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Texas A&M Studies Method to Treat Radioactive Wastes

By Jennifer Robinson

TWRI Science Writer

Texas A&M University (TAMU) chemists have devised a method that may be a faster and less expensive way to remove radioactive elements from aquifers and waste sites. The technique uses a highly selective inorganic ion exchanger to separate such radioactive elements as strontium and cesium from tank wastes and groundwater.

The research is being conducted by researcher Paul Sylvester and graduate student Elizabeth Behrens of the TAMU Chemistry Department. Behrens and Sylvester concentrated their efforts on waste at the Hanford nuclear plant in Washington state. There, high-level radioactive waste is stored in 177 steel tanks, 66 of which are known to be leaking. This could lead to contamination of the Columbia River and aquifers used for drinking water supplies. The N-springs aquifer runs under the Hanford site and it is equipped with strontium and cesium detectors to monitor the water quality.

Behrens explains that "the structure of the exchanger resembles a Rubik's cube where the metal atoms that compose the framework reside in the corners of the cube and the exchangeable potassium cations reside in the six face centers." When the cubes come into contact with strontium and cesium in contaminated water,

Paul Sylvester and Elizabeth Behrens test this water sample to determine its radioactivity.

they exchange with the non-toxic potassium and become fixed in the cube where they can be removed.

"Potassium is only one element used to exchange with the radioactive elements. We have also used the technique with sodium." After the radioactive elements have been removed, the waste can be mixed with cement and buried without the potential of harmful elements leaking into nearby water sources.

"Industry commonly will recycle the removed strontium and cesium through a process of stripping, because it is more economically feasible," Behrens notes. The U.S. Department of Energy wants to take the researchers' exchangers and add them to soils around the tanks at Hanford. When the exchangers become saturated with strontium and cesium, they can be dug out of the ground, removing the radioactive threat to nearby water sources.

"Some of our exchangers have been tested on groundwater from the Hanford site, and our materials are as good, if not better than materials that are being produced right now," explains Behrens.

Sylvester notes that this technique may be less time-consuming and less costly than "pump and treat" methods which are now widely used. Pump and treat methods pump groundwater into the ion exchange columns and then pump the treated groundwater off the site.

TAMU Social Scientists Examine Media Messages About Edwards Aquifer

For a number of years, it's been difficult to pick up a San Antonio or Austin newspaper without finding at least one article touching on the controversy over how to manage and protect the Edwards Aquifer. That prompted a team of Texas A&M University social scientists to wonder what the ideas expressed in newspaper articles can tell us about the points of view of many different aquifer stakeholders in the region. Can these articles give us any clues about what type of management solution all water users in the region could agree to?

The study was carried out by Linda Putnam, Tarla Rai Peterson, and Karen Taylor of the Speech Communications Department; Charles Samuelson of the Psychology Department; and Ron Kaiser and of the Recreation, Parks and Tourism Sciences Department.

In the study, the researchers first utilized the Newsbank database to identify 122 newspaper articles that contained the keywords "Edwards Aquifer" or "Texas and aquifer." The Newsbank search was conducted for newspapers published between 1988 and 1996. In addition, press clippings from the same time period were examined. From these newspaper articles, which were supplied by the Texas Natural Resource Conservation Commission, 58 more articles were identified. For each article, the researchers coded the content to identify which interests were mentioned in the articles, whether a particular value about the aquifer was clearly stated, and if a preferred way to

manage the aquifer was noted. So far, 74 newspaper articles from the Newsbank database that were published in 1996 have been coded

The results of the study show that major stakeholders identified from the press clippings include the San Antonio Water System (SAWS), San Antonio businesses, San Antonio politicians, farmers and ranchers in the Western part of the region, individuals living near the recharge zone, and recreation and tourism interests in New Braunfels and San Marcos. The newspaper analyses clearly reflected regional differences about the nature of the Edwards management controversy.

The research suggests that environmentalists are most likely to prefer the courts or the Federal or Texas government to resolve the conflict. In contrast, San Antonio residents expressed more diverse, pluralistic views. As far as how the Edwards controversy should be settled, environmentalists preferred adjudication, while regulatory actions were the most favorable option by SAWS, Texas government officials and agencies and recreation and tourism interests.

"An interesting result of this study," Samuelson says, "is that it indicates that some stakeholder groups appear to be flexible about the conflict resolution methods they would support. This may be an encouraging sign that there may be some common ground to solve the region's water issues, even though the conflict has been on-going for many years and the positions appear to be intractable."

NOTE: This research was sponsored by the Program on Conflict and Dispute Resolution in the Center for Public Leadership Studies of the Bush School of Government and Public Service.

Developing a Modern Flood Prediction System for Brays Bayou and the Houston Area

Researchers: Philip Bedient, Brian Hoblit, Dawn Gladwell, Anthony Holder, and Stephanie Piepho, Environmental Science and Engineering Department, Rice University, Houston, TX, and Baxter Vieux, Civil Engineering School, University of Oklahoma, Norman, OK.

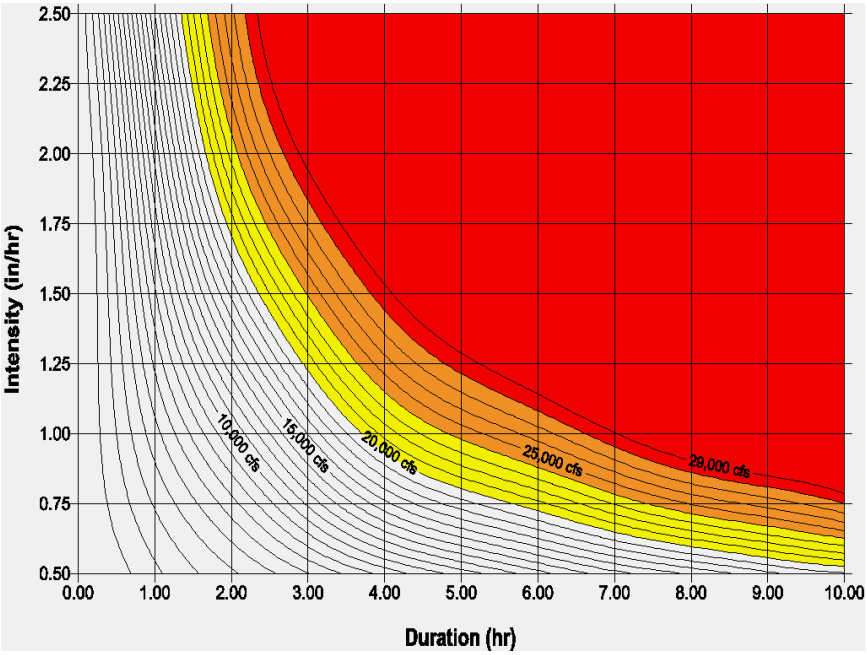
Problem: Flooding conditions have increased greatly in the Houston area over the past 30 years, due largely to urbanization and the introduction of a large area of paved surfaces (impervious cover). Brays Bayou, which flows through central Houston, the Texas Medical Center, and Rice University, is especially vulnerable to flooding because its watershed is fully developed. For example, a relatively small (5- to 10- year) rainfall event can cause the bayou to flow over its banks in as little as four hours. To help avoid flooding problems, an accurate flood prediction and warning system is urgently needed.

Objectives: 1) To evaluate information about the Brays Bayou watershed so that flooding risks can be assessed, 2) To create and test a flood warning system that incorporates the latest technology, and 3) To utilize NEXRAD weather data to estimate rainfall and runoff in the watershed.

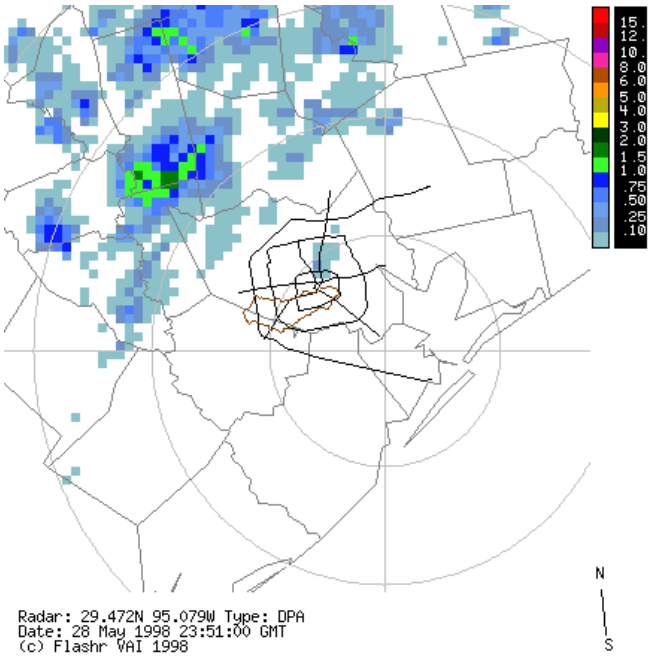
Background Information: The Brays Bayou watershed covers roughly 130 square miles and contains 46 sub-basins. Significant flooding has occurred in the bayou in 1976, 1979, 1981, 1983, 1992, 1994 and 1997. Currently, there are eight gages along the bayou that record water levels during rainfall events. Throughout much of its length, the bayou has been channelized and lined with rip-rap and concrete. The Harris County Office of Emergency Management maintains the ALERT (Automated Local Evaluation in Real-Time) system of 150 rainfall and stream gaging stations throughout Harris County. Since 1992, Harris County has been equipped with the National Weather Service NEXRAD weather system, which allows users to track incoming storms and to analyze the storm's direction, velocity and intensity to predict when severe weather will hit.

Methods: HEC-1 and HEC-2 computer modeling software from the U.S. Army Corps of Engineers was used to generate peak flows and hydrographs on more than 2,000 runs from several hypothetical storms, based on historical data. A formula has been developed that integrates information about the duration and intensity of storm events to generate warnings for "flooding caution," "flooding possible" and "flooding probable" conditions. NEXRAD weather data were calibrated and converted to rainfall amounts.

Results: Work is now in progress to develop a World Wide Web (WWW) site which would incorporate real-time weather, rainfall, and water level values. In the future, the flood alert system will link the rainfall data with hydrologic models to better predict the likely impact of future rainfall events. The WWW site will warn various management agencies about the likelihood and severity of flooding and would give these groups more lead time to react to such events. When used together with ALERT, this flood prediction and warning system may greatly improve the accuracy and timeliness of flood warnings in the region.



Iso-Flow Chart. To use this chart, determine the intensities of rainfalls for various durations of the storm. One combination of intensity and duration will be an accurate predictor of the peak flow in the bayou.



FLASR Image. This image shows the integraged NEXRAD - GIS system produced by FLASR. The brown outline is the Brays Bayou watershed and the estimated rainfall which falls over the watershed is integrated real-time and will be presented on the Flood Alert Homepage.

Reference: Bedient, Philip, "Rice University-Texas Medical Center: Flood Prediction Manual for Brays Bayou," Rice University, 1998.

NOTE: This study was funded by the Texas Medical Center, the Harris County Office of Emergency Management, the City of Houston, the Texas Department of Transportation and the U.S. Geological Survey. Bedient can be contacted at (713) 527-4953 or bedient@rice.edu. Hoblit's e-mail address is hoblit@rice.edu.

Environmental Impact of an Oil Spill on the South Texas Coast

Researchers: Wes Tunnell, David Hicks, and Beau Hardegree, Center for Coastal Studies, Texas A&M University - Corpus Christi, Corpus Christi, TX.

Problem: A rupture in a 40-centimeter diameter pipeline in January 1992 resulted in a spill of roughly 2,950 barrels of oil into a marsh habitat near Chiltipin Creek in San Patricio County, TX. Experts estimate that 1,250 barrels of oil were recovered from the blowout hole, 500 barrels were recovered by pumping, 50 barrels were recovered by sorbent booms, and as much as 1,150 barrels could not be accounted for. The marsh acts as a drainage basin. Waters from this site flow towards the creek and the Aransas River at their confluence in Upper Copano Bay. After oil spills occur, efforts need to be made to both decide on an appropriate rehabilitation plan and to evaluate the success of restoration efforts.

Objectives: To assess the environmental impact of the spill, to evaluate the effectiveness of burn techniques that were used to remediate the pollution, and to monitor changes in vegetation and the total petroleum content of soils after the burn.

Background Information: The Texas General Land Office authorized burning off the remaining oil. The rationale was that burning was the preferred method to remediate this site because mechanical methods may result in a loss of marsh habitat and leaving the oil in place might pose a potential contamination threat to nearby waters. In contrast, it was thought that burning would not harm the root and rhizome systems of marsh plants because soils were saturated by heavy rains and the oil would float on a layer of rainwater covering most of the marsh. In addition, proponents of burning say it may be an environmentally preferable method of dealing with oil spills because large quantities of oil can be converted into combustion products (carbon dioxide and water), oil removal is rapid, and vegetation may be less harmed over the long term. Before the burn was conducted, two areas were designated not to be burned. These were to be used for comparison purposes but were uncontrollably burnt and, therefore, could not be used.

Methods: Much of the effort in this project dealt with examining the characteristics of vegetation before and after the burn was carried out (from 1992 to 1995). Species diversity was studied by counting the number of plants along 20 transects that covered much of the marsh area. Vegetation biomass was determined by clipping and measuring above-ground vegetation throughout the study area. Soils were analyzed for hydrocarbon levels. Areas with initially high oil levels were resampled.

Results: A total of 13 marsh vegetation species were identified within the study area. Some plants (salt grass) were more commonly found in the area that was burned, while others (bulrush) were dominant in the control area (where burning was not used). The amount of vegetation (biomass) found was higher in the control area than in sites where the burn was employed to remediate the spill. Levels of hydrocarbons in soils ranged from 108 to 4,538 parts per million (ppm) when sampled in 1992. When samples were repeated in 1993, oil concentrations varied from 29 to 4,440 ppm. In this study, the researchers observed that some perennial marsh vegetation species decreased in numbers. This may be due to the intensity and duration of the burn that was conducted to remediate the oil spill. The research suggests that burning was probably the best cleanup alternative in this situation, because of the significant amount of water that was standing in the marsh. Full recovery will take 8 to 10 years, but mechanical cleanup methods would have done more and longer-lasting damage to the marsh. Doing nothing would have allowed the oil to reach the bay, which is unacceptable.

Reference: Tunnell, J. W., B. Hardegree, and D. Hicks, "Environmental Impact and Recovery of a High Marsh Pipeline Oil Spill and Burn Site," Proceedings of the 1995 International Oil Spill Conference, Long Beach, CA, published by American Petroleum Institute.

NOTE: Tunnell can be contacted at (512) 994-2736 or jtunnell@falcon.tamucc.edu. Hicks is a graduate student at the University of Texas at Arlington and can be reached at (817) 272-5577 or hicks@exchange.uta.edu. Hardegree is with the Texas Parks and Wildlife Department and can be contacted at (512) 980-3244 or beau.hardegree@tpwd.state.tx.us.

Estimating the Water Quality of Runoff from Agricultural Lands in the Odem Ranch Watershed Near Corpus Christi

Researchers: Bobby Eddleman, Larry Falconer, and Rick Jahn, Texas A&M University Agricultural Research and Extension Center, Corpus Christi, TX, and Darwin Ockerman, U.S. Geological Survey, San Antonio, TX.

Problem: The Odem Ranch watershed covers 2,775 acres of cropland in San Patricio County. Flows from this watershed run off into the Nueces River Basin and eventually enter Corpus Christi Bay and nearby coastal waters. There were concerns that the runoff of contains agricultural and urban contaminants that have the potential to pollute the Bay. This study was done to determine the impact of agricultural activities on runoff water quality in the watershed.

Objectives: To assess the levels of sediments, nutrients, organic and inorganic chemicals, and other water quality constituents that run off agricultural croplands in the Odem Creek watershed during rainfall events that produce stormwater runoff.

Methods: Data were collected from four storms in 1996 and 1997. Samples were collected during the growing season (June 1996 and 1997), immediately following the harvesting of crops (August 1996), and when fields were not being used to grow crops and were relatively bare (October 1997). Fixed station streamflow gages and automated water quality sampling equipment were installed at the edge of agricultural fields where waters would run off. Rainfall and water quality samples were collected for each storm event that produced runoff. Rainfall samples were analyzed for total forms of

ammonia, ammonia plus organic nitrogen, phosphorus, and dissolved forms of nitrites, nitrate-plus-nitrite, ammonia, ammonia plus organic nitrogen, and phosphorus. Surface water analyses included ammonia, nitrate, nitrite and total Kjehldal nitrogen, total phosphate and orthophosphate, organochloride and organophosphorus pesticides, total suspended solids, total dissolved solids, and inorganic chemicals. Slopes are relatively flat. Rainfall averages only 30 inches per year annually and, during the study period, ranged from 18 inches in 1996 to 33 inches in 1997. Total annual runoff ranged from 4.5 million cubic feet (cf) in 1996 to 13.5 million cf in 1997. Most croplands in the watershed are farmed using best management practices (BMPs) recommended by the U.S. Department of Agriculture Natural Resource Conservation Service.

Results: The following water quality data were gathered for 1995: total nutrients applied to crops were 113 tons of nitrogen and 35 tons of phosphates; total loadings of nitrogen in runoff was 453 pounds; total amount of organic pesticides (synthetic herbicides, insecticides, defoliants, desiccants, and crop growth regulators) applied to crops was 14,109 pounds. For 1996, similar water quality data were collected: total nutrients applied to crops were 108 tons of nitrogen and 59 tons of phosphates; the total loading of nitrogen in runoff were 1,852 pounds; the total loading of phosphorus in runoff was 106 pounds; the total amount of organic pesticides applied to croplands was 12,819 pounds. For 1997, the total loading of phosphorus in runoff was 409 pounds. Levels of nutrients, inorganic chemicals, and organic pesticides in runoff waters were generally less than

TNRCC drinking water standards. Values for ammonia plus organic nitrogen, total phosphorus, and orthophosphates were 1.5 times higher than TNRCC minimum screening levels for freshwater streams. Eddleman says this study suggests that the use of BMPs on agricultural croplands is effective at limiting the loads of nutrients and pesticides in stormwater runoff.

Reference: Eddleman, B.R., D. Ockerman, L. Falconer, and R. Jahn, "Assessment of Surface Water Runoff for Sediment, Nutrients, and Chemicals from Agricultural Croplands in the Odem Ranch Watershed (Draft Report)," Submitted to Corpus Christi Bay National Estuary Program (CCBNEP), 1998.

NOTE: This study was funded by the CCBNEP. Eddleman can be contacted at b-eddleman@tamu.edu or (512) 265-9201.

Water Quality Trends in the San Marcos River

Researchers: Alan Groeger, Patrick Brown, Todd Tietjen and Travis Kelsey, Biology Department, Southwest Texas State University, San Marcos, TX.

Problem: The San Marcos River is a truly unique ecosystem. It emerges from the nearby San Marcos Springs and is fed by artesian waters from the Edwards Aquifer. The headwaters of the San Marcos River are known for relatively constant temperatures and flows. The upper portion of the river contains specialized habitat for many threatened and endangered species. This ecosystem needs monitoring to ensure that the river and its habitat are protected.

Objectives: To characterize important chemical and physical aspects of the San Marcos River.

Methods: Sites were sampled from the headwaters of the San Marcos River to its downstream confluence with the Guadalupe River. A total of 17 sampling sites included four upstream locations, a downstream from the San Marcos Sewage Treatment Plant (SMSTP), a location downstream of the confluence of the Blanco and San Marcos rivers, a site near the Luling gaging station, and the most downstream site at Gonzales near the confluence of the San Marcos and Guadalupe rivers. The sites were measured on seven dates from 1992-94. Measurements were taken for temperature, pH, dissolved oxygen, specific conductivity, alkalinity, turbidity, and nutrients. In 1995, experiments were conducted to determine limiting nutrients in the upper reaches of the San Marcos River upstream and downstream of the SMSTP. Unglazed bathroom tiles were placed in the river to measure periphyton colonization rates. Simultaneously, water samples were collected at these same sites for use in nutrient limitation bioassays. Some of the treatments in these nutrient limiting studies examined the effect of nitrogen and phosphorus, nitrogen and metals, and phosphorus and metals on algal growth. Data about water quality and flows in the river were also obtained from U.S. Geological Survey gaging stations.

Results: This study shows that the chemical and physical quality of the San Marcos River evolves spatially and temporally as it flows from its source waters to its confluence with the Guadalupe River. Water from the Edwards Aquifer exhibits high carbon dioxide levels, low pH, and large concentrations of calcium and alkalinity. The water chemistry of the Blanco River is similar to other rivers in the region. At the confluence of the Blanco and San Marcos rivers, the Blanco River (which has a much larger drainage area) exerts a significant influence on water quality in the San Marcos River. The influence of the Blanco River on water quality in the San Marcos River is pronounced during storm events. Nutrient levels in the San Marcos River are greatly influenced by sewage inputs (including the SMSTP). These wastewater plants typically increase phosphorus loads and increase algal growth. If wastewater plants were to lower their phosphorous levels, the water quality in the river should increase.

Reference: Groeger, A., P. Brown, T. Tietjen, T. Kelsey, "Water Quality in the San Marcos River," Texas Jour. of Science, Nov. 1997.

NOTE: Groeger can be contacted at AG11@swt.edu or (512) 245-3815.

Developing a Digital Atlas of the World's Water Balance

Researchers: Daene McKinney and David Maidment, Civil Engineering Department, University of Texas at Austin, Austin, TX.

Problem: In the late 1970s, the United Nations published an "Atlas of the World Water Balance" and "World Water Balance and Water Resources of the Earth." The atlas includes 65 maps covering the major geographic regions of the world and contains information about annual and monthly precipitation, potential evapotranspiration and runoff. Since the publication of these landmark reports, no updated versions have been published. The advent of geographic information systems (GIS) and digital mapping has created new opportunities to assess water resources in a spatial format.

Objectives: To assemble a digital atlas of the world's water balance using GIS, digital mapping, and computer modeling techniques that would allow users to trace the movement of water between the atmosphere, soils, and surface and ground waters.

Methods: The spatial framework used in this digital atlas is a mesh of half-degree cells that cover the Earth. The size of each cell is an area roughly 50 kilometers long and wide, and it takes 314 cells to cover Texas. For each cell, the researchers quantified mean monthly precipitation, temperature and net radiation. The Legates-Wilmott global climatology database, which covers 1920-80, was used as the source of information for precipitation and temperatures. The National Aeronautics and Space Administration (NASA) provided data on monthly net radiation for 1983-91. Runoff data were obtained from the Global Runoff Data Center in Germany. Estimates of plant extractable water capacity were gathered from the U.S. Geological Survey Geophysical Fluid Dynamics Laboratory.

Results: This atlas allows users to calculate values of monthly soil-water balances. The atlas also helps users predict soil-water storage, evaporation, and water surpluses and deficits. Exercises have been developed in many languages (English, Spanish, French, and Portuguese) in association with the atlas to help users learn about GIS methods. Topics covered in these lessons include the use of climate and spatial data, map projections, modeling soil-water balances, the use of water simulation models which are map-based, simulating ground and surface water flow patterns, and the use of GIS to delineate watershed and stream networks. To date, the atlas has been applied to case studies in Africa, South America and Central Asia.

Reference: McKinney, D., and D. Maidment, "Digital Atlas of the World Water Balance," Water Science and Technology Board newsletter, National Research Council, Washington, DC, Vol. 15, No. 1, 1998.

NOTE: The atlas is on the World Wide Web at http://www.ce.utexas.edu/prof/maidment/atlas/atlas.htm. Maidment can be contacted at maidment@danube.crwr.utexas.edu or (512) 471-3131.

Texas Tech Scientist Studies How Hurricane Winds Change As They Flow Over Land Surfaces

Strong winds from hurricanes cause significant damage as they travel over coastal and inland areas. Recently, Chia-Bo Chang of the Atmospheric Science Department at Texas Tech University was awarded a research grant from the Texas Higher Education Coordinating Board to study how the effects of strong winds change as they move over different land surfaces.

Chang's research will be conducted using a numerical model to simulate hurricane winds moving over the earth's surface at what is called the boundary layer. "The atmospheric boundary layer is the layer of air adjacent to the earth's surface," explains Chang. Air flows in the boundary layer are directly influenced by the earth's surface and, as a result, can be very irregular and turbulent.

Several hurricane-prone areas along the Gulf of Mexico and the East Coast will be used for the modeling studies. The modeling work will measure the effects of coastal and inland terrains, the angle at which hurricane winds strike the land, and the parameters of internal boundary layers.

"If clear correlations between the boundary layer winds and damage field in the coastal areas can be established, rapid and effective damage assessment can be made," Chang says. Chang hopes that findings of this study (including a database of hurricane winds) may provide assistance in innovative approaches for land-use planning and zoning, as well as the design of buildings and facilities for coastal areas where hurricanes are likely.

For more information contact Chang at (806) 742-3143 or wacbc@ttacs.ttu.edu.

TAES to Make Sorghum More Resistant to Droughts, Aphids

Grain sorghum is a major Texas crop and is grown on 3.9 million acres. Often, grain sorghum is grown in harsh environments which receive little rainfall. Two major stressors can significantly damage grain sorghum crops. Drought stress can reduce yields from 27% to 55%. Meanwhile, the greenbug aphid annually infests 85% of the grain sorghum acreage in the U.S. In Texas, annual economic losses in grain sorghum crops due to drought and greenbugs are estimated at $6.5 million. Recently, two researchers at the Texas A&M University's Agricultural Research and Extension Center at Lubbock were awarded funds from the Texas Higher Education Coordinating Board to conduct research into developing resistant grain sorghum using a technique called marker-assisted selection (MAS).

The research is being led by plant breeders Gary Peterson and Darrell Rosenow. Peterson and Rosenow will incorporate such diverse sciences as breeding, entomology, and molecular biology to use MAS to develop sorghum genotypes that may be resistant to droughts and aphids. "If we are able to develop lines of grain sorghum that use the natural diversity of the species to perform well under natural conditions, we can reduce production costs and less disrupt the environment," Peterson says. With drought and greenbug resistant sorghum, farmers may use less water for irrigation and fewer pesticides to treat greenbug infestations.

In this project, the researchers will focus on two resistance traits. The first is the "stay green" trait, which resists premature leaf and plant death, develops grain normally, and resists "charcoal rot" when exposed to drought in the grain development stage. The second is the greenbug resistance trait. When a plant resists greenbugs, a sorghum producer may use fewer pesticides and chemicals.

The researchers' first goal is to identify molecular markers that are linked to the stay green trait and the greenbug resistance trait, in order to develop the MAS procedure. The second goal is to apply the MAS procedure to select for stay green and other drought tolerance traits as well as the greenbug resistance trait. "Preliminary research has been done to identify markers related to the traits we are interested in. We will use this information to screen new populations of sorghum for drought and greenbug resistance," explains Peterson. After identifying plants possessing these traits, the sorghum plants will be back-crossed to produce a genotype with drought and greenbug resistance. Grain sorghum developed through this method will be made available to private seed companies to produce hybrids which may be available to Texas producers and consumers.

For details, contact Peterson at (806) 746-6101 or g-peterson1@tamu.edu; or Rosenow at (806) 746-6101 or d-rosenow@tamu.edu.

TAMU to Study Cooperative Water Management Strategies

Information about the relative costs and benefits of water for different uses is a major consideration when water transfers or sales are developed. Common examples include selling treated water and wastewater for landscape irrigation as well as inter- and intra-basin transfers. Recently, Bruce McCarl and Fred Boadu of the Texas A&M University Agricultural Economics Department received a grant from the Texas Higher Education Coordinating Board.

The purpose of the grant is to examine the economic, institutional, and legal aspects needed to develop cooperative management strategies, which foster joint administration of surface and ground water resources within a watershed. The research builds upon ongoing research McCarl has conducted regarding optimal management strategies for the Edwards Aquifer.

McCarl cites three goals of the project. First, a computer simulation model will be designed to analyze the economic and hydrologic implications of cooperative water management alternatives for regional ground and surface waters. Second, the researchers will analyze regional water management institutions to demonstrate the comparative costs and benefits of conjunctive water resources management. Finally, the researchers will study the implications of legal and institutional constraints on water transfers.

The research will focus on the Edwards Aquifer region. "We would like to see how much more value could be added to the region by cooperative management," explains McCarl. Researchers will focus on existing water use patterns and find the optimum combination of variables. "This computer model will allow us to simulate different kinds of institutional actions that are consistent with existing laws or conditions we think are likely to exist in the future," explains Boadu. From the different scenarios, researchers can project an accurate picture of the value added to the region from different water resources management and legal scenarios.

UTMSI Researcher Studies Whether Estrogen Levels in Pollutants Induce Feminization of Male Fish

There has been heightened awareness among the general public and the scientific community over the reproductive hazards of xenobiotic estrogens and other endocrine-disrupting chemicals to wildlife and humans. The list of environmental contaminants which disrupt reproductive processes in male fish and other vertebrates is growing as pollution increases in estuarine and marine environments. For example, male fish collected from polluted rivers in Europe show evidence that the presence of endocrine disruptors is "feminizing" male fish. Up to now, however, there have been no comprehensive surveys of male fish populations inhabiting estuaries and marine waters, which are more complicated to study than rivers. Recently, Peter Thomas of the Marine Science Institute of the University of Texas (UTMSI) was awarded a grant from the Texas Higher Education Coordinating Board to conduct a field study of the populations of male Atlantic croakers in Texas estuaries.

During the first year of the project, Thomas and other researchers will collect samples of male Atlantic croakers from seven sites in Texas estuaries. Most of the sites will reflect areas where industrial effluents, urban runoff, or agricultural runoff are present, while two sites will be uncontaminated and will serve as controls. Male Atlantic croakers will be tested to determine if the yolk precursor protein, vitellogenin, is present in their blood. "Vitellogenin is a marker of the presence of estrogen in an animal. Any female animal that lays eggs makes this protein," explains Thomas. "Males are capable of producing vitellogenin when they are exposed to chemicals which have estrogenic actions. The presence of vitellogenin in male plasma is a useful biomarker of environmental exposure to these kinds of compounds."

During the second year of the study, the researchers will return to sites that were found to contain fish with evidence of feminization and study the site more in depth. "An objective of the study is to measure biomarkers of male sex hormone (androgen) action in these fish, because certain pesticides have been shown to antagonize the actions of androgen hormones," explains Thomas. Testicular growth and the presence of sperm are markers that will indicate the presence of antiandrogens, which are synthetic chemicals that interfere with the actions of androgenic hormones, such as testosterone. The final objective will be to characterize reproductive dysfunction in male croakers and identify endocrine-disrupting chemicals.

The study will provide researchers with evidence about contaminants in estuarine environments that may affect human reproductive health and may give regulators useful information on how to better protect natural resources.

TAMUG Studies Sediment-to-Water Exchange in Estuaries

Researchers from the Department of Oceanography at Texas A&M University-Galveston (TAMUG) have been awarded a grant from the Texas Higher Education Coordinating Board to test whether the sediment-to-water exchange varies daily according to light-dark cycles. Preliminary data from a Texas estuary suggests that the sediment-to-water exchange of interstitial pore fluids varies daily with light and dark cycles.

TAMUG graduate student Kent Warnken holds this sediment core which was taken from Lavaca Bay.

The project will be led by researcher Gary Gill and graduate student Kent Warnken. Gill says the idea that the sediment-to-water exchange varies with daily light and dark cycles is a marked contrast to current thinking and it may revolutionize our understanding of sediment processes.

Interstitial pore fluids, the water which fills spaces between grains of near-surface sediments, are the initial focus of the study because they are the region where most chemical reactions in estuarine sediments occur. Because more chemical reactions take place in the interstitial pores than in open waters, there is a diffusion of chemicals from the pore spaces into the open water. This movement is commonly known as a steady-state flux (which means that the flow of material is not changing over time and the amount of material in the pore spaces is constant over time). To maintain this gradient, new material must constantly be entering the pore fluid from chemical reactions with sediments.

Gill says that his preliminary data suggest that, in any given 24 hour cycle, the movement of chemical materials is not in a steady-state flux. He notes that "most studies of sediment movement have been limited in scale or the monitoring process has not been designed to detect daily changes." Gill's hypothesis is that benthic organisms act to move the boundary between oxygenated and non-oxygenated sediments deeper as they photosynthesize during light periods. In essence, this slows down the transfer of elements from interstitial pore fluids. Two elements which respond most markedly to this daily shift are iron and manganese.

In this research project, Gill will perform field and laboratory tests to identify the processes and mechanisms responsible for producing the varying sediment shift observed in the preliminary work. "This study will build upon the understanding of how estuaries work. Sediments in Texas estuaries markedly control the concentration of elements in the water column. With this work we hope to better understand interactions in the estuarine environment," Gill says.

Texas A&M Study Asks How Fishermen Feel About Access to Rivers, Streams

One of the major hurdles confronting recreational water users in Texas is access. Obviously, a fisherman or canoeist needs to know if they will be shot at or arrested before crossing private lands to get into a river or creek. Recently, a Texas A&M University undergraduate student and his faculty adviser examined the feelings Texas sportsmen have about access to Texas waters, as well as what they feel should be done to improve things. The project was undertaken by Troy Baker, a Wildlife and Fisheries Sciences Department major who graduated in 1998 and participated in the TAMU Undergraduate Research Fellows Program. The project was supervised by Robert Ditton of the TAMU Wildlife and Fisheries Sciences Department.

In this project, Baker first collected background data about recreational water use issues. He noted that a simple but challenging paradox exists that makes recreational use difficult. Although there are roughly 80,000 miles of waterways in Texas that can be used for recreation, nearly all the land adjacent to rivers and streams is privately owned and thus difficult for nature lovers and sportsmen to access. In addition, there are only relatively few river access points designed specifically for recreational water users. To gather needed information, Baker sampled anglers who held fishing licenses in 1994 and indicated they had fished on rivers and streams from a boat or the shore in the past year.

Baker developed a 20-item survey which included questions about the fishing methods they used, whether they were satisfied with river access, and demographic characteristics.

What do the results of the survey suggest? More than 4,888 individuals responded to the survey. The average angler spent 51 days in various fishing activities and had built up 28 years of experience in fishing and related activities. More than two-thirds of anglers indicated they would fish rivers and streams more often if more access points were provided. Responses also show that a third of river fishermen believe that river and stream access points are overused and that it is difficult to portage around obstacles that limit access to rivers. Perhaps most importantly, sports fishermen said they would be willing to pay as much as $51 a year to make river access easier and better.

Texas A&M - Weslaco Scientists Study Relationships Between Salinity, Sugarcane Growth and Yields

Because of the rapid population growth in the Lower Rio Grande Valley, many of the freshwater supplies that were traditionally used for agriculture are now being tapped by cities and urban residents. As a result, agricultural producers are considering whether alternative water resources (often of a poorer quality) can be successfully utilized to grow crops. Recently, researchers at the Texas A&M University Agricultural Research and Extension Center in Weslaco conducted experiments to assess if high salinity waters can be used to grow sugarcane without lessening the amount and quality of sugar that is produced.

The research was carried out by Robert Wiedenfeld of the Texas Agricultural Experiment Station and Jim Irvine and Sarah Lingle of the U.S. Department of Agriculture Research Service in Weslaco.

Bob Wiedenfeld of TAMU Agricultural Research and Extension Center in Weslaco samples saline waters used to grow sugarcane in test plots. A recent project investigated how different levels of salinity influence the amount of sugar produced by different sugarcane varieties.

The project consisted of comparing the growth and sugar yields of two sugarcane varieties. NC0310 has been used for many years, can tolerate salty water, but typically doesn't produce high yields, while CP70321 is a new early-maturing variety that may produce more sugar. Both varieties were treated with four levels of saline

water (rain water, tap water, and blends of shallow groundwater and tap water). The salinities in these waters ranged from 6 to 3,000 parts per million (ppm).

Wiedenfeld says results of the project show that yield levels from the two sugarcane varieties are similar when salinity levels are less than 800 ppm. However, when salinities become greater, growth and yields of CP70321 declined significantly.

"The importance of this study," Wiedenfeld says, "is that it shows you can grow the higher yielding sugarcane varieties with waters that are moderately saline. Because sugarcane requires so much water, the use of saline waters will influence how much of the crop farmers are able to grow here."

TWDB Report Describes Transboundary Aquifers

The Texas Water Development Board (TWDB) recently published a technical report with detailed information about international aquifers in the El Paso region. The report, *Transboundary Aquifers of the El Paso/ Ciudad Juarez/ Las Cruces Region*, was developed by Barry Hibbs, Radu Boghici, Mark Hayes and John Ashworth of TWDB, and Bobby Creel, Adrian Hanson, Zohrab Samani, and John Kennedy of New Mexico State University. The report contains a comprehensive review and analysis of the Mesilla Basin Groundwater Aquifer System, the Hueco - Tularosa Aquifer, the Hueco Aquifer, the Southeast Hueco Aquifer, the Rio Grande Aquifer, and the Diablo Plateau Aquifer. The report is well-illustrated and contains many figures and data tables.

The printed report and a CD that can be incorporated into geographic information systems can both be purchased from TWDB. For more details, contact Boghici at (512) 463-6573 or rboghici@twdb.state.tx.us.

Trinity River Water Quality Gets Mixed Grades, USGS Says

Water quality in the Trinity River Basin received a mixed report card, but an encouraging sign is the remarkable recovery of the river's fish, according to a new report from the U.S. Geological Survey. The report, The USGS National Water-Quality Assessment Study (NAWQA) of the Trinity River Basin, was written by USGS scientists Pete Van Metre and Bruce Moring.

To develop this report, USGS scientists collected data on such diverse issues as the chemistry of ground and surface water, sediments, and fish tissues. Aquatic biological communities were described, and aquatic habitats were mapped. In 1994, water samples were collected from 43 stream sites in the basin and analyzed for pesticides and other water quality parameters.

According to the report, there were decreases in lead, DDT, and PCBs throughout much of the upper portions of the Trinity River. Major improvements in the health of fish communities were noted below Dallas. However, 28 herbicides and 12 pesticides were detected in the watershed (atrazine, metolachlor, prometon, simazine, and diazinon were the most widespread).

"Both these trends suggest water quality is improving," Moring says, "but some troubling water-quality issues remain," including frequent occurrences of pesticides in agricultural and urban streams, as well as increases in some toxic contaminants associated with urban development."

More information about the Trinity River Basin study can be found on the Internet at URL http://txwww.cr.usgs.gov/trin/. Moring can be contacted at (512) 873-3085 or jbmoring@usgs.gov.

"Water for Texas" Describes Statewide Water Needs, Policies

If you want to learn more about Texas' future water needs and how the state plans to meet them, you may want to look into two reports recently published by the Texas Water Development Board (TWDB).

The reports are titled, *Water for Texas* (Volumes 1 and 2). Volume 1, *Water for Texas Today and Tomorrow - The Texas Water Plan*, is only available on the TWDB WWW site at http://www.twdb.state.tx/www/twdb/water_plan.html. It outlines Texas' water and wastewater needs over the course of the next 50 years and discusses water policy issues and alternatives. Volume 2, *Water for Texas (Technical Appendix)*, contains detailed information about the state water planning process, estimates of future conditions and prospective water needs, and policy considerations.

To obtain either report or for more details, contact Diane Burr of TWDB at dburr@twdb.state.tx.us or fax her at (512) 463-9983.

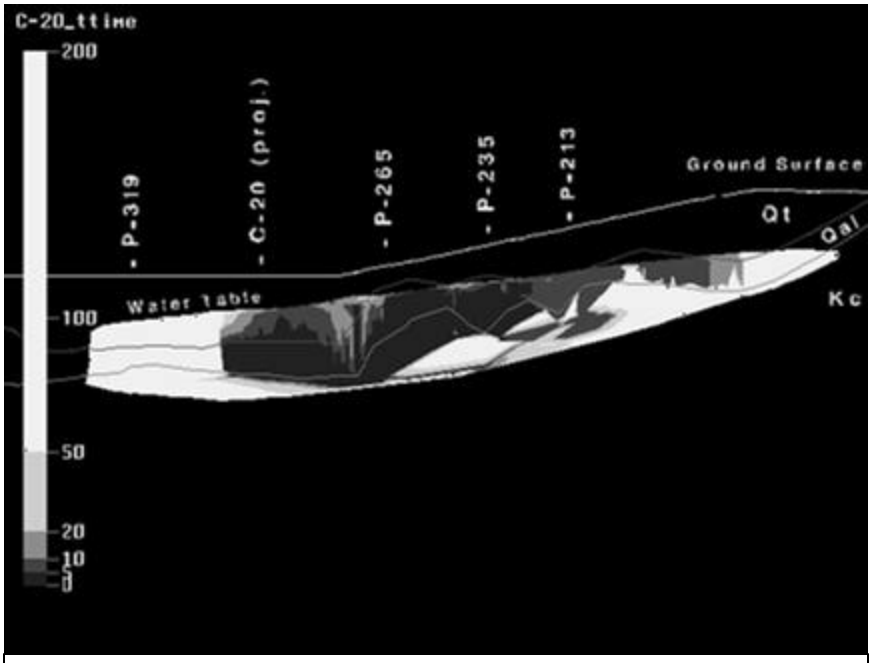
UT Press Book Discusses Texas Land Ethics

UT Press Book Discusses Texas Land EthicsTexas Land Ethics, was co-authored by Pete A. Y. Gunter and Max Oelschlaeger of the Philosophy Department at the University of North Texas. In this book, the authors offer a new vision for living on the land, a "land ethic" that respects the stability, integrity, and beauty of the "land community." They discuss how economic and environmental goals may be reconciled so that Texans can conintue to enjoy a reasonable prosperity while living in a land free of pollutants and scars, where some wild lands still exist and animals range freely. The authors urge humans to respect the land--with all of its animal and plant inhabitants--that supports us. This is an ethic to take Texas into the 21st century, in which the wise choices we make now will create a stable and sustainable future. The UT Press can be contacted at utpress@uts.cc.utexas.edu"utpress@uts.cc.utexas.edu or (800) 252-3206. Gunter can be contacted at (940) 565-2257 or gunter@unt.edu"gunter@unt.edu, while Oelschlaeger can be reached at 940-565-3331 or max@unt.edu"max@unt.edu.

UT Dallas Scientist Creates "3-D" Wellhead Protection Model

An innovative, high-tech method to delineate wellhead protection areas in three dimensions has been developed by a researcher at the University of Texas at Dallas (UT-D).

UT-D Geosciences Department researcher Tom Brikowski has created a computer simulation model that utilizes detailed descriptions of aquifers and their properties. The computer model can be used to depict capture zones, which estimate where and how far within an aquifer pollutants can be expected to travel in a given time period. Outputs from the model include three-dimensional figures showing the extent of a contaminant plume.



The UT-D computer model lets users view contaminant plumes in aquifers in three dimensions.

Using the model, for example, scientists and policy makers can assess how quickly pollutants can flow through soils and contaminate groundwater supplies or which nearby activities pose the greatest threat to aquifer quality. This approach allows policy makers and their constituents to virtually "fly through" their drinking water aquifers. The result is a much better understanding of the local sources of drinking water, and the need for aquifer protection and management.

"We feel this model more accurately reflects real world conditions because it uses three dimensional traits found in the environment," Brikowski says. "This model does especially well in simulating conditions and threats in complex groundwater systems."

Some of Brikowski's latest work involves using sophisticated World Wide Web authoring techniques and making the model available through the Internet.

Brikowski's e-mail address is brikowi@utdallas.edu. The simulation model is can be found on the WWW at
http://www.utdallas.edu/~brikowi/Publications/Hays_Underground/index.html

SWTSU Creates Environmental Geography Research Center

The Department of Geography and Planning at Southwest Texas State University (SWTSU) has formed a Center for Hazards and Environmental Geography. The center will provide institutional support for scholarship concerning a variety of hazards topics, ranging from adverse meteorological and geological events, to landfills and hazardous wastes, to flooding and hurricanes.

The center's objective is to foster cooperative exploration of hazards-related topics by faculty and students. It is currently comprised of eight SWT faculty.

Several funded projects are already underway, including studies of freeze impacts on agriculture in the Lower Rio Grande Valley, industrial waste management practices and policies in Texas, avalanche impacts in Montana, and response to recent floods in Nevada. The center is also conducting an inventory and analysis of closed landfills in Texas.

For details, contact Center Director David Butler in the SWTSU Geography and Planning Department at (512) 245-7977 or db25@swt.edu.

Texas Tech Studies Economics of Depleting Ogallala Aquifer

How would the feasibility of agricultural production be affected by further depletion of the Ogallala Aquifer? That issue is being investigated in two research projects at Texas Tech University (TTU).

In one study, researcher Phillip Johnson and graduate student Bonnie Terrell of the Agricultural and Applied Economics Department are studying how changing levels of the Ogallala Aquifer may impact a 14-county area of the Texas High Plains from the present time to 2035. In this project, the researchers are trying to estimate how the declining groundwater levels of the Ogallala Aquifer may affect cropping patterns (which crops are grown, whether they are being irrigated or not, and the acreage being farmed). The project will also estimate the regional economic effect of depleted groundwater supplies on many aspects of the economy. Finally, the scientists are using a dynamic optimization computer model to explore how farmers may react to lower groundwater tables. For example, might they switch to more efficient irrigation or dryland crops that don't have to be irrigated?

In another project, Eduardo Segarra, who holds a joint appointment between the TTU Agricultural Economics Department and the Texas Agricultural Experiment Station, is examining whether agricultural producers derive any economic benefits when they make their irrigation systems more water efficient. In this project, Segarra is interested in measuring both short- and long-term benefits. Ideally, he hopes to determine optimal rates of groundwater pumping that will help farmers maximize incomes over the long term. In this project, Segarra is using a computer optimization model that determines maximum economic benefits as well as other simulation tools that demonstrate how changes in pumping lifts and saturated thickness affect how much water can be withdrawn from a given aquifer and other hydrologic conditions.

Segarra says his research suggests that widespread conversions to efficient irrigation systems may not necessarily result in regional water savings. "More efficient irrigation methods may bring more acres into production that would not otherwise be irrigated," he says. As a result, Segarra says he would not be surprised if irrigated acreage in the region remains fairly constant over the next 30 years if efficient irrigation methods are used.

Papers on these research projects were presented at a December 1997 meeting of the High Plains Ogallala Area Regional Water Management Plan and detailed articles about these studies were published in the January 1998 issue of the TTU Water Resources Center newsletter. For details, contact Segarra at (806) 742-2022 or zgseg@ttacs.ttu.edu, or Johnson at (806) 742-0261 or uypnj@ttacs.ttu.edu.

UH Research to Better Identify Location of Wastewater Mains

Many cities across the United States are plagued with deteriorating wastewater systems, stimulating massive projects to replace or rehabilitate corroded pipes and overloaded treatment plants. Currently, the City of Houston is involved in a $1.2 billion wastewater system rehabilitation program because its urban wastewater collection system is experiencing corrosion of the pipes and infiltration of rainwater is overloading the system.

In 1995, the University of Houston (UH) took steps to solve some of these problems by participating in the National Science Foundation Civil Infrastructure System Initiative. UH's project is an integrated effort that addresses corrosion control, system assessment, pipeline renewal, operations, and system integration.

As part of the program, Electrical Engineering researcher Richard Liu has developed an electromagnetic imaging device to identify the location of sewer manholes that have been paved over by street work. The device can be dragged through the wastewater pipes on a wire, and is useful in identifying leaks and the void areas behind the pipes.

"Existing technology involves using TV cameras or smoke," Liu said. "Television cameras are expensive and sometimes are unable to go all the way through the pipes, and smoke is not always reliable. There are hundreds of manholes that are paved over in Houston. We have developed a simple device that can go through the pipeline and detect manhole covers."

UH has selected the Fifth Ward area of Houston for its demonstration model, involving the community in the project and helping homeowners improve their connections to the main lines. Upon completion of the project, the UH teams will have addressed and evaluated the physical and financial effects of the program, identifying the most cost-effective techniques to rehabilitate Houston's wastewater system.

For details, contact Liu at (713) 743-4421 or Cliu@uh.edu.

TAEX Study To Gather Data on Canal Water Losses

How much water is being lost in unlined agricultural canals in the Lower Rio Grande Valley in South Texas and is there a possibility of "creating" new water supplies by making these systems more efficient? These are a few of the questions that will be investigated in a research project that will be conducted this summer by the Texas Agricultural Extension Service (TAEX).

The investigation, which is funded by the U.S. Bureau of Reclamation, will be led by Guy Fipps of the Texas A&M University Agricultural Engineering Department and TAEX. Two Texas A&M University students, Kyle Chilek and Craig Pope, as well as two students from Cornell University, will be performing much of the field work associated with the project.

The goal of the study, Fipps explains, is to increase the amount of available data about the amount and location of conveyance losses from canals used by South Texas agricultural irrigation districts. The Lower Rio Grande Valley Water District Managers Association and the International Irrigation Management Association are cooperating in the effort. The study complements Reclamation efforts to develop a broad integrated water resources management plan for the region.

Steve Driewer prepares to measure the velocity of water movement in this canal near Edinburg.

"Over the course of this summer," Fipps explains, "we hope to have a number of graduate students collecting data in the field. We're hoping to learn more about the amount of water that evaporates from open canals and the volume of water that seeps into the banks of unlined canals. This information will be valuable as we develop water budgets for irrigation districts in the region."

Ultimately, the information will be useful in determining the overall water use and distribution efficiency of these water districts and may identify opportunities for potential water saving activities.

This project will be administered by TWRI. For details, contact Fipps at (409) 845-7454 or g-fipps@tamu.edu, or Allen Whitley of the Bureau of Reclamation Austin office at (512) 916-5648 or awhitley@gp.usbr.gov.

25th TWRI "Water for Texas" Conference is Dec. 1-2 in Austin

TWRI is now making plans for its 25th "Water for Texas" conference. This year's conference will meet December 1-2 in Austin. The conference site is the Red Lion Inn.

The conference is being co-hosted by TWRI, the Texas Agricultural Extension Service, and the Texas Water Conservation Association.

The conference theme is "Water Planning Strategies for Senate Bill 1." The thrust of the conference will be to discuss concepts and information on water supply and demand management strategies.

"We feel the conference will be especially important for regional planning group members, agency personnel, consulting engineers, officials with local and regional governments, and others interested in regional water planning activities," says TWRI Director Wayne Jordan. "Speakers at the meeting will discuss concepts and factual information that they need to make critical decisions when developing regional water management plans."

TAEX Report Explains Effectiveness of "Something's Fishy" Educational Program

An evaluation of a water education program designed for elementary school students has been published by the Texas Agricultural Extension Service. The program, "Something's Fishy," utilizes an educational exhibit, curriculum materials, and a CD-ROM to teach students about water related issues.

The report, *Something's Fishy - A 4-H School Enrichment Program* (3-98), was written by project leader Billy Higginbotham, who is a wildlife and fisheries extension specialist in Overton, TX. Other members of the project team include TAEX extension assistant Ryan Templeton, Mary Ann Mooring, Gloria Martin, Annie Williams, Diann Mitchell of the Extension Data Center, and Carla Beals, Judy Winn, Roxy Pike, and Ray Santos of the Texas A&M University Agricultural Communications Department.

Information in the report describes the development and testing of this water education program. The report includes information about how much students learned in response to specific questions about water issues and how much knowledge they retained after going through the curriculum.

"Student knowledge of aquatic science issues, including water quality and water conservation, was increased an average of 41%, when pre-test and post-test scores were compared," Higginbotham says. "On the pre-test scores, students answered roughly 54% of the questions correctly, but post-test scores reveal that, 60 days after completing the curriculum, students were still able to answer 76% of the questions correctly."

"Something's Fishy" was funded in part by TWRI, as well as many other groups. The report is available by calling Agricultural Communications at (409) 845-2211. For more

details about the curriculum or the CD-ROM, contact Higginbotham at b-higginbotham@tamu.edu or (903) 834-6191

Lamar U. "Tidewatch" WWW Site Displays Current Data from Upper Texas Coast

People needing up-to-the-minute information about water conditions along the Upper Texas Coast may want to log onto a new World Wide Web (WWW) site developed by an engineer at Lamar University (LU).

The WWW site, titled "Tidewatch," was created by Peter Mantz of the LU Civil and Environmental Engineering Department.

Through this site, users can obtain recent information on tides, winds (gusts, speed and direction), air and sea temperatures, barometer readings, and salinity and conductivity. The site features recent radar and satellite images and weather forecasts.

Mantz notes that Tidewatch presents data from the Upper Texas coast (roughly from Galveston Bay to the Louisiana border) as part of LU's work in the Texas Coastal Offshore Observation Network. This effort also contains a link to a WWW site maintained by Texas A&M University - Corpus Christi which contains information about the Lower Texas coast (from Galveston Bay to the Mexico border)

The WWW address is http://tidewatch.lamar.edu. For details, contact Mantz at PMantz@aol.com

Texas Tech U. Creates WWW Site, Database, Describing Playa Lakes, Ogallala Aquifer

A comprehensive database describing water resources of the Texas High Plains has been created by librarians at Texas Tech University (TTU).

The World Wide Web (WWW) site, "Playa Lakes/ Ogallala Aquifer - A Bibliographic Database and Full Text Resource," was developed by Bill Johnson and Marina Oliver of the TTU Library.

The site includes searchable databases covering the region's biology (aquatic and terrestrial ecology and wildlife) and physical processes (geology, hydrology and soils). Special topics of this site describe the history and management of the region's waters, indices that list reference materials by subject and geographic sites, and a gallery of photographs and images.

The WWW site address is http://www.lib.ttu.edu/playa/playa.htm. Johnson can be contacted at wtjohnson@ttu.edu or (806) 742-0737.

UT Student Develops WWW Site Describing Laguna Madre

Water resources of the Laguna Madre and other hypersaline waters are the focus of a World Wide Web site developed by a graduate student at the University of Texas at Austin (UT).

"Visions of a Lagoon - Encounters with the Geography of Texas' Laguna Madre" was created by Keene Haywood, a graduate student in the UT Geography Department.

The site describes and contains links to resources associated with hypersaline ecosystems and wildlife and natural history. The site also discusses such resource conservation and management issues as the brown tide, dredging of the Gulf Intracoastal Waterway, the impact of severe storms on coastal barrier islands, and the environmental impact of modifying the JFK Causeway in Corpus Christi.

A unique feature of this site is that it includes digitized video clippings that allow users to experience flying over the coast and viewing the Laguna Madre as if they were in the middle of Baffin Bay.

The WWW site address is http://wwwvms.utexas.edu/~ifio365/lagunamain.html. Haywood can be contacted at khaywood@mail.utexas.edu.

'Nonpoint Source Book' Features Ways to Treat Stormwater

Comprehensive information about methods to control nonpoint source pollutants is available from a new World Wide Web (WWW) site created by a statewide task force.

Currently under development, the site will include an urban nonpoint source pollution primer, a description of urban runoff management programs, methods to characterize urban waters, a compilation of water quality and watershed characteristics in Texas, and details about practices to manage runoff water quality. An interactive way to help users select the appropriate best management practice for specific sites is being developed.

The WWW site, "The Texas Nonpoint Source Book," is being developed by the Statewide Storm Water Quality Task Force, which is sponsored by the Texas Chapter of the American Public Works Association (APWA). Technical assistance for the development of the WWW site include Camp Dresser & McKee, Inc., Espey Huston & Associates, Carter & Burgess, the law firm of Booth, Ahrens & Werkenthin, and the Center for Watershed Protection.

The WWW site was funded through a Section 319 nonpoint source pollution grant as well as funds from 20 Texas cities and APWA. The site address is http://www.txnpsbook.org. The WWW site is now in draft form and will be finalized this fall. For details, contact Keith Kennedy of the North Central Texas Council of Governments at (817) 695-9221 or kkennedy@nctcog.dst.tx.us

Austin WWW Site Lets Users Delve into Barton Springs

Fascinating facts about many issues relating to Barton Springs are contained in a comprehensive World Wide Web site developed by the City of Austin.

The WWW site, "Barton Springs Edwards Aquifer - Resource Management Knowledge Base," provides users with facts ranging from archaeology to recreation, geochemistry to geology, and history to regulations. Other information on this site discusses such issues as research related to the aquifer, biology and ecology, climatology, hydrology and hydrogeology, remote sensing, and water resources planning and management.

The site also contains an issue paper by scientists and engineers in the region that discusses the future of the Edwards Aquifer. The WWW site address is http://www.ci.austin.tx.us/aquifer.