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Scientists Use Supercomputers to Solve Water Problems

Some of the world's most powerful computers are now being used at Texas A&M to solve water problems including groundwater cleanup techniques and global climate change.

Researchers George Moridis and Don Reddell in the Agricultural Engineering Department are investigating whether air injected underground at low pressures can slow the movement of pollutants. Moridis and Reddell also built a large physical model to study the effectiveness of air injection on groundwater pollution under laboratory conditions.

Using the Texas A&M University Cray allowed the scientists to solve complex mathematical equations to predict how different air injection scenarios can protect groundwater quality. Increasing the pressure of the injected air or injecting air over longer periods of time make the procedure more effective.

"Injecting air reduces the permeability of pollutants, slows their migration, and reduces contamination risks. We hope to use the technology to stop contaminant plumes in real world conditions," Reddell said. "Describing the process with mathematical models gives us information we need to design field studies."

The scientists used the Cray because of the number and complexity of the mathematical equations that had to be solved to simulate the effects of air injection over 5 years. Reddell said more than 15,000 equations representing both two- and threedimensional problems had to be solved simultaneously over short intervals. The model was designed to frequently verify and self- correct any errors to improve its accuracy. The process required more than 10,000 computations at small time steps.

Results show the movement of the contaminants was greatly reduced when air was injected at low pressures over short periods. Some injected air stays in the aquifer after the injection has ceased and seals the oil in the aquifer.

Gerald North of the Climate System Research Program has been utilizing the super computer to determine if the impacts of global warming can be accurately estimated. North first developed a computerized version of a simplified earth he called "terra blanda" so that the needed mathematical computations could be performed. Terra blanda

is all land (there are no oceans), all the mountains were removed, the tilt of the earth was set to zero so that there was a perpetual solar equinox, and surface temperatures were made symmetrical. Later, the model was altered to simulate a featureless dry planet ("terra sicca") and a rainy planet ("terra humida").

"There are advantages of using simplified spheres rather than the real earth," North said. "When there are no seasons or months and the hemispheres are equal, more comparisons of like conditions can be made. If we modeled the real earth we would have fewer common points," North says. "Simulating the earth's climate for 15 years takes 75 hours on the Cray and produces 15 results for each month for that vary from site to site. Using terra blanda we can generate 180 months of climate for that same period over all locations based on uniform conditions."

Surface temperatures were simulated using energy balance climate models. A version of the National Center for Atmospheric Research's Community Climate Model was utilized that represents the earth with nine layers and 4.5 x 7.5deg. grids. Responses to variable solar inputs and steady surface heat sources were modeled to verify the accuracy of climate predictions.

Results suggest that GCMs can provide reasonable simulated results for earth surface temperatures and that many aspects of the climate cycle are somewhat linear and can be predicted accurately.

Estimating the Risks from Hazardous and Municipal Landfills

Researchers : Kirk Brown, K.C. Donnelly, and Gregory Schrab, Soil and Crop Science Dept., Texas A&M University, College Station, TX.

Problem: While much concern is now being focused on groundwater pollution from Superfund and hazardous waste sites, less attention is being paid to the occurrence and concentration of harmful chemicals leaching from municipal solid waste landfills. Federal regulations imply that municipal landfills are not hazardous, but this has not been confirmed by scientific analyses.

Objective: To collect data on toxic organic chemicals found in municipal landfill leachate; to compare this information to data on landfills known to contain hazardous waste; and to evaluate human health risks associated with both leachates.

Methodology: Data were collected on leachate above the landfill liners and from plumes of contaminated groundwater. Tables were constructed from the data showing the minimum and maximum levels of specific chemicals found in municipal and industrial landfills. The chronic toxic potential of leachate samples was assessed by computing the median average cancer risk based on drinking 2 liters per day of water contaminated with specific chemicals. Although it is unlikely that an individual would consume this much contaminated water, the information helped compare the chronic toxic potential of municipal and industrial landfill leachates.

Results: More than 60% of the cancer risk associated with municipal landfills was due to high concentrations of butane and/or 2- propanol. These compounds are used for industrial and household purposes. This suggests that the toxicity of municipal landfill leachate may be due to the past disposal, legal or illegal, of industrial waste. Cancer risks from industrial leachates were most likely to be caused by PCBs and chloroform. Results show that it is doubtful that there is any appreciable difference between cancer risks and toxic potentials associated with municipal and industrial landfill leachates. From a policy perspective, the findings suggest that subjecting municipal landfills to relatively little regulation may be allowing the disposal of wastes which still produce toxic and hazardous leachates and pollute groundwater supplies. Field studies at four sites by Greg Schrab of Texas A& M University confirmed that the leachate from municipal landfills has levels of toxicity similar to those in industrial landfills.

Reference: Brown, Kirk, and K.C. Donnelly, "Estimation of the Risk Associated with the Organic Constituents of Hazardous and Municipal Waste Landfill Leachates," *Hazardous Waste and Hazardous Materials*, New York, NY, Vol. 5, No. 1, 1988.

Optimizing Coagulant Use at Water Treatment Plants

Researchers : Anthony Tarquin, Civil Engineering Dept., University of Texas at El Paso, El Paso, TX, Diana Tsimis, Civil Engineering Dept., Texas A&M University, College Station, TX, and Doug Rittman, El Paso Water Utilities, El Paso, TX.

Problem: Municipal water treatment plants are faced with the dilemma of providing water that is safe to drink for the lowest possible cost. Cost savings and increased efficiency can be obtained when numerous treatment processes are evaluated as a system.

Objective: To determine the most cost effective coagulant dosages when the coagulation, sedimentation, and filtration processes are considered simultaneously, and to estimate cost savings resulting from lower coagulant use.

Methodology: The study was conducted at a 25 million gallon per day (MGD) water treatment plant in El Paso. The plant treats river water from March to September when irrigation releases are made from Elephant Butte Dam in New Mexico. Chemical costs for varying strategies were obtained by examining the relationship between chemical dosages and water turbidity after coagulation but before filtration. Relationships between the amount of backwash water required and the turbidity of the water to be filtered were also determined to assess needed chemical dosages. Because most of the data from the actual treatment plant operations fell within a limited range of turbidities, laboratory jar tests were used to provide comparative data. Residual turbidity was plotted against coagulant dosages. Backwash rates were compared to entering turbidity. Relationships between backwash water and treated water costs were computed for each coagulant dosage. Backwash and coagulant costs were added to produce the total cost of treatment as a function of coagulant dosages.

Results: Results from both the water treatment plant and laboratory jar tests were similar. A significant improvement in coagulant removal was obtained by increasing ferric sulfate

dosages to roughly 10 mg/l. However, little improvement was made by increasing ferric sulfate doses to 20 mg/l. Reducing levels of ferric sulfate from 12 mg/l to 6 mg/l can reduce costs by 23% which translates to a savings of more than \$25,620 annually. These savings are based on operating procedures that would increase the amount of backwash water required by 49%. Additional savings may be possible if the backwash rate could be reduced.

Reference: Tarquin, Anthony, Diana Tsimis, and Doug Rittman, "Water Plant Optimizes Coagulant Dosages," *Water Engineering and Management* Des Plaines, IL, May 1989.

Historical Shoreline Changes on Padre Island

Researchers : Jennifer Prouty, Geology Dept., Corpus Christi State University, Corpus Christi, TX, and Daniel Prouty, Coastal Research Associates, Corpus Christi, TX.

Problem: The western shoreline of Padre Island at the north end of the Padre Island National Seashore is eroding. Coastal researchers generally attribute barrier island erosion to sea level rise, local subsidence and damming of rivers which reduces sediment loads to coastal areas, but other causes seem more logical at this site.

Objective: To document long-term changes in shoreline shape and position and to identify causes of those changes.

Methodology: Researchers studied aerial photographs dating from 1941 to 1987 to document changes in shoreline shape and position. They traced shoreline positions onto a mylar overlay and compared shoreline positions in subsequent photographs, relative to the 1987 shoreline position, along 10 transects.

Results: Shoreline retreat is a recent phenomenon. From 1941 to 1979 shoreline outbuilding, not retreat, dominated the area. Outbuilding rates were moderate to extreme (greater than 25 feet per year) from 1950 to 1964 and outbuilding rates slowed from 1964 to 1979. Shoreline retreat first dominated between 1979 and 1983; the rate was minor to major (0 to 25 feet per year) from 1979 to 1983 and minor to moderate (0 to 15 feet per year) from 1983 to 1987. The shoreline built out faster during droughts, possibly because droughts enlarged preexisting migrating dune fields and supplied more wind-blown sand to the west side of the island. Origin of the dune fields is unclear but they possibly formed in the late 1800s or early 1900s as overgrazing and grass burning by ranchers and a series of droughts destroyed island grasslands. In the past few decades, higher average rainfall and the cessation of ranching on the National Seashore have limited the size of dune fields and reduced the supply of wind-blown sand to the shoreline. This encourages minor erosion because sands washed away are not easily replaced.

Reference: Prouty, Jennifer, and Daniel Prouty, "Historical Back Barrier Shoreline Changes at Padre Island National Seashore, Texas", *Transactions of the Gulf Coast Association of Geological Societies*, " Vol. 39, 1989.

Responses to Agricultural Pesticides in the Freshwater Community

Researchers : Kyle Hoagland, Forestry, Fisheries and Wildlife Dept., University of Nebraska, Lincoln, NE, and Ray Drenner, Biology Dept., Texas Christian University, Fort Worth, TX.



TCU biologists take this water quality sample from fiberglass tanks near the campus. The studies were conducted to determine how pesticide runoff affects fish and other aquatic species.

Problem: There is little knowledge on the combined impacts of pesticides and herbicides based on field studies. Detailed studies on commonly used pesticides and herbicides will help assess whether aquatic communities in lake and river systems will suffer from exposure to these chemicals.

Objective: To determine the individual and combined impacts of atrazine (used on more than 2 million acres of Texas cropland) and bifenthrin (a new pyrethroid insecticide for cotton) on lake communities.

Methodology: Experiments were carried out in large fiberglass tanks on the TCU campus. Three levels of both atrazine (0,100, and 1,000 micrograms per liter) and bifenthrin (0,100, and 1,000 nanograms per liter) were placed in the tanks. Pesticides were introduced as a soil slurry to simulate a sediment plume generated by a runoff event. Zooplankton were collected from a small pond on the TCU campus and from a nearby reservoir and were placed in the tanks along with bluegill. Phosphorus was added to

prevent phosphorus depletion. Zooplankton and phytoplankton populations, and data on temperature, dissolved oxygen, turbidity, total nitrogen and total phosphorus were measured on a regular basis.

Results: Bluegill mortality was unaffected by either pesticide. Atrazine reduced chlorophyll levels one week after it was added but had no significant effect by day 14. Intermediate atrazine concentrations used in the study were higher than those typically found in the environment, but produced few adverse impacts on primary production. Relatively high atrazine levels may have significant impacts up to 7 days of exposure, followed by rapid recovery of the algal community. Bifenthrin produced a significant reduction in most zooplankton groups both 7 days and 14 days following exposure. The combined impacts of both pesticides were noted on only one zooplankton species, *Bosmina*. This suggests the two pesticides were not acting synergistically.

NOTE: This study was funded by TWRI and results were published as TWRI Technical Report 151. To obtain a copy, contact TWRI at 409-845-1851.

Impact of Selenium on Fathead Minnows

Researchers : Mark Pyron and Thomas Beitinger, Biology Dept., University of North Texas (UNT), Denton, TX.

Problem: Selenium (Se) is a necessary trace element, but manmade pollution from solid wastes and coal-fired power plants can result in harmful levels of selenium in aquatic environments. Populations of fish species that accumulate selenium in their bodies have declined in many instances. Because fathead minnows are used as indicators of pollutants in wastewater effluents, it is important to know more about the impact of selenium on this species.

Objective: To determine the impacts of selenium on the reproductive behavior and the offspring of fathead minnows.

Methodology: Six-month-old fathead minnows were taken from stocks maintained at UNT and were placed in aquaria containing aged tap water at 70deg. F. Fish were fed twice daily. Fluorescent lighting was used to simulate day and night periods. Ten fish per treatment were exposed to Se as sodium selenate at concentrations of 0, 20, 30, and 60 mg/l for 24 hours. Behaviors were observed in aquaria equipped with split PVC tubing for nesting sites. Observations were made between 6 and 10 AM for courtship behaviors including occurrences of males and females in the territory, males approaching females, males leading females into their territory, males moving in front of females and extending their fins, tail beating, vibrating, and males moving towards females and butting and pushing them with their snouts. Roughly 30 data recording sessions were made for each selenium concentration.

Results: More than 4500 individual behaviors were recorded. Measured concentrations of selenium in water samples were 66, 36, and 20 mg/l. Five fish exposed to 60 mg/l Se died within 24 hours and the remaining fish in this group died within 48 hours. Only a single death occurred in fish exposed to 30 mg/l SQ and no mortalities occurred in fish exposed to 20 mg/l Se. Exposures to Se levels of 20 and 30 mg/l for 24 hours did not produce noticeable impacts on reproductive behaviors. The most commonly observed behavior was male within female territories, followed by males approaching females. Hatching appeared to take place normally in all three groups but nearly all larvae exposed to 20 and 30 mg/l Se had gross morphological abnormalities, especially edema (swellings of organs caused by excess amounts of fluids). No minnow larvae with edema survived longer than 7 days after hatching. These results suggest that the reproductive behavior fathead minnows does not make a good bioassay model for selenium, although the survival and condition of minnow fry are sensitive to varying Se levels.

Reference: Pyron, Mark, and Thomas Beitinger, "Effect of Selenium on Reproductive Behavior and Fry of Fathead Minnows," *Bulletin of Environmental Contamination and Toxicology*, 1989 (pp 609-613).

Relationships Between Herbivores and Zooplankton in Lakes

Researchers : Robert Sterner, Biology Dept., University of Texas at Arlington, Arlington, TX.

Problem: Ecological interactions between herbivores like zooplankton and the phytoplankton they prey on encompass a rich set of dynamic relationships that are poorly described by classic "plus-minus" predator-prey relationships. Reasons for these more complex dynamics include compensatory growth and nutrient recycling. Grazing by zooplankton also influence the chemical environment utilized by phytoplankton and can increase the availability of resources by regenerating nitrogen (N) and phosphorous (P) and by reducing algae populations. More information is needed on the role of herbivores in altering their competitive arena to better understand lake ecosystems.

Objective: To examine the recycling of N and P by zooplankton grazers with physiological models that are biologically realistic and assume: 1) metabolism occurs at a rate that is constant on a mass- specific basis (basal metabolism), 2) grazers accumulate a constant fraction of the N and P they ingest (constant accumulation efficiency), and 3) grazers maintain the ratio of N to P in their tissues at a constant value (strict homeostasis).

Methodology: The three models utilized a common framework with pools of N, P for phytoplankton and zooplankton as well as pools of dissolved N and P. Other factors used in the model include grazing rates, rates of N and P resupply, base metabolic release rates, accumulation efficiencies of N and P, rates of loss from zooplankton pools, the ratio of N to P in zooplankton food, the ratio of N to P resupplied to the dissolved pool, and the ratio of N to P in the zooplankton pool. Only fluxes in and out of the zooplankton pool are considered, grazing on non- algal foods is thought to be negligible, and grazing falls equally on all algae species.

Results: Results suggest that grazers do maintain a degree of homeostasis but that it is not strict. This implies that zooplankton nutrient regeneration can diverge the nutrient limitations in algae such that either single limitation by N or P, but not colimitation by both, is favored. Resupply ratios of N to P by grazing zooplankton is positively related to N to P ratios in their food supply. When nutrient recycling by herbivores dominates nutrient supply to the dissolved pool, the N to P in the grazeable particulate matter may be a good proxy for the supply ratio of N to P. The homeostatic model appears to be the best of the three models. The rates of turnover of nutrients (the microbial loop) appear to be very significant in lake ecosystems. Zooplankton grazing may also limit nutrient availability to algae.

Reference: Sterner, Robert, "Ratio of Nitrogen to Phosphorous Resupplied by Herbivores: Zooplankton and the Algal Competitive Arena," *American Naturalist*, August, 1990.

Three Dimensional Modeling of Groundwater Flow and Subsidence in the Houston Area

Researchers : Rolando Bravo, Jerry Rogers, and Theodore Cleveland, Civil and Environmental Engineering Dept., University of Houston, Houston, TX.

Problem: Land subsidence is a major problem in the Houston area caused mainly by excessive groundwater pumping. Subsidence makes many areas more vulnerable to flooding and threatens the foundations of buildings. Accurate modeling of the relationships between groundwater pumping and subsidence are needed.

Objective: To develop a methodology to analyze subsidence problems in the Houston area using a modified version of the Three- Dimensional Finite Difference Ground Water Flow Model developed by the U.S. Geological Survey (USGS).

Methodology: The model simulates the hydrological conditions of the Evangeline and Chicot Aquifers. The Chicot Aquifer was modeled as an isotropic system (flow is equal in all directions) with the potential for confined or unconfined horizontal flow. The Evangeline Aquifer was modeled as a confined leaky isotropic aquifer. Logs were used to generate geologic profiles at five sites. Changes in aquifer levels are linked with models that simulate compression and compaction in soil layers. The subsidence analysis uses a method that is independent of the time interval used to solve groundwater flow equations. Components of the subsidence model included the specific weight of water, soil porosity, moisture content above the water table, and changes in water table elevation. The model is calibrated with USGS data.

Results: The flow problem was solved using the Modular Three- Dimensional Finite Difference Ground Water Flow Model developed by the USGS. Flows were simulated for one year using initial data from 1983. The model performed well in predicting changes in pressure in the Evangeline and Chicot aquifers at locations where actual data were available. The model performed adequately, even in areas where data was limited. Subsidence was calculated for 1984 based on the assumption that there was no subsidence in 1983. Results suggest the model is better than previous efforts at estimating conditions for locations from which there are data, simulating the combined impacts of water level changes in multiple aquifers, and describing the transmissivities and leakage between aquifers .

Reference: Bravo, R., J. Rogers, and T. Cleveland, "A New Three Dimensional Finite Difference Model of Ground Water Flow and Land Subsidence in the Houston Area," Presented at 4th International Conference on Land Subsidence, Houston, TX, May 1991.

126 Texas Dams Ranked As High Hazards, May Fail After Heavy Rains

Roughly 126 Texas dams may be unreliable and may not be able to hold water after heavy rains, according to the Texas Water Commission (TWC). In addition, the TWC estimates that 430 other Texas dams may not meet State safety standards.

The 126 worst dams are classified as "high hazards" by the TWC. This means that the TWC expects loss of life and excessive economic losses would occur should the dams fail. The hazard status is based on downstream development, not the physical condition of the dams. Collin County has the most high hazard dams with 9, followed by Brown and Ellis counties (8 each) and San Saba County (7). Only three of the dams are in large urban areas Lake June Dam in Dallas Lake Worth Dam in Fort Worth, and Camelot Dam in San Antonio.

In a related story, Jacksboro officials have filed a \$24 million lawsuit against the contractor and engineer it hired to help build Lost Creek Reservoir. A slide occurred on the downstream slope of the dam only 10 days before it was scheduled to be completed in May of last year. Jacksboro officials claim that more than \$23 million of raw water was lost by construction delays when more than 5 billion gallons of water (valued at \$4 per 1,000 gallons) had to be drained. That water could have otherwise been held in storage and used if the dam was operating properly.

New Mexico Struggles to Cope With Pecos River Settlement

Now that the Pecos River lawsuit between Texas and New Mexico is settled, New Mexico officials are considering options to make sure that Texas receives its fair share of water.

Possible strategies being considered by New Mexico include funding \$60 million to acquire and permanently retire surface water rights, amendments to New Mexico law that could make sure water rights that are not being used are forfeited, and authorizing the State Engineer to shut off junior water rights under the prior appropriation system in anticipation of periods when Pecos River flows would be less than normal. In addition, better systems of monitoring water rights transfers are being considered to better keep track of available water supplies. Other alternatives include pumping groundwater into the Pecos River, importing water from other New Mexico river basins, and retiring water rights through purchase or lease programs.

The information was featured in the Winter 1990 issue of the *Divining Rod* newsletter published by the New Mexico Water Resources Research Institute. Call 505- 646- 4337 for a copy.

Free Trade Pact Could Increase Border Pollution

Increased pollution along the Texas-Mexico border is resulting from maquiladora factories in northern Mexico and those problems may only get worse in the future, according to some recent studies.

According to *Border Trouble: Rivers in Peril*, a report published this month by the National Toxic Campaign Fund, severe water pollution and public health hazards are resulting from toxic discharges from maquiladoras. The report charges that releases of concentrated toxic wastes into waterways is a common practice carried out by maquiladoras in northern Mexico. Roughly 33% of sites that were sampled showed levels of toxic chemicals that were as much as 215,000 times greater than U.S. standards for

receiving stream water quality. A car manufacturing plant in Matamoras was discharging xylene at levels of 2.8 million parts per billion (6,300 times higher than the U.S. drinking water standard), and methylene chloride (a suspected carcinogen) was found at levels 215,000 times greater than ambient water quality standards. Irina Cech of the University of Texas School of Public Health in Houston participated in epidemiological testing of residents in the region. The Fund can be reached at 617- 232- 0327.

Meanwhile, the proposed free trade agreement between the U.S. and Mexico could increase pollution problems along

the Texas- Mexico border, according to a new Texas A&M study. *The U.S. Mexico Free Trade Agreement: Natural Resource and Environmental Issues*, was coauthored by Teo Ozuna of the Agricultural Economics Dept. and Ramon Quiroga of the University of Neuvo Leon in Monterrey, Mexico. The study suggests that more water supplies will be needed if the Agreement is implemented. These demands could require increased watertransfersfrom agriculture to urban uses or increased groundwater pumping. Freshwater inflows could also be lessened and endangered species could be threatened. The report suggests that the Mexican counterpart of the U.S. EPA could be strenghtened or that a binational agency could coordinate environmental protection efforts. Ozuna can be reached at 409- 845- 3225.

Another report on the subject, *A Response to the Bush Administration's Environmental Action Plan for Free Trade Negotiations with Mexico*, was recently published by the Texas Center for Policy Studies in Austin. The report says that the free trade agreement fails to deal with critical issues such as how to fund improvements in Mexico's environmental regulations and physical improvements in water and sewer treatment plants. The Center can be reached at 512-474-0811.

El Paso Fails Environmental Stress Test, OKs Conservation Programs

The City of El Paso has been given the dubious distinction of being the most environmentally stressed city in the U.S. in an annual survey conducted by Zero Population Growth (ZPG), but some of those stresses may be lessened by a water conservation plan the City recently enacted.

ZPG annually ranks environmental quality in urban areas. Factors contributing to the rankings include air and water quality, water supplies, sewage treatment, toxic emissions, and population increases. El Paso received failing scores for water quality (because of high salinity in the Rio Grande), water supplies (overpumping of groundwater)and sewage (flows are greater than the capacity at some treatment plants).

El Paso averaged 4.4 (1 is best and 5 is worst). Scores for other Texas cities include Houston (3.4), Dallas (3.2), Fort Worth (3) and Austin (3).

Despite the bad news, the City is taking firm steps to increase water use efficiency and conservation. Ordinances approved by the City earlier this year are geared at reducing per capita use by 20% to an average of 160 gallons per day by the year 2000. Conservation

measures that were OK'd include limiting lawn watering to three days a week, banning the use of water to clean streets and sidewalks, permitting summer lawn watering **only between 7 PM and 9 AM**, allowing noncommercial vehicle washing only with a bucket or hand-held hose, and requiring large water consumers to submit conservation plans.

Finally, some political analysts are saying that urban runoff may have been one of the key factors in the defeat of incumbent Suzie Azar in the May mayor's race. Azar announced a proposal to create a new urban stormwater management district that would be funded by assessing fees of only \$1 a month to property owners. The concept was widely criticized and Bill Kaigh, a statistics professor at the University of Texas at El Paso, said he is virtually certain the runoff district played a key role in the election's outcome.

San Antonio Votes to Abandon Applewhite

San Antonio citizens voted to abandon construction of the Applewhite Reservoir by a small margin in early May and the results are sending ripples throughout the region.

Slightly more than half of the voters (51.4%) voted to abandon the project. Even so, the dam may not be dead. City Council members were debating the legality of the ordinance, while the City Water Board sued the city of San Antonio to declare the election null and void. The results will leave San Antonio citizens a bill that could range from \$13 million to \$83 million to pay for land acquisitions and other expenses, even if the reservoir is not built.

Shortly after the vote, the Sierra Club released details of its lawsuit to protect endangered species that live in nearby springs. The suit asks that flows at Comal Springs be maintained at a minimum of 350 cubic feet per second (cfs). Opponents said that this level of springflow was a "scorched earth" policy that would reduce pumping to less than half of current levels and would allow no pumping during droughts. The Sierra Club wants the Fish and Wildlife Service to determine optimal springflows and to guarantee minimum flows.

Two other items need to be mentioned. Aquarena Springs in San Marcos will begin to collect waterweeds immediately after they've been cut instead of letting them float downstream. Until now, the clippings would form mats as large as 100square feet in nearby rivers blocking sunlight for underwater plants and creating a haven for snakes. Aquarena Springs arranged to borrow a boat that can be used to harvest waterweeds for a year. The boat is owned by the City of New Braunfels. In exchange, the Springs leased a glass-bottomed boat to the City of New Braunfels for a year. Also, the Alamo Water Conservation and Reuse District OK'd a master plan that includes more than \$30 million of projects that include facilities to transport wastewater to golf courses and parks and a demonstration project to determine the feasibility of groundwater storage and recovery in the Carrizo Springs Aquifer in Atascosa County.

Urban Runoff Causing Pollution Problems in Austin

Urban runoff appears to be a likely culprit for water pollution problems that are impacting the sensitive Barton Creek watershed. Fecal coliform levels have forced

officials to close Barton Springs to swimmers 10 times this spring. In addition, the springs were kept open on occasions when fecal coliform levels exceeded State standards because of delays in obtaining results of water quality tests. Austin officials believe that nonpoint source pollution, not leaky sewer lines, is causing most of the contamination.

Construction of a new freeway interchange also appears to be increasing the amounts of toxic chemicals, oil and grease, and silt which are flowing into the watershed. Because the project crosses the Edwards Aquifer recharge zone, the Texas Water Commission (TWC) required that five complex and expensive filtration ponds be built to trap the runoff. Options being considered include letting runoff flow over vegetated areas before reaching the creek, and catchment basins that trap runoff and slowly filter it through sands before releasing it into streams.

Texas Passes Oil Spill Cleanup Legislation

Legislation to create a \$50 million fund to clean up oil spills along the Texas Gulf Coast has been aigned into law by Governor Ann Richards.

The law levies a two cent per gallon tax on oil transported through Texas waters and designates the General Land Office as the primary agency responsible for coordinating the state's response to coastal oil spills. State officials say the new law will help the state to immediately respond to coastal spills.

Aquaculture Abstracts Available

Abstracts covering a variety of aquaculture topics including problems with bird predation, nutritional requirements for striped bass, results from shrimp mariculture experiments, larviculture of red drum, the feasibility of aquaculture in saline West Texas waters, and many others are available from the Texas Aquaculture Association. The papers were presented at the 1991 Texas Aquaculture Conference in Houston by researchers and extension specialists at numerous Texas universities, State and Federal agencies, and private companies. The abstracts can be obtained by contacting the Texas Aquaculture Association at 512-474-4600.

Agricultural Nonpoint Source Pollution Evaluated in Soil and Water Board Report

The impact of agricultural, rangeland, and forestry operations on water supplies and water quality in Texas watersheds is the focus of a new report from the Texas State Soil and Water Conservation Board.

The report, *A Comprehensive Study of Texas Watersheds and Their Impacts on Water Quality and Quantity*, includes specific information on land use changes, soil erosion and sedimentation, and agricultural water use for each watershed. Sections of the report focus on range and forestry issues, (including brush infestation by watershed and evaluations of brush control efforts), and the impact of agriculture on water quality. Surface and ground

water quality results for nitrates, arsenic, sulfates, and numerous pesticides are displayed and agricultural chemical use is estimated.

To order a copy of the report or the *Executive Summary*, contact the Board at 817-773-2250.

Subsidence Proceedings Now Available

Proceedings from the 4th International Conference on Land Subsidence are now available. The Conference convened May 12- 17 in Houston and was cosponsored by the Harris- Galveston Coastal Subsidence District.

The Proceedings cover such topics as the impact of groundwater pumping and oil and gas exploration on subsidence as well as earth fissures, increased coastal and inland flooding caused by subsidence, theory and modeling and instrumentation and measurement. Numerous papers on Texas' subsidence problems are included and several papers were written by Texas university scientists.

For information on ordering a copy, contact the Harris- Galveston Coastal Subsidence District at 713-486-1105.

The Water Planet Contains Striking Color Photos

Some of the most striking color photographs about water-related issues are combined with an easy to read text in *The Water Planet: A Celebration of the Wonder of Water*.

The book was written by Lyall Watson and photographed by Jerry Derbyshire. Chapters of the book include water and earth, water and life, water and science and water and history. A list of additional sources is included for those who want additional information.

The book can be ordered from the Water Information Center, Inc., at 516-249-7634.

Strategies to Manage Coastal Marshes Outlined

Strategies to manage coastal marshes are outlined in a new report produced by Southeast Texas Resource Conservation and Development, Inc. The report, *Coastal Marsh Management*, includes information on water quality, marsh soils, vegetation, and wildlife, fisheries, recreation, beach and dune management, and marsh structures. An appendix lists optimal water depths and salinity for marsh plants, plant species used for waterfowl nesting, and nesting habitats preferred by waterfowl, and wild duck plant foods. A glossary, and bibliography are also included. The report was produced with the help of the USDA Soil Conservation Service, the Texas A&M Marine Advisory Service, and Chevron, Inc. For information, contact Southeast Texas Resource Conservation and Development at 409-327-2235.

Health of Earth Ecosystem Assessed in New Reports

A number of new books assess the state of the global environment including water resources issues. *One Earth, One Future* is published by the National Academy of Sciences (phone 800-624-6242). Sections deal with the earth as an ecosystem, depletion of the ozone layer, acid rain, and the impact of global warming on food, water and sea level rises. *The Climate System* is a color pamphlet produced by the University Center for Atmospheric Research (phone 303-497-1682) that explains general hydrologic principles and the expected impact of global warming on climate change. *The State of the Environment* is published by the Organization for Economic Cooperation and Development (phone 202-785-6323) and describes issues including water resource development, water quality, drinking water, water management, marine environments, the impact of agriculture on water quality, and other issues. *Our Changing Planet* is published by the U.S. Geological Survey (703-648-4450) and describes the 1991 research plan of the U.S. Global Climate Change Research Program. Sections deal with science elements, crosscutting issues, international collaboration and education and training programs.

Beneath the Bottom Line Focuses on Groundwater Pollution

Methods to reduce agricultural contamination of groundwater are outlined in a new report by the Congressional Office of Technology Assessment titled *Beneath the Bottom Line*. The report includes basic information on aquifer contamination, technologies to improve nutrient and pest management, farmer decision-making and technical assistance programs that can reduce pollution risks, and potential policy options for the Federal government. Major Federal programs and activities that influence agricultural groundwater pollution are also outlined. The 337-page report can be ordered from the Government Printing Office at 202-783-3238.

University Research Centers Highlighted in Directory

Information on university research centers in Texas that deal with water, environmental and other issues is available in a new directory from the Texas Innovation Information Network System (TIINS). The directory, *Texas Research Centers: Higher Education*, classifies centers by the type of research they perform and features sections for research groups dealing with agriculture, the environment, engineering, biology, and other issues. Information for individual research centers includes budgets, staffing, programs and activities, equipment and facilities, and current research areas. TIINS produced the report in cooperation with the Texas Higher Education Coordinating Board and can be reached at 214-746-5140.

Sea Grant Pamphlet Focuses on Freshwater Inflows

The value of freshwater inflows to bays and estuaries and threats that may impair the amount or quality of those flows are highlighted in a new color pamphlet from the Texas A&M University Sea Grant College Program. The pamphlet also summarizes research

activities and priorities. *Freshwater Inflow: Survival in a Sea of Salt* is available from the Sea Grant program by calling 409-762-9800.

GAO Studies Examine Bottled Water Quality and Pesticide Contamination

New reports by the General Accounting Office charge that the Food and Drug Administration (FDA) is not doing enough to ensure the safety of bottled water and that the Environmental Protection Agency (EPA) is waiting too long to ban pesticides that threaten drinking water quality. In one report, *Stronger FDA Standards and Oversight Needed for Bottled Water*, GAO says the FDA has not adopted all the healthbased EPA public drinking water standards that set maximum levels for contaminants. As a result, bottled water and mineral water may contain pollutants that are not allowed in public drinking water. Benzene was found in Perrier last year. GAO also criticized the accuracy of bottled water labels. In another report, *EPA Could Do More to Minimize Groundwater Contamination*, GAO charges that EPA acts far too slowly in reviewing scientific studies that assess a pesticide's potential to pollute groundwater. As a result, many pesticides that pose environmental and health risks are allowed to cause pollution while they are still under study.

The reports can be obtained from the GAO, P.O. Box 6015, Gaithersburg, MD 20877.

New TWRI Reports Include Pesticide Impacts, Rural Water Systems, Researcher Directory

Two new technical reports dealing with rural water systems management and the impact of pesticides on aquatic communities and a new computerized database of water researchers at Texas universities are available from TWRI.

Freshwater Community Responses to Mixtures of Agricultural Pesticides: Synergistic Effects of Atrazine and Bifenthrin (TR-151) was co-authored by Ray Drenner of Texas Christian University and Kyle Hoagland of the University of Nebraska. The report describes the results of a study to determine the impacts of pesticide runoff on aquatic species using field experiments (see the Abstracts section of this newsletter for details).

On Managing Texas Rural Water Systems: A Socioeconomic Analyses and Quality Evaluation, was written by R.N. Singh of East Texas State University. The report describes socioeconomic procedures that can be used to measure the operation of rural water systems. The report includes case studies that evaluate the performance and customer perceptions of selected rural water systems and analyzes sociodemographic conditions of such systems throughout the State.

Water Related Researchers at Texas Universities is a directory developed by Ric Jensen, Mark Barnes, and Lisa McClain of TWRI. The directory is now available on diskette for Macintosh computers and operates using the FileMaker Pro software program. The directory allows users to search by key words, institutions, locations and individual scientists. A printed version will be available shortly.

To order any of these items, contact TWRI at 409-845-1851.

New TWC Studies Deal With Dam Safety, Pesticide Disposal, Education Programs

A number of new reports dealing with topics including dam safety, pesticide disposal, educational programs, and wastewater treatment are available from the Texas Water Commission (TWC).

Guidelines for Operation and Maintenance of Dams in Texas includes information on dam safety, measures to reduce the consequences and likelihood of dam failures, guidelines for inspecting, maintaining, and monitoring dams, and emergency action plans.

Results of a pilot program in West Texas to encourage agricultural producers and others to safely dispose of pesticides and other chemicals are summarized in *The Texas Pesticide Amnesty Day Program*. Educational activities that can be used in public schools are highlighted in *The Water Education in Texas Instruction Handbook*. Basic water quality information, and seven suggested activities are described.

Operation and Maintenance Guide for Imhoff Tank and Oxidation Pond Wastewater Treatment Plants is intended to help small communities manage such facilities. State agency efforts to protect aquifers are summarized in *Activities of the Groundwater Protection Committee*.

Numerous reports on lake and river quality have also recently been published by the TWC.

International Falcon Reservoir and Its Rio Grande Headwaters(IS91-02) includes information on nutrients, physical and chemical parameters, heavy metals, and pesticides in water, sediment and fish samples. *Analysis of Fish Kills and Associated Water Quality Conditions in the Trinity River: Assessment of Biotic Integrity* (LP 91-03) summarizes the results of surveys conducted in 1987-88 that compare water quality during ambient conditions and "black rise" events when fish kills occurred. *Guadalupe River Toxicity Assessment* (LP 91-04) assesses the potential impact of a wastewater treatment plant near Victoria on the river, while the *Intensive Survey of the Leon River*, (IS 91-01) was conducted in 1988 to collect water quality data from 19 sampling stations and tributaries.

To order any report, contact the TWC at 512-463-7834.

The TWC has also begun publishing a newsletter called *Texas Watch* that describes efforts to monitor water quality in rivers. Call 512-239-4720 for details.

Controlling Hydrilla is Aim of SFA Study

Almost half of Nacogdoches Reservoir is heavily infested with hydrilla, a submerged waterweed that grows rapidly and makes lakes unnavigable for boaters and unusable by fishermen.

Biologists at Stephen F. Austin State University (SFA) are assessing the impact of controlling the waterweed by drawing down the water level of the reservoir by nine feet annually. Biologist Jack McCullough is working with SFA graduate students to see if drawing down the reservoir during winter months will kill much of the plant growth by exposing it to freezing temperatures. Turbid spring waters may also limit plant growth.

McCullough says the object is to control the spread of hydrilla, not eliminate it, because the weed helps reduce nutrient levels and provides habitat for bass and other fish. Drawing down the reservoir may be preferable to introducing grass carp or using herbicides to control the hydrilla. Grass carp often remove all the waterweeds from a reservoir and this can result in higher levels of nutrients, phytoplankton, suspended solids, and increased odor and taste problems. The absence of aquatic vascular plants also decreases populations of game fish like the black bass.

McCullough and Kathryn Phillips collected one year of water chemistry data from the lake before it was drawn down. At the same time, Michael Prater collected one year of data on benthic macroinvertebrates in the lake and information on species diversity, evenness, richness, and community ordination. A taxonomic list of species that were collected was compiled. Data from the studies will be compared to information collected after the reservoir has been drawn down and refilled.

For details, contact, Jack McCullough, Biology Dept., Stephen F. Austin State University, Nacogdoches, TX 75962 or call 409-568-3601.

SW Texas Scientists Seek Links Between Caddis Fly Populations, Stream Temperatures

Because springs maintain near constant warm temperatures, biologists at Southwest Texas State University believe they could provide key clues to the life history and reproduction of caddis flies.

Caddis flies are four winged insects often found near rivers, streams, and springs. The number of generations produced each year is thought be strongly influenced by stream temperatures and other factors.

To compare the role of different stream temperatures, biologists Tom Arsuffi and Sidne Tiemann collected caddis flies from the San Marcos River, Honey Creek in Comal County, and the Guadalupe River during 1989 and 1990. The San Marcos River and Honey Creek displayed near constant temperatures of 70 to 75deg. F. in part because they are influenced by nearby spring discharges. Temperatures in the Guadalupe River varied from 60 to 42deg. F. One species was found that occurs in all three streams. Twenty-three species were identified and three species were common to at least one stream.

Results suggest that the year-round warm waters of spring-fed streams allow for growth and development of caddis flies throughout the year. As many as seven generations of caddis flies are possible annually in spring-fed rivers. In the Guadalupe River, however, year-round development of caddisflies depends on the number of winter days with warm

air and water temperatures. The researchers also hope that follow-up studies under controlled conditions can provide more accurate data on the relationships between caddis fly populations and stream conditions.

For details, contact Tom Arsuffi, Biology Department, Southwest Texas State University, San Marcos, TX 78666 or call 512-245-2329.

New Centers Will Aid Water Research at Texas A&M-Galveston

Two new research centers will provide a focus for water research at Texas A&M University at Galveston.

The Institute of Marine Life Sciences was approved by The Texas A&M University System Board of Regents in March. The Institute will work with scientists in marine ecology, conservation biology, environmental chemistry and toxicology, mariculture, marine policies and other issues. Researchers from Texas A&M University at Galveston, Texas A&M University, and Corpus Christi State University will be eligible to participate in the Institute's activities. For details contact Randall Davis in the Marine Biology Department at 409-740-4528.

The Texas Institute of Oceanography is a new research center that will focus on such issues as the impact of global climate change on the Gulf of Mexico and coastal areas, the impact of man's activities on Galveston Bay, marine life studies including efforts to protect endangered and threatened species, and marine and coastal management and policy issues. William Evans was recently named President of the Institute. For more information, contact: Texas Institute of Oceanography, Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX 77550 or call 409-740-4406.

Search for Nonpoint Source Pollutants Underway at Corpus Christi State

If you see someone standing kneedeep in mud or water in Corpus Christi this summer, there's a good chance they may be part of a team from Corpus Christi State University (CCSU) that's trying to learn more about nonpoint sources of pollution.

Alan Berkebile, Sherri Smith, and undergraduate students in the CCSU Geology Department are now working with the City of Corpus Christi to locate, map, and inventory all of the stormwater outlets and discharge points in the region. The project includes visually inspecting bays, creeks and rivers for noticeable signs of pollution, gathering information on land uses, and describing the condition of stormwater outfalls. Once the initial mapping is completed, runoff sampling will be conducted during dry and wet weather periods.

So far, the monitoring has trekked to such diverse locations as the concrete sea wall in downtown Corpus Christi to waist deep gumbo and muck along the snake and reed-infested banks of coastal creeks. The efforts have paid off--more than 200 previously unmapped stormwater outfalls have been located so far.

The information CCSU develops will be used as the initial phase of a comprehensive study conducted by local and regional governments and private consultants to identify sources of nonpoint source pollution and urban runoff. Results will be entered into a computer database. Eventually, the information will be used to develop a stormwater quality and quantity management plan to help Corpus Christi comply with EPA regulations.

For details, contact: Alan Berkebile, Geology Dept., CCSU, 6300 Ocean Drive, Corpus Christi, TX 78412 or call 512-994-2358.

Effectiveness of Immunoassays Evaluated at TAES-Temple

Low cost, quick, and easy to use methods to screen surface and ground water samples for pesticides and other pollutants called immunoassays are now being evaluated at The Texas Agricultural Experiment Station (TAES) Blackland Research Center in Temple.

Dennis Hoffman, who heads the Center's analytical lab, has been working with the tests along with Anthony Owen, a high school teacher in Temple who's now on a sabbatical with the Center.

Immunoassay kits have been developed for many pesticides including atrazine. Commonly used atrazine tube kits require only four drops of water and the tests take only 10 minutes to conduct. Each kit costs roughly \$150 and can be used for up to 16 tests. Results can be interpreted visually to detect levels of atrazine as low as 0.5 parts per billion (ppb). Lab tests at Temple are showing that the immunoassays can be even more precise and can spot levels as low of 0.3 ppb. Hoffman and Owen are also using the test to sample area streams and groundwater supplies for the presence of atrazine and other chemicals.

There are some concerns, however, about whether or not uniform results will always be obtained. Because the immunoassays use visual keys, the color perception of the person conducting the test may influence the results. Also, the tube kits do not differentiate from 12 triazines that may be confused with atrazine.

For details, call Dennis Hoffman at the Center at 817- 770- 6600

Texas A&M Developing New Oyster; Assessing Economics of Catfish Farms

Developing a new breed of oyster that grows fast and is unattached and assessing the viability of catfish farms are among two aquaculture projects sponsored by The Texas A&M University System.

Leonard DiMichele, a researcher in the Wildlife and Fisheries Department at Texas A&M University, is working with Sammy Ray of Texas A&M University at Galveston % to develop a domestic strain of 1 oysters that are clutchless. In other words, these oysters would not have to attach themselves to materials on the sea floor in order to grow. This

would allow aquaculturists to cultivate and raise oysters in facilities where the water quality could be controlled and away from bays that may be impacted by pollution and disease. DiMichele is also working to help develop oysters that would have twice the meat of regular oysters and that can reach market size in 9 a year. Faster growing oysters can avoid a fatal oyster disease called dermo which is found in the Gulf of Mexico and other open waters. For details, contact DiMichele at 409-845-5793.

In another project, Wade Griffin, Ron Lacewell and Johannes Lambregts of the Agricultural Economics Department are working with James Davis of the Texas Agricultural Extension Service to develop a model farm for catfish production.

Goals of the project include determining the minimum market price necessary to make catfish farms economically viable estimating the economic impact of large catfish processing plants in South Texas and the Gulf Coast region, and projecting consumer demands for fillets and whole catfish. The project should help define which conditions are necessary to make catfish aquaculture economically viable and could accelerate the rate at which such operations are developed in Texas. For details, contact Griffin at 409-845-5222.

TCU Study Shows Satellite Images Are Useful in Mapping Paved Surfaces

Researchers at Texas Christian University think you can get a better idea of the amount of paved surfaces (parking lots, streets, and rooftops) and runoff pollution by looking to the skies.

Ken Morgan of TCU's Center for Remote Sensing has been using Landsat satellite to measure the amount of impervious surfaces in Fort Worth watersheds. In the past, the only way to estimate paved areas was by using aerial photographs or field surveys. These methods were time consuming, labor intensive and costly. In contrast, analyzing Landsat images with computerized Geographic Information Systems is quicker, less costly and takes advantage of data analysis capabilities.

In a recent project, Morgan utilized a Landsat image of the Upper Sycamore Creek watershed in Fort Worth from January 1985 (a winter image was selected because trees are barren and more paved surfaces show through). The image was manipulated and enhanced so that paved surfaces, waters, vegetated areas and bare soils could be identified by their color spectral signatures. Results were then compared to previous analyses of impervious cover performed on the same watershed with aerial photography and field surveys. Use of the Landsat images was estimated to be more than 90% accurate in mapping impervious surfaces. Results also show that 28% of the watershed was comprised of paved surfaces, an increase of 60% in seven years. This technology could also be used in follow-up studies to estimate nonpoint source pollution.

The research was featured in the September October 1990 issue of the *Journal of Soil and Water Conservation*. For details, contact Morgan at 817-921-7273.

Safety of Proposed Low Level Radioactive Waste Site Evaluated by UT

Scientists at the Center for Research in Water Resources (CRWR) at The University of Texas at Austin have spent much of the past two years modeling what many would consider unthinkable the impact of radioactive contamination on Texas' water supplies.

The studies are needed to evaluate whether a site 40 miles southeast of El Paso is appropriate for a low level radioactive waste disposal facility. The analyses were headed by CRWR Director Randall Charbeneau and Nolan Hertel of the Mechanical Engineering Department.

One part of the study evaluated ways that radioactive wastes could be released into the environment if concrete cannisters holding the wastes failed. In the study, the cannisters were assumed to fail after 100 years while other wastes were assumed to be released into the environment after 300 years. Ways that the wastes could then pollute surface and ground waters were examined. Other aspects of the study included projecting the dosage of radioactivity the general population could be exposed to under various circumstances and modeling potential pathways of radioactive contamination into the environment.

Results suggest that the dry climate may greatly reduce the risk of pollutants leaching to aquifers or running off into surface waters. This makes the West Texas region attractive for storing low level radioactive wastes.

For details, contact: CRWR, Balcones Research Center, Austin, TX 78712 or call 512-471-3131.

Texas Tech, UT Researchers Evaluate Impact of Pantex Site on Water Pollution

Assessing the impact of the U.S. Energy Department's Pantex nuclear weapon assembly plant on ground and surface waters is the focus of a new multidisciplinary research program by scientists at The University of Texas at Austin and Texas Tech University.

Pantex assembles nuclear and conventional weaponry at a site near Amarillo and has been linked to pollution problems in the region. Until now, wastewaters from the plant have been discharged to a single playa lake. Previous studies have shown that water and contaminants can seep downward from that playa toward the Ogallala Aquifer.

Scientists with UT's Bureau of Economic Geology (BEG) are integrating high resolution seismic geophysical surveys and data on existing wells to map the subsurface geology of the region. Geologic, hydrologic, and geochemical data are being collected and synthesized and will be used to help model groundwater flows and pollutant transport. Alternative methods of restoring groundwater quality are also being evaluated.

In one part of the project, Texas Tech researchers are examining the transport of contaminants into groundwater supplies. Wastewater flows entering playa lakes will be measured and an inventory of contaminant sources and sinks will be compiled. Soil cores

will be analyzed to determine groundwater pollution risks. Texas Tech is also measuring the ability of playa lake ecosystems to assimilate pollutants. To see if playa lake vegetation biologically remove and degrade pollutants, water quality flowing into and out of lakes will be compared. First, organisms living near playas will be inventoried and water quality will be measured. Later, tanks will be filled with playa soils and vegetation and will be exposed to pollutants. UT researchers Tom Gustavson and Marcus Milling of the BEG played key roles in the study. Texas Tech scientists involved in the project include Ken Rainwater, Lloyd Urban, Billy Claborn, R. Heyward Ramsey, and Tony Molihaugen of the Civil Engineering Department, John Borrelli of the Agricultural Engineering Department and Hal Schramm of the Range and Wildlife Management Department.

More details on UT's role in the project can be obtained by calling the BEG at 512-471-1534. The project was featured in the January 1991 newsletter of the Texas Tech Water Resources Center. For more information, call 806-742-3597.