New Waves
The Research Newsletter of the Texas Water Resources Institute
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Texas A&M University Creates Environmental and Natural Resources Team; TWRI Will Play Lead Role

A new program has been created to more effectively coordinate environmental and natural resources efforts within the Texas A&M Unive rsity Agricultural Program. Activities of the program include the research, teaching and service missions of the Land Grant University System.

The Environmental and Natural Resources Program (ENRP) was officially established in November, 1995, by Edwa rd Hiler, who serves as the Director of the Texas Agricultural Experiment Station (TAES) and the Vice Chancellor and Dean for the College of Agriculture and Life Sciences for Texas A&M. Wayne Jordan, the Director of the Texas Water Resources Institute (TWRI), has been named the initial coordinator for this program. Jordan will direct both TWRI and the ENRP.

The ENRP is established in a team framework. Team members consist of representatives from such institutes and centers as TWRI, the Center for Natural Resources Information Technology, and the Institute for Renewable Natural Resources. Representatives of special Agricultural Program initiatives will also participate. These include the water conservation and quality initiative, the integrated pest management program, the natural resources, environmental, and land stewardship initiative, the waste management initiative, the environmental public issues education initiative, th e environmental affairs team, resource policy analysis, forest resources and products, and natural resources and environmental management.

"One emphasis of this program is to provide a high level of focus and visibility for environmental and natural r esources activities within the Agricultural Program," Jordan said. "We will move aggressively into electronic communications to create a link for the ENRP that will be included on the Agriculture Program's internet home page. We will also develop marketin g strategies to effectively tell the story of what we're doing to protect and improve the environment and Texas' precious natural resources."

Jordan said another area the ENRP must be active in concerns coordinating natural resources efforts of the Ag ricultural Program and working to increase the opportunities for multi-disciplinary, multi-location research. "We've been charged with coordinating environmental and natural resources activities and programs so that we can fully assess the cumulative impa ct of these efforts and then tell that message to others," Jordan said.

The ENRP is already examining ways to increase collaboration and communication among Agricultural Program projects. In the future, the ENRP will work with Agricultural Program Leaders to develop high priority program initiatives that the Texas Legislature or U.S. Congress may consider funding.

In this way, Jordan said, the ENRP will allow the Agricultural Program to rapidly respond to major challenges in research, education, and s ervice when they occur. "The ENRP will give us a framework to anticipate major issues so that we can prepare ideas, materials, and programs to deal with these challenges when they arise," Jordan said. "It will benefit our clientele groups because it will allow Agriculture Program faculty a better opportunity to develop well thought-out, cost-effective solutions, rather than putting us in a position of crisis management."

UCOWR Annual Meeting will be in San Antonio, July 30 - August 2

The Universities Council on Water Resources (UCOWR) annual meeting will be July 30 - Aug. 2 in San Antonio and the topic of discussion is especially appropriate for the Edwards Aquifer region. The theme of the meeting is "Integrated Management of Surface and Ground Water."

"This meeting will provide water resources scientists and professionals with an opportunity to learn more about such topics as legal and policy issues that may constrain integrated use of ground and surface water, water quality impacts of integrated use, how to incorporate groundwater supplies into watershed protection efforts, and artificial recharge," said TWRI Director Wayne Jordan. "These topics are especially important for the Edwards Aquifer and Texas, which may soon begin conjunctive management."

The meeting will be at the historic St. Anthony Hotel in downtown San Antonio, not far from the River Walk. To submit an abstract, contact Lloyd Urban at Texas Tech at (806) 742-3597 by Feb. 1.

Regional Distribution of Permeability in the Edwards Aquifer

Researchers: Alan Dutton, Robert Mace, Susan Hovorka, and Eddie Collins, Bureau of Economic Geology (BEG), the University of Texas at Austin (UT).

Problem: Understanding how water flows through the Edwards Aquifer is essential so the aquifer can be properly managed. Although many studies of the aquifer have been conducted, detailed work is still needed to quantify and understand complex factors that influence aquifer permeability.

Objective: To assess the distribution of permeability in the San Antonio segment of the Edwards aquifer.

Methodology: This study was funded by the Edwards Underground Water District (EUWD). Data sets with integrated information on hydrology, stratigraphy, and aquifer structure were used to display the spatial distribution of permeability in the aquifer. Data recently collected by EUWD were utilized. Updated hydrologic and geologic techniques

were developed and used to visualize, integrate, and analyze the data. Researchers developed an equation relating specific capacity to transmissivity for the fractured and karstic Edwards aquifer. Geostatistical analysis was used to characterize spatial continuity and randomness of permeability. SGM "StrataModel" software was used to create a three- dimensional image of matrix permeability in the aquifer using wireline log data. Recent surface mapping of structures along the Balcones Fault Zone was used to reinterpret structural features in the subsurface. Outcrop analogs were quantified to better understand the relationships between matrix, fracture, and cave permeability.

Results: The area of highest transmissivity lies in the deepest part of the confined aquifer, suggesting that more dolomite has dissolved near the fresh/ saline water interface where, over geologic time, two waters have been mixed. The average transmissivity in the unconfined aquifer, where fresh/saline mixing has occurred, is 240 times lower than the average in the confined aquifer. The average permeability calculated from specific-capacity tests, which includes flow through fractures, caves, and matrix, is 125 times greater than the average permeability of the matrix alone. The distribution of matrix permeability overlaps the low end of the distribution of total permeability, showing that some of the lower- yield wells could be producing from the matrix. The effect of faults as barriers to flow is limited because faults are arranged in an en echelon pattern, leaving areas of continuous strata known as relay ramps between them. Typically, faults of the Balcones Fault Zone are surrounded by areas of highly fractured strata that may create a zone of high permeability parallel to the fault plane. Many fractures have been enlarged by solution, producing fracture porosities as high as 0.3% near faults. Caves, accounting for 1 to 3% of the volume of the aquifer, form preferentially in dolomitic rocks and in calcitized evaporite beds, as well as along faults and fractures. The team used these results to interpret the observed stratigraphic and structural controls of permeability in test wells. Structural, isopach, hydrologic and matrix porosity data sets have been prepared as map coverages in an ARC/INFO geographic information system. This new permeability data set can be used to create new hydrologic models of the Edwards aquifer.

Reference: Hovorka, S., R. Mace, and E. Collins, *Regional Distribution of Permeability in the Edwards Aquifer*, UT BEG, 1995.

Computer Models to Manage Water in Irrigation Districts

Researchers: Guy Fipps and Dinku Endale, Agricultural Engineering Department, Texas A&M University, College Station, TX.

Problem: Irrigated agriculture is the largest single user of water in Texas, accounting for 8.8 million acre-feet (AF) per year. Irrigation districts serve more than 900,000 acres of farmland and supply nearly 1.4 million AF of water annually. Most of these districts are concentrated in the Lower Rio Grande Valley. Others are located in the Upper Rio Grande Valley, West Texas, and rice growing regions along the Gulf Coast. Typically, these districts have small staffs and low cash flows. Under new regulations, these districts may have to submit water conservation and drought contingency plans to the Texas Natural Resource Conservation Commission (TNRCC). Most districts lack the

knowledge or tools required to effectively develop such plans. Water management and conservation planning is a complex process and involves processing substantial data on crops, soils, weather conditions, water availability, agronomy, economics and administration. Computer simulation models could be an effective way for water districts to manage supplies and water quality.

Objectives: 1) To describe the development of a computer simulation model, 2) to test this model against other simulation tools, and 3) to identify future research needs.

Model Development and Description: The Irrigation District Decision Support System (IRRDES) is a menu driven computer program that simulates crop production and water demand at individual fields, and water supplies to each and all fields in an irrigation district. The program is composed of a simulation model, a routing program, and a utility module. The simulation model estimates daily crop growth with a generic crop model. The generic crop model can simulate potential crop yields under normal and water-stress conditions; the impact of different irrigation strategies on crop production; and crop yields under different weather conditions. The routing program tracks daily water demands of a group of fields served by the same canals in a conveyance system. Water distribution systems can be divided into primary, secondary, and tertiary categories to accurately estimate the amount of water running off individual fields and into a canal network. Utility modules can be used to calculate daily potential evapotranspiration, even when daily weather data is not available.

Dinku Endale and colleagues with the Texas A&M University Agricultural Engineering Department gather data to develop a model to simulate water use in irrigation districts. The model should be helpful for managers of these districts.

Results of Model Applications: IRRDES was used to simulate crop production of maize, cotton and wheat in Greece from 1987 to 1989. Model performance was compared to actual field data. Results show that the model was able to predict yields within 8% of measured values. The model was utilized to analyze water management in an irrigation district in Ethiopia that was designed and constructed by international consultants. Cotton was the primary crop and problems experienced by the district include high variability in yields, interruption of scheduled water deliveries, and high groundwater tables. The objective of this simulation was to determine which of 12 irrigation strategies being used produced the highest yields with the lowest variability. Crop coefficients were adjusted to

produce the yield level expected under optimal conditions. Results suggest that significant variations in year-to-year yields can often occur, even when only one irrigation strategy is used regularly. In general, generic simulation models like IRRDES can be very effective when complex variables including crops, soils, weather conditions, and management decisions must be considered. IRRDES could be improved in the future if is expanded to include site-specific soil conditions, fertility, variations in water quality, and linked to geographic information systems.

Reference: Endale, D., and G. Fipps, "Managing Water in Irrigation Districts," in *Proceedings of the 1995 Water for Texas Conference*, TWRI, College Station, TX; Endale, D., and G. Fipps "Quantified Approaches for Evaluating Different Irrigation Strategies in Irrigation Districts".

Water Quality and Benthic Organisms in Central Texas Streams

Researcher: Tina Coan, Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, TX.

Problem: Many studies suggest that as much as 67% of streams in the U.S. are now degraded by contamination, alteration of habitats, and changes in flows. One way of assessing the health of streams is by looking at biological characteristics such as species richness and populations. Benthic (bottom-dwelling) macroinvertebrates are useful in such studies. These organisms and their habitats are directly affected by changes in riparian vegetation, land uses, and erosion, and loadings of sediments, nutrients, and pesticides. The Upper North Bosque River area provides a good site for these studies because of concerns that dairy wastes, fertilizers, urban stormwater runoff, and treated wastewater may be adversely affecting water quality in the basin.

Objectives: To utilize data on benthic organisms and communities to investigate relationships between watershed parameters, physical and chemical characteristics, and water quality in rural North Central Texas watersheds.

Methodology: Eight sites were sampled in the study. All the sites but one were located in the Upper North Bosque River watershed. Two sites were above Stephenville on the North Fork and South Fork of the Upper North Bosque River. Other sites were south of Stephenville and include two sites on the main stem of the river, and sampling locations at the confluence of the river with Alarm Creek and Green Creek. Samples were taken at a reference site, which represents a "least impacted" stream segment at South Bear Creek in the Trinity River watershed. Benthic macroinvertebrates were collected bimonthly from September 1992 to January 1994. Samples were taken from stream riffles using kick nets, and were only collected when flows were observed. Benthic samples were transported to the TIAER laboratory for identification. Benthic taxonomic data was analyzed for each site for each sampling period. Habitat assessment surveys were conducted each time benthic macroinvertebrate samples were collected. For the sites in the Upper North Bosque River watershed, land use characteristics, including the percent of vegetative cover and the size of drainage areas, was determined from Landsat satellite imagery and verified using ground surveys. Ground reconnaissance and U.S. Geological

Survey maps were used to identify land use for the reference site. Chemical analyses were performed for nitrate, nitrogen, ammonia, orthophosphates, and phosphorus on monthly grab samples and storm events.

Results: Many benthic samples were not collected from intermittent streams due to lack of flow in riffle areas. Water flowed consistently at sites on the main stem of the river because of treated wastewater discharged by Stephenville. Mean species diversity, scores using a modified family biotic index (FBI), and the percent contribution of the dominant taxon were highest at the most downstream site on the main stem of the river in Hamilton County. The highest mean habitat scores were recorded for sites on the main stem of the river and at the confluence of the river and Green Creek. Levels of ammonia, nitrate, and orthophosphates were highest on the main stem of the river downstream from Stephenville and lowest at the Trinity River reference site. The most intense agricultural activity occurs near the North Fork site, upstream of Stephenville. Most intense urban and agricultural activity is downstream of Stephenville.

Discussion: Sustained pools near riffle areas provided for recovery of benthic organisms following periods when no flow was observed. Initially, benthic macroinvertebrates recolonized in stagnant pools, rather than riffles. Lowest values for taxa richness occurred immediately following the return of flows. Communities from the main stem of the river were degraded when flows from the tributaries were dry, but recovered quickly after flows increased. Sites with a larger percent of woods and rangeland plants generally had lower nutrient levels. The reference site presents an interesting dilemma. It is small and is mainly rangeland, but was classified as "least disturbed" because of water chemistry and land use. Although it showed very low levels of ammonia, nitrates, and orthophosphates, populations and diversity of benthic macroinvertebrates were among the lowest in the study. This suggests the site may be nutrient limited. This study illustrates the importance of a holistic, multimetric approach to the retrieval and interpretation of biological data. Complex ecological principles cannot be accurately depicted with a single biometric or by simple chemical analysis of the water column.

Reference: Coan, T., "Factors Affecting Benthic Macroinvertebrates in the Upper N. Bosque Watershed," *Proceedings of 1995 the Water for Texas Conference*, TWRI, College Station, TX.

Water Quality and Fish Levels in the San Marcos River

Researchers: Bobby Whiteside, Alan Groeger, Patrick Brown, and Travis Kelsey, Aquatic Station and Biology Department, Southwest Texas State University, San Marcos, TX.

Problem: The Upper San Marcos River is one of the most dependable and environmentally stable sources of water in Texas. The river receives a steady flow of relatively pure water from San Marcos Springs, which is fed by the Edwards Aquifer, and temperatures are stable in the headwaters. Two species in this system (the San Marcos salamander and Texas wild rice) are listed as threatened, while two others (the San Marcos Gambusia and the San Marcos fountain darter) are classified as endangered.

Special care needs to be taken to protect this river so that these species and high quality waters can be maintained.

Objectives: To provide baseline data on fish community structure and physical and chemical parameters of the San Marcos River.

Methodology: Physical and chemical data were collected at 17 sites along the length of the San Marcos River. The most upstream sites were in San Marcos, while the furthest downstream site was below the confluence of the San Marcos and Guadalupe rivers. Sites included locations above and below major tributaries and areas that may be adversely affected by man's activities. Seven of the sites are in the Edwards Plateau region, which contains high quality water and dense aquatic macrophytes. Five sites are in the Blackland Prairie ecological region, which is characterized by moderate water clarity, high flows, and a gravel-clay riverbed. The remaining three sites were in the Post Oak Savannah, which typically has poor water clarity, low flows, steep banks, and a muddy riverbed. The river was divided into 16 sampling regions for collecting fishes, based on habitat characteristics. Headwaters were divided into four sampling regions that include Spring Lake and a site where the San Marcos wastewater treatment plant discharges effluents. These waters typically contain high water clarity, high flows, dense growth of aquatic plants and constant temperatures. Regions 5 through 9 stretch from the confluence of the San Marcos and Blanco rivers to Staples Dam and generally consist of moderate clarity, low flows, cut banks, and dense riparian growth. Regions 10 to 16 extend down the length of the San Marcos River and waters are typically deep, slow moving and turbid and are often interrupted by log jams and riffles. Physical and chemical sampling was carried out in March, July, and November 1992 and January, April, and September 1993. Data were collected in the field on temperatures, dissolved oxygen (DO), pH and specific conductance. Flow rates were calculated by direct observation. Special efforts were made to sample the area where the San Marcos wastewater plant discharges effluents before and after the facility began dechlorinating wastewater in 1992. Several methods were used to sample fish populations including gill nets and electrofishing devices. Most large fish were identified in the field and returned to the river, except for a few reference species.

Results: DO levels were highest in November and January and varied more in warmer months when oxygen demands increased. The pH levels at the first two sites never exceeded 7 but were higher downstream. Turbidity consistently increased from the headwaters to downstream reaches of the river. Alkalinity levels decreased downstream. Nutrient data showed that soluble phosphorus and ammonia concentrations increased markedly near the San Marcos wastewater treatment plant, but quickly decreased below the junction of the San Marcos and Blanco rivers. Nitrate levels were generally higher above the confluence of the San Marcos and Blanco rivers. Total nitrogen and phosphorus levels increased sharply near the San Marcos wastewater plant. Downstream of the plant, nitrate levels remained constant while phosphorus concentrations varied greatly. Ten fish species (including six species that are native to the river) were collected only in the headwaters region of the river. Below the junction of the San Marcos and Blanco rivers, 17 species were found (12 of which are native to the river). Meanwhile, 13

fish species that were found in previous studies were not collected in this effort. The study suggests that dechlorination of San Marcos' wastewater effluents is having a positive effect on fish species in the river. Only seven species were found in the reach of the river near the plant before dechlorination was being used, while 15 species were identified afterwards.

Reference: Whiteside, B., A. Groeger, P. Brown, and T. Kelsey, *Physicochemical and Fish Survey of the San Marcos River*, Report Submitted to Texas Parks and Wildlife Department, January 1994.

Water Policy and Water Quality Issues Associated with Interbasin Transfers from the Canadian River Project

Researchers: Otis Templer, Geography Department and Lloyd Urban, Water Resources Center, Texas Tech University, Lubbock, TX.

Problem: Water is in short Supply on the semi-arid Texas High Plains. The region receives only about 15 to 20 inches of precipitation each year and surface water runoff averages less than 25 acre-feet (AF) per Square mile. Runoff mainly accumulates in thousands of shallow plays lakes, and most soon evaporates. Some runoff recharges the underlying Ogallala Aquifer, long the major water source on the High Plains. Because Ogallala groundwater is finite and groundwater levels in some parts of the aquifer have declined since pumping began for irrigation, drinking water and other uses, there has long been great interest in developing renewable surface water supplies. The Canadian River has been the only High Plains stream capable of providing significant amounts of water and thus it was chosen for development through the Canadian River Project. This project provides a unique opportunity to examine crucial issues relating to urban water supplies on the High Plains since utilization and regulation on of water from this river involves an interstate compact and multiple state and local water agencies. The Canadian River also generally has high salinities, which presents additional problems for water manages

Objectives: 1) To review the creation and development of the Canadian River Project and the Canadian Municipal Wear Authority (CRMWA), 2) To discuss actions the Authority is taking to assure that adequate high quality water supplies can be provided an the future; and 3) To suggest strategies to resolve some of these problems.

Analysts: Until the 1960s, almost all cities on the Texas High Plains relied solely on the dwindling Ogallala Aquifer for municipal water supplies. Although several major Texas streams, such as the Red, Brazos, and Colorado rivers have their headwaters on the High Plains, they typically provide little surface water runoff east of the Caprock Escarpment. Only the Canadian River, which rises in New Mexico and flows for 180 miles across the Texas Panhandle before joining the Arkansas River in Oklahoma, has significant sustained flow. In the 1950s it became the loyal choice for a regional water project because it had sufficient water available for allocation and was largely undeveloped. In 1950, Texas, New Mexico and Oklahoma entered into the Canadian River Compact and the Canadian River Project was approved as a federal reclamation project. In 1953, the Texas Legislature created the CRMWA to distribute water from the project. In 1956, the

Authority received a permit from the State to appropriate more than 103,000 AF of water for municipal purposes and 51,200 AF for industrial use. The Bureau of Reclamation began work on the project in the late 1950s, Lake Meredith was completed in the 1965, and water deliveries through the system began in 1968. The project is unique because this effort developed water for municipal and industrial uses unlike most Bureau efforts to enhance water supplies for irrigation. The project transfers waters from the Canadian River basin into the Red, Brazos and Colorado River basins and is one of the oldest and lengthiest interbasin water transfers in Texas. The CRMWA now has 11 High Plains communities as members including Lubbock and Amarillo, and serves more than 450,000 urban residents

Since the Canadian River Project has been in operations several water policy and water quality concerns have arisen. A major policy issue involves the interstate compact by which water is allocated among the three slates. The compact limits the amount of water that New Mexico and Texas can store in reservoirs, but does not specify the amount of water that must be delivered annually by the upstream states. As a result, Texas, New Mexico, and Oklahoma have interpreted the compact differently and this has resulted in lengthy and costly lawsuits. Water quality problems (mainly excess salinity) are also a major concern. Salinity in the lake continues to increase due to salt cellar infestation, oil field brine, and high chloride concentrations of geologic formations the river flows through. Most salts coma from a brine aquifer in New Mexico. Plans have been developed to control salinity by pumping brine from the aquifer to lower the water table and disposing, of it through deep injection wells. Federal funding for this salinity control project has been authorized by Congress, but has still not been secured. The CRMWA is now working to purchase rights to high quality groundwater in Roberts County that can be blended with water from Lake Meredith to lower salinities and increase the quantity of usable water. Finally, the threat of regulation to protect endangered species is a concern. The U. S. Fish anal Wildlife Service (USFWS) has proposed that a minnow (the Arkansas River Shiner) be classified as endangered. They contend that withdrawals from the Ogallala Aquifer have decreased streamflow by lowering water tables and reducing seepage from the aquifer into the Canadian River. If the USFWS were to recommend that groundwater pumping be reduced so that natural recharge levels are maintained, the effect would be devastating to the region's irrigated agriculture and to many small towns that still rely steely on the Ogallala. It could also seriously affect member cities of the CRMWA that use groundwater to supplement water supplies as well as CRMWA efforts to provide additional water for blending.

Reference: Templer, O., and L. Urban, "The Canadian River Project: A Quarter Century of Interbasin Transfer," in Proceedings of a Symposium on Water Management In Urban Areas, Houston, TX 1995, published by the American Water Resources Association.
NOTE: This is a different version than was originally published in the PRINTED version of New Waves. It contains corrected, revised information provided by the authors.

Higher Education Board Funds 29 "Water-Related" Projects

The Texas Higher Education Coordinating Board has announced that it will fund 29 "water-related" research projects worth more $2.9 million through its 1996-98 programs.

The awards (listed below) include 9 grants through the Advanced Research Program (ARP) totaling roughly $913,000, 19 awards in the Advanced Technology Program (ATP) worth roughly $1.7 million, and two projects in the Development and Transfer Program totaling more than $330,000.

Significantly, this was the first year that water research was included as a distinct category. As a result, 10 projects were funded in the ATP category titled "Environmental Science and Engineering/ Water Resources" dealing with such issues as reservoir sedimentation, dairy runoff, remediation of groundwater contamination, water and wastewater distribution systems, and global climate change.

Water-related research projects were funded to the following universities: the Texas Agricultural Experiment Station (6), Texas A&M University (5), the University of Texas at Austin (4), the University of Houston (3), Rice University (2), Texas A&M University -- Galveston (2), Texas Tech University (1), Baylor University (1), Southern Methodist University (1), the University of Texas at Arlington (1), the University of Texas Marine Science Institute at Port Aransas (1), the University of Texas -- Pan American (1), the University of Texas Medical Branch at Galveston (1).

We will feature these projects in this and future issues of *New Waves*.

Advanced Research Program

Atmospheric Science

"Prediction and Influence on Severe Storms of the Low Level Southerly Flow over Texas," Dusan Djuric, Meteorology Department, Texas A&M University, $61,085

Biological Science

"Remote Sensing of the Rio Grande Floodplain Vegetation," Robert Lonard, Biology Department, University of Texas--Pan American, $51,917

Earth Sciences

"Geochemistry of Sedimentary and Dissolved Organic Matter in Aquifer Systems," Ethan Grossman, Geology and Geophysics Department, Texas A&M University, $87,627

"Electromagnetic Wave Propagation in Heterogenous Porous Media," David Dobson and Michael S. Pilant, Mathematics Dept., Texas A&M University, $87,207

Marine Science

"A New Tracer for Distinguishing Terrestrial from Marine Organic Matter," Peter Santschi, Oceanography Department, Texas A&M University -- Galveston, $181,173

"Development of Methods for the Control of Shrimp Baculoviruses," Linda Guarino and Donald L. Jarvis, Entomology Department, Texas Agricultural Experiment Station, $127,300

"Why Has the Texas Brown Tide Persisted for Five Years?," Edward Buskey and Paul Montagna, Marine Science Institute, University of Texas Port Aransas, $121,410

"Test of Hypothesis that Variance in Reproductive Success Limits Effective Population Size in Marine Organisms," John Gold, Wildlife and Fisheries Sciences Dept., Texas Agricultural Experiment Station, $117,762

"Computer Assisted Photo-identification of Individual Bottlenose Dolphins," Phillip Levin, Marine Biology Department, Texas A&M University -- Galveston, $81,985

Advanced Technology Program

Agriculture and Aquaculture

"Commercial Development of Environmentally Isolated Specific Pathogen-Free Marine Shrimp," Phillip Lee, University of Texas Medical Branch at Galveston, Marine Biomedical Institute, $200,000

"Synthetic Peptides for Control of Plant Pathogens," Carlos Gonzalez and Daniel J. Ebbole, Plant Pathology and Microbiology Department, Texas Agricultural Experiment Station, $148,302

"Utilization of Dietary Marine Algae for Production of Nutritionally Enhanced Poultry Meat," Mary Van Elswyk, Poultry Science Department, Texas Agricultural Experiment Station, $95,031

"Risk and Uncertainty in Assessing Impact of Animal Agriculture on the Environment," Don Vietor, Soil and Crop Sciences Department, and Paul B. Thompson, Biotechnology Policy And Ethics Center, Texas Agricultural Experiment Station, $75,305

Computer and Information Engineering

"Computer System for Modeling and Interpreting 3-Dimensional Geological Data," Joe Warren and Ronald Goldman, Computer Science Dept., Rice University, $176,512

Energy

"Numerical and Experimental Validation of a New Ringing Design Procedure for Deepwater Offshore Platforms," Anthony Williams and Keh-Han Wang, Civil and Environmental Engineering Department, University of Houston, $41,011

Environmental Science and Engineering/ Water Resources

"Multichannel Surveying System for Reservoir Sedimentation Studies," John Dunbar and Peter Allen, Geology Department, Baylor University. $163,612

"Reducing Nitrogen and Phosphorous Loading from Dairy Cattle Production Systems," L.W. Greene and Michael Tomaszewski, Animal Science Department, Texas Agricultural Experiment Station, $150,000

"Environmental History of Northern Mexico: Prehistoric and Historical," Karl Butzer, Geography Department, University of Texas at Austin, $149,700

"Comparison of Overland Flow with Constructed Wetlands for Treating Dairy Lagoon Wastewater," Andrew Kruzic, Civil and Environmental Engineering Department, University of Texas at Arlington, $89,200

"Oxidative Degradation of Organic Contaminants in Aqueous Media Using Ultrasound," Dominick Casadonte, Chemistry and Biochemistry Dept., Texas Tech University, $116,348

"Development of a Model to Simulate Benefits and Costs of Remedial Investigation Studies," Robert Gilbert, Civil Engineering Dept., University of Texas at Austin, $109,160

"Nutrient Fluxes from Laguna Madre Sediments: Impact on Water Quality and Brown Tide," Jim Cotner, Wildlife and Fisheries Sciences Department, Texas Agricultural Experiment Station, $99,200

"Development Of A Sewage Pipe Inspection System," Ce Liu and David P. Shattuck, Electrical Engineering Department, University of Houston, $116,000

Marine Technology

"Depth Profiling of Temperature and Sound Velocity in the Ocean," Edward Fry and George Katttawar, Physics Department, Texas A&M University, $203,279

"High Accuracy Bathymetric Surveying and Real Time Global Positioning System," Robert Morton, Bureau of Economic Geology, and Bob Schutz, Aerospace Dept., University of Texas at Austin, $191,560

"Dynamics of Offshore Platforms," Anestis Veletsos, Rice University, $91,760.

"Development of an Economical Technology to Measure Geothermal Heat Flow on Shallow Seafloors," Seiichi Nagihara, University of Houston, and Kenneth Griffiths, Institute for Geophysics, University of Texas at Austin. $22,500

"Integrating Cavity Absorption Meter for Oceanography Applications," Nelson Duller, Physics Department, Texas A&M University, $35,672

Development and Transfer Program

Agriculture and Aquaculture

"Winter Survival for Mariculture Using Geothermal Heat," Stanley Kleis and Nagaraja Shamsundar, Mechanical Engineering Dept., University of Houston, $158,332

Energy

"Removal of Heavy Metals from Industrial and Hazardous Wastewaters by Recycled Shot Blast Fines," Ed Smith, Mechanical Engineering Dept., Southern Methodist University, $173,360.

UT-Pan American, UT Researchers Team Up to Measure, Map, Rio Grande Riparian Vegetation

Riparian vegetation is an essential component of any watershed. Plants and trees that surround river banks play key roles in providing habitat and foodstuffs for animal species and reducing pollutants. Surprisingly, little quantified information is known about riparian vegetation in the Lower Rio Grande. Researchers with the University of Texas System are now beginning efforts to gather detailed information about the plant life along the Lower Rio Grande. The study is led by Robert Lonard and Frank Judd of the Biology Department at the University of Texas -- Pan American (UTPA), Melba Crawford of the Center for Space Research at the University of Texas at Austin (UT), and Mita Desai of the Engineering Division at the University of Texas at San Antonio (UTSA). Lonard and Judd will conduct field studies, while Crawford and Desai will coordinate image analysis work.

Robert Lonard (left) and Frank Judd measure the trunk of this Texas ebony tree, which is one of many species they hope to find in the Lower Rio Grande Valley.

The project involves gathering field data and analyzing remotely sensed images. Goals of the study are to integrate these data sets into a geographic information system and to determine if native riparian vegetation zones are maintaining themselves. Six locations will be sampled downstream of Falcon Dam to where the Rio Grande enters the Gulf of Mexico in Cameron County. At each site, data will be gathered on the identity and numbers of key plant species as well as soil types and topographical features. Multispectral SPOT data and color infrared photographs flown by the U.S. Geological Survey in 1994 will be analyzed to classify major land

types and the presence of forests, wetlands, and agricultural lands.

This project was funded by the Texas Higher Education Coordinating Board's Advanced Research Program. For details on this project, contact Lonard at (210) 381-3656.

Texas A&M Researchers Work to Improve Thunderstorm Predictions

Violent thunderstorms and other severe weather events are, unfortunately, commonplace in Texas. Few of us have avoided having our cars dented by hailstones of getting drenched as we walk outdoors during frequent afternoon showers.

A study by researchers at Texas A&M University is developing new methods to more accurately predict how these storms are created. They're focusing efforts on examining a weather-related phenomenon called "low level southerly flow" or LLSF.

Dusan Djuric of the Meteorology Department is leading the efforts. The project consists of gathering atmospheric data from radiosondes -- barometers, thermometers, and hygrometers loaded into boxes that are sent into the air with balloons -- and satellite observations. Data will also be developed with computer modeling forecasts.

Initially, Djuric will select several prominent instances where severe thunderstorms formed in LLSFs and develop a database. New computer hardware and software at Texas A&M will be used to construct specialized synoptic and isentropic weather charts. Afterwards, the researchers will evaluate and trace key characteristics that may form LLSFs.

One strength of this project is that it builds on many studies now being conducted by such agencies as the National Weather Service, the National Severe Storms Laboratory, the Cooperative Institute for Mesoscale Meteorological Studies, and the Cooperative Institute for Applied Meteorological Studies. Djuric feels that results of this study should also provide new insights into how large quantities of water vapor, heat, and latent heat are transported throughout Texas and the Lower Gulf Coast.

This project is funded through the Texas Higher Education Coordinating Board's Advanced Research Program. For details, contact Djuric at (409) 845-5522 or "Djuric@ariel.tamu.edu"

Texas A&M-Galveston Research Uses Iodine Isotopes to Identify Carbon Sources in Trinity River, Rio Grande

Researchers at Texas A&M University at Galveston are now investigating if measuring iodine isotope ratios in the environment can help identify the age and sources of organic matter in Texas rivers. The research is being conducted by Peter Santschi, Jean Moran, and Sarah Oktay Marshall of the Oceanography Department.

Like many substances in the environment, iodine (I) occurs in many chemical forms. It occurs as different isotopes, which all have the same chemical properties. Its stable

isotope is I-127. One of its radioactive isotopes, I-129, is very long-lived and can be generated naturally or by man's activities. Iodine is produced in small amounts by processes in the atmosphere and the breakdown of uranium in rocks, and can also be found in the environment as a consequence of nuclear bomb tests or nu clear fuel reprocessing. Man-made sources of iodine are now much greater than natural ones.

Texas A&M University-Galveston researchers on the research ship "Gyre" use this box corer to sample sediments..

Because the two iodine isotopes occur in different ratios on land than in the sea, Santshci says it is possible that isotope ratios can be used to date organic matter and to distinguish the two sources of organic compounds, which are difficult to distinguish in coastal regions. Iodine from each of these sources tends to have its own unique signature. Santschi hopes that the ratios of the two different iodine isotopes, (129-I and 127-I) can help determine the age of organic matter and to assess what fraction of organic matter was produced by terrestrial or marine processes.

In the project, Santschi will sample river and rain water; dissolved, colloidal and particulate organic matter; and sediment and soil samples from the Trinity River, the Rio Grande and the Mississippi River. These samples will be analyzed for isotopes of iodine, plutonium, cesium, carbon and other radioactive elements. Iodine isotopic ratios will also be analyzed in sediment cores taken from the Gulf of Mexico.

Santschi feels this new tracer will provide insights to help understand climate change and carbon cycling in coastal areas. The project was funded by the Texas Higher Education Coordinating Board's Advanced Research Program. For details, contact Santschi at (409) 740-4476 or send e-mail to Santschi_P@tamug2.tamu.edu"

UH Develops System to Inspect Wastewater Pipes

Knowing if buried pipes are structurally sound, leaking or malfunctioning is difficult. Because these pipes are underground, the only way of determining if a pipe has problems is by looking for leaks or drop-offs in pressure. Engineers at the University of Houston are now developing a system that uses remote sensing and high tech electronics to inspect pipes and mains that carry water and wastewater. The research will be conducted by Richard Liu and David Shattuck of the Electrical Engineering Department.

The goal is to develop an electromagnetic imaging system that could sense changes in the electrical properties that occur when these pipes are degraded. The device could be inserted into a wastewater main to map the exterior and interior of the pipe and surrounding soils. Liu and Shattuck hope to evaluate and develop prototype hardware

devices that would work best in different sized pipes. Computer software that converts electromagnetic fields into images of the pipes, their location, and the amount of deterioration that has occurred will be developed.

Ultimately, the system could utilize tomography to generate images of the pipes interior and nearby soils, and sinkholes. The researchers feel this study could help develop products to economically and accurately inspect wastewater pipes. This method could then be used by water districts and water resources managers. This study was funded by the Texas Higher Education Coordinating Board's Advanced Technology Program. For details, contact Liu at (713) 743-4421 or "Cliu@uh.edu" or Shattuck at (713) 743-4204.

Texas A&M to Examine Brown Tide Growth in Laguna Madre

For more than five years, the Laguna Madre has been plagued by recurring blooms of a small plankton-based algae commonly called the "brown tide." The immediate impacts of the brown tide include fish kills and turbid waters that limit the growth of seagrasses and other vegetation. A study by Texas A&M University researchers will investigate if sediments of the Laguna Madre may be partially responsible for the brown tide and its effects. The work will be led by Jim Cotner and graduate students of the Wildlife and Fisheries Sciences Department.

A goal of this study is to measure nutrient levels in the Lower Laguna Madre to determine the cause of the red tide. In this photo, a member of Jim Cotner's staff dives to collect water quality data.

One of the major algae species identified in previous studies of brown tide is *Aureococcus anophagefferens*. It's suspected that this algae relies on ammonium and nitrite (but not nitrate) as its major nitrogen source. In many shallow estuaries, ammonium is regenerated in sediments and then moves into the water column. In addition, the presence of sulfides and other sulfur-based compounds generated in sediments may limit nitrification rates. Cotner believes these microbial processes may be occurring in Laguna Madre sediments and may influence the growth and persistence of the brown tide.

In this study, Cotner will measure sediment oxygen demands and nutrient fluxes with benthic chambers placed at four sites in Laguna Madre sediments. He also will determine sulfate reduction rates and sulfide levels in sediments, and will develop a geographic information system based on field data. Cotner says the results of this research could have implications for water management. For example, if ammonium is shown to be a major cause of the brown tide, the only option may be to re store circulation.

This project is funded by the Texas Higher Education Coordinating Board's Advanced Technology Program. For details, contact Cotner at (409) 845-0169 or 'j-cotner@tamu.edu"

Quantified Approaches for Evaluating Different Irrigation Strategies in Irrigation Districts

- **G. Fipps and D.M. Endale** (Associate Professor and former Lecturer, respectively, Department of Agricultural Engineering, Texas A&M University, College Station, TX 77843-2117)

Abstract

This paper presents an overview of ***Irrigation District Decision Support System (IRDDESS)***, a computer model that was developed specifically to serve as a tool for irrigation districts in water conservation and drought contingency planning and in optimization of water deliveries. IRDDESS allows for the simulation of different crops on individual fields within a district. It can determine potential crop production and corresponding water demand under various alternatives, while assessing the ability of the supply system (i.e., pipelines and canal system) to meet this demand. In this paper, some of IRDDESS's capabilities are illustrated with a hypothetical irrigation district located in the Lower Rio Grande Valley of Texas.

Keywords: Crop Growth Modeling, Irrigation Districts, Scheduling, Water Management

Introduction

Irrigation districts require vase amounts of information in order to evaluate different strategies for maximizing water use efficiency and production levels within the capabilities of their water supply systems. Optimal management of the delivery systems can reduce in-transient water storage, preventing losses due to evaporation and seepage. In Texas, irrigation districts may also be required to submit water conservation and drought contingency plans under Water Conservation Plan regulations. However, few decision aid tools exit for irrigation districts that consider the complex data that must be analyzed. Fewer exist which integrate plant growth processes into the decision process.

IRDDESS (Irrigation District Decision Support System) is a software package for personal computers which was developed in order to assist irrigation districts with scheduling, water management and drought contingency planning. It which takes advantage of recent advances in computer technology and crop modeling to analyze complicated interrelationships in irrigation districts related to crop production, soils, irrigation timing and amounts, weather, rainfall and drought, water supply capacity and management.

Model Background

IRDDESS has the capability to model real irrigation districts with a mixture of soils, crops, and irrigation water management strategies. It consists of four groups of programs or "modules" as discussed below.

Simulation Modules

The simulation modules determine crop growth and production levels based on crop genetics, water availability, planting dates and density, etc. Pests and diseases are assumed to be under optimal control, and nutrient under optimal supply. Different scenarios can be considered to evaluate the effect of water availability. The **no water stress scenario** assumes optimal water supply from rainfall and/or irrigation and represents the upper limit of potential crop yield for a particular field under the historic or hypothetical weather conditions. The **water stress scenario** determines crop production under three irrigation options as follows.

1. Irrigation based on a pre-established schedule.
2. Irrigation initiated based on the management allowed depletion (MAD) concept. MAD is the percentage of available water that can be depleted from the soil between irrigations without reduction in plant growth.
3. Irrigation based on a critical soil moisture concept where the soil moisture is maintained in a range to prevent any plant stress. The corresponding soil moisture content is termed the critical soil moisture. Initiating irrigation at or above the critical soil moisture avoids the exposure of the plant to water related stress at all times. This option requires more frequent irrigations than that based on the MAD concept.

Crop Growth and Weather Modules

Crop growth is influenced by genetic crop characteristics. These include such factors as the photosynthetic pathway, maximum and minimum specific leaf area, drought tolerance classification, heat unit required for physiological maturation, the threshold temperature for development, relative maintenance respiration rate for different plant parts, the efficiency of conversion of primary assimilates into structural plant material, partitioning factors of gross daily dry matter assimilation into various plant parts, and initial and maximum rooting depth. Default coefficients for these variables have been incorporated into IRDDESS for 13 crops: barley, cassava, cotton, groundnut, maize, potato, rice, sesame, sorghum, soybeans, sugar-cane, sunflower and wheat. However, adjusting the coefficients for local conditions and crop varieties improves the prediction of the crop growth process.

Historical or stochastic weather data can be used to evaluate the long term effect of the weather on yield under a given management strategy. The daily weather data required consists of maximum and minimum temperatures, precipitation, average relative humidity, sunshine hour, and potential evaporation and evapotranspiration (ET).

Routing Modules

Three levels of conveyance systems are considered: primary, secondary and tertiary. The tertiary system supplies the canals or pipelines from which the fields are directly irrigated. The secondary system supplies the tertiary canals. The primary system supplies the secondary canals. Seven routing sub-modules keep track of the daily water demand and supply of each field and the conveyance system. The routing sub-modules work as follows:

1. Initially, the first sub-module estimates yield under a given irrigation schedule from each field in a tertiary unit. Up to 17 irrigations per field can be scheduled. Up to 20 fields per tertiary can be simulated.
2. Next, the second sub-module determines the net irrigation depth for each day of the season at each gate on a tertiary canal.
3. The third sub-module determines the opportunity time for each different irrigation depth for each field.
4. The forth sub-module tabulates the flow rate for the required number of days.
5. The fifth sub-module determines the total daily flow rate and time of delivery required for each tertiary canal. Demand is compared with the supply capacity.
6. The sixth sub-module determines the total daily flow rate and time of delivery required for each secondary canal. Demand is compared with the supply capacity.
7. The seventh sub-module determines the total daily flow rate and time of delivery required for each primary canal. Demand is compared with the supply capacity.

Case Study: Water Management in the Lower Rio Grande Valley

IRDDESS has been evaluated for three cases. Experimental data on maize and cotton (Danalatos, 1993) were used to compare yields predicted by IRDDESS with the measured yields. IRDDESS predicted maize yields within 5 and 6% of measured yields for one maize variety and 14% for a second variety. Seed cotton yield was predicted within 8% (Endale, 1995). IRDDESS was used to analyze irrigation district management for a district in Ethiopia (see Endale and Fipps, 1995) and for a hypothetical district in the Lower Rio Grande Valley of Texas which is discussed in this paper.

The Lower Rio Grande Valley (LRGV) is one of the most intensely farmed areas of the State of Texas. Over 310,000 hectares of land are under irrigated crop production. The main crops include cotton, grain sorghum, corn, vegetables and citrus. Other crops include forage crops, hay-pasture, sugarcane, soybeans, peanuts, alfalfa and wheat. Over 1,200 million cubic meter of water is used annually for irrigation. Much of the irrigation area is located in Hidalgo and Cameron Counties and is administrated through some 29 irrigation districts. Irrigation districts in the LRGV accounted for approximately 13 percent each of the total irrigated area and irrigation water use in Texas in 1989 (TWDB, 1991). Table 1 presents the extent of irrigated land and water use by county and crop for 1989.

IRDDESS was used to analyze the effects of water management cotton production. Daily weather data published by the National Oceanic and Atmospheric Administration for

Brownsville was used in the analysis. The 1993 Cotton Variety Test and Demonstration Report (TAEX, 1994) was used to estimate genetic coefficients and potential yield. The highest yields varied between 1300 and 1650 kg/ha of lint (A lint yield of 1100 kg/ha or higher is considered good in this area), and the lint turnover was between 33 and 38 percent. However, yields were as low as 275 kg/ha of lint in some areas. Table 2 presents parameters pertinent for cotton growth in LRGV as used in IRDDESS.

For each year in the period 1988 to 1993, IRDDESS determined the (1) yield potential, (2) amount and frequency of irrigation at a management allowed depletion (MAD) of 40, 50 and 60 percent, and (3) actual yield under various realistic irrigation schedules. These results were used to identify the "best" irrigation schedules.

Results

Table 3 presents predicted potential and dry land lint yields, and lint yields under irrigation schedules at 40, 50 and 60 percent MAD. The potential yield represents yield under non-stressed conditions (i.e., only temperature, radiation and the crop genetics characteristics determine this yield level, not water availability). The potential yield is highest in 1993 followed by 1988 and 1992. A MAD of 40% produced yields closest to the potential. It is interesting to note that many irrigation schedules use 50% MAD as a "rule of thumb" for triggering irrigation. With a 60% MAD, yields were about half of the potential yield in three out of the six years. The dry land yields predicted by IRDDESS were similar to those reported by TAEX (1994).

At 40% MAD, the number of irrigations varied from 5 in 1991 to 13 in 1988. Each irrigation varied from 0.6 and 2.0 inches and the total seasonal total irrigation varied from 9.1 and 18.9 inches (depending on the year) with from 6 to 10 days between irrigations. At 50% MAD, the number of irrigations varied between 4 and 8, with from 8 to 15 days between irrigations. Also with 50% MAD, each irrigation was between 1.6 and 2.4 inches. At 60% MAD, the number of irrigations was reduced to two for all years except 1989 which required three.

Alternate Irrigation Strategies

It is unlikely that the irrigation schedules for 40% or 50% MAD as discussed above would be widely adopted under current conditions. The intervals are shorter than most growers presently use. Typically for cotton, growers average 4 to 5 irrigations with a season of about 24 inches. Thus, IRDDESS was used to exam 5 alternative irrigation schedules which we believed could be implemented under the current situation. In these alternatives, the number of irrigations vary from 4 to 8 per season, with 15 to 30 days between irrigations. The intervals were designed such that the timing and amount of irrigation varied in the development stages, especially the water-sensitive periods of flowering and boll formation. Details of five of these schedules are given in Table 4.

The predicted cotton yields for each alternative irrigation schedule are presented in Table 5. The first schedule gave the lowest yield in 5 of the 6 years. It also gave the lowest

average yield over the period. The fifth schedule produced the highest yield in 4 of the 6 years. It also produced the highest average yield in the period. Lint yield variation of up to 450 kg/ha is observed under each schedule over the six year period.

The amount and distribution of the water supply affects yield. The reason for highest dry land yield in 1991 and the low dry land yield for 1988 and 1989 can partly be explained by the rainfall distribution. In 1991 good rainfall occurred during the vegetative, flower and boll formation and yield formation periods. The year 1993 had moist periods early in the growth stage, followed by good rain in the second half of the flower and boll formation, and early in the yield formation periods. In `988 and 1989, relatively dry periods persisted well into the middle of the second half of the boll formation period. Irrigation provided additional water supply, in amount and in time, to further influence the yield.

All five schedules had little effect on yield in 1991, the year with good rainfall. Three of the schedules actually show yields lower than that under rainfall alone. This is because IRDDESS also accounts for excessive irrigation or excessive wet soil conditions on crop growth and yield. Under very wet conditions, root activity is hindered resulting in curtailment in transpiration, which in turn affects assimilation rates. The fifth schedule supplemented the rainfall to give total water supply of 50 mm or more in all the years during the critical growth periods.

Summary and Conclusions

When tested and validated, and where the integrity of the underlying assumptions are maintained, crop models can be useful tools to answer a number of "what if" questions. These answers can then be used to evaluate strategies that seek solutions to short and long term on-farm and regional water management related problems. Comprehensive analysis of crop performance can be conducted for different soil types, crop cultivars, planting dates, planting densities, and irrigation strategies; thereby determining which practices are most promising and least risky. The effect of rainfall variability on yield can be studies in a way that cannot easily be achieved with field experiments. Crop models can be combined with canal and pipe conveyance routines to improve irrigation efficiency at the farm level and in the water delivery system. However, models must be tested for specific crops and conditions if they are to be meaningfully used as problem solving tools.

Two levels of constraints for crop production are currently considered in IRDDESS; temperature and radiation at the first level, and water availability at the second level. Pests and diseases are assumed to be in optimal control and nutrients in optimal supply. The predicted yields are indicative of the yield levels achievable under good management.

A number of crop growth processes are still not fully understood. Some of these include partitioning biomass to plant parts, maintenance requirement and age or stress related leaf senescence. IRDDESS supplies default coefficients for these processes which can be

modified if coefficients based on experimental work are available. Default coefficients are available for thirteen crops.

The application of IRDDESS for the LRGV demonstrates how historic or stochastic weather data can be used to study the long term performance of different irrigation schedules. Those that meet certain objectives, such as maximum yield, can be identified. Future research will improve the water balance module to consider heterogenous soils, add nutrient balance, and develop a linkage to a GIS (Geographic Information System). GIS will give the model additional capability to capture, store, update, analyze and visually present spatial and temporal data.

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UT-Pan American Researchers Produce Rio Grande Valley Water Bibliography

Researchers at the University of Texas - Pan American Coastal Studies Laboratory have developed a bibliography that contains citations, abstracts or annotations, and keywords for professional publications on water and water-related natural resources of the Lower Rio Grande Valley. The effort was led by Don L. Hockaday, Gayle Robinson, and Cheryl Salaiz.

Researchers at the University of Texas -Pan American Coastal Studies Lab developed a computerized database of water quality in the Lower Rio Grande.

The work, titled "Water Related Natural Resources of the Rio Grande Valley of Texas: An Annotated Bibliography," was developed in coordination with the Texas General Land Office. The bibliography covers an area within a 60 mile radius of the mouth of the Rio Grande and within 60 miles of each side of the Rio Grande between its mouth and Falcon Dam.

The bibliography was compiled through a manual search of issues of 17 journals and Texas Parks and Wildlife Department (TPWD) archives of job reports for the project

area. More than 30 years of issues were searched for twelve of these titles. In addition, 31 electronic and paper bibliographies were searched, and seventeen libraries were visited. A master database of over 3,000 citations was compiled and 846 publications were selected for the bibliography. Of these, 717 entries include an abstract or annotation. An index is provided and index citations includes first author, date of publication, and the first several words of the title. Major subject areas in the bibliography include plants and animals, water bodies, habitats, water quality, and state and federal agencies.

The bibliography was compiled using EndNote Plus-2 for the Macintosh and can be searched or converted to other bibliographic database formats. Information about this project can be viewed on the WWW at "http://cslix.csl.panam.edu/rgcimp/rgcimp.html" For details, contact Hockaday at (210) 761-2444 or "hockaday@panam.edu"

Texas Water `95 Proceedings Published by ASCE

A conference proceedings dealing with Texas water issues was recently published by the Texas Section of the American Society of Civil Engineers (ASCE). The proceedings, *Texas Water `95*, summarizes papers that were presented at an ASCE international conference on water resources engineering in San Antonio. Many articles in the proceedings were written by scientists at Texas universities, professionals with federal, state and local water agencies, and people in the private sector. The proceedings were edited by Marshall Jennings of the U.S. Geological Survey Austin office, Quentin Martin of the Lower Colorado River Authority, and Tommy Knowles of the Texas Water Development Board. Limited copies are still available by contacting the Texas section of ASCE at (512) 472-8905.

Texas Environmental Almanac *Includes Water Information*

A comprehensive analysis of Texas water and environmental issues has been published by the Texas Center for Policy Studies. The 371-page report, Texas Environmental Almanac, contains sections on water quantity, water quality, public lands, and municipal and industrial wastes. Specific focus is given to such areas as the North American Free Trade Agreement (NAFTA) and the Texas/ Mexico border environment, environmental justice, and pesticide use. The report can be ordered from the Center by calling (512) 474-0811.

Book Describes History of Texas' Forgotten Ports

A history of historic ports in Texas has been published by Eakin Press. The series, *Texas Forgotten Ports*, was authored by Keith Guthrie. Volume I describes ports from Corpus Christi to Matagorda Bay. Volume II describes ports on the Red, Brazos, and Rio Grande rivers, ports at Jefferson, Galveston and Houston, and landings at Caddo Lake and Buffalo Bayou. Volume III provides details about ports on the Trinity, Neches, Angelina and Sabine rivers, as well as ports at Beaumont, Orange, Port Arthur, Port Neches and Sabine Pass. The books can be ordered from Eakin Press at (512) 288-1771.

UT Study Examines If Nitrate Can Contaminate Aquifers

The Center for Research in Water Resources at the University of Texas at Austin has published a new technical report that examines the likelihood of nitrate contamination of Texas groundwater supplies. The report, *A Spatial and Statistical Assessment of the Vulnerability of Texas Groundwater to Nitrate Contamination (CRWR 260),* was written by David Maidment and graduate Thomas Evans of the Civil Engineering Department. It contains detailed information on the risks of contamination for specific groundwater systems including the Carrizo-Wilcox, Edwards, Hueco-Mesilla Bolson, Ogallala, and Seymour aquifers. Maps display county-by-county nitrate contamination risks. The Center also recently published *Water Quality and Quantity Impacts of Highway Construction and Operation: Summary and Conclusions* (CRWR 266) by Michael Barrett, Joseph Malina, Randall Charbeneau and George Ward of CRWR and the Civil Engineering Department. To order either report, contact CRWR at (512) 471-3131.

AWRA Proceedings Include Texas Water Issues

Two proceedings have recently been published that contain many papers dealing with Texas water issues. *Water Management in Urban Areas* was edited by Mark Loethen of Pate Engineers of Houston. *Advances in the Development and use of Models in Water Resources* was edited by Ted Cleveland of the Civil Engineering Department at the University of Houston. Both proceedings summarize papers that were presented at the 1995 the American Water Resources Association (AWRA) international conference that was held in Houston, TX. Many papers in the proceedings were given by researchers at Texas universities, state, federal and regional agencies, and the private sector. The proceedings can be ordered by contacting AWRA at (703) 904-1225.

ETSU, Israeli Scientists to Investigate if Municipal Sludge Can be Used as Peat Moss Substitute

Don Cawthon of ETSU and Roelie Vellenga of Vellenga Dairies in Como, TX discuss the performance of this experimental composter. This device will be used to convert municipal sludge into a compost product that can be a substitute for peat moss.

Researchers from East Texas State University and Israel are teaming up to investigate new uses for municipal sludge and animal wastes. The effort could provide a new method to dispose of potential water pollutants, while generating a new substitute for peat moss for horticultural operations. Lead scientists on the project are Donald Cawthon and Larry Klingbeil of ETSU Agricultural Sciences Department, and Zev Gerstl, P. Fine, Nir Atzmon, and Dan Levanon of Israel. The study is funded by the Texas Department of Agri culture's Texas Israeli

Exchange program.

Currently, municipal wastewaters and wastes from confined animal feeding operations (dairies, feedlots, and poultry farms) often contribute significant amounts of nitrate, phosphorous, and contaminants to ground and surface waters. Finding ways to dispose of and beneficially use large amounts of sludge is challenging for many urban areas.

The goal of this study is to identify and implement technologies needed to convert solid animal waste and municipal se wage sludge into an organic product that can be used in nurseries and horticultural operations. The researchers will try to determine the feasibility of co-composting animal wastes and sewage sludge with other waste products. Information will be obtained on microbial processes and reactions involving enzymes. Cawthon hopes to develop methods to commercially produce composted products that can be substituted for peat moss in greenhouses and nurseries. Peat moss often represents up to 70% of the potting soil used to grow out young trees and landscape plants in greenhouses. However, peat moss is non-renewable and there are concerns supplies may be exhausted by the end of the 21st century. The study will include extensive testing of an aerobic composter developed at ETSU using municipal sludge and dairy wastes. Work in Israel will involve determining the characteristics of many waste sources including municipal sludge, poultry litter, cattle manure, and industrial wastes. For details, contact Cawthon at (903) 886-5350 or "Don_Cawthon@etsu.edu" or Klingbeil at (903) 886-5379.

TAMUCC Uses Sea Sled to Survey South Padre Island Beach

Researchers at Texas A&M University - Corpus Christi used this sea sled to conduct a survey of the beach bottom at South Padre Island. This unique device has two, 16-foot long runners and is towed along the beach bottom by a boat. It has a 40-foot high adjustable mast so surveys can be taken in deep waters.

Researchers at Texas A&M University -- Corpus Christi (TAMUCC) recently tested the use of a new device to survey the beach at South Padre Island. The research was conducted by Nick Kraus, Cheryl Brown, and students Dan Prouty, Niall Durham, Russell Ochs of TAMUCC's Conrad Blucher Institute for Surveying and Science. To survey underwater areas, a unique sea sled was used that Prouty designed. The sled has two 16-foot long runners and is towed along the sea bottom by a boat. It includes a 40-foot high adjustable mast so surveys can be taken in deep waters. In this study, the sled reached depths of nearly 30 feet in areas 1 mile offshore. The land survey was conducted from the dunes to the shoreline and was performed with standard methods. An infrared light beam was focused on glass prisms located on top of the sled and distances and elevations were calculated based on time

intervals between reflections and angles of the beam. The survey was performed on 25 onshore lines that were spaced 1,100 feet apart and covered more than 5 miles of shoreline. Sand samples were taken to characterize native beach sediments. These data are being used to build a map of the beach as it now exists that can be used to develop designs for beach protection. The studies were funded by the U.S. Army Corps of Engineers as part of overall effort to find ways to beneficially utilize dredged material. The Corps wanted to determine if the beach was being eroded by coastal storms and if more sand needed to be imported to provided additional protection. For details, contact Prouty at (512) 994-2752 or Kraus at (512) 994-2376 or "kraus@cbi.tamucc.edu"

TWRI May Issue RFP this Spring

The FY1996 Interior Appropriations Bill contains language recommending a small base grant for each Water Resource Research Institute with the balance of the funding for a competitive grant program. Details of the new competitive program have not been released by USGS, but some likely characteristics are given below as preliminary information. This new competitive grant competition will probably be a regional program with Texas joining 12 other states to form a Western region.

This process will likely be followed. First, an RFP will be issued by TWRI some time this Spring. Total funds available for awards in the Western region are approximately $750,000. Program priorities will be established by Institutes in the Western Region. Proposals may address needs for research, information transfer or information management.

All proposals will be evaluated by peer review. A non-federal match of at least 2:1 is required. Matching funds are the responsibility of the principal investigator's institution. TWRI may assist in providing this match, but funds to do so are extremely limited. Project start dates may vary but project duration should not exceed 3 years, with funding for years 2 and 3 contingent on the previous year's performance. Projects involving more than one institution and state are encouraged. Participants need not be in the same region.

TAES Scientists to Model Effects of Brush Control in Edwards Aquifer Region

Texas Agricultural Experiment (TAES) researchers will use a computer simulation model to evaluate if removing ashe juni per can increase water yields in the Edwards Aquifer region. The research, which is funded by the Texas Water Development Board (TWDB), will be led by William Dugas and Ranjan Muttiah of the TAES Blackland Research Center at Temple.

Increasing water yields from the watersheds above the recharge zone of the Edwards Aquifer is one way to increase flows into the aquifer. Groundwater use is increasing substantially in the region and there are concerns about whether enough water can be supplied to meet the region's needs for cities, irrigation, and endangered species. A land management strategy that may be of value is to remove some of the ashe juniper from these watersheds and replace it with native grasses that may use substantially less water.

Research Dugas conducted on experimental plots on the Edwards Plateau suggests that water used by plants and soil in evaporation decreased after juniper was removed, even when precipitation decreased. The amount of water saved was substantial in the first couple of years and then decreased. In this project, the researchers will focus on the use of a computer simulation model of the surface hydrology (Soil Water Assessment Tool or SWAT), developed by ARS scientists at Temple, to quantify potential water yields that could result if brush removal was implemented on selected sites in the region. First, SWAT will be calibrated and validated using data from Dugas' watersheds where brush management has and has not been implemented. Then, the model and geographically referenced databases with information on climate, soils, land use, and vegetative cover systems will be used to simulate the surface hydrology for larger watersheds on the Edwards Plateau under current land use conditions where brush management has not been implemented. Simulations will be compared with measured stream flow. Finally, the model will be used to simulate the surface hydrology for these large watersheds after various amounts of ashe juniper have been removed, using the model inputs derived from the small watershed analyses with and without brush.

Researchers with the Texas Agricultural Experiment Station's Blackland Research Center at Temple install this flume to measure runoff from plots where nuisance brush species were removed.

The study is needed to provide improved predictions of the amount of water that can be saved as a result of brush management. This will help decision makers determine where selected brush control strategies may be especially useful. For details, contact Dugas at (817) 770-6605 or "dugas@brcsun0.tamu.edu" or Muttiah at (817) 770-6670 or "muttiah@brcsun0.tamu.edu"

Texas Tech to Develop Updated Manual on Crop Water Use

Water use by crops and evaporation from lakes, reservoirs, and other surface waters are large consumers of water in Texas. Unfortunately, the methods used to calculate crop water use (CWU) and free water evaporation (FWE) in Texas are outdated and not as accurate as they could be if new technologies were used. The manual recommended by the state to calculate these values was written in 1960, and uses data and methodologies from the 1940s and 1950s.

A grant from the Texas Water Development Board is funding a project to compile an updated handbook to help calculate these values. The study, titled developing a manual for crop consumptive water use and free water evaporation for Texas, will be conducted by John Borelli, Cliff Fedler, Robert Sweazy, and James Gregory of the Civil Engineering Department at Texas Tech University.

In the project, the researchers will collect climate data for the past 30 years from all first order weather stations, information from neighboring states, and data recorded by state agricultural experiment stations. Crop coefficients will be gathered for crops, turfgrasses, and native vegetation in Texas as well as bare soils. Updated procedures will be selected to calculate CWU and FWE rates and computer programs will be developed using those formulas.

Examples of the use CWU and FWE to solve typical water resource problems and sample calculations will be developed. This could include water use by turfs and landscape plants, crop water use for irrigated and dryland agriculture, and estimating evaporation rates from rivers and reservoirs. This information will be developed into a manual that will be published by TWDB. Borelli says the main benefit of this project is that it will provide accurate data on CWU and FWE values that scientists and decision makers can use. This data is valuable in determining beneficial uses of water, assessing the need for water transfers, and evaluating water permits.

For details, contact Borelli at (806) 742-3523 or "jborelli@coe1.coe.ttu.edu" or Fedler (806) 742-2801.

Texas A&M Researchers to Study Incorporating Risk Into Water Management

Ronald Griffin and James Mjelde of the Agricultural Economics Department at Texas A&M University have been awarded a grant from the Texas Water Development Board (TWDB) to analyze how incorporating risk into water management strategies may improve water supply planning.

Water resource practices focus on management, development, conservation, and water transfer, usually with the goal of assuring dependable municipal water supplies. To keep lawns green, bathtubs full, and car washes running, water utilities typically size water supply systems for a worst-case scenario to deal with severe droughts and other nightmares.

Because water consumers are risk averse, and because water utilities are able to pass on the cost of development to their consumers, many utilities still size their water supply systems for severe droughts, even though there is only a low probability they will occur. A survey of 72 cities by the TWDB revealed that seasonal use may account for only 25% of total water use, but peak demands still strain systems. In fact, in some affluent communities, peak day use is 400% higher than on average days. This places a big burden on utilities because it requires them to make a large capital investment.

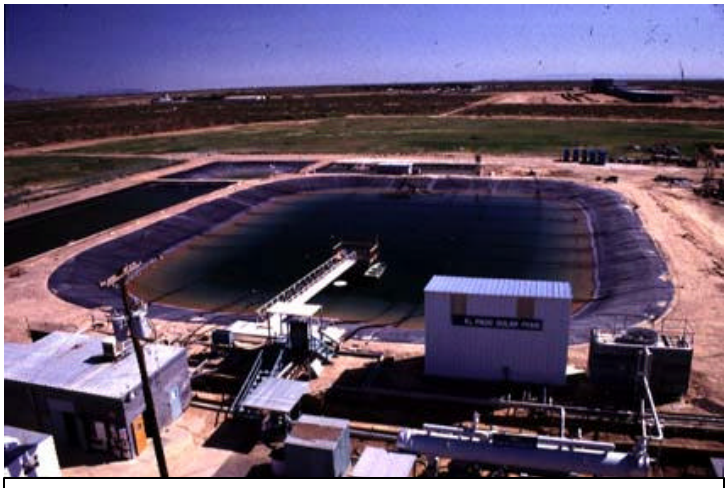
The research involves three steps. First, Griffin and Mjelde will assess existing suitable risk-based management models. Then, they will survey residents of selected communities to obtain risk preference of actual consumers. Finally, they will apply the data to simulation models to develop efficient, reliable plans for selected communities.

The research may also provide some environmental benefits. When municipal water users decrease the risk of water supply shortfalls, they shift risks to non-municipal users. By being willing to take slightly higher risks, they may actually increase the amount of water available for aquatic habitat systems and ecosystems.

For details, contact Griffin at (409) 845-7049 or "ron-griffin@tamu.edu" or Mjelde at (409) 845-1492.

Texas A&M, UTEP Researchers, Team Up to Solve Brine Management Problems

Researchers at Texas A&M University (TAMU) and the University of Texas at El Paso (UTEP) are part of a team that is evaluating economical and reliable methods of brine management. The study is being funded by the Texas Water Development Board. The project was awarded to Kleber J. Denny, an engineering consultant in Houston. Working with him will be Wes James of the TAMU Civil Engineering Department and Andrew Swift and John Walton of the Center for Environmental Resources Management (CERM) at UTEP. Other participants include F.J. Spencer of International Management Services, Inc. of Houston, Jim McNutt of J. McNutt and Associates, Inc. of Dallas, and Ed Gieschecker of Ionics, Inc. of Watertown, MA.



This photo displays a saline solar pond at the University of Texas at El Paso developed by John Walton and Andrew Swift. The pond produces energy from salt water.

The research is needed because high levels of naturally-occurring sources of salt water are widespread in the upper portions of the Brazos River basin. This has led to widespread soil contamination and damage to agricultural crops and livestock. The project involves examining currently utilized methods of brine disposal and management. These include the recovery and beneficial use of brine by-products, the use of salinity gradient solar ponds to produce supplemental electricity, heat and freshwater through desalinization; recovery and dehydration of salts that can be commercially used to reinforce road beds, to deice pavements, and for livestock feed supplements; and applications in aquaculture systems. Field studies will be conducted in the Dove Creek area of Stonewall County and nearby counties that suffer from excessively high salinity levels.

James has studied brine disposal methods such as pumping brines from saline aquifers. Swift and Walton have developed strategies to operate saline solar ponds. For details, contact Denny at (713) 993-0333, James at (409) 845-4550 or "wesley-james@tamu.edu" or Walton at (915) 747-5494 or "jwalton@cs.utep.edu"

Texas A&M Researchers to Examine Economic and Policy Impacts of "Dry-Year Option" Irrigation Strategy

The effects of short-term transfers of water from agricultural to urban users in the Edwards Aquifer is the focus of a research project being carried out by Texas A&M University agricultural economists. The study is led by Bruce McCarl, Ron Lacewell, and Lonnie Jones of the Agricultural Economics Department and is funded by the Texas Water Development Board (TWDB).

The Edwards Aquifer region is characterized by large variations in rainfall and runoff. Recharge to the Edwards Aquifer has been as low as 50,000 acre-feet (AF) and as high as 2 million AF. Obviously, there may be economic opportunities for willing agricultural producers to market excess waters to nearby cities and industries. Another way of transferring water from agricultural to urban users is the "dry year option." Under this strategy, farmers could lease water supplies at the beginning or middle of the growing season and be compensated for lost income from reduced yields.

This study will examine policy and economic issues associated with the dry year option. Lacewell will utilize computer models to simulate the effects of deficit irrigation that farmers would have to resort to if water supplies were interrupted. McCarl will develop a simulation model that will examine how farmers can maximize their incomes by growing different crops or using alternative irrigation strategies when a dry year option is introduced. McCarl will also create models that assess how changes in agricultural water use at individual farms will increase the amount of water available to specific areas and springs. Jones will examine the secondary effects of the dry year option on local economies, including changes in sales, employment, taxes and value added processing, and will study methods to compensate farmers and rural areas for economic losses caused by implementing the dry year option. The researchers will also assess the level of compensation that may be required based on when the dry year option is implemented, the length of time it is needed, and the amount of water transferred. For details, contact McCarl at (409) 845-1706 or "mccarl@tamu.edu", Lacewell at (409)845-8476 or "r-lacewell@tamu.edu" or Jones at (409) 845-2333 "ljones@tamu.edu"

Meetings

- The Texas Agricultural Extension Service will teach the **Texas Landscape Irrigation Auditing Short Course** in Midland/Odessa Feb. 21-21, in El Paso April 23-24, and in San Antonio May 22-23. For details, contact David Smith at (409) 845-5614 or "dws@diamond.tamu.edu"
- The **Texas Academy of Sciences** will meet Feb. 29-March 3 in Galveston. For details on the meeting, contact Andy Tirpak of Texas A&M University -- Galveston at (409) 740-4459 or "tamg81@aol.com"
- The **Universities Council on Water Resources Annual Meeting** will be July 30 - Aug. 2 in San Antonio. To submit an abstract, contact Lloyd Urban at Texas Tech at (806) 742-3597 by Feb. 1. For more details about the meeting, contact TWRI at (409) 845-1851 or "twri@tamu.edu"

- The **University of Texas at Austin** is hosting these short courses: Flood Plain Hydrology Using HEC-1 (March 18-22) and Advanced Water Pollution Control (Feb. 19-23). For details, call (512) 471-3506.
- The **Texas On-Site Wastewater Treatment Research Council** will hold its annual meeting March 10-12 in College Station. For details, contact Warren Samuelson of the TNRCC at (512) 239-4799. The **International Conference on Evapotranspiration and Irrigation Scheduling** will be Nov. 3-6, 1996 in San Antonio. For details, call ASAE at (616) 428-6323.
- The **Geological Society of America** will hold a regional meeting in Austin March 11-12. For details, contact Neven Kresic at TCU at (817) 921-7506 or John Sharp at UT at (512) 471-3317.
- A workshop, **Constructed Wetlands for Animal Waste Management**, will be May 15-18 in Fort Worth. For details, contact Paul DuBowy of the Texas A&M University Wildlife and Fisheries Sciences Department at (409) 845-5765 or 'p-dubowy@tamu.edu"
- Short courses from the **Texas Engineering Extension Service** include Water Utilities Management (March 6-8 in San Antonio and March 11-13 in Mesquite), Operation of Activated Sludge Plants (Feb. 26-28 in Lewisville), and Wastewater Technology (Feb. 26 - March 1 in San Antonio). For details, call (409) 845-6246.
- The **Texas Water Conservation Association Annual Conference** will be Feb. 7-9 in Austin. For details, call (512) 472-7216.