New Waves
The Research Newsletter of the Texas Water Resources Institute
Volume 14, Number 2, September 2001

University Researchers throughout Texas Provide Insights into SB 1 Regional Water Planning Process

Since the Texas Legislature enacted Senate Bill 1 (SB 1) in 1997, the water planning process in the State has been altered dramatically. In broad terms, SB 1 replaced a centralized planning process led by the Texas Water Development Board (TWDB) with a requirement that individuals within 16 regions of Texas study their own unique water needs and come up with solutions tailored to their circumstances.

This paradigm shift in water planning provided an opportunity for researchers at Texas universities to conduct innovative studies to examine the process of crafting regional water management strategies.

In one study, researcher David Eaton and a team of graduate students at the University of Texas at Austin (UT) Lyndon B. Johnson School of Public Affairs (LBJ School) worked with the TWDB to identify performance measures that could be used to evaluate strategies created by the regional water planning groups. The project involved interviewing staff members from TWDB, the Texas Natural Resource Conservation Commission (TNRCC), the Texas Parks and Wildlife Department (TPWD), and river authorities, as well as individual water users from various sectors, to gain their perspectives on what types of studies may benefit SB 1-related planning activities. According to Eaton, the results suggest that individual water users were much more optimistic about the future availability of water supplies than were agency officials.

Observing the regional water planning process to learn more about the organizational structure within groups was the emphasis of a recent study by Valeen Silvy, a graduate student in the Planning Department at UT. Silvy used a conceptual framework to identify who participated, how the planning process was socially constructed, and how legitimacy was determined within four regions. She observed several meetings of planning groups throughout 1999 as a member of the audience; reviewed minutes, reports, and websites; and interviewed planning group members and others who attended these meetings. The data were aggregated and sorted chronologically and by region. From this data, a typology of regional planning groups was created that was used to classify the structure, funding, administration, representation, and composition of each group, as well as how plans were reviewed. Silvy's results provide insights into the dynamics of group leadership, how each organization responded to tensions created in preparing plans, the

extent that groups were willing to cooperate with adjacent regions, and how dissent within groups was resolved.

In 2000, Ronald Kaiser of the Texas A&M University (TAMU) Recreation Parks and Tourism Sciences Department, Bruce Lesikar of the Agricultural Engineering Department, C. Scott Shafer of the Texas Cooperative Extension (TCE), and Jan Gerston of TWRI surveyed regional planning group members to obtain their impressions about which water demand and supply strategies were preferred and thought to be most feasible. Results were published in a TWRI fact sheet that aggregates the responses from each region.

Two things stand out from these efforts. First, there is a profound need to examine management structures that create water strategies. Secondly, university researchers have the capability to address current, timely policy issues that will profoundly affect water planning and management in Texas.

TAMU Student Studies if Parasites in Fish Can Provide Insights into Water Quality in Rivers

Testing the efficiency of metazoan fish parasites as water quality indicators is the basis of Mary Bhuthimethee's graduate studies at Texas A&M University (TAMU). Her work is being supervised by researchers Norman Dronen and William Neill of the TAMU Wildlife and Fisheries Sciences Department. Bhuthimethee was recently selected as one of 11 graduate students to be awarded a Mills Scholarship from the Texas Water Resources Institute (TWRI).

According to Bhuthimethee, there is a critical need for cost-effective and efficient methods to determine water quality trends, and how rivers and streams are affected by nonpoint source pollution. However, currently-used methods to evaluate water contamination are often costly.

The goal of this project is to determine if parasites in fish can be used as water quality indicators, since parasites are very sensitive to external factors and changes in water conditions. Bhuthimethee believes that using parasites can be an excellent, low-cost tool to assess water quality.

In this study, Bhuthimethee is gathering data at four sites in the upstream and downstream portions of the Leon and Salado Creek watersheds. At each site, she placed 12 bluegill fish in cages that were staked to underwater fence posts. Bhuthimethee left the fish in the cages for periods of 10 and 20 days. Every day, Bhuthimethee or colleagues fed the fish and collected stream data using an electronic multi-environment meter that measures water temperature, dissolved oxygen, pH, and conductivity, as well as water flow rates. Later, the fish were euthanized and taken to the lab for further study.

Currently, Bhuthimethee has begun work to identify parasites that were found on these fish. Soon, she will perform heavy metal assays on bluegill fish muscle to compare levels from fish caught in the wild and those used in this experiment. She will use her findings about the correlation of metazoan parasites and heavy metals to determine the impact of environmental factors on fish health and water quality, and how well the parasites indicate if water quality problems are occurring in Texas rivers.

"I hope my findings may be beneficial to watershed managers and other scientists interested in finding a less costly method of determining water quality and environmental degradation," Bhuthimethee said. "There has not been much research done on the use of parasites as bioindicators for environmental degradation, and I hope this research will add to that base of knowledge."

For details, contact Bhuthimethee at (979) 845-5777 or mary-b@tamu.edu.

Assessing the Water Corridors of the Big Thicket National Preserve

Researchers: Paul Harcombe, Ecology and Evolutionary Biology Department, Rice University, Houston, TX; and Glenda Callaway, Ekistics Corporation, Houston, TX.

Problem: The Big Thicket National Preserve is located in the East Texas Piney Woods. The Preserve is made up of 15 geographic units, and covers an area of 96,970 acres. Eight of the units of the Thicket are river, creek, and bayou corridors. These water corridors are intended to preserve critical aquatic habitats, and to link these areas with surrounding bottomland hardwood forests. The characteristics of each of these water corridors need to be examined in order to develop management strategies for the Preserve.

Objectives: The broad goal is to develop baseline information and management options that the U.S. National Parks Service (NPS) can use to best care for the Preserve. The management options must meet NPS objectives for the Preserve including the following: 1) Water corridor management must be consistent with the missions and policies of NPS; 2) Waterways should be managed to preserve the natural setting and prevent further degradation; 3) The management system must be economically efficient; 4) Opportunities for experiencing nature should be maintained and enhanced; 5) Educational measures should be developed to enhance the opportunities for visitors to learn about the natural

resources of the Preserve; and 6) A scientific monitoring program should be implemented to study the riparian ecosystem and how human activities affect the Preserve.

Methods: This assessment is organized around the concept of protecting the critical resources of the Preserve. Critical resources are defined as those that are essential to maintaining the integrity of the ecosystem and are particularly sensitive to adverse impacts by external activities and decisions. Critical resources for the water corridors include water quality and quantity; woody snags in rivers, streams, and bayous; stream banks; and floodplain forests. The first step in this project was to characterize the biota and natural process of the ecosystem, including water quality and flow trends, fish and aquatic invertebrates, vegetation, and threatened and endangered species. Land uses and types of ownership were mapped. Potential threats to the ecosystem were characterized according to the extent to which they could alter natural processes. Public uses of the Preserve and interagency and inter-institutional issues were addressed. A matrix was developed to summarize relationships between the Preserve's natural resources (habitats and species) and how they may be impacted by human activities (boating, fishing, hunting, farming, and commercial logging). Interestingly, the hydrology of the region was put in the human impact section of the matrix, since the flows in the Preserve have been substantially altered by man's activities.

Results and Discussion: Water quantity and quality are the most important resources to support the aquatic corridors. Even though the region generally receives an average of 36 to 55 inches of rainfall annually, substantial impairments or restrictions in flows may affect the ability of the Preserve to maintain current ecosystem functions. Woody, instream, snags provide cover for fish and serve as a stable habitat for invertebrates, which are in turn a food supply for fish. Intact stream banks are critical to the ability of the Preserve to provide habitat and resources for reptiles and amphibians. Conversely, streambank erosion will result in siltation of the rivers and streams of the area, thus adversely affecting water quality. Floodplain forests provide habitats and refuge areas for forest species, and buffers that protect aquatic communities. The report describes a variety of issues that need to be addressed in order to manage the resources of the Preserve, including biodiversity, endangered species, exotic species, water quality and quantity, woody in-stream snags, floodplain forests, aesthetic and scenic qualities, and archaeological and cultural resources. The possible impact of such public uses of the Preserve as hunting and trapping, fishing, boating, swimming, and the use of houseboats on the quality of the ecosystem are addressed. Results of the study suggest that cooperative efforts with neighboring landowners and communities need to be fostered and emphasized, since the Thicket is comprised of several independent land units that are not integrated. At the same time, since several units of the Preserve now have relatively little human use, this may be an ideal time to plan for and prepare for the long-term future of this ecosystem.

Reference: Harcombe, P.A., and G. Callaway, *Management Assessment of the Water Corridor Units of the Big Thicket National Preserve,* Report developed for the NPS, September 1997.

Using GIS to Develop Floodplain Maps

Researchers: Kevin Donnelly and David Maidment, Center for Research in Water Resources (CRWR), the University of Texas at Austin (UT), Austin, TX.

Problem: While national and local governments have been building dams and levees to reduce and respond to flood damage, these actions have not eliminated the destruction and losses associated with floods. Additionally, these remedies do nothing to aid flood victims should they fail. The National Flood Insurance Program (NFIP) was created as a measure to reduce property losses, encourage flood mitigation practices, and assist those impacted by floods. The NFIP uses flood hazard maps and Flood Insurance Rate Maps (FIRMs), created by the Federal Emergency Management Agency (FEMA), to determine premiums. As lands surrounding floodplains are developed or better topology data becomes available, updates to FIRMs are needed to provide homeowners and agencies with the most accurate and precise flood hazard maps possible. Specifically, the implementation of a new Digital Flood Insurance Rate Map (DFIRM) spatial database would allow for national maps to be accessed through the Internet, more widely used, and should increase the level assistance FEMA provides nationwide.

Objectives: 1) Enact production processes and methods for a DFIRM conversion project; 2) Use data to study Colorado River; and 3) Create a DFIRM spatial database that works with the ArcGIS Hydro Data Model.

Methods: The research in this project was conducted for Lago Vista, TX, and the surrounding areas. In order to develop a process for converting FIRMs to a digital form, the researchers decided to study a set of six FIRM maps in the pilot study. A "quilted" base map was created using two different sets of aerial photos: USGS Digital Orthophoto Quadrangles (DOQs) and local photos developed at a higher resolution. Using a geographic information system (GIS), a shape file was created containing the location and attributes of each FIRM such as panel numbers and the latitude and longitude of map corners. Recently developed contour data and existing 100-year and 500-year water surface elevations were used by researchers to redefine floodplains. The ArcGIS Hydro data model was expanded to encompass DFIRM features based upon FEMA's Standard DFIRM Spatial Database. Another aspect of this project allowed for the conversion of contour data between the vertical datums, NGVD29 and NAVD88, and the use of HEC GeoRAS to further refine the 100-year old floodplain initially developed using FEMA's "approximate" study methods.

Results and Discussion: Based on the findings from this research, GIS proved to be an efficient environment for creating, assessing, and storing FIRM maps for the Lago Vista area. Using such a DFIRM conversion program will reduce the cost of future changes to FIRMs. Once a DFIRM is developed for a given area, each individual layer can be updated and changed in the database without having to completely recreate the base map. Additionally, GIS was found to be a sufficient platform for use in converting elevation information to different vertical data and developing FEMA's "Zone A" flood hazard area.

Reference: Donnelly, K., and Maidment, D., *Developing Digital Flood Insurance Rate Maps for Lago Vista*, CRWR Technical Report 01-2, UT, May 2001.

Note: This report is available on the UT CRWR website, at http://www.ce.utexas.edu/org/crwr/index.htm. You can contact Donnelly at kdonnelly@alumni.tufts.edu, or Maidment at maidment@mail.utexas.edu or (512) 471-0065.

Estimating the Economic Contributions of Texas Coastal Recreation and Tourism

Researchers: Lonnie L. Jones and Aysen Tanyeri-Abur, Agricultural Economics Department, Texas Agricultural Experiment Station, Texas A&M University.

Problem: The Texas Gulf Coast region is the site of much water-based recreation and tourist activities. This study examines six Texas bays and estuaries which encompass 26 counties and the cities of Houston and Galveston. Together, these counties have a total population of 5,155,7000 people. As populations in surrounding metropolitan areas increase, so does the potential regional and statewide economic impact of recreational and commercial fishing and water-related recreational activities.

Objectives: 1) Estimate economic impacts of recreational and commercial fishing and bay and estuary related recreational activities in six areas along Texas Gulf Coast; and 2) Estimate direct impacts of recreation per estuary.

Methods: Researchers implemented IMPLAN to create eight input-output models for use in the analysis. IMPLAN is a computer algorithm which identifies the correlation between different sectors of the economy, represented by a system of equations. For this project, the eight models developed included one regional model for each of the six bay and estuary regions, one regional model for the 26 counties in the study, and one model to represent the Texas economy and simulate statewide impacts. Updated information from the 1987 Fesenmaier study, which was a public survey of recreation participants, was used along with data from the Texas Department of Commerce (TDOC) to estimate direct impacts of regional recreational activities.

Results and Discussion: Explanations from the input-output models were presented regionally and statewide in terms of total output, income, and value-added, and employment impacts. Regional results estimate that bay and estuary recreation-related sales to final demand generated total regional business sales of about $1.6 billion, personal income of $651 million, value-added revenues of $999 million, and roughly 32,168 jobs in the Gulf Coast Region. Fishing was estimated to yield an economic impact of $265 million in bays and estuaries, personal incomes of $80 million, and 5,558 jobs in the region. Recreational sectors were estimated to have an output of $1,655 million, personal incomes of $674 million, and 33,529 jobs. For commercial fishing statewide, an

output of $276 million was estimated, with a value-added impact of $185 million, and 6,111 jobs created statewide. The project's findings also reveal that while both the recreation and commercial fishing industries are significantly impacting the Gulf Coast and Texas economies, they are doing so at different rates. While tourism and recreational bay use continue to increase, the commercial fishing industry shows decline in the areas of fish landings and value.

Reference: Jones, L., and A. Tanyeri-Abur, *Impacts of Recreational and Commercial Fishing and Coastal Resource-Based Tourism on Regional and State Economies*, 2001. This report was published by Texas Water Resources Institute as TR-184.

Note: For more information, contact Jones at (979) 845-3555 or lljones@tamu.edu.

Investigating Sources of Hypoxia, and the Extent to Which Hypoxia is Occurring, in Corpus Christi Bay

Researchers: Christine Ritter and Paul Montagna, University of Texas at Austin Marine Science Institute, Port Aransas, TX.

Problem: Hypoxia is an estuarine condition characterized by low dissolved oxygen (DO) concentrations. It is a phenomenon that has been observed in more than 44 water systems worldwide and has been noticed in the southeastern region of Corpus Christi Bay, since 1988. Hypoxia can create "dead zones" in which few marine organisms can survive. While hypoxia in the Corpus Christi Bay only occurs in water 1-2 meters above the bottom, it affects benthic organisms. According to this study, hypoxia is to blame for a 10-fold reduction in the amount and variety of benthic life in the southeast corner of Corpus Christi Bay, Texas. However, further study is needed to determine the conditions leading to hypoxia and its ecological consequences.

Objective: 1) To identify the physical factors that lead to the occurrence of hypoxia; and 2) To determine the ecological repercussions of hypoxia in Corpus Christi Bay, Texas.

Methods: Researchers measured spatial and temporal scales of hypoxia, and evaluated water quality in the summer of 1999 and 2000, through use of continuous oxygen recorders. Caging experiments were used to observe and record the effects of hypoxia on trophic relations within the benthic food chain. The measurements taken from water columns during spatial surveys indicated benthic oxygen depletion occurred with and without salinity stratification, but they rarely captured hypoxia. The continuous oxygen monitoring did capture a variety of hypoxia-related events, including those that were brief and of low intensity. However, such continuous oxygen monitoring captured one intense hypoxia event, which lasted more than 24 hours.

Results and Discussion: From the data, researchers concluded that hypoxia is a transient event that results from a conjunction of biotic processes such as respiration, and abiotic

processes such as low mixing potential due to small tidal ranges. The community structure of hypoxic and normoxic regions were also found to differ as a result of species loss in the area experiencing hypoxia, but the extent of the affected area is relatively small. This study proved that hypoxia in Corpus Christi Bay is the result of interacting biotic and abiotic processes and does negatively affect benthic life in the area. At this time, however, indirect ecological effects do not appear to pose a significant threat.

Reference: Ritter, M. Christine, Montagna, Paul A., *Cause and Effects of Hypoxia (Low Oxygen) in Corpus Christi Bay, Texas*, The University of Texas at Austin Marine Science Institute, March 2001.

Note: For more information, contact Ritter at ritter@utmsi.utexas.edu, or Montagna at paul@utmsi.utexas.edu.

Investigating Policy Issues Associated with Effluent Trading Policies in Texas and the Clean Water Act (CWA)

Researchers: Arnold Vedlitz, Texas A&M University (TAMU), Director of the Institute for Science, Technology and Public Policy (ISTPP) in the George Bush School of Government and Public Service, and the Political Sciences Department; Mark Fossett, TAMU Sociology Department; Ronald Kaiser, TAMU Recreation, Parks, and Tourism Sciences Department; Marty Matlock, TAMU Agricultural Engineering Department; and Richard Woodward, TAMU Agricultural Economics Department.

Background Information: At the request of the Texas Natural Resource Conservation Commission (TNRCC), the ISTPP initiated and assembled this team interdisciplinary team of researchers for the purpose of responding to the issue of regulatory and policy impediments that need to be overcome to facilitate effluent trading in Texas. Implementing the current standard for water regulation at a state and national level involves technology-based regulating of point-source emitters. Despite the success of these restrictions, they are an expensive regulatory option and fail to address nonpoint sources of pollution.

Objectives: 1) To analyze how effluent trading programs can be incorporated into the policies under the Clean Water Act (CWA) to reduce the loading of certain pollutants and further improve the quality of water supplies, and 2) to provide recommendations to the TNRCC on how the agency might proceed toward the development of such programs.

Methods: In order to develop successful effluent trading strategies, the researchers first had to consider issues of process, structure, and scale. The acts of a regulatory agency to enter the market and conduct trades are considered acts of process which have to be examined. Issues of structure include market form, methods and authorities of enforcement, regulatory oversight, and the legal rights and responsibilities of agencies and participating parties. Scale issues pertain to the geographic scale, the variety of

trading participants, and the number of pollutants traded. Another important aspect of the project involved clearly defining goals and objectives for the trading program. While developing effluent trading strategies, researchers considered technical elements, and established that trading should typically exist only with pollutants that are biodegradable and assimilable. They established trading boundaries to correspond with watersheds and watershed segments, focusing on point and nonpoint pollution sources. In terms of economic elements, researchers considered how effluent trading programs satisfied the criteria of equivalence, additionality, and accountability. They emphasized that an effluent credit purchased should offset the pollution load it was replacing. This requirement would give rise to trading ratios representing the number of units of reduction per source needed to offset a single unit of pollution by another source. The criteria of additionality states that credits offered for purchase must represent true water quality improvements. Accountability allows credit to be reviewed for independent verification. The researchers considered legal and regulatory elements, such as enforcement devices to secure trading performance, as well as sociopolitical elements including the education of stakeholders.

Results and Discussion: Researchers developed five broad approaches to effluent trading that might be taken by the State of Texas.

- *Approach 1: Develop Statewide Rules for Effluent Trading* – This involves the implementation of statewide regulations which would provide continuity and set standards for trading throughout Texas. The fear that some sectors may not fit neatly into such a uniform structure, and the challenge posed to TNRCC staff to create such rules are disadvantages to this approach.
- *Approach 2: Allow Trading Through Associations* – This involves the TNRCC selecting an association, or encouraging stakeholders to form associations through which to trade. This approach may be of lower cost to TNRCC and might require fewer regulatory requirements and less management. It would offer flexibility. Yet, this idea has negative legal aspects, since conducting trade through this approach may warrant legal challenges, if it were deemed an inappropriate delegation of TNRCC's Authority to administer the Clean Water Act.
- *Approach 3: Promote Agency-Brokered Trades* – This would require the TNRCC to broker pollutant trades between parties. This method would allow the TNRCC to have immediate control and influence over trading programs. Disadvantages include increased transaction costs and restricted efficiency and flexibility within the trading process.
- *Approach 4: Conduct Demonstration Projects* – This would allow the TNRCC to simulate trading processes on a smaller scale in a limited area. The advantage is the ability to test these programs. This approach would offer a restricted scope and could result in immediate payoffs only on a small scale, at the cost of much agency time and resources.
- *Approach 5: Maintain Current Policies and Procedures* – This suggests the TNRCC maintain current procedures in trading policies. Such a traditional approach has the advantage of following existing regulatory structures. However, the current trading program can be inefficient and unable to equitably react to

changing conditions, especially for nonpoint source pollutant loadings. Researchers fear that, under this approach, conflict would increase between rural and urban water users and ultimately result in reduced water quality.

Reference: Fossett, M., Kaiser, R., Matlock, M.D., Vedlitz, A., and Woodward, R.T. (1999). *Effluent trading: A policy review for Texas*. College Station, TX: Center for Public Leadership Studies, George Bush School of Government and Public Service, TAMU.

Note: For additional details, contact Vedlitz at ISTPP at (979) 845-2929 or avedlitz@bushschool.tamu.edu.

Texas Tech Receives Grant to Investigate Perchlorate Contamination at Caddo Lake

Texas Tech University's Institute of Environmental and Human Health (TIEHH) has been awarded $1.4 million to study the effects of ammonium perchlorate on the environment. The award, from the Strategic Environmental Research and Defense Program, will investigate the Longhorn Army Ammunition Plant, in Karnack, TX, which is near Caddo Lake.

Ammonium perchlorate is a chemical used in rockets and fireworks that has entered many watersheds across the United States. Still, little is known about how it effects the environment. Currently, the Department of Defense is addressing ammonium perchlorate contamination at a number of its facilities across the nation. The U.S. Environmental Protection Agency (EPA) designated the Longhorn Plant as a Superfund site. As a result, it is eligible to receive funding for cleanup purposes. The TIEHH research team will assess the ecological effects of perchlorate at this location.

The project is coordinated by TIEHH Director Ronald Kendall, who is also a researcher in the Environmental Toxicology Department. Phil Smith will lead on-site team ecotoxicology studies, while researchers Chris Theodorakis, Jim Carr, and Reynaldo Patino will study the effects of ammonium perchlorate on aquatic organisms. Researcher Todd Anderson will oversee analytical work to determine concentrations of ammonium perchlorate in the water, soil and organisms. Ken Dixon will lead efforts to perform an ecological risk assessment that will analyze the effects of ammonium perchlorate in water and land environments.

Ultimately, TTU plans to evaluate the cleanup of the site, so it can be used as a public use fish and wildlife refuge. To achieve this goal, representatives of the U.S. Fish and Wildlife Service have requested that TIEHH develop risk-based approaches to evaluate the effects of ammonium perchlorate on the environment.

Note: For details, contact Kendall at (806) 885-4567 or ron.kendall@ttu.edu.

UT Investigates Development, Use of Surfactants to Clean Up Pollutants in Aquifers

Can we clean polluted aquifers in the same way that we wash dirty, greasy clothes? Although it sounds like something from a futuristic novel, researchers at the University of Texas (UT) Petroleum and Geosystems Engineering Department are working to make the idea a reality.

Researcher Gary Pope and students Vinitha Weerasooriya, Mojdeh Delshad, Eric Bruesewitz, Sean Murray, Sheakar Jayanti, and Bruce Rolf are endeavoring to improve the use of surfactants to clean up recalcitrant contaminants in aquifers. Funding for this project was provided through an Advanced Technology Program grant from the Texas Higher Education Coordinating Board.

The contaminants being studied are non-aqueous phase liquids (NAPLs), and dense, non-aqueous phase liquids (DNAPLs). NAPLs include coal tars and creosote from utility plants, while DNAPLs are oils and cleaning solvents often found at military bases. These pollutants are difficult to clean up because they are denser than water. When spilled, they can pass through soils and groundwater, and end up trapped in aquifers and pools.

Pope is testing surfactants (which are similar to detergents), to clean up NAPLs and DNAPLs. Under natural conditions, oil and water do not mix. However, adding surfactants causes the oil and water to mix, creating a microemulsion.

The difficulty is finding the right amount and type of surfactant to use in site-specific circumstances. "Coal tar and creosote are hard to remediate and it is equally tough to find the detergent that will clean it up. We are working to create new detergents that can get the job done," Pope said. Pope is studying whether surfactants can be combined with xanthan gum, which is a biopolymer used to thicken foods, to help them dissolve in water.

Currently, the research team is working to match the detergent strength that will be needed to treat key pollutants. Studies will involve observing the behavior of the contaminant, surfactant, and water in test tubes, and measuring the effectiveness and viscosity that will result from the use of surfactants in specific conditions. Later, surfactants will be pumped through soil columns to test how much contaminant can be flushed out of the soil.

After a successful surfactant has been created, Pope will model the flow and transport of surfactants and pollutants by using the UT chemical flooding simulator (UTCHEM).

"From the data received from UTCHEM, private industry will be able to apply the technology to real-world situations. In these situations, two wells could be drilled at the tainted site. One well would inject the water and detergent mixture into the soil and through sand, which would flush out the oil. Then the second well, about 20 feet away, would pump the oil, detergent, and water mixture out," said Pope.

For more information about the project, contact Gary Pope at gary_pope@pe.utexas.edu, or (512) 471-3235. For more information about DNAPL remediation, visit the SEAR Technology Alliance project web page at http://www.napl.net/challenge.html.

New TWRI Technical Reports Discuss Drought Management, Water Savings in Irrigation

The Texas Water Resources Institute (TWRI) has recently published technical reports dealing with water management, irrigation efficiency, and the economic impact of coastal tourism.

Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin (NMWRRI Technical Completion Report No. 317), was written by Frank Ward, Robert Young, Ronald Lacewell, J. Philip King, Marshall Frasier, J. Thomas McGuckin, Charles DuMars, James Booker, John Ellis, and Raghavan Srinivasan. This report was a collaborative effort of TWRI, the New Mexico Water Resources Research Institute, and the Colorado Water Resources Research Institute. This report examines how economic losses during periods of severe drought might be reduced by interstate coordination of water withdrawal and reservoir operations. It comes with a CD that provides additional data about the study.

Potential Water Savings in Irrigated Agriculture in the Lower Rio Grande Basin of Texas (TWRI TR-183), was written by Guy Fipps. Published as part of the Efficient Irrigation for Water Conservation in the Rio Grande Basin Initiative, this report examines potential water savings resulting from irrigated agriculture. Improvements in conveyance efficiency and on-farm practices, and estimates of regional and county water-savings are provided.

Impacts of Recreational and Commercial Fishing and Coastal Resource-Based Tourism on Regional and State Economies (TWRI TR-184), was co-authored by Lonnie Jones and Aysen Tanyeri-Abur. This report examines the economic effects of recreational and commercial fishing and recreational activities on six bay and estuary systems along the Texas Gulf Coast. This research was funded, in part, by the Texas Water Development Board and the Texas Sea Grant Program.

Ecological, Economic and Policy Alternatives for Texas Rice Agriculture (TR-181) was written by Leticia Alston, Thomas Lacher, R. Douglas Slack, Arnold Vedlitz, Richard Woodward, and several others. The report, which was co-published by Institute for Science, Technology and Public Policy at The Bush School, examines economic and policy issues associated with rice irrigation.

Texas Tech Publishes Guide on Evapotranspiration Rates

A useful manual has been published by Texas Tech University that contains data on mean crop consumptive use and free-water evaporation for many locations throughout Texas.

The report, *Mean Crop Consumptive Use and Free-Water Evaporation for Texas*, was published in 1998. Authors include John Borrelli, Clifford Fedler, and James Gregory of the TTU Civil Engineering Department. This project was funded by the Texas Water Development Board.

The report includes comprehensive information on mean consumptive water use for agricultural crops and turfgrasses, as well as contour maps of evapotranspiration. It also includes crop coefficients, information on free-water evaporation from shallow ponds, ways to estimate irrigation efficiency, and leaching requirements for salinity control. The report also describes how you can use this information to design center pivot irrigation systems, to estimate evapotranspiration from wetlands, and to estimate water use by native vegetation.

Information in this report will be very useful in determining how much effluent could be safely applied over a given area. It is also very useful to people involved in agricultural production, as well as landscape irrigation.

Note: This report is being sold by Texas Tech for $25. To place an order, email Clifford Fedler at clifford.fedler@coe.ttu.edu or call him at (806) 742-3597.

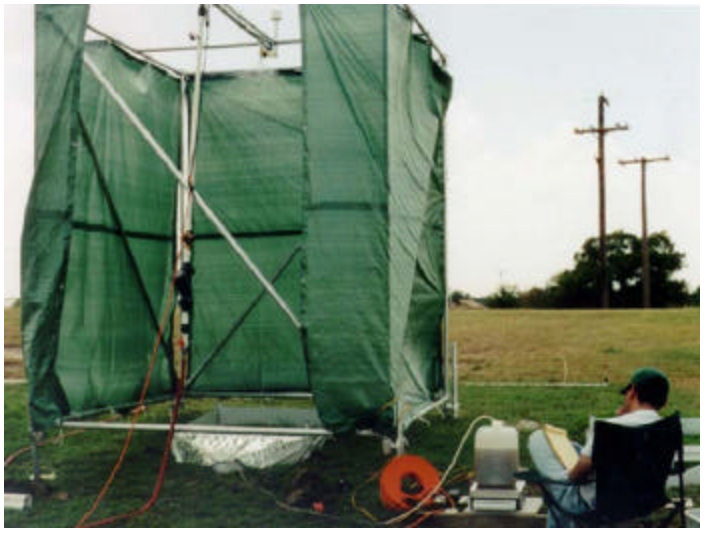
TAMU to Study Whether Growing Turfgrass Sod with Dairy Manure Can Improve Water Quality

Researchers from the Texas A&M University (TAMU) Soil and Crop Sciences and Agricultural Engineering Departments recently received a grant from the U.S. Geological Survey (USGS) to assess the impacts of best management practices (BMPs) that move manure nutrients from rural to urban watersheds.

The project, "Assessing Water Quality Impacts of Nutrient Imports into an Urban Gradient," was funded through the USGS National Competitive Grants Program. Clyde Munster of the Agricultural Engineering Department, and Don Vietor, Richard White, and Tony Provin of the Soil and Crop Sciences Department are the lead investigators in this study. TWRI will administer the project. The goal of this study is to ascertain the water quality benefits that may result in impaired watersheds by exporting manure nutrients in turfgrass sod grown with composted dairy manure. The project will also determine the water quality impacts of manure nutrients in the importing watersheds.

In this project, dairy manure from the Bosque River basin will be put to use to generate compost that will be then be utilized in the production of turfgrass sod. The Bosque River

watershed contains roughly 165 dairies and 41,000 cows, which generate sizeable levels of manure. The Texas Natural Resource Conservation Commission (TNRCC) recently recommended that phosphorus loads in this watershed area be reduced by half. Removing manure nutrients from dairy waste by growing and harvesting turfgrass sod has the potential to improve water quality in the Bosque River watershed.



The environmental impacts of transplanted turfgrass sod will be evaluated for urban developments in the Dallas-Fort Worth area, which is part of the Trinity River watershed. The researchers will use a rainfall simulator to monitor P and N transport in runoff from transplanted sod produced with composted dairy manure. Measurements of runoff losses will be used to estimate losses from transplanted sod in urban areas.

According to the research team, turfgrass sod may prove to be a valuable, efficient, and sustainable mechanism to transport nutrients contained in dairy manure from impaired watersheds.

"Turfgrass sod produced with composted dairy manure may not require routine applications of phosphorous fertilizers for many years after planting in lawns and other turf areas," White says. "Integration of BMPs derived from this work could help reduce phosphorus loads near dairies, as well as in urban areas, if phosphorus fertilization of lawns and turf areas can be reduced by using sod grown with composted dairy manure." The research team will be working closely with the USGS to integrate this study with the second cycle of the National Water Quality Assessment of the Trinity River basin.

For details, contact Munster at c-munster@tamu.edu or (979) 847-8793, Vietor at dvietor@tamu.edu, White at (979) 845-5357 or rh-white@tamu.edu, or Provin at t-provin@tamu.edu or (979) 862-4955.

Texas-Israel Exchange Funds Water-Related Grants

In 2001, the Texas-Israel Exchange Fund Board, which is administered by the Texas Department of Agriculture, awarded several water-related research grants. Here are some of the projects.

- "A Pilot-Scale, Environmentally Friendly, Land-Based, Integrated System for the Production of Shrimp, Fish, and Seaweed," Tzachi Samocha, TAES, Corpus Christi, TX; and Muki Shpigel, National Center for Mariculture, Eilat, Israel.
- "Use of Wastewater to Irrigate Vegetable Crops With Subsurface Drip Irrigation Systems," Juan Enciso, Texas Cooperative Extension, Fort Stockton, TX; and Gideon Oron, Ben-Gurion University of the Negev, Israel.
- "Safe Application of Sewage Products to Sustain Irrigated Agriculture," Naomi Assadian, TAES, El Paso; and Pinchas Fine Guy Levy, Volcani Center, Bet-Dagan, Israel.
- "Advancement of Cotton Drought-Tolerance by Plant Breeding, Model Systems and Genetic Engineering," Wayne Smith, Texas A&M University (TAMU) Soil and Crop Sciences Department ; and John Hemphill and Jean Gould, TAMU Forest Sciences Department; and Dudy Bar-Zvi, Ben-Gurion University, Kiryat Boker, Israel.
- "Assessment of the Feasibility of Using Reclaimed Nursery Runoff and Treated Domestic Graywater for Irrigation of Cut Flowers and Bedding Plant Flowers," Michael Arnold, Horticulture Department, TAMU; Bruce Lesikar, Agricultural Engineering Department, TAMU, and Dennis Hoffman, TAES, Temple, TX; and Amit Gross and Zeev Ronen, Ben-Gurion University of the Negev, Israel.
- "Chlorophyll Fluorescence, Canopy Temperature Depression and Reflectance in Visible Spectrum as Crop Stress Indicators of Wheat and Cotton under Semi-Arid Conditions of Texas and Israel," William Payne, TAES, Amarillo, TX; and Anatoly Gitelson, Ben-Gurion University of the Negev, Israel.
- "Development of Selected Ornamentals Tolerant to Recycled and Saline Irrigation Water," Cynthia McKenney and Steve George, TAES, Dallas, TX; Dick Auld and Cary Green, Plant and Soil Science Department, Texas Tech University (TTU), Lubbock, TX; Robert Sweazy, TTU, Lubbock, TX; and Zohara Yaniv, Bruria Heuer, and Y. Spiegel, Volcani Center, Bet-Dagan, Israel.
- "Genetic Resources of Drought Resistance in Wild Emmer Wheat for Wheat Improvement," Henry Nguyen, TTU Plant and Soil Sciences Department, Lubbock, TX; and E. Nevo, Abraham Korol, and Tzion Fahima, University of Haifa, Haifa, Israel.

Note: For details, visit the Texas Department of Agriculture website, http://agr.state.tx.us.

TTU Geoscientists Study Groundwater Level Declines in the Texas High Plains

Scientists in the Texas Tech University Geosciences Department are now studying the dynamics of the groundwater tables of the High Plains. Specifically, they are exploring why aquifer levels are increasing are some sites in the region. They are also designing a geophysical system that can monitor short-term variations in depth to water table and soil moisture.

This research is being carried out by Harold Gurrola and George Asquith of the TTU Geosciences Department, and is funded by the Texas Higher Education Coordination Board Advanced Technology Program.

In this project, the researchers designed stations to monitor groundwater levels at the Brownfield Lakes in Terry County as well as a site near Lubbock. The stations will monitor variations in the groundwater table, soil moisture, and the migration of brackish groundwater. These sampling sites were chosen because they have exhibited unexplainable variations in the groundwater table.

Gurrola and Asquith are testing various geophysical tools, such as ground-penetrating radar, resistivity, and spontaneous potential. They are using electromagnetic and seismic methods to measure short-term water table fluctuations and soil moisture variations.

During the first year of the project, the researchers constructed a monitoring station in Terry County that will record measurements of groundwater conditions, the zone of aeration, the active zone, and the surface conditions once every two hours over a year. The stations will also measure groundwater height, temperature, salinity, electrical conductivity, SP measurements over 200 meters, resistivity, and such meteorological conditions such as barometric pressure, temperature, and precipitation.

Currently, the researchers are conducting experiments of groundwater tables near Lubbock to adapt the system to study how agricultural water use may affect water tables. “We are monitoring soil moisture as a function of the crop watering schedule to determine how to maximize moisture near plant roots as well as how to minimize loss due to evaporation and run-off,” Gurrola said.

Gurrola, Asquith and TTU Susan Barrick are coring and describing the soils, and conducting grain size analyses.

The goal of this project is to design a system that can be used to monitor short-term variations in the water table and soil moisture. “We hope this will be applicable in planning water use and recharge, and designing water monitoring systems,” said Gurrola.

For more information, contact Gurrola at harold.gurrola@ttu.edu or at (806) 742-3299.

UTEP Studies Zero Discharge Waste Brine Management for Desalination Plants

Andrew Swift and Huanmin Lu of the Center for Environmental Resource Management at the University of Texas at El Paso (UTEP) have developed a plan to improve desalination procedures. The goal is to better utilize supplies of abundant brackish groundwater. This project addresses the problem of managing and disposing of brine concentrates that result from desalination procedures.

The researchers have proposed to improve brine management and disposal methods at desalination plants by coupling a salinity gradient solar pond (SGSP) with a brine concentrator and recovery system (BCRS). The SGSP is an open-air pond with extremely high concentrations of salt, that serves to suppress convection and to provide a layer of insulation near the top of the pond. This insulation creates temperatures between 60° and 90° C (140° to 194° F) in the lower levels of the pond. Thermal energy from the pond can then be used to power the BCRS. This produces additional fresh water and a near-slurry salt discharge, which can be used to recharge the solar pond, add to SGSP capacity, or be sold.

The BCRS is the final stage in a desalination process. Reject concentrates from primary desalination procedures such as membrane treatment of multistage flash systems will feed the SGSP, which supplies feed brine to the BCRS as well as thermal energy.

Researchers say this system may have several environmental advantages over conventional desalination procedures. First, it reuses brine concentrates for energy and chemical production from excess recovered salts, rather than depositing brines in high cost and potentially polluting disposal wells. Second, the energy requirements for this process are provided by the use of the brine concentrate in the SGSP, rather than outside sources. Finally, additional potable water is recovered from the brine concentrate, and does not become part of the waste-stream.

Although a detailed economic analysis of the SGSP-BCRS system has not yet been completed, comparisons with alternatives such as evaporation ponds and injection wells suggest that the SGSP-BCRS system may likely save land area, energy, and produce more freshwater.

For more details, please contact Lu at (915) 747-5282 or lhuanmin@utep.edu.

TAMU Project Incorporates Satellite Data to Study Evapotranspiration Rates in Texas

Using satellite images to calculate evapotranspiration rates (ET) is the focus of a new TWRI study. The project is being carried out by student Balaji Narasimhan of the Texas A&M University (TAMU) Agricultural Engineering Department and researcher Raghavan Srinivasan of the TAMU System Spatial Sciences Laboratory.

The study, "Determination of Regional Scale Evapotranspiration of Texas from NOAA-AVHRR satellite," is one of 11 projects funded by the Texas Water Resources Institute (TWRI) in 2001.

ET is the loss of water through soil evaporation and plant growth or transpiration. Typically, ET is responsible for returning 70% of the precipitation back into the atmosphere.

An accurate method for estimating ET is essential for developing efficient drought and water balance models. Currently ET is estimated using information such as air temperature, relative humidity, and wind velocity collected at weather stations. However, approaches now being used rely on data collected at one site to forecast and estimate conditions for an entire region. Often, weather stations are not located within the specific areas being studied.

"With the help of satellite data, we can get real-time ET estimates with better spatial accuracy, since satellites provide continuous data over an entire region," Narasimhan said.

Narasimhan is presently examining satellite images to establish a relationship between surface temperature measured by satellites (Ts) and air temperature measured at weather stations. This study will utilize an advanced very-high resolution radiometer (AVHRR) sensor, which is aboard an orbiting earth satellite, to develop more accurate ET estimates. The satellites are used by the National Oceanic and Atmospheric Administration (NOAA). He will attempt to create a method to compute ET from satellite images based on an energy balance approach.

Findings from this project may be particularly beneficial to agricultural producers, since they will allow farmers to better determine planting times and irrigation strategies.

"This project will develop a method to estimate evapotranspiration that may eventually be used by farmers to schedule irrigation, in water balance modeling to estimate soil moisture conditions, to determine better planting time for crops, and to manage droughts," Narasimhan said.

For details, contact Narasimhan at (979) 845-3600 or balaji@tamu.edu.

UTMSI Studies How Water Temperatures Affect Growth of Red Drum

A project funded by the Texas Water Resources Institute (TWRI) is enabling a graduate student at the University of Texas Marine Science Institute (UTMSI) to investigate the effects of water temperatures on the endocrine systems of red drum larvae.

Graduate student Rafael Perez is working with researcher Gloria Joan Holt to examine how fluctuating environmental parameters in red drum nursery habitats may influence habitat quality, as well as larval growth and endocrine functions of these fish.

Perez is monitoring such ecological parameters as temperature, oxygen, pH, and salinity in sea grass habitats. For his project, data were obtained on daily and tidal cycles. This collected data was then used in a controlled laboratory environment to simulate and to test the effects of temperature variations on the growth, survival, and endocrine development of larval fish.

Fish in the laboratory are either placed in a control tank that is maintained at a constant temperature, or in a tank that imitates a daily temperature cycle with high temperatures in the morning and midday, and lower temperatures at night. Perez produces these temperature changes using time-released heaters in each of the observed tanks.

During two preliminary test trials, Perez found that growth rate of the larvae in the control tank was similar to that of the fish in the tank with the fluctuating temperature. The sizes of fish in the fluctuating temperature tank varied much less than the fish in the constant temperature tank. Further testing is still required to fully understand and evaluate these growth results.

This research is important because it covers a previously uncharted topic. “There is very little information about the endocrine development of small marine larvae, and no information on the hormones of red drum larvae,” Perez said.

Past research concerning the effect of temperature on fish has only involved testing tanks of species at varying constant temperatures to determine which temperature offers the best survival rate. “Researchers haven’t varied temperatures on a daily cycle in one tank,” Holt says. “From this project, we hope to be able to suggest what would be a good habitat based on ecological parameters and what would be a marginal habitat,” Holt said.

Research results could assist in determining where fish should be stocked to increase survival rates, to identify ideal redfish habitats, and to assess the amount of suitable habitat in Texas bays.

For details, contact Perez at rperez@utmsi.utexas.edu.

Texas Tech Researchers Develop Economic, Water Policy Models for the High Plains

Developing a water policy model that may be able to recommend water allocations among agricultural water users in the Texas High Plains is the focus of a TWRI-funded research project. The project is being conducted by graduate student Biswaranjan Das and researcher David Willis of the Texas Tech University (TTU) Agricultural and Applied Economics Department.

“The problem we are investigating in this project is how to optimize agricultural water use, and how to achieve sustainable levels of water use in the Texas High Plains economy over the long-term,” Das said.

The Texas High Plains region has been experiencing increased energy costs in recent years due to the depletion of the Ogallala Aquifer, Das said. The region has suffered from prolonged droughts and decreased groundwater availability at some sites. These factors have made long-term water planning a high priority.

In this project, Das will work to develop a temporally and spatially disaggregated water model for the region, that will measure long-term effects of proposed water policies.

“The general goal is to derive a relation between agricultural water use and long-run water depletion and sustainability of water use for the region, considering rising energy prices,” Das said. “Specifically, we want to determine the impact of rising energy prices on agriculture profitability through direct and indirect effects. We hope to learn more about the interrelationships of water use with other sectors of the economy, and we want to develop a water planning model useful for policy makers.”

County-specific data is being collected to determine the agricultural base of the region. Researchers in the TTU Agricultural and Applied Agricultural Economics Department are now developing an agricultural water use survey that will be sent to several

agricultural producers that use irrigation in the region. These results will be incorporated into the economic portion of the integrated water policy model Das is developing.

Das suggests results from this project may help policymakers formulate legislation and policies that may contribute to sustainable water use policies for the Texas High Plains.

For details, contact Das at biswaranjan.das@ttu.edu, or (806) 742-0277.

TAMU Petroleum Engineers Receive Grant to Examine Regulatory, Policy Issues Related to Brine Reuse

A team of Texas A&M University petroleum engineering researchers recently received a follow-up grant to examine regulatory issues that may limit the reuse of oilfield brines.

The project is being led by researcher David Burnett of the Petroleum Engineering Department, and will involve graduate students Mustafa Siddiqui and Leila Mamedzadeh.

In 2000, TWRI funded a faculty incubator grant to Burnett to conduct preliminary studies to determine whether oilfield brine could be treated and reused at or near sites where it is produced. Because of the significant oil and gas production in Texas, a tremendous volume of water is produced – 400 million barrels per day or an amount equal to 10% of the total water use in the State. However, little of this water is being reused, in large part because of its poor quality. Instead, it's being disposed of, mainly through underground injection wells.

Partially as a result of work Burnett's team accomplished in the TWRI project, the researchers recently obtained a grant from the U.S. Department of Energy Stripper Well Consortium, which is located at Pennsylvania State University. In this project, Burnett will examine Federal and State regulations that need to be overcome to initiate the treatment and reuse of oilfield brines in two regions – Texas, Oklahoma, and New Mexico; and New York, West Virginia, and Pennsylvania.

"In order to make the reuse of oilfield-produced brines a reality," Burnett said, "we must be aware of the regulatory barriers that exist. In several instances, we may be able to inform regulatory agency officials and policy makers of current, research-based, information that shows that the reuse of oilfield-produced waters does not have to harm the environment."

The Stripper Well project includes other components. Burnett will also further the work on developing a portable module to treat oilfield-produced waters at the site, to a level that makes them suitable for various uses. The research team will also define appropriate uses for oilfield-produced waters, based on water quality, as well as methods to monitor how irrigation with these waters may affect the environment.

Burnett is now working to recruit oil and gas production companies to fund and take part in these studies.

For details, contact Burnett at (979) 845-2274 or Burnett@gpri.org.

Building Conditional Reliability into WRAP Models is Goal of TAMU Study

Graduate students and researchers in the Texas A&M University (TAMU) Civil Engineering Department have begun a TWRI-funded project to incorporate conditional reliability into water modeling efforts.

The study, "Conditional Reliability Modeling to Support Short Term River Basin Management Decisions," is being undertaken by graduate student Adalberto Andrés Salazar and researcher Ralph Wurbs. The goal is to develop a conditional reliability modeling (CRM) tool to examine and compare operational strategies for water management.

In 1997, the Texas Legislature approved Senate Bill 1, which authorized the implementation of a Water Availability Modeling (WAM) System. The Texas Natural Resources Conservation Commission (TNRCC) has linked with contractors and the Texas Water Development Board to develop the WAM model. WAM relies on the Water Rights Analysis Package (WRAP), which Wurbs developed, for generalized river simulations. WRAP has been used to simulate water availability in more than 22 river basins in Texas and elsewhere.

Salazar's project will work to broaden the capabilities of the WRAP, by adding a CRM component. CRM allows water managers to calculate the reliability and failure values for river basins and reservoirs. It assists in the analyses of various operational strategies.

Use of CRM methods may help water suppliers better plan for anticipated demands months in advance. The use of CRM tools may also be helpful in developing rules about how to manage reservoirs, since it will provide data about what predefined conditions may make it necessary to trigger or implement water conservation measures.

Salazar's project will include case studies of the Guadalupe, San Antonio, and Nueces river basins, and the effectiveness of drought planning strategies used by the cities of Corpus Christi and San Antonio.

According to Salazar, this project may be beneficial to state and local water managers who are faced with combatting droughts and other water emergencies.

"This project should be useful in developing strategies to set water management practices that are needed during dry periods," he said. "Equally importantly, conditional probability modeling will give professionals a more precise tool to determine the likelihood or risk that water may be available, based on recent hydrologic and meteorological conditions."

Note: This is one of 11 projects funded by TWRI in 2001. For details, contact Salazar at (979) 862-2348 or andres@acs.tamu.edu .