characterized by two distinct reaches: an upper segment, located in a steep canyon, is virtually fish-free; while the canyon broadens and is less steep in the lower portion. In the lower reach, fish such as rainbow trout and

yellowbelly and green sunfish, and vegetation such as sawgrass, watercress and horsetails are found.

**Methodology:** Six locations were sampled at points representing changing stream environments. Substrate samples along with suspended and dislodged organisms were collected from the streambeds. Organisms were then separated and identified to generic levels.

**Results and Discussion:** Creek segments with continuous flows showed similar benthic populations. The benthic community structure of stream segments differed significantly when they were separated by dry pools. In the separated segments, the immediate environment may affect benthic populations more than the nature of upstream waters. Creek bed structure may also impact predation patterns and thus affect insect communities.

**Publications:** Meyerhoff, Richard, and Owen Lind, "Factors Affecting the Benthic Community Structure of a Discontinuous Stream in Guadalupe Mountains National Park, Texas," Internationale *Revue ges. Hydrobiologie,* Berlin, East Germany, May-June, 1987.

## *Preliminary Investigation of Tracer Gas Reaeration Method for Shallow Bays*

**Authors:** Sarah H. Baker and Edward R. Holley, Civil Engineering Department, University of Texas at Austin.

**Funded by:** Texas Water Resources Institute, Texas A&M University, U.S. Geological Survey Matching Grant Program.

**Problem:** Accurate estimates to predict pollutant movement, retention time, and surface exchange rates for volatile pollutants such as benzene, chloroform, methylene chloride, DDT, and toluene in bays are needed. The tracer gas technique has been used to measure surface transfer rates for gases in rivers. This technique could be extremely useful in bays, but it is complicated by differences in the hydrodynamics and density stratification that can exist because fresh water can over-ride heavier saline water.

**Objectives:** To investigate field procedures that could be utilized to apply the tracer gas technique to bays.

**Methodology:** Two procedures were tested in Lavaca Bay on the Texas coast near Point Lavaca. The first test involved a short duration injection (10 to 30 minutes) of tracer gas and a conservative tracer. The tracer cloud was sampled as it moved through the bay. The second test involved a long-duration injection (3 to 4 hours) to obtain quasi-steady conditions.

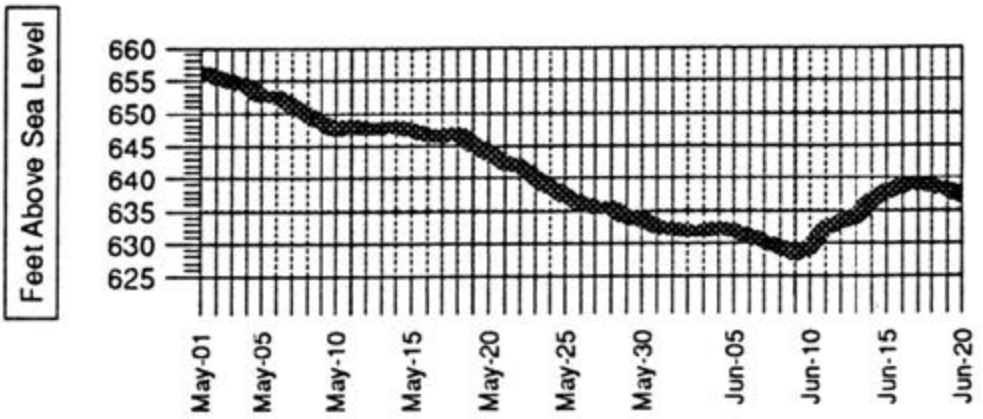
**Results and Discussion:** The most promising method appears to be the short injection method, with a pulse of a second dye released during the injection to mark the middle of the tracer cloud. An injection box was designed to prevent mixing of the tracers with

heavier saline water near the bed of the bay during injection. Follow-up studies, sponsored by the USGS matching grant program, are currently underway.

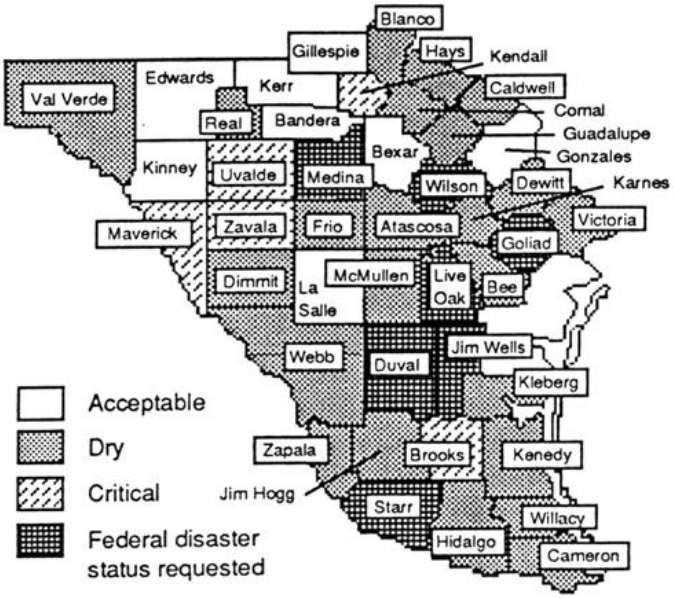
**Publications:** Baker, Sarah H. and Edward R. Holley, *Preliminary Investigation of Tracer Gas Reaeration Method for Shallow Bays (TR-141),* Texas Water Resources Institute, Texas A&M University, College Station,TX, 1987. Co-published under the same title as *UT-CRWR Report 222* by Center for Research in Water Resources, University of Texas, Austin, TX.

## *Edwards Aquifer Drops to Lowest Level Since 1984; Other Regions Hard Hit*

Water levels in the Edwards Aquifer in San Antonio fell to just over 627 feet above sea level in mid-June. This was the lowest level since the drought of the summer of 1984.




Below normal rainfall and above average demands brought about by record high temperatures, and increased irrigation demands in Uvalde and Medina counties contributed to the falling water table. During May and June, the aquifer level was falling an average of more than 1 foot per day (see figure above). The aquifer's declining levels caused Comal Springs at New Braunfels to temporarily stop flowing.




The high temperatures and low rainfall had a number of significant side effects. The City of San Antonio reported that the number of breaks in water mains jumped by 50% over last year because soils expanded at a time when the pipes were carrying above normal flows due to increased demands. The cities of San Antonio, San Marcos and New Braunfels, and military

bases in the San Antonio area all were asking users to conserve water by as much as 15%.

Ironically, the crisis comes just after the Texas Legislature failed to agree on bills that would have managed regional groundwater supplies in the area. In a related development, the newly created South Texas Watermaster's Office stated that water supplies in the western and southern portions of the Nueces and Frio river basins were well below normal levels (see map above). Because of the high temperatures and lack of rain, many south Texas counties including Medina, Wilson, Goliad, Live Oak, Duval, Jim Wells and Starr have requested federal disaster assistance.

Meanwhile, in San Angelo, outside watering will be prohibited between noon and 6 p.m. daily during the summer in an effort to reduce consumption by 20%.

## *Monitoring Study Gathers Data on Salinity Levels in Galveston Bay*

An improved understanding of salinity levels in Galveston Bay may be the result of a comprehensive 3day study conducted in May by state and federal agencies.

The study, which involved more than 80 people from agencies including the U.S. Army Corps of Engineers, the Texas Water Development Board, the Texas Water Commission, and others, gathered water samples at 15 locations on Galveston Bay. Samples were taken hourly for 72 consecutive hours on such water quality factors as temperature, salinity, dissolved oxygen and pH levels. Flow rates were also determined. Data from the study will be used to develop a computer model to simulate salinity and circulation patterns in the bay.

## *Texas is Nation's Biggest Polluter, EPA Study Says*

Texas industries put more toxic pollutants into the environment than any other state in 1987, according to the U.S. Environmental Protection Agency (EPA). More than were 660 million pounds of pollutants were released into waterways, and over 616 million pounds were discharged underground, EPA says.

Many of the toxic materials were discharged between Corpus Christi and Beaumont. Texas produces 67% of the nation's petrochemicals, and is home to 40% of the U.S. chemical industry.

In a separate EPA study, five Texas counties (Harris, Calhoun, Brazoria, Milam, and Jefferson) are among the top nine counties in the U.S. in the volume of toxic chemicals that industries release to the environment. Harris County was ranked second nationally.

Officials at EPA and the Texas Water Commission said the results of studies do not necessarily suggest a health threat is present. TWC officials said much of the wastes are disposed of under approved procedures such as injection wells.

## *Texans Gulping Bottled Water, Texas Monthly Says*

Texans consumed more than 5.2 million gallons of bottled water in 1987 the third highest rate in the U.S. behind California and New York, according to a recent article in Texas *Monthly* magazine. The article, "The Battle of the Bubbles," appeared in the December, 1988 issue. Bottled water sales in Texas soared by about 15% per year since 1980. Fears about the safety of municipal tap water fueled the increase, the article said.

The article also noted that many of the state's biggest bottled water companies including Ozarka, Oasis and Five Springs Water are owned by French companies (Artesia is the only major Texas-owned bottled water company in the state). It also charged that the source of much of the drinking water sold by many bottled water companies is really municipal drinking water which has been treated and chlorinated by the bottled water companies. For example, the article says that the source of Oasis Spring drinking water is the Waco city water system, and sources of Ozarka Drinking Water include the Fort Worth and Houston city water systems.

## *Six Texas Waterways on EPA Cleanup List*

The U.S. Environmental Protection Agency (EPA) announced in June that six river and stream segments in Texas have problems with toxic chemical pollution that need quick cleanup action.

EPA said dioxin was a problem in the Houston Ship Channel, the Neches River near its tidal zone, Paper Mill Creek near Lake Sam Rayburn and the Sulphur River near Texarkana. Other listed sites include the Upper Trinity River (lead) and Linville Bayou near Sweeny (chromium).

The Texas Water Commission (TWC) had proposed that six additional sites be included in the listing. Sites with pollutant problems from industrial discharges that were proposed include the San Bernard River near its tidal zone, the Neches River below Lake Palestine and the upper San Antonio River. Lavaca, Chocolate and Cox bays were proposed by TWC because of mercury contamination. Those sites were not included in EPA's list because specific sources of pollution were not identified.

## *Guadalupe-Blanco RA Sues to Declare Edwards Aquifer an 'Underground River'*

Lawyers for the Guadalupe- Blanco River Authority (GBRA) filed suit in State District Court in San Marcos June 22 to declare the Edwards Aquifer an underground river whose waters are owned by the state. The lawsuit comes after a plan to regulate groundwater usage in the region could not be agreed on by local interests or in the Texas Legislature. Preliminary indications are that the City of San Antonio and agricultural interests in Uvalde and Medina counties will fight the lawsuit.

The suit asks the Texas Water Commission (TWC) to allocate water rights to the aquifer. If the aquifer is declared an underground river, TWC could apply surface water law to the

aquifer. Although Texas water law contains provisions that could designate groundwater systems as underground rivers, that statute has never been applied to any Texas aquifer.

In a related development, GBRA took a first step towards a lawsuit in a federal court to protect four endangered species that depend on spring flows for their survival. The species include a fountain darter, the San Marcos salamander, the San Marcos gambusia, and Texas wild rice. GBRA alleges that the species should be protected under the Federal Endangered Species Act and that aquifer levels need to be maintained that will keep the springs flowing.

## *TWC Watermaster Program Extended into South Texas*

The Texas Water Commission's watermaster program has been extended to include the Nueces, San Antonio and Guadalupe river basins in south Texas. Previously, only the Rio Grande area was managed by the program. Eventually, the program will be extended statewide.

The watermaster program, which will regulate surface water usage by both farmers and cities, is intended to assure that state water is used in accordance with established rights. The program requires water rights holders to notify the watermaster when diversions are planned. The watermaster will then determine if there is enough streamflow to meet the request. Most users will be required to utilize a flow meter to measure how much water is being diverted. Users will help pay for the program: there is a base charge of $50 for each water right as well as a fee based on total annual usage.

For more information, contact: Toby Cisneroz, South Texas Watermaster Division, TWC, 140 Heimer Rd., San Antonio, TX 78232. The toll-free phone number is (800) 733-2733.

## *Governor Signs Legislation to Provide Water, Sewer Services to 'Colonias'*

Governor Bill Clements has signed a bill into law that is a first step in addressing water and sewer problems along the Texas-Mexico border. The bill will allow the Texas Water Development Board to issue up to $100 million ($25 million annually through 1993) for loans to finance water and sewer improvements in the colonias. Colonias are subdivisions along the Rio Grande that were developed without water and sewer service.

To participate in the program, individual counties will have to adopt rules to regulate subdivision development and stop the growth of colonias. As many as 30 counties could be eligible for aid under the program. Half of the amount of the loans will have to be repaid by colonia residents. The bill also contains provisions to coordinate and finance wastewater treatment plants along the Rio Grande.

Voter approval of constitutional amendments is needed in November to OK the issuance of $500 million in water development bonds to fund the program.

Colonias residents in the El Paso area are already getting relief from a similar program. For the first time, a colonias household in that area was hooked up to water and sewer service June 17. The joint venture between the City of El Paso Public Service Board and

the El Paso County Lower Valley Water District hopes to provide 600 colonias families with water and sewer service by the end of the year.

## *Proposed FEMA 100-Year Floodplain Elevations Draw Fire From Landowners*

A multi-agency flood insurance study in Burnet County has proposed 100-year flood elevations that many realtors and land developers say will make properties surrounding some Hill Country lakes harder to sell or develop.

The Federal Emergency Management Agency (FEMA) study was conducted in cooperation with the U.S. Army Corps of Engineers and the Lower Colorado River Authority. Burnet County has historically used a standard figure of 829 feet above mean sea level (AMSL) to estimate flood plain elevations throughout the county. Results of the study show that 100-year flood elevations surrounding Inks Lake were as high as 844 feet AMSL and flood elevations near Lake Marble Falls were as high as 837 feet AMSL.

Burnet County participates in FEMA's National Flood Insurance Program and flood insurance is available anywhere in the county. However, if county commissioners decide not to accept the new floodplain elevations, flood insurance and disaster assistance would no longer be available and federal financing for developing or improving structures in the floodplain could be restricted.

## *Lower Colorado, Brazos River Authorities Consider Water Management Plans*

Plans for managing the Colorado and Brazos rivers have been developed by agencies that regulate those water bodies. The Lower Colorado River Authority Board of Directors has approved a water management plan. The plan, which now goes to the Texas Water Commission for approval, recognizes recreation and tourism as beneficial water uses and intends to keep lake levels constant to protect those interests. The plan guarantees rice growers as much water as they have historically used, and calls for the creation of interruptible water rights which could be sold in years when water is abundant.

Meanwhile, the Brazos River Authority (BRA) has adopted a drought contingency plan. The plan sets forth reservoir operating rules, describes a mechanism for determining if shortages exist, and provides trigger points at which specific conservation plans will be implemented. The BRA also adopted a drought management plan specifically for 1989, because lake levels in the area were below 75% of capacity earlier this year.

## *Upper Guadalupe RA Begins Aquifer Storage Program; Installs Flood Sensors*

The Upper Guadalupe River Authority (UGRA) in Kerrville has approved an innovative underground water storage system called aquifer storage recovery (ASR) and will begin tests this fall to see if the plan is feasible. ASR calls for pumping treated river water into several city-owned wells. The water could be recovered during emergencies or when demands exceed UGRA's water treatment plant capacity. If the plan is successful, it could

delay expanding existing water treatment plants and could postpone reservoir development. A consulting firm earlier indicated the program would work in the area.

In another matter, UGRA has begun installing the first of a network of 21 flood sensors along the Guadalupe River. The system will employ rainfall gauges and water flow sensors to measure if floods are likely to occur. Real-time data will be sent via computer to an emergency operations center that would issue alarms n rainfall rates reach set criteria. The need for such a system was tragically demonstrated after a 1987 flash flood swept a bus into the Guadalupe River, killing 10 teen-age campers.

## *Legislature OKs 6-Member Board to Regulate Pesticides Other Bills*

Bills affecting a number of water- related issues including pesticides, cleanup of polluted groundwater sites and other issues were passed in the last session of the Texas Legislature.

One of the bills established a sixmember board to oversee pesticide regulation. Board members will include the Commissioner of the Texas Department of Agriculture (TDA), the Texas State Chemist from Texas ARM University, the Dean of the University of Texas School of Public Health in Houston, the Dean of the School of Agriculture at Texas Tech, the Director of the environmental epidemiology program at the Texas Department of Health, and the Chief of the groundwater conservation section of the Texas Water Commission. Previously, pesticide regulation was primarily a TDA function.

The Legislature also approved the Groundwater Protection Act that would create a $50 million fund to clean up groundwater pollution caused by leaking storage tanks containing petrochemical products.

## *New Water Districts Created*

The Legislature also created a number of new water districts to regulate surface and ground water usage. Underground Water Conservation Districts (UCWDs) were created in Dawson (Mesa UCWD), Bell (Clearwater UWCD), Burnet (Central Texas UWCD), Crockett, Kent, Reagan, Yoakum, Live Oak, and Lampasas (Brush Country UWCD)counties. Other groundwater districts that were created include the Fort Bend Subsidence District; the Plum Creek Conservation District in Caldwell, Hays, and Bastrop counties; and the Spring Hills Water Management District in Bandera County. Bills to create groundwater districts in Pecos, Ector, Uvalde and Medina counties were not approved.

Surface water districts that were created include the Canyon Regional Water Authority, the Collin County Water Authority, and the Grayson County Water Control and Improvement District No. 1.

## *Video Produced by TWRI to Honor 25 Years of Water Resources Research*

*Water-the Life Giving Resource* is the title of a 12- minute videotape produced by Ric Jensen of the Texas Water Resources Institute. The video commemorates the 25th anniversary of the Water Resources Research Act which created water research centers at land grant colleges throughout the U.S.

The video describes the role of institutes in research, technology transfer and training future water professionals. It highlights accomplishments in university water research and defines emerging water issues that are the subject of current and future research.

Copies of the videotape are available in VHS format for $10 or 3/4 inch format for $20. Requests should be sent to: Al Powell, Ag Communications, 229 Reed McDonald, Texas A&M University, College Station, TX 77843-2112. The phone number is (409) 845-2211.

## *'Major Rivers' will Lead 4th Graders Through Water Adventures*

Elementary school teachers across Texas will have a new friend named "Major Rivers" to help them teach 4th graders about water this fall.

Major Rivers and his horse "Aquifer" are fictional characters that will introduce concepts such as water quality, conservation and water supplies into grade school classrooms. The program meets requirements of the Texas Education Agency.

The Lower Colorado River Authority helped fund the curriculum materials and is making the program available free to schools within its service area. The Texas Water Development Board, the Texas Water Commission, and the Texas Department of Health are providing funding to assist local school districts in other parts of Texas that may want to purchase the program.

For more information, contact: Donna Darling, Texas Water Development Board, PO Box 13231, Capitol Station, Austin, TX 78711-3231. The phone number is (512) 463-7869.

## *New TWC, TWDB Reports Discuss Hazardous Waste, Groundwater Protection*

Reports discussing hazardous waste management, groundwater protection, groundwater supplies and river ecosystems have recently been published by the Texas Water Commission. *Hazardous Waste Management in Texas: A Report to the 71st Legislature* describes the state policy for managing hazardous waste and projects the numbers of future hazardous waste sites. *Ground Water Protection and Management Strategies in the Texas High Plains (LP 89-02)* includes information on groundwater regulatory agencies in the region and estimates the economic impact of groundwater management and protection. *Ground Water Investigation and Contamination Potential of a Portion of Southeast Val Verde County, Texas (Report 89-02)* describes the vulnerability of

groundwater supplies in the Del Rio area to contamination and describes a welihead protection plan that was developed to protect the aquifer. *Intensive Survey of the Navasota River (IS 89-01)* and *Intensive Survey of Armand Bayou (IS 89-03)* describe water quality in those two water bodies.

A new publication by the Texas Water Development Board (TWDB) describes the hydrology and geology of the Texas southern High Plains. The publication, *Hydrogeology of the Lower Cretaceous Strata Under the Southern High Plains of Texas and New Mexico (Report 314)* includes information on the area s hydrology and geology including regional aquifer characteristics, recharge and discharge.

For information on ordering any of these publications, contact: Library, Texas Water Commission, PO Box 13087, Capitol Station, Austin, TX 78711. The phone number is (512) 463-7834.

## *Irrigation Software Available from Ag Extension Service*

The Texas Agricultural Extension Service has developed four computer software packages to manage irrigation systems and maximize profits. Titles of the software packages include: *Calculating Irrigation Capacity Unknowns, Irrigation Fuel Cost Calculation, Irrigation Pumping Plant Efficiency,* and *Irrigated vs. Dryland Crop Production.*

The software is available in MS DOS and CP/M formats and instructions are included. Each program costs $25 for Texas residents and $35 for persons outside of Texas. To order, contact: TAEX Software Distribution, Special Services Bldg, Room 119, Texas A&M University, College Station, TX 7784-32468, or call (409) 845-3929.

## *Rice Professor Co-authors Hydrology and Floodplain Analysis*

Phillip Bedient of Rice University and Wayne Huber of the University of Florida have written a textbook titled *Hydrology and Floodplain Analysis.* The 544-page book includes sections on hydrologic principles, rainfall and runoff analysis, flood routing, hydrologic simulation models, watershed studies, urban hydrology, flood plain hydraulics, and groundwater hydrology. Also included are 10 computer programs in hydrology and hydraulics, and three major case studies.

The book is available for $52.75 from: Addison-Wesley Publishing Co., Reading, MA 01867-9984. The phone number is (800) 447-2226.

## *New Book By Texas Tech, TWC Guides Groundwater District Operations*

A two-volume manual that provides directors and managers of groundwater conservation districts in Texas with information on legal, technical and procedural requirements has recently been published by the Texas Water Commission (TWC).

The report includes sections on such topics as how to create a groundwater district, programs, activities and operations. Authors of the manual include James Jonish of the

International Center for Arid and SemiArid Land Studies and Lloyd Urban of the Water Resources Center at Texas Tech University; Bill Klempt of the TWC and Wayne Wyatt of the High Plains Underground Water Conservation District No. 1 in Lubbock.

*Groundwater Conservation District Operations Manual* is available for $20 from: Texas Water Commission, PO Box 13087, Capitol Station, Austin, TX 78711-3087. The phone number is (512) 463-7834.

## *TAES Study Says Grass Carp Removed Weeds From Lake Conroe*

Grass carp reduced the concentrations of hydrilla and other waterweeds in Lake Conroe, and helped return the lake's environment to its natural state, according to a new Texas Agricultural Experiment Station (TAES) report.

The report, *Control of Aquatic Macrophytes by Grass Carp in Lake Conroe, Texas, and the Effects on the Reservoir Ecosystem (MP-1664),* summarizes the results of a 7-year TAES study. When 270,000 grass carp were introduced into the lake in 1981, submersed aquatic weeds covered roughly 45% of the lake. By 1983, virtually all of the waterweeds had been removed.

The grass carp also changed the lake's environment in the following ways: 1) Concentrations of blue-green algae increased; 2) Amounts of nitrate, ammonia nitrogen, sulfates and phosphates initially increased (the compounds were bound by the waterweeds) but later returned to former levels; 3) Numbers of fish that were better suited to survive in open waters such as shad and minnow increased, while numbers of sunfish that use waterweeds for vegetative cover decreased; 4) Water clarity decreased by 40% and 5) Chlorophyll concentrations increased in open waters.

The study is available from: Agricultural Communications Dept., Texas A&M University, College Station, TX 77843. The phone number is (409) 845-5856.

## *New TWC Publication Details Texas Groundwater Quality*

*Groundwater Quality of Texas: An Overview of Natural and Man- Affected Conditions (Report 89- 01)* is the title of a new 197-page report published by the Texas Water Commission.

The report describes the chemical quality of the state's major and minor aquifers and assesses known and potential sources of man-made pollution. Included in the report are 57 full-color maps depicting water quality in various regions of the state and two oversized color plates that utilize the DRASTIC methodology to display groundwater pollution potential from agricultural, municipal and industrial sources.

To obtain a copy, contact: Texas Water Commission, PO Box 13087, Capitol Station, Austin, TX 78711-3087. The phone number is (512) 463-7834.

## *League of Women Voters Study Examines Impact of Safe Drinking Water Act*

The results of a recent survey that asked state drinking water administrators and local water utility officials to gauge the impact of the 1986 amendments to the Safe Drinking Water Act have been published in a new report by the League of Women Voters.

*Crosscurrents: The Water We Drink* details the results of surveys taken from nearly 600 local water utility officials and 49 state drinking water administrators from across the U.S. Texas cities that were surveyed include Bryan, College Station, Orange, Dallas, Fort Worth, Arlington, Harlingen, Palms, Lubbock, Midland, Friendswood, Beaumont, and Victoria. The North Texas Municipal Water District and Galveston County WCID No. 1 also participated.

Results showed that 98% of local utilities surveyed reported levels of trihalomethanes in their drinking water below current EPA standards. However, 25% of those utilities now exceed tightened standards expected to be imposed in the future. A third of local utilities felt that current rate structures were inadequate to fund the capital improvements needed to comply with the act.

The report is available for $4.95 from: League of Women Voters, 1730 M Street NW, Washington, DC 20036. The phone number is (202) 429-1965.

## *Global Warming Spotlighted in New TDA, TWRI Reports*

Two reports focusing on the impact of global warming on Texas have recently been produced.

*Global Warming and the Future of Texas Agriculture* is a new 46- page report published by the Texas Department of Agriculture. The study examines the implications of climate change on production agriculture, cropping patterns, fisheries and forestry, and suggests policy responses for slowing the rate of warming and adjusting to a different climate. The report is available from: Texas Department of Agriculture, Office of Natural Resources, PO Box 2847, Austin, TX 78711, or call (512) 463-7504.

"Are Things Warming Up? How Climate Changes Could Affect Texas" is the title of the new issue of *Texas Water Resources*, a quarterly six- page newsletter produced by the Texas Water Resources Institute. The report looks at the impact of anticipated climate changes on streamflows in river systems, coastal flooding, agriculture and other areas, and describes recent university research to better understand the phenomena. *Texas Water Resources* is available from: Texas Water Resources Institute, Texas A&M University, College Station, TX 77843-2118. The phone number is (409) 845-1851.

## *General Accounting Office Study Says Clean Water Act Not Fully Enforced*

A new report prepared by the General Accounting Office (GAO) charges that more EPA action is needed to assure that rivers and streams with limited water quality are being cleaned up according to provisions of the Clean Water Act.

Under the Clean Water Act, individual states are to establish stringent pollution standards in rivers and streams where conventional wastewater treatment cannot meet water quality standards. However, the GAO study found that these actions have not been taken on most streams with limited water quality. The report noted that many states do not plan to accelerate actions to control toxic point substances as required by the 1987 Water Quality Act, and that EPA does not have sufficient information to monitor water quality and cleanup activities on those streams.

The report, *Water Pollution:More EPA Action Needed to Improve the Quality of Heavily Polluted Waters*, is available from: General Accounting Office, Box 6015, Gaithersburg, MD 20877. The phone number is (202) 275-6241.

## *U.S. Geological Survey Publishes 1986 National Water Summary*

The U.S. Geological Survey recently published the *National Water Summary 1986: Hydrologic Events and Ground Water Quality*. Texas-specific information in the 560-page report includes summaries of the amount of dissolved solids, nitrate, sodium and fluoride in aquifers; maps showing the locations of landfills and Superfund sites; and summaries of major floods and pollution events.

The report also details such national issues as natural radioactivity in aquifers, point and non-point source contamination of groundwater supplies, state and local strategies for protecting aquifers, and national drinking water regulations.

For more information on ordering the report, contact: Library, U.S. Geological Survey, 8011 Cameron Road, Bldg. 1, Austin, TX 78753-6716. The phone number is (512) 832-5791.

## *UT-Galveston Researchers Find Better Way to Grow Squid*

A new way to mass produce squid is being developed by scientists at the University of Texas Medical Branch (UTMB) at Galveston that may improve neurological research. Roger Hanlon, a researcher at UTMB, is working on a system to grow Japanese squid year- round. The juvenile squid are exposed to artificial sunlight 24- hours a day, and are fed shrimp, crabs, and fish 18 hours a day. The squid weigh more than 4 pounds within 4 months, (usually it takes 1.5 years). So far, two generations have been raised in captivity (a biological world record). In the past, researchers had to travel to the Northeast U.S. during the summer to capture Atlantic squid.

Neurologists study squids because the animals have an unusually large nerve cell component called an axon. The axon transmits signals that tell muscles to expand and

contract, and relays information to the brain. Squids may have evolved this large axon to achieve efficient propulsion because the animals move about by contracting powerful muscles that run the length of their elongated bodies. By studying the axon, clues about such disorders as Alzheimer's disease and ALS (Lou Gehrig's disease) may be found. The research was featured in the Fall/ Winter issue of *Biomedical Inquiry* magazine. To receive a copy, contact: University of Texas Medical Branch at Galveston, Public Affairs Office, 200 University Blvd., #136, Galveston, TX 77550. The phone number is (409) 761-2618.

## *Texas A&M Receives NIH Grant to Study Toxic Chemicals in Hazardous Waste Dumps*

A $2.6 million grant to establish a national center to study toxic chemicals in hazardous waste dumps has been awarded to Texas A&M University scientists by the National Institutes of Health.

The four- year grant will enable toxicologists, chemists, biochemists and disease specialists from Texas A&M University, Texas A&M University at Galveston, and the Baylor College of Medicine in Houston to develop and test new ways to assess the toxic potential of chemical wastes.

The center is one of nine NIH-funded toxic waste centers established by federal Superfund legislation passed by Congress in 1986. The center will aim to develop new methods to determine the risks such waste dumps pose to human health. It will also develop new methods for degrading chemical wastes and will assist regulators in prioritizing sites for cleanup and remediation.

## *North Texas Researchers Study Trinity River Water Quality*

Researchers at the University of North Texas are now involved in two projects dealing with the environment of the Trinity River.

A recent study headed by Sam Atkinson of the Center for Remote Sensing and Land Use Analyses involved analyzing and georeferencing airborne multispectoral data to assess point and nonpoint source pollution loadings in the upper Trinity River watershed. Results identified sites of pollutant loadings and were used to develop management plans. The study found that water quality could be improved to meet specific goals but cost-benefit ratios need to be examined in more detail.

In a separate project, UNT scientists are identifying and evaluating toxics in sewage effluents from Dallas' central wastewater treatment plant. Ken Dickson and Tom Waller of UNT's Institute for Applied Sciences, will lead the project. The study also involves analyzing Trinity River samples from areas upstream and downstream of the plant for toxicity to aquatic organisms.

## *Texas A&M Studies Utilize Biological Controls To Clean Up Toxins*

Three research projects at Texas A&M University are investigating if biological controls can be used to destroy hazardous wastes and toxic chemicals.

In one project, Emily McCreary, Jim Bonner and Robin Autenrieth of Texas A&M's Civil Engineering Department, and Aydin Akgerman of the Chemical Engineering Department are utilizing microbial bacteria to degrade toxins such as phenols, halogenated hydrocarbons, and volatile organic chemicals into harmless byproducts. Results indicate that the microbes completely degrade phenol concentrations of up to 300 mg/l, and that the microorganisms can adapt to the toxins if chemical oxygen demand remains constant. The study was funded by a grant from the Hazardous Substance Research Center at Lamar University.

In another project, Donald Sawyer of the Texas A&M Chemistry Department has developed an industrial scale process to dispose of PCBs (polychlorinated biphenyls). The process utilizes a reaction involving superoxide ions (oxygen molecules with an additional electron) to convert PCBs into the chemical equivalent of table salt and baking soda. Up until now, PCBs had to be disposed of by incineration. The research was funded in part by Captiva Capital, Ltd., a Denver, CO, based company that will fund a pilot project and be a part owner of the new technology. In a third project, James Wild of the Biochemistry Department and Frank Raushel of the Chemistry Department have developed an enzyme that could help clean up pesticides and obsolete chemical weapons. The enzyme, which occurs naturally in common soil bacteria, degrades chemicals called organophosphates by attacking bonds that hold molecules together. It could provide an inexpensive, effective way to break down these toxic compounds.

## *Rice University Research Focuses on Biorestoration of Polluted Aquifers*

Researchers in the Environmental Science and Engineering Department at Rice University are investigating if subsurface microorganisms could be utilized to destroy petroleumbased organic compounds that may be polluting groundwater supplies. In one project, C.H. Ward is determining if biorestoration could be cost effective at sites where groundwaters are circulating and where sufficient amounts of nitrogen, phosphorus and dissolved oxygen are present In a related project, Philip Bedient is developing an expert system designed to assist technical personnel working on EPA "Superfund" projects to select the best strategy to clean up polluted aquifers. The system, called the OASIS project, includes two groundwater models and three data bases.

The research was supported by the EPA. Rice University is pan of the National Center for Ground Water Research, an EPA Center of Excellence.

## *Texas Tech Scientists Pull Fords Underwater to Test Aerodynamics, Wind Drag*

Texas Tech University is building a new underwater tow tank to test the aerodynamics, wind drag, cooling and fuel economy of cars. The 80-foot long, 15-foot wide and 10-foot

deep tank, big enough to pull a full size car, is being funded by a $60,000 grant from the Ford Motor Company Fund.

According to Timothy Maxwell an associate professor in the Mechanical Engineering Department, the experiments consist of injecting dye into the water and following its movement as it passes in and around radiators, batteries and other auto parts. Maxwell says the underwater experiments provide a better view of underhood and underbody airflows than conventional wind tunnels.

## *SW Texas Uses Theater to Teach Kids About Edwards Aquifer*

What's the best way to keep the attention of children and teach them about groundwater? One alternative to textbooks may be a musical play called "Cave Song" that was produced by Charles Pascoe of the Theater Arts Department of Southwest Texas State University. The plot of "Cave Song" centers around a group of stalactites and stalagmites who awaken after years of dormancy and learn they have stopped growing due to a lack of water and polluted conditions. They are visited by two water spirits who are charting escape routes from the aquifer to the surface. A band of rock musicians who are not sensitive to the ecology of the aquifer invade, but are eventually enlisted to help rid the underground region of unwanted surface creatures.

"Cave Song" had its debut last November. It will be shown at Southwest Texas State's University Theatre on July 12 and 15. For more information, contact the university's Edwards Aquifer Research and Data Center at (512) 245-2329.

## *Texas A&M Developing Water Education Resources for High School Students*

Texas A&M University's Center for Mathematics and Science Education is currently developing a system that uses on-line data to teach junior high and middle school students about water resources. Bob Swift and Jim Zuhn of Texas A&M's Education and Curriculum Instruction Department are spearheading the project which lets students gain access to real-time data from satellites and mainframe computers. Data are being provided by the Lower Colorado River Authority and other sources. Learning activities about streamflows and water quality have already been developed.

The pilot program is now underway at schools in College Station, Richardson, Austin, San Antonio and Bellville and is a joint venture between Texas A&M and GTE Education Services. For more information, contact: Bob Swift, EDCI Department, Texas A&M University, College Station, TX 77843 or call (409) 845-6041.

## *Water Rates in Texas Cities, Water Demands Studied by Texas A&M Economists*

An in-depth analysis of municipal and domestic water pricing in Texas has just been completed by researchers in the Agricultural Economics Department at Texas A& M University. Ron Griffin and Chan Chang collected data on monthly water use and water

and sewer rates from 221 Texas communities. The information was combined with census data and climate records to identify the impact of pricing on urban water demands.

Information was generated on monthly and annual water use, water and sewer rate structures, marginal water and sewer prices, water and sewer bills and water demands for major regions of Texas. Results suggest that consumers respond more to changes in average water prices than to marginal prices, that sewage prices and water prices both influence water demand, and that pricing is a more effective conservation policy during the summer because consumers are more price responsive during that time. Other uses of this research could include economic evaluations of such issues as water marketing, expansion of water and wastewater facilities, estimation of water demands, and evaluating the cost effectiveness of water conservation programs. The study, *Community Water Demand in Texas,* will be published later this year as a Texas Water Resources Institute technical report and a Texas Agricultural Experiment Station bulletin.

## *East Texas State Researchers Study Rural Water Systems*

Researchers at East Texas State University are identifying emerging needs and problems of rural water systems as part of a two-year study funded by the Texas Water Resources Institute.

The study is being conducted by Raghu Singh of the Sociology and Anthropology Department and Michael Ellerbrock of the Agriculture Department. It will examine impacts of new state and federal legislation, and will investigate structural problems such as water quality, water losses and operating costs.

The researchers hope to identify demographic, social and economic characteristics associated with rural water suppliers, and to evaluate the quality and effectiveness of 12 Texas rural water systems representing different regions of the state.

## *UT Developing Methods to Evaluate Water Distribution Systems*

Graduate students at the University of Texas at Austin are developing new ways to evaluate water distribution systems. In one project, Joong- Hoon Kim is developing a model that would optimize the rehabilitation and replacement of pipes in aging water distribution systems. The model would also determine if pumping capacities should be increased to satisfy multiple demands. In other projects, Mao- Chang Shih is working on a computer program to evaluate the reliability of water distribution system components, and Lehar Brion is devising a model to optimize pumping operations at wastewater treatment plants.

The information was contained in the last issue of *Watermarks. To* receive a copy or for additional information on these and other graduate student projects, contact: Center for Research in Water Resources,10100 Burnet Road, Austin, TX 78758-4497. The phone number is (512) 471-3131.