Texas Water Resources Institute

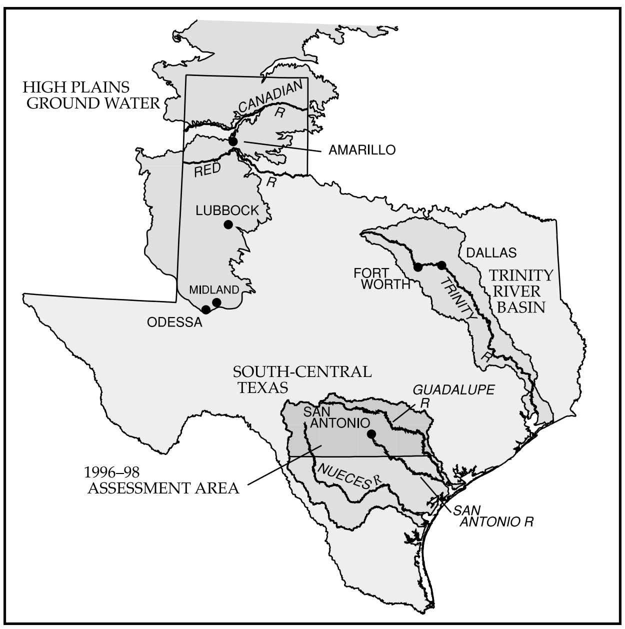
Texas Water Resources

April 2001
Volume 26
No. 1

The USGS National Water-Quality Assessment Program in Texas

A Consistent, Long-Term Approach to Understanding Water Quality in Three Regions of the State

By Peter Bush, Kevin Dennehy, and Bruce Moring, U.S. Geological Survey (USGS)



The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other federal, state, and local agencies, the NAWQA Program is designed to answer these questions: What is the condition of our nation's streams and groundwater? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and groundwater, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic biota, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities.

Since 1991, the NAWQA Program has begun interdisciplinary assessments in more than 50 of the nation's most important river basins and aquifers, referred to as study units. Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the nation's diverse geographic and environmental settings.

The design framework for NAWQA is based on repeating decade cycles of three-year high-intensity monitoring, alternating with six-year low-intensity monitoring. The USGS believes that continual monitoring using exacting, well-documented sampling protocols and analytical methods is the key to establishing definitive trends in nutrients, pesticides, volatile organic compounds (VOCs), trace metals, and aquatic biota.

Texas has two NAWQA study units—the Trinity River Basin and South-Central Texas. The Trinity River Basin assessment began in 1991 and is cycling into its second high-intensity phase this year. The South-Central Texas assessment began in 1994 and currently is in its first low-intensity phase. Texas is also taking part in a NAWQA High Plains Regional Ground-Water Study that began in 1998. That project encompasses the vast High Plains (Ogallala) Aquifer, which covers parts of Texas and seven other states.

Trinity River Basin

The hydrology of the Trinity River Basin is largely defined by precipitation, streamflow, and water storage in more than 22 large reservoirs (greater than 10,000 acre-feet of storage) in the basin. Surface water supplies 90% of the water used in the basin, while the 10% that is supplied by groundwater is pumped from small municipal or rural domestic wells

Streams in the Trinity River Basin generally have low gradients and meander across a physiography dominated by rolling prairies in the northern part of the basin, gently rolling timbered lands in the middle part, and extensive hardwood bottomlands and coastal prairies and marshes in the southernmost reaches of the drainage. Major aquifers outcrop in a southwest-to-northeast direction that reflects the multiple sea encroachments over geologic time.

The first cycle of high-intensity monitoring in the study unit (1992–95) was designed to provide information on the occurrence and distribution of dissolved chemical constituents in water and organic compounds and trace elements in streambed sediment and fish. The status of biological communities—algae, invertebrates, and fish—also was studied as an indicator of stream quality. An inventory was designed to assess the effects of urban and agricultural land practices on the water quality of streams, reservoirs, and major aquifers in the basin. Water samples were collected and aquatic biota were assessed throughout the basin. Most of the monitoring during the first high-intensity phase took place in the upper part of the basin in the vicinity of the Dallas-Fort Worth metropolitan area.

During the high-intensity monitoring, 480 water samples were collected from streams in the Trinity River Basin. The majority of these samples were collected at four "intensive" sites on a weekly-to-monthly basis and during some storms. Several stream synoptic studies were done to obtain greater spatial coverage of the basin than the intensive sites provided.

Findings indicate that total nitrogen concentrations in urban and agricultural streams are very similar and are larger than concentrations in streams in rangeland and forested areas. Only two of the 480 samples from streams had nitrate concentrations that exceeded the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 10 milligrams per liter. The largest nutrient concentrations were from streams downstream from urban wastewater discharges, and the smallest were from streams immediately downstream from reservoirs. Pesticides were analyzed in 277 water samples from streams, and more herbicides than insecticides were detected in urban and agricultural streams.

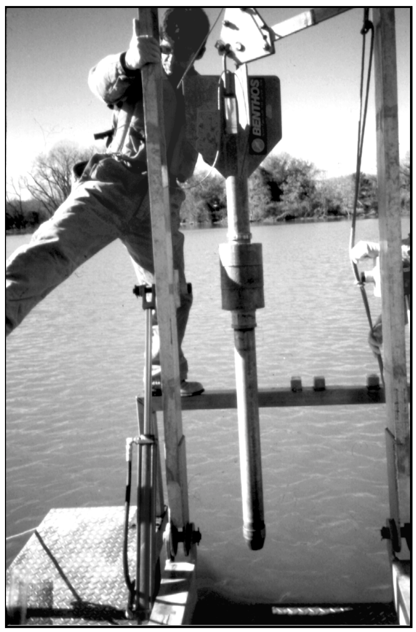


Photo Courtesy of Barbara Mahler/ USGS

USGS research hydrologist Peter Van Metre takes a core sample of sediments in Mountain Creek Lake near Dallas. The NAWQA program began a national study of water quality trends using bottom sediment cores in 1992.

Atrazine was the most commonly detected pesticide, and all of the samples from urban streams had detections of atrazine. Atrazine concentrations generally were highest in agricultural streams.

The occurrence and distribution of organochlorine pesticides and polychlorinated biphenols (PCBs) in streambed sediment and tissues of fish and clams were surveyed at 16 sites in the Trinity River Basin. Sediment concentrations of chlordane, dieldrin, and the DDT breakdown products DDD and DDE were larger in streams draining urban areas than agricultural areas. Concentrations of these organochlorines in sediment commonly exceeded the Texas Natural Resource Conservation Commission (TNRCC) screening criteria for these compounds. More organochlorines were detected in sediment than in fish and clam tissues. Chlordane, DDT, and PCBs were more frequently detected in fish tissue in streams draining urban areas than agricultural areas.

Fish communities in urban and agricultural streams of the Trinity River Basin were more degraded than those in forested areas and were dominated by tolerant species that adapt to a human-altered environment. The urban and agricultural streams had more variable and "flashy" streamflows, less diverse physical habitat, and fewer meanders than streams in forested areas. One urban bright spot was the finding that the fish communities in the Trinity River downstream from major wastewater discharges in the Dallas-Fort Worth area have improved since the mid-1970s. Changes in wastewater treatment that result in less ammonia and organic nitrogen being discharged into the river have increased dissolved oxygen concentrations, thus creating a more favorable environment for fish.

Reservoirs are sinks for many contaminants, particularly the so-called "legacy" pollutants (banned or restricted-use contaminants that are environmentally persistent) such as chlordane, DDT, PCBs, and lead. Reservoir sediment cores can be age-dated and analyzed from the top (younger sediment) to the bottom (older sediment). Water-quality trends can be reconstructed for selected legacy pollutants. A sediment core from White Rock Lake in Dallas indicated decreasing trends in lead, DDT, and PCBs, but increasing trends in chlordane, polycyclic aromatic hydrocarbons (PAHs), and zinc since the mid-1960s. PAHs are trace contaminants produced by combustion of hydrocarbons. The White Rock Creek watershed drains into White Rock Lake and has become considerably more urbanized since the 1960s. Urban use of chlordane (primarily to control termites and ants) was permitted until 1988, and homeowners could use existing stocks after that. Increases in PAHs and zinc are believed to be associated with increases in vehicular traffic.

The USGS sampled 28 wells, each less than 50 feet deep, in the Woodbine Aquifer underlying the Dallas-Fort Worth metropolitan area to determine the influence of urban land use on water quality in a shallow recharge zone. Nearly three-fourths (71%) of the samples from the Woodbine Aquifer exceeded the EPA secondary MCL for dissolved solids, while 61% of the samples exceeded the secondary MCL for iron and sulfate. In addition, 13% of the samples from the Woodbine had nitrate concentrations that exceeded the EPA MCL. The most commonly detected VOC was methyl tert-butyl ether (MTBE), a gasoline additive that has received recent publicity because of its potential to contaminate groundwater. None of the pesticide concentrations in shallow groundwater from the Woodbine and three other aquifers sampled in the study unit exceeded drinking-water standards or guidelines.

This year, the Trinity River Basin assessment is beginning its second cycle that will include three years of high-intensity monitoring. For the second cycle, the NAWQA Program has two principal objectives: (1) continue monitoring at established intensive sites to detect any changes in the status of contaminants found during the first high-intensity phase; and (2) develop local, regional, and national studies that address the source, transport, and effects of contaminants in streams. A focal point for the Trinity River Basin assessment will be the effects of urbanization on stream ecosystems in the Dallas-Fort Worth metropolitan area.

The findings of the first high-intensity monitoring phase are summarized in USGS Circular 1171, *Water Quality in the Trinity River Basin, Texas, 1992–95*. The circular can be viewed on the World Wide Web (WWW) at http://water.usgs.gov/pubs/nawqasum/. Additional information about the Trinity River Basin assessment can be obtained from the project WWW site at http://tx.usgs.gov/. Questions about the project can be directed to Bruce Moring, Project Chief, Austin, Texas, at jbmoring@usgs.gov or (512) 927–3585.

South-Central Texas

The first high-intensity monitoring phase in the South-Central Texas Study Unit (1996–98) focused on the upper part of the study unit, which comprises parts of the topographically rugged Edwards Plateau and the comparatively flat Gulf Coastal Plain physiographic regions. The upper part of the study unit contains the Edwards Aquifer in the Balcones Fault Zone and the Trinity Aquifer in the Texas Hill Country.

Surface and ground water in the upper part of the study unit are uniquely interrelated. Streams deeply incised into the rocks of the Edwards Plateau often gain water as they flow south-southeastward from headwaters in the higher elevations of the plateau. As the major streams flow across the faulted and fractured Edwards Aquifer outcrop (recharge zone), they lose substantial amounts of flow directly into the aquifer. The highly permeable rocks that compose the Edwards Aquifer recharge zone, as well as increasing development in the watersheds of major streams in the Edwards Plateau and the recharge zone, make this aquifer vulnerable to contamination.

Single water samples from 88 Edwards Aquifer wells and 31 Trinity Aquifer wells were analyzed for natural constituents (including nutrients), pesticides, VOCs, and trace metals. Numerous contaminants were detected in Edwards Aquifer samples, while fewer were found in Trinity Aquifer samples. Concentrations were low (fractions of a part per billion) and well below all current EPA drinking-water standards and guidelines.

Although the findings in South-Central Texas do not imply any current health risk, they are an early warning that human activities are having an effect on regional ground- and surface-water quality. Pesticides and VOCs in the Edwards Aquifer were detected most frequently in wells in urbanized parts of the recharge zone. Detections were less frequent in Edwards Aquifer wells in undeveloped parts of the recharge zone, and also in wells in the confined zone, where the aquifer is buried under rocks that restrict the downward movement of water and contaminants.

Water samples from three intensive stream sites—two in urban settings and one in an agricultural setting—were collected weekly to monthly (plus storms) for 15 months and analyzed for essentially the same constituents as groundwater. The findings indicate that streamwater quality is affected more by urbanization than by agriculture in the region. More pesticides and VOCs at generally higher concentrations were found in urban streams than in agricultural stream water. In some (mostly urban) stream samples, concentrations of each of six pesticides and one organic compound (chloroform) were higher than Canadian guidelines for the protection of aquatic life. The herbicide tebuthiuron had the highest concentration among pesticides. The potential risk to aquatic life can only be partially addressed because many of the contaminants lack regulatory standards. No U.S. guidelines for the protection of aquatic life have been established.

Photo by Kelley Gehrke/ USGS

Biologist Evan Hornig (left) and hydrologic technician Peter Spatz (both of the USGS South-Central Texas NAWQA Team) seine for fish in the Blanco River near Wimberley. Later, fish tissue were analyzed and the community structure of this stream was assessed.

Streambed-sediment and fish-tissue samples collected one or more times from more than a dozen sites in urban, agricultural, and rangeland settings also seemed to be affected the most by urbanization. The average number of organic contaminants detected in urban sediment samples was substantially greater than the average number detected in agricultural or rangeland sediment samples. Similar findings were reflected by organochlorine pesticides and total PCBs in whole-body fish tissue. The greatest number of contaminants and generally the highest concentrations were found in urban samples.

Biological community status also reflected watershed development and land use. The algal and fish communities at an urban site in San Antonio were among the most degraded of NAWQA biological sites sampled nationwide. In contrast, the algal, invertebrate, and fish communities at rangeland sites in the Hill Country ranked among the healthiest of NAWQA biological sites sampled nationwide.

The findings also suggest there may be a correlation between the quality of recently recharged urban groundwater and the quality of urban stream water. Four of the five most frequently detected pesticides in water from urban recharge-zone wells in the Edwards aquifer—the herbicides atrazine, its breakdown product deethylatrazine, simazine, and prometon—are the same as four of the five most frequently detected pesticides in surface water at urban stream sites in the San Antonio region. Those four pesticides also are the most frequently detected by the USGS in shallow groundwater in urban areas nationwide.

Fewer organic chemicals were found in the Trinity Aquifer, which supplies most of the water to wells in the Hill Country, than in the Edwards Aquifer. Water that could contain contaminants does not recharge the Trinity Aquifer as readily as the Edwards Aquifer. Little development overlies the Trinity Aquifer.

The South-Central Texas assessment began its first low-intensity phase in late 1999. Eight Edwards Aquifer recharge-zone wells (five urban and three non-urban) are sampled annually, and three stream-water sites (two urban and one rangeland) are sampled monthly. The assessment will begin its second cycle that includes three years of high-intensity monitoring in 2004. The USGS does not yet know when monitoring will begin in the southern part of the study unit.

The findings of the first high-intensity monitoring phase are summarized in recently published USGS Circular 1212, *Water Quality in South-Central Texas, 1996–98*. The circular can be viewed on the WWW at http://water.usgs.gov/pubs/nawqasum/. More information about the South-Central Texas assessment can be obtained from the project WWW site at http://tx.usgs.gov/. Specific questions about the project can be directed to Evan Hornig, Project Chief, Austin, Texas, at cehornig@usgs.gov or at (512) 927–3589.

High Plains Regional Ground Water

The High Plains Aquifer (also known as the Ogallala) is the most abundant source of groundwater in any agricultural region of the United States. Use of the High Plains aquifer has transformed the area into one of the major agricultural regions of the world. During 1995, water use in the eight-state area covered by the High Plains Aquifer was estimated to be 19.9 billion gallons per day. Of this amount, 81% was pumped from the aquifer, while 19% was withdrawn from rivers and streams. About 96% of water pumped from the aquifer is used to irrigate crops on about 27% of the irrigated land in the United States. Withdrawals account for about 30% of the groundwater used for irrigation nationwide.

The High Plains Regional Ground-Water Study is different from traditional NAWQA study units in three ways. First, the original NAWQA Program plan delineated study units in the High Plains area of the United States that corresponded primarily to surface-water drainages and, to a lesser extent, aquifer boundaries. Water use and hydrologic considerations indicated that it was better to assess water resources in the High Plains on the basis of groundwater resources and to define the study area by the aquifer boundary. Second, the focus of the water-quality investigation within the High Plains study area is groundwater. The High Plains assessment also investigates major rivers that are hydrologically connected with the High Plains Aquifer, where appropriate. Third, the High Plains Regional Ground-Water Study was designed with a 10-year initial phase that contains 6 years of high-intensity water-quality monitoring, due to the complexity of groundwater monitoring and the large geographic area. High-intensity monitoring is in years three through eight, with two years each being spent in the central, southern, and northern High Plains regions. About one-third of the central High Plains and two-thirds of the southern High Plains are in Texas. Initial high-intensity monitoring during 1999–2000 focused on the central High Plains. In 2001, the investigation shifted to the southern High Plains for two years and will end with a 2-year intensive effort in the northern High Plains. The final two years of the study will culminate with a series of technical and non-technical reports describing the results of the high-intensity data-collection activities across the High Plains Aquifer system.

Photo by Lindy Harris/ South Plains Underground Water Conservation Dist.

USGS hydrologist Lynne Fahlquist examines this groundwater well on the Texas High Plains.

A series of studies is planned for each region of the High Plains to determine the occurrence and distribution of chemical constituents in the aquifer, and to develop an understanding of the processes that currently influence water quality in the aquifer. The goal of this assessment is to characterize, in a nationally consistent manner, the broad-scale geographic distribution of water-quality conditions in relation to major contaminant sources and background conditions. To accomplish this goal, studies of the primary hydrogeologic units that compose the aquifer (the Ogallala Formation in the central and southern High Plains in Texas) and land use studies are planned. Hydrogeologic unit studies characterize water quality without targeting specific land uses. Domestic wells are randomly selected for sampling in each major hydrogeologic unit in the study area.

Land-use studies attempt to characterize the quality of recently recharged groundwater associated with a particular land-use setting. In a land-use study, 30 water-table wells are installed at randomly selected sites within a prescribed land-use setting for a given hydrogeologic unit. A land-use study in a large irrigated agricultural setting is planned in the Ogallala Aquifer in the southern High Plains. Results from these studies can be compared with results from major-aquifer studies to determine the effects of land use on regional groundwater quality.

Process-oriented studies identify and quantify factors that influence groundwater quality. Two process-oriented studies planned for the southern High Plains are a transect study and an unsaturated-zone study. The objectives of the transect study are threefold: (1) measure vertical gradients in the groundwater chemistry and age in the Ogallala Formation; (2) develop an understanding of groundwater residence times and recharge rates in the Ogallala Formation; and (3) provide a better understanding of contaminant sources and sinks in the Ogallala Formation. The objectives of the unsaturated-zone study are twofold: (1) determine the rate of movement of water and chemicals from land surface to the water table beneath irrigated fields; and (2) estimate recharge rates for comparison to other settings across the Ogallala Formation.

USGS scientists and researchers from Texas Tech University and the University of Texas at Austin Bureau of Economic Geology will be collaborating in the southern High Plains on the transect and unsaturated-zone studies.

Additional information about the High Plains Regional Ground-Water Study can be obtained from the project WWW site at http://co.water.usgs.gov/nawqa/hpgw/HPGW_home.html. Specific questions about the High Plains Regional Ground-Water Study in Texas can be directed to Lynne Fahlquist, Hydrologist, Austin, Texas, at lfahlqst@usgs.gov or at (512) 927–3508 or Kevin Dennehy, Project Manager, Denver, Colorado, at kdennehy@usgs.gov or at (303) 236–4882, x 312.

Coordination and Collaboration

External coordination at all levels is critical for the most complete understanding of water quality and for cost-effective management, regulation, and conservation of water resources. The NAWQA Program depends extensively on the advice, cooperation, and information sharing from other federal, state, and local agencies, as well as non-government organizations, industry, higher education, and other groups interested in or responsible for water resources.

Each study unit has at least one liaison committee. The High Plains Regional Ground-Water Study has three (one for each of its geographic regions). These committees comprise representatives from many water resources organizations. Liaison committees meet periodically to exchange information about water-quality issues, identify sources of data, assist in site selection and the design and scope of study products, and discuss study progress and findings.

The Trinity River Basin Study Unit is reestablishing its liaison committee as preparations begin for the second high-intensity monitoring phase. A meeting is planned for Fall 2001. Because the South-Central Texas Study Unit is in its low-intensity phase, no liaison committee meeting currently is planned. The first and second High Plains Regional Ground-Water Study liaison committee meetings (held in March 1999 and February 2000) focused on the central High Plains. Current plans call for the next regional liaison committee meeting to be held in the southern High Plains in Fall 2001. The High Plains Regional Ground-Water Study communicates and coordinates activities through local meetings and forums, where appropriate, to reach those who are unable to participate in regional liaison committee meetings.

Note: For details about liaison committee activities for a particular assessment, contact the respective project chief or manager noted previously in this article. The Texas Water Resources Institute is funded in part by the USGS.

For More Information

Bush, P.W., Ardis, A.F., Fahlquist, L., Ging, P.B., Hornig, C.E., Lanning-Rush, J., 2000, *Water Quality in South-Central Texas, 1996–98*, USGS Circular 1212.

Dennehy, K.F., 2000, *High Plains regional ground-water study,* USGS Fact Sheet FS-091-00.

Ging, P.B., 1999, *Water-quality assessment of south-central Texas—Comparison of water quality in surface-water samples collected manually and by automated samplers*, USGS Fact Sheet FS–172–99.

Ging, P.B., 1999, *Quality of stormwater runoff from an urbanizing watershed and a rangeland watershed in the Edwards aquifer recharge zone, Bexar and Uvalde Counties, Texas, 1966–98*, USGS Open-File Report 99–245.

Ging, P.B., 1999, *Water-quality assessment of south-central Texas—Descriptions and comparisons of nutrients, pesticides, and volatile organic compounds at three intensive fixed sites, 1996–98*, USGS Water-Resources Investigations Report 99–4155.

Land, L.F., Moring, J. B., Van Metre, P.C., Reutter, D.C., Mahler, B.J., Shipp, A.A., and Ulery, R.L., 1998, *Water quality in the Trinity River Basin, Texas, 1992-95*, USGS Circular 1171.

Land, L.F., 1997, *Water-quality assessment of the Trinity River Basin, Texas — Nutrients and pesticides in the watersheds of Richland and Chambers Creeks, 1993-95*, USGS Water-Resources Investigations Report 97-4132.

McMahon, P.B., 2000, *A reconnaissance study of the effect of irrigated agriculture on water quality in the Ogallala Formation, central High Plains aquifer*, USGS Fact Sheet FS-009-00.

Moring, J.B., 1997, *Occurrence and distribution of organochlorine compounds in biological tissue and bed sediment from streams in the Trinity River Basin, Texas, 1992-93*, USGS Water-Resources Investigations Report 97-4057.

Moring, J.B., and Rose, D.R., 1997, "Occurrence and concentrations of polycyclic aromatic hydrocarbons in semipermeable membrane devices and clams in three urban streams of the Dallas-Fort Worth metropolitan area, Texas," *Chemosphere*, Vol. 34, no. 3, pp. 551-566.

TWRI Funds 11 Research Projects at 7 Universities

The Texas Water Resources Institute (TWRI) has selected 11 research projects it will fund during 2001–2002. The projects will explore a wide assortment of topics. Research projects were selected at Texas A&M University (TAMU), Texas Tech University (TTU), the University of Texas at Austin (UT), Texas A&M University–Corpus Christi, the University of North Texas (UNT), the University of Texas at Austin Marine Science Institute at Port Aransas (UT MSI), and Texas A&M University–Galveston.

TWRI received 35 submissions in response to this year's request for proposals. The research program is funded by the United States Geological Survey. Research projects were developed by graduate students in collaboration with faculty members. Projects were evaluated by TWRI staff as well as key TAMU faculty. Each project will be awarded a $5,000 grant. Matching funds are provided by each cooperating university. The projects will start March 1, 2001 and run through February 28, 2002. At the conclusion of these studies, TWRI will publish a scientific paper or technical report describing the research.

The following projects were funded:

• Jill Brandenberger (student) and Patrick Louchouarn (researcher), Conrad Blucher Institute for Surveying and Science, TAMU–Corpus Christi, "Arsenic Concentration in Water Resources of the Choke Canyon/Lake Corpus Christi Reservoir System: Surface and Ground Waters." The research will investigate the cycling of arsenic and trace elements in the waters of Lake Corpus Christi, Choke Canyon Reservoir, and points along the Nueces, Atascosa, and Frio rivers.

Photo By Patrick Louchouarn/ A&M–Corpus Christi

Jill Brandenberger of Texas A&M–Corpus Christi will collect water quality samples from Choke Canyon Lake and the Lake Corpus Christi Reservoir.

• Bryan Brooks (student) and Thomas La Point (researcher), Institute of Applied Science, UNT, "Sublethal Effects of Cadmium and Linear Alkylbenzene Sulfonate Mixtures on *Pimephales promelas* Exposure and Effect Endpoints: Laboratory and Field Assessments." The study will investigate how fish and aquatic organisms may be affected by exposure to cadmium and other pollutants in North Texas surface waters using fathead minnows as a test species.

• Yesim Buyukates (student) and Daniel Roelke (researcher), TAMU Wildlife and Fisheries Sciences Department, "Plankton Succession: Investigation Regarding New Approaches to Management." This study will assess how releasing treated wastewater in pulses to the Rincon Delta may affect the flora and fauna of coastal wetlands, and how nutrients in wastewater effluents affect phytoplankton growth.

• Richard Hoffpauir (student) and Ralph Wurbs (researcher), TAMU Civil Engineering Department, "Incorporation of Salinity in Evaluating Water Availability." This project will expand the modeling capabilities of a comprehensive water rights simulation modeling tool (the Water Rights Analysis Package or WRAP), to assess natural salt pollution.

• Jeffrey Johnson (student) and Phillip Johnson (researcher), Agricultural and Applied Economics Department, TTU, "Regional Economic Impacts of Aquifer Decline in the Southern High Plains of Texas." This project will investigate the short- and long-term economic impact of strategies to limit groundwater pumping in the Texas High Plains through the use of dynamic optimization models.

• Balaji Narasimhan (student), TAMU Agricultural Engineering Department, and Raghavan Srinivasan (researcher), TAMU Spatial Sciences Laboratory, "Determination of Regional Scale Evapotranspiration of Texas from a NOAA-AVHRR Satellite." This study will use an advanced high-resolution radiometer (AVHRR) sensor which is aboard an orbiting earth satellite to develop more accurate estimates of evapotranspiration (ET) from various land uses.

• Rafael Perez (student) and G. Joan Holt (researcher), UT MSI Port Aransas, "Fluctuating Environmental Parameters in Red Drum Nursery Habitats: The Influence of Habitat Quality on Larval Growth and Endocrine Function." The goal is to examine how natural variations in temperatures and storm cycles may affect the growth of larval stages of red drum using laboratory studies.

• Andres Salazar (student) and Ralph Wurbs, (researcher), TAMU Civil Engineering Department, "Conditional Reliability Modeling to Support Short-Term River Basin Management Decisions." Case studies will be conducted of the San Antonio, Guadalupe, and Nueces River basins to identify how the WRAP computer modeling software can estimate water reliability at specific sites.

• Daniel Stein (student) and David Eaton (researcher), the Lyndon B. Johnson School for Public Affairs, UT, "Texas Groundwater Management and Global Applications." This study will carry out a comparative analysis of how multiple political jurisdictions have tried to manage transboundary groundwater supplies.

• Kevin Yeager (student) and Bruce Herbert, TAMU Geosciences and Geophysics Department and Peter Santschi, TAMU–Galveston (researchers), "Resolution of Fluvial Sediment Sources, Residence Times and Resuspension Using Lithogenic, Atmospheric and Cosmogenic Radionuclides, Bayou Loco, Texas." This study will use radionuclide fingerprinting to investigate sediment production, transport, and deposition within Bayou Loco near Galveston Bay.

• Biswaranjan Das (student) and David B. Willis (researcher), Agricultural and Applied Economics Department, TTU, "Towards an Integrated Water Planning Model for the Texas High Plains." The project will develop a water policy planning model that can be used to evaluate proposed water resources policies.

To learn more about any of these projects, contact TWRI at (979) 845-1851 or twri@twri.tamu.edu.

TWRI Produces 2 New Technical Reports

Two technical reports were recently published by TWRI. *Brush Management/Water Yield Feasibility Studies for Eight Watersheds in Texas* (TR-182) was developed by the TAES Blackland Research Center (BRC) in Temple, TX in conjunction with the Texas A&M University Rangeland Ecology and Management and Agricultural Economics Departments. The report was published for the Texas State Soil and Water Conservation Board. *Ecological, Economic, and Policy Alternatives for Texas Rice Agriculture* was published by TWRI as TR-181. The report was produced by the George Bush School's Institute for Science, Technology and Public Policy (ISTPP). To order either report, contact TWRI at (979) 845-8571 or twri@twri.tamu.edu.

Tell Us How You Feel About *Texas Water Resources* and Win a Book!

As Editor of *Texas Water Resources*, I want to know what readers think about the newsletter. Please take a few moments and fill out this survey form. Fax your answers, along with your name and address, to TWRI at (979) 845-8554.

We will conduct a random drawing of those who respond. The winner will receive a free copy of *Isaac's Storm*, a book about the Galveston flood of 1900. The winner of the last drawing was Lawrence Wilson of Dallas, TX.

Ric Jensen, Editor, *Texas Water Resources*

1. Do you read *Texas Water Resources*? (Y/N)
2. Do you think TWRI should continue publishing *Texas Water Resources* ? (Y/N)
3. Do you circulate *Texas Water Resources* to colleagues? If so, how many? (Y/N)
4. If *Texas Water Resources* were published only on the World Wide Web (not printed) would you still read it? (Y/N)
5. Which topics should be discussed in future issues of this newsletter?

Texas
WATER RESOURCES
is published quarterly by
the Texas Water Resources Institute.
C. Allan Jones, Director
Ric Jensen, Editor and Graphic Design
TWRI is supported by funds provided in part by the U.S. Geological Survey, U.S. Department of the Interior, as authorized by the Water Resources Research Act of 1984. Subscriptions are available free upon request. For details, call TWRI at 979-845-8571. The fax number is 979-845-8554; e-mail: twri@tamu.edu. The WWW address is http://twri.tamu.edu.

Texas
WATER RESOURCES

Texas Water Resources Institute
301 Scoates Hall
Texas A&M University
College Station, Texas 77843-2118

NON-PROFIT ORG.
U.S. POSTAGE PAID
COLLEGE STATION, TEXAS
PERMIT NO. 215

ADDRESS CORRECTION REQUESTED