



Volume 3, Number 1, March 1990

Computer Models Mimic Groundwater Management Plant Water Use

Three new easy to use Macintosh computer programs have been developed by scientists at Texas universities to simulate groundwater pollution and cleanup, aquifer management, and water use by plants and crops.

Sources of information are listed at the end of this article. In future issues we'll present more information on simulation models and other computer management tools. If you have information that you would like to submit on waterrelated computer models being developed at Te universities, please write to us and we'll try to publicize them in future issues.

OASIS is a decision support system that helps users calculate DRASTIC ratings (DRASTIC is a method to assess the potential vulnerability of aquifers to pollution). Details about DRASTIC were published in past issues of *New Waves*.

OASIS links databases dealing with such subjects as hydrology, hydrogeology, chemicals, and pollutant sources. Extensive online help is provided and one of the best features of OASIS is that it's user friendly. The program contains many illustrations. Choosing an icon often takes the user to another part of the program with more details.

OASIS is also linked to analytical and numerical models. Information developed by using DRASTIC can be imported into models such as BioPlume 11 (which simulates the effect of using bacteria to clean up polluted aquifers) and models that depict pollutant transport and remediation efforts.

Researchers at Southwest Texas State University have been collaborating with scientists at the University of Texas at Austin to determine if groundwater management models originally developed for workstations can be adapted for use with the Macintosh.

Nisai Wanakule of Southwest Texas State and Larry Mays (formerly Director of the Center for Research in Water Resources at the University of Texas at Austin) developed a model called **GWMAN** (see the abstracts section of this issue for more information on this program) that can be used to determine optimal pumping and recharge rates for aquifer systems. GWMAN can be utilized for such diverse purposes as determining the total maximum pumpage that can occur while maintaining water levels within the aquifer

at a constant rate, and creating a cone of depression so that hydrocarbons and other pollutants will be confined to a particular area and won't migrate to and contaminate other regions. Other potential uses include determining optimal groundwater yields while maintaining springflow.

The researchers compared results that were obtained by running the program on a workstation and a Macintosh. Results suggest that the model can be run successfully on the Macintosh, although it runs somewhat slower than on the workstation.

McStress is the name of a simulation model that was developed by Keith McCree (professor emeritus of the Soil and Crop Sciences Department at Texas A&M University). This program allows users to simulate plant growth as it's affected by water availability and drought stress. Complex processes including water stress, the soil water balance, air temperature, solar irradiance, evaporation, transpiration, energy balances, photosynthesis, carbon balances, biomass growth, rates of new leaf production and others can also be calculated. McCree also developed a hypercard application titled **Exploring Crop Physics** that breaks down the individual components of the McStress model into separate stacks.

For More Information

OASIS Bedient, Philip, G. Anthony Gorry, Charles Newell, John Haasbeek, Loren Hopkins, Sarah Alder Schafer, and Hanadi Rifai, *OASIS: Parameter Estimation System for Aquifer Restoration Models* (CR- 814495), Rice University, Houston, TX, 1989. Contact: Philip Bedient, Environmental Sciences and Engineering Dept., Rice University, PO Box 1892, Houston, TX 77251 or 713- 527- 4951.

GWMAN Wanakule, Nisai, and Larry Mays, "A Groundwater Management Model for the Macintosh Microcomputer," Presented at the American Society of Civil Engineers 16th Water Resources Specialty and Management Conference titled "Water Resources for the Future: the Management Challenge," Sacramento, CA, May 1989. Contact: Nisai Wanakule, Edwards Aquifer Research and Data Center, SW Texas State University, San Marcos, TX 78666 or call 512- 245- 2329.

McStress and **Exploring Crop Science** McCree, Keith, and C.J. Fernandez, "Simulation Model for Studying Physiological Water Stress Responses of Whole Plants," *Crop Science*, Madison, WI, March- April, 1989. Contact: Keith McCree, Soil and Crop Sciences Department, Texas A&M University, College Station, TX 778432474 or call 409845- 3041.

"White Christmas" Not So Pleasant for Water Suppliers, Users

Impacts Include Frozen Pipes, Loss of Citrus Crops

Although the idea of a "white Christmas" may sound romantic, talk to Texas water managers and you may get a much different idea.

The Christmas freeze that swept through much of the state left a trail of havoc in its wake and disrupted the Edwards Aquifer, nuclear power, citrus production, and other diverse water-related activities.

Preliminary statewide estimates placed a price tag of \$645 million on the big chill. In Dallas, property damage from burst water pipes was expected to top \$25 million while in neighboring Fort Worth more than 4,000 people were temporarily without water .

In Houston, thousands of city residents found themselves without water and coped by taking sponge baths with bottled water and flushing toilets filled with water from nearby swimming pools. Many of those who lived in areas where the pipes remained intact suffered from low water pressure caused by other Houstonians who left their faucets dripping to avoid frozen pipes. Pipes also froze at the "disaster proof" South Texas Nuclear Project, which was designed to withstand earthquakes and terrorist attacks but apparently not cold weather. Fortunately, the pipe breaks resulted in no contamination.

Mike Erdman, the consumer supervisor for the Austin Water Department, said more than 350 water mains sprung leaks and damages were projected to be "hundreds of thousands" of dollars. "Most of the leaks from broken mains and pipes in the central part of the city that were laid 40 to 50 years ago," Erdman said, "because they were made of cast iron which isn't as flexible as the new materials. They've expanded and contracted so much over their lifetime that they became brittle and a hard freeze like this one was more than they could withstand." Erdman also noted that because many fire hydrants used in Texas aren't designed for cold weather, the hydrants actually froze, transferred the cold into the pipes and mains beneath them, and actually caused some of the mess.

In San Antonio, workers had to sand several icy streets after lawn sprinklers broke and leaked water that quickly froze. The level of the Edwards Aquifer dropped more than a foot in one day, in part because people kept their faucets running.

Finally, frigid temperatures as low as 15deg. in the Rio Grande Valley caused an estimated \$500 million in damages to the region's citrus, fruit and vegetable industry. The long term impact of those losses is not yet known.

Influence of 'Naturally Occurring' Methane on Texas Aquifers

Researchers: Ethan Grossman and B. Keith Coffman, Geology Dept., Texas A&M University, College Station, TX; Steven Fritz, Earth and Atmospheric Sciences Dept., Purdue University, West Lafayette, IN; and Hideki Wada, Institute of Geosciences, Shizuoka University, Shizuoka, Japan.

Problem: Methane is found in many aquifers in eastern Texas often resulting in high levels of hydrocarbons. The source of methane in these groundwater systems is often difficult to determine. Origins may include migration into an aquifer through leaks in well casings used for oil production, bacterial methane from landfills or other aquifers,

and natural causes. Efforts are needed to determine the causes of methane and its impact on groundwater quality.

Objectives: 1) To utilize the stable isotope ($2\text{H}/1\text{H}$, $13\text{C}/12\text{C}$) and chemical composition of hydrocarbons to determine the origin of methane in aquifers; 2) to utilize $13\text{C}/12\text{C}$ ratios in bicarbonate to determine if high bicarbonate contents in waters result from methane production or oxidation.

Methodology: Gas- rich water was sampled from aquifers in Robertson, Brazos, and Burleson counties in east Texas at depths ranging from 78 to 2,000 feet. Carbon isotopes and the proportion of ethane and higher hydrocarbons to methane were used to distinguish hydrocarbons of different origins. Carbon isotopes in dissolved bicarbonate were employed to determine the impact of methane production or oxidation on bicarbonate content in Texas aquifers. Chemical and isotopic analyses were also performed on gaseous hydrocarbons from two gas production wells in Brazos County located near sources of gas- rich water.

Results and Discussion: Methane- bearing gas was detected in 16 of the 45 wells sampled. Ethane was the only other hydrocarbon detected in these gases. Occurrence of the methane did not correlate with oil production wells or landfills. Isotope ratios suggest that methane originated from bacterial processes in the aquifer, and that these processes are responsible for high bicarbonate contents in these waters.

Reference: Grossman, Ethan, B. Keith Coffman, Steven Fritz, Hideki Wada, "Bacterial Production of Methane and Its Influence on Groundwater Chemistry in East- Central Texas Aquifers," *Geology*, vol. 17, pp. 495- 499, Boulder, CO, June, 1989.

Analyzing Costs and Benefits of Reservoirs

Researcher: John Merrifield, Economics Dept., University of Texas at San Antonio, San Antonio, TX. Problem: Although water development projects involving federal funds must undergo benefit- cost analyses, such studies do not have to be performed for dams built without federal monies such as the proposed Applewhite Reservoir near San Antonio. Such analyses are needed to evaluate the desirability of the project.

Objectives: To estimate net benefits and to identify scenarios in which the ratio of benefits to costs is greatest.

Methodology: The study utilized conservative cost data (present costs represented actual costs) and benefits were calculated on an average annual yield of 48,000 acre feet (AF). Value of the water subject to climate conditions (water would in theory be worth more when yields were low and vice versa) were not considered. Indirect benefits (lower groundwater pumping costs and increased springflows in some years) and environmental costs (lost opportunities to utilize flooded lands for other purposes) were also not analyzed. Analyses did include the economic value of water from the project (how much are people willing to pay for a set amount of water) and estimates of benefits and costs under different scenarios including water conservation measures.

Results: A cost of \$317/AF was established as an indicator of the value of additional supplies based on the sales of 170,627 AF of groundwater to metered customers for \$54.1 million in 1988 (a year the region was affected by drought). As a comparison, the direct cost of pumping groundwater from the Edwards Aquifer by the City Water Board was estimated at \$62/AF. The study specifically addressed whether the value of water in the region would be high enough to justify producing it from Applewhite Reservoir. The study estimated increases in water demand at rates including 1.1%, 1.3% and 1.78% per year and compared them to the cost of developing water by constructing Applewhite. Results suggest that even under "bestcase" conditions only \$0.88 will be returned for each \$1 invested over the life of the project. The study recommends the reservoir should not be built until after the year 2010 or until customers willingness to pay is greater than or equal to present costs. The study points out that people may be willing to pay high prices for drinking water but that people will be less willing to pay large amounts for supplemental water to facilitate additional landscaping and other uses.

Reference: Merrifield, John, "A Benefit Cost Analysis of the Proposed Applewhite Reservoir." This paper is scheduled to appear in Auber's Research in Business and Economics Working Paper Series later this year. To get a copy of the paper, contact the author at: Economics Dept., UTSan Antonio, 78285.

Groundwater Optimization Models for Barton Springs and the Edwards Aquifer

Researcher: Nisai Wanakule, Edwards Aquifer Research and Data Center, Southwest Texas State University, San Marcos, TX.

Problem: The Barton Springs/Edwards Aquifer is a 155 square mile limestone aquifer which is located in northeast Hays County and extends into the southern part of Travis County. Barton Springs is the major discharge point and has a mean flow of 50 cubic feet per second (cfs) or 36,000 acre feet per year (AF/year). In 1981, the total pumpage from wells was estimated to be 1,238 million gallons or 3,800 AF which is about 10% of the mean annual recharge. Aquifer pumpage provides water supplies for agricultural and livestock operations, industrial and commercial uses, and public and private drinking water for more than 10,000 people. Investigations by the U.S. Geological Survey (USGS) and the City of Austin in 1985 raised concerns that springflows and water levels could be decreased if pumping from the aquifer reached excessive levels.

Objectives: Development of a groundwater management model for the Barton Springs-Edwards Aquifer using the Groundwater Management (GWMAN) code.

Results and Discussion: USGS data from 1981 were utilized and simulations were run. The model determined the maximum total pumpage of all existing wells during that year, subject to actual physical conditions and maintaining minimum springflows at Barton Springs at 25 cfs. Results suggest that the size of the dewatered area (areas that may run out of water if pumping exceeded aquifer levels) and not minimum springflows was the main factor limiting groundwater pumping. Two case studies were developed that simulated different amounts of dewatering . The optimum yield would be nearly 9,000

AF if a large area were allowed to become dewatered, but would drop to 5,000 AF if a smaller dewatered area were desired. The model also compared optimal pumping rates for cities and water districts in the area.

Reference: Wanakule, Nisai, *Optimal Groundwater Management Models for the Barton Springs- Edwards Aquifer (EARDC RI- 89)*, Edwards Aquifer Research and Data Center, Southwest Texas State University, San Marcos, TX, March 1989.

Sand Transport and Erosion Near Rollover Pass

Researchers: Jerad Bales and Edward Holley, Civil Engineering Department, University of Texas, Austin, TX.

Problem: Rollover Pass, built in 1954, is a manmade, artificially stabilized inlet situated on Bolivar Peninsula at the east end of Galveston Island. Throughout the life of the project, there have been concerns about the effects of the pass on beach erosion. Relatively few studies have compared the effect of different methods to predict sand transport through passes and the resulting effects on predicted beach erosion.

Objectives: To compare rates of sand transport as derived from the longshore transport, excess beach erosion, the amount of dredged material, and direct measurements.

Methodology: Net longshore transport was calculated. Beach erosion was estimated by comparing how shoreline positions have changed by analyzing aerial photographs taken from 1930 to 1984. Data on the amount of sediments that were dredged from the Gulf Intracoastal Waterway (GIWW) were obtained from the U.S. Army Corps of Engineers and dredging rates for the periods before and after the pass was built were compared. Sediment samples were collected in the pass to determine rates of sediment transport.

Results: Net longshore transport was estimated at 75,000 to 115,000 cubic yards per year. Results suggest that the pass causes 9,000 to 26,000 cubic yards of excess erosion per year (if it is assumed that 5 to 25% may be trapped by the inlet, transport rates would be 3,800 to 29,000 cubic yards per year). A 5,300 foot area southwest of the pass is most affected. Much of the sediment transported to the pass maybe deposited in the GIWW. Increased rates of dredging since the pass was built suggest that transport rates are 240,000 to 290,000 cubic yards per year through the pass. Limited direct transport measurements were consistent with these rates.

Reference: Bales, Jerad, and Edward Holley, "Sand Transport in Texas Tidal Inlet," *Journal of Waterway, Port, Coastal and Ocean Engineering*, New York, NY, Vol. 115, No. 4, July, 1989.

Impacts of Dams on Sediment Transport and Erosion

Researchers: P.M. Allen, Geology Department, Baylor University, Waco TX; R. Hobbs, Geological Science Department, University of Southern California, Los Angeles, CA; Nathan D. Maier, Consulting Engineers, Inc., Dallas, TX.

Problem: Dams have been shown to cause extreme changes in stream hydrology and sediment transport. Before dams are built, sediments that could cause deltas to form are flushed through river systems in periodic floods. Each system was self cleansing because delta forming sediments were transported downstream. However, deltas often form in river systems downstream from dams because tributary flood flows lose velocity and flow depth. Other impacts **can include changes in** river gradients, meander patterns, and channel dimensions. Analysis of such downstream changes has been limited by a lack of theoretical and quantitative models to simulate some of the processes and by impractical data requirements for some of the existing models.

Objectives: To describe some of the complex adjustments that have taken place downstream of Whitney Dam near Waco, TX, and to formulate recommendations and methodologies to minimize delta buildup in the future.

Methodology: A 22- mile stretch of Lake Whitney Dam was selected for analysis. Data suggest that Whitney Dam has reduced 2- year flood flows of the Brazos River from 36,000 cubic feet per second (cfs) to 11,700 cfs. Maximum floods have been reduced from 71,800 cfs to 58,200 cfs. A two- dimensional model was also utilized to describe sediment transport, velocity and motion. Utilizing the model, a normal discharge of 1,700 cfs was maintained on the Brazos River and a flood flow of 1,900 cfs was simulated for Coon Creek. The model provided information on flow velocities, flow direction and water elevation and resulted in the identification of four distinct hydraulic regions including low velocity zones, flow deflection zones, deceleration zones, and flow recovery zones. Delta growth and streambank erosion were analyzed utilizing historical aerial photographs and management alternatives were evaluated and rated by local landowners, engineers and contractors.

Results: Results from the model simulations suggest that deltas initially form where the flow deflection, low velocity and deceleration zones converge. Delta growth in alluvial sections of the Brazos River and cutbanks associated with river meanders were identified as areas most vulnerable to erosion. Management measures identified as most likely to control channel and bank losses were constructing dams to prevent downstream transport of sediment flows and mining tributary deltas and sediment bars in the Brazos River. It was also recommended that guidelines be developed to control development along erosion prone areas.

Reference: Allen, P.M., R. Hobbs, and Nathan D. Maier, "Downstream Impacts of a Dam on a Bedrock Fluvial System, Brazos River, Central Texas, *Bulletin of the Association of Engineering Geologists*, Lawrence, KS, Vol. 26, No. 2, 1989.

Excessive Chlordane Levels Present in Fish Samples from Upper Trinity River, Austin

Two new reports show that high levels of chlordane have been found in fish samples taken from the Trinity River in the Dallas- Fort Worth area and from Town Lake in Austin. As a result, part of the Trinity River has been closed to public fishing and Austin residents are being advised not to eat certain fish species taken from Town Lake.

According to a new 200- page Texas Water Commission (TWC) report, *Use Attainability Analysis of Trinity River Segment 0805*, chlordane levels in nine fish samples taken from the river in the DallasFort Worth area exceeded the U.S. Food and Drug Administration action level of 0.3 milligrams per kilogram (mg/kg). Chlordane was utilized to control termites before being banned by the EPA in 1988 and is highly persistent. It accumulates in river sediments and some aquatic organisms. The report suggests the most likely source of chlordane was urban or suburban runoff. Signs have been posted in Dallas and Fort Worth warning fishermen not to eat fish from the vicinity. The City of Fort Worth, which stocks trout in the Trinity near downtown, says the trout it puts in the river are safe to eat because they are in the river for only a short time. For details, contact: Jack Davis, Water Quality Division, TWC, PO Box 13087, Capitol Station, Austin, TX, 787113087 or call 512- 463- 8474.

In Austin, concerns are being raised about the safety of eating fish caught from Town Lake. A report titled *Pesticides and Other Contaminants in Water, Sediments and Fish Tissues in the Lower Colorado River of Texas* noted that roughly 15% of the fish sampled from Town Lake contained excessive chlordane levels. As a result, residents are advised to not eat carp, shad and striped bass taken from Town Lake and persons

who regularly ate fish from the lake over the past two years are being told to stop eating all fish caught from the lake. Details on this report, which was written by the Lower Colorado River Authority, the Texas Parks and Wildlife Dept., the Texas Department of Health, the Austin- Travis County Health Department and the Texas Water Commission, is available from: Resource Protection Div., Texas I Parks and Wildlife Dept., 4200 Smith School Rd., Austin, TX 78744 or by calling 512389- 4726.

Fish and Wildlife Service, Private Groups, Announce Plans to Protect Playa Lakes

A plan to preserve 25,000 playa lakes in Texas and four other states has been announced by the U.S. Fish and Wildlife Service, the National Wildlife Federation and private groups.

The \$1.3 million plan, the "Playa Lake Joint Venture," will fund purchases of land and water rights and will encourage land owners to enact measures to protect habitat for migratory birds such as ducks. Phillips Petroleum will contribute \$125,000 annually through 1994 and that amount will be matched collectively by the five states. Roughly 95% of all playa lakes are now privately owned.

Playa lakes are basins that flood temporarily and serve as habitat for 32 species of ducks, geese, swans and other birds during their regular spring and fall migrations.

Environmental Group Wants to Make Houston Ship Channel a "Toxic Hot Spot," Sends EPA Dead Fish to Protest

Texas Clean Water Action (TCWA) wants the Environmental Protection Agency (EPA) to put Houston Ship Channel on a toxic "hot spot" list that could require tight controls on

industrial pollution. To make their point, they sent a packet of dead fish to EPA's Dallas office as a protest.

TCWA was prompted to send the dead fish after EPA regional water quality chief Myron Knudson was quoted as saying an "occasional fish kill" in the ship channel now is a mark of progress. Previously, the channel was too polluted for any fish to live there. Now that water quality has improved, fish are often able to live in the channel although some fish kills still occur. Mary Ann Neely, a TCWA spokesperson, responded that she didn't accept dead fish as symbol of water quality progress in the channel.

A report issued last year showed that industries discharged 150 million pounds of pollutants, many of them toxic, in 1987. EPA is now inventorying industrial releases of toxic pollutants into the channel and TCWA has begun a study to determine which industries are violating their discharge permits.

A Texas Water Commission (TWC) spokesman said that even if the ship channel were placed on the list, nothing would be done that isn't being done already. Current actions include issuing stringent discharge permits, enforcing water quality standards, and developing water quality protection measures which could come on line in 1991.

Brackish Groundwater to be Used Instead of Drinking Water at El Paso Laundry

An El Paso laundry has announced that it wants to use roughly 320,000 gallons of brackish groundwater a day in place of drinking water. Brackish water is too salty for drinking and is mainly used now only for industrial purposes.

The facility, Economy Laundry, Inc., is the first in El Paso to exploit underground pools of salty water rather than tapping into the city's water supply. One motivation is economics - it now costs the plant \$18,000 per month in water bills while the brackish groundwater would be free except for pumping costs.

However, a Texas Water Commission spokesman said community service was also another motive. He said the laundry's owner was concerned about water supplies in the area and wanted to do his part to conserve them.

TWC Brokers Compromise in Edwards Aquifer Lawsuit, Legal Fees Top \$1 Million

Officials with the Texas Water Commission (TWC) have proposed a settlement for the Guadalupe Blanco River Authority's (GBRA) lawsuit over regulation of the Edwards Aquifer.

The draft proposal calls for dividing the aquifer into three regulatory districts: a western district would cover Uvalde and Medina counties; an eastern district would include Hays and Comal counties and a separate district would be created for Bexar County in San

Antonio. Under the proposal, each district would regulate its own amount of water usage and the TWC would referee any disputes between the three entities.

The plan has met with resistance from New Braunfels and Comal county officials because it sets the acceptable aquifer level at 612 feet above sea level - that's a level at which Comal Springs would go dry. "Spring flow is the whole ball game," said GBRA General Manager John Specht. "We are concerned that Comal Springs does not go dry."

Meanwhile, a San Antonio newspaper reported that legal fees associated with the lawsuit have topped \$1 million in the last six months. The biggest spenders were the City of San Antonio (\$371,000) followed by the San Antonio City Water Board (\$272,000), GBRA (\$221,000) and the Edwards Underground Water District (\$173,000).

Two other items are worth noting. At the north end of the aquifer near Buda, officials with the Barton Springs Edwards Aquifer Water Conservation District said that groundwater levels were lower than they were during the record drought of the 1950s and were nearing record lows. Also, a tanker truck that leaked a hazardous flammable material didn't pollute the aquifer, but officials say the results could have been much worse had the mishap occurred in other areas of the region where the groundwater system is more vulnerable to pollution.

Houston Manufacturer 1st in U.S. to Utilize 'Pollution Tower'

A Houston chemical manufacturing firm whose parent company invented aspirin doesn't expect to have any headaches about water pollution at its new Baytown manufacturing plant.

Mobay Corp., a subsidiary of Bayer AG of West Germany, is the first company in the U.S. to use the "Bayer tower biological treatment system" to clean up wastewater. The \$30 million system uses 60foot tall steel tanks to treat wastewater with oxygen-fed bacteria. Company officials say the system eliminates any threat of groundwater pollution and accomplishes in less than 12 hours the level of treatment it would take weeks to achieve in conventional earthen lagoons.

"The system is unique because it puts everything above ground where you can see it, you can get to it, you can observe it and you can repair it," said Nick Prater, the president of Mobay.

In simple terms, the system mixes primary treated wastewater with oxygen that's forced into the water with high efficiency nozzles. The oxygen invigorates natural bacteria which consume the waste. Mobay hopes to offer the technology to other chemical producers in Texas and the U.S.

Abilene Grades 'A+' on Environmental Quality in 'Urban Stress Test'

If you're one of the many people who value water quality and the environment, the place for you may be, surprisingly, Abilene, Texas.

Zero Population Growth recently conducted its annual "urban stress test" in which it compared cities across the U.S. in their management of such environmental issues as water quality, hazardous wastes, wastewater treatment, and air quality.

Abilene was tied with Roanoke, VA, and Winston- Salem, NC, as the best cities at handling these problems. Results were published in the December issue of Garbage magazine. One of the major factors leading to Abilene's high ranking is that the city has a totally automated residential and commercial waste management system.

On the other end of the scale, Houston was ranked as one of the five worst cities in the nation.

Lubbock Seeks to Expand Wastewater Irrigation Farm, Despite Neighbors' Criticism

The City of Lubbock is attempting to increase the amount of treated wastewater it can apply to agricultural crops at the Gray Farm, but some folks who live close to the site don't think that's a good idea.

Lubbock wants to boost the size of the farm by adding 5,380 additional acres and would like to increase the application rate from current levels of 4.1 acre- feet (AF) of wastewater per acre to 4.8 AF/ acre. They would also like to relax the water quality standard for biochemical oxygen demand from current limits of 45 milligrams per liter (mg/l) to 60 mg/l.

Two families living near the farm testified that permit violations had taken place close to the site. They said treated wastewater had run off into ditches and caused fish kills in nearby playa lakes. They say a study needs to be performed to determine where dikes and berms should be built to contain effluent runoff.

'Colonia' Residents May Be Storing Drinking Water in Chemical Waste Drums

Reports from El Paso say that at least 10 barrels used to store PCBs, malathion, and other toxic chemicals in the U.S. have been sold to colonia residents in Mexico to store drinking water.

According to the reports, a Juarez merchant who regularly imports scrap metal from El Paso sold the drums to colonias residents who don't have water hookups and who used the drums to store water they purchase from vendors.

If the remnants of the contaminants remained in the drums before they were used to store drinking water, they could pose a definite risk to human health, officials said.

Historians, Volunteers, Search San Antonio River for Alamo Cannons, Artifacts

A 4- foot long,150- pound cannon that may have been used to defend the Alamo eluded several volunteer archaeologists who scoured the San Antonio River in January.

A study of diaries and maps led some to speculate that at least one cannon used in the battle may be buried in the bed of the San Antonio River in downtown San Antonio.

The workers sloshed through the deep water and sifted through mud and gravel while the river was lowered for yearly maintenance. Although they didn't find the cannon, one historian with the project said they uncovered a "treasure trove of early Texas" including ancient flint dart points, whiskey bottles and pottery from the 1800s, Alamo- era pistol parts and bullets, and U.S. coins, buttons and other objects. The group also was unsuccessful in locating rare copper coins called "jolas" that were minted in 1818 (they were the first coins bearing Texas' Lone Star emblem).

The group included members of the non- profit National Underwater Marine Agency which has helped locate such Texas landmarks as the Texas Navy warship *Zavalla* off Galveston Island and has attempted to find the "Twin Sisters" cannons used to defeat Santa Ana which are believed to be buried near the Houston Ship Channel.

Study by University of North Texas, UT- Dallas Assesses Trinity River Water Quality

A comprehensive study of the water quality and ecology of the Upper Trinity has just been published by the University of North Texas in cooperation with the University of Texas at Dallas.

The two- volume 340- page report, titled *A Water Quality and Environmental Study of the Trinity River*, surveys water quality and populations of fish and invertebrates as the Trinity River flows through the Dallas- Fort Worth area.

Specific topics included in the report detail physical, chemical, and biological characterization of river sediments and assessments of the toxicity of water and sediments in the river. The report also developed a database that may be useful in understanding linkages between point and nonpoint sources of pollution and the fish kills that often occur in the region.

Scientists involved in the study include Kenneth Dickson, William Wailer, James Kennedy, Ray Arnold, William Desmond, Scott Dyer, Jerry Hall, John Knight, Diane Malas, Maria Martinez and Stacy Mazner.

For information, contact: Institute for Applied Sciences, University of North Texas, PO Box 13078, NTSU Station, Denton, TX 76203 or call 817- 565- 2694.

Alternative Irrigation Highlighted in TAES Studies

Two recent technical reports from the Texas Agricultural Experiment Station (TAES) outline alternative irrigation plans and their economic implications.

Yield and Economic Implications of Alternative Irrigation Distribution Systems: Texas High Plains (TR 88-1) by Kent D. Hall, Ronald D. Lacewell, and William M. Lyle deals with the profitability of low energy precision application (LEPA), drip, sprinkler, and furrow irrigation systems.

Field trials on cotton, soybeans, corn, and onions were used to compare the economic implications of the four types of systems. The trials were conducted in 1980, 1981, 1984, and 1985. LEPA was the most profitable of the systems that were tested.

Yield and Profit Implications of Alternative Irrigation Levels for Selected Crops: Texas Trans Pecos (TR 88-2) by Ron Lacewell, Jaroy Moore, and John Ellis focuses on crop enterprise budgets for cotton irrigated with different quantities of water as well as selected other crops. The study was conducted using simulation of crop yield and associated budgeting analyses. Results suggest that cotton will continue to be the major crop in the Trans-Pecos region.

For more information, contact: Department of Agricultural Economics, Texas A&M University, College Station, TX, 77843- 2124 or call 409- 845- 2116.

UT's Maidment is Editor-in-Chief of Handbook of Hydrology

David Maidment of the Department of Civil Engineering at the University of Texas at Austin is now editing a comprehensive book titled the *McGraw-Hill Handbook of Hydrology*.

Chapters in the book are being written by 60 authors in the US and seven other countries and will include topics such as the hydrologic cycle, hydrologic transport, hydrologic statistics and hydrologic technology. Specific topics such as groundwater, climatology, streamflows, flood runoff and flood routing, hydrologic effects of land use changes, frequency analysis of extreme events and others are examined in detail.

Maidment is writing part of the section on the hydrologic cycle. Other Texas researchers who have written articles for the book include Randall Charbeneau, the Director of the Center for Research in Water Resources at the University of Texas at Austin, and Philip Bedient of Rice University.

The *Handbook of Hydrology* is scheduled to be ready for publication in 1992. There are opportunities for qualified individuals to take part in assisting with reviewing of draft chapters of the book. For details, contact David Maidment, Civil Engineering Department,

University of Texas at Austin, Austin, TX, 78712 or call 512- 471- 4620.

Texas Water and Environmental Guide Lists Federal, State, Agencies, Water Districts

A new book that provides basic information on Texas' water districts and profiles on government agencies dealing with water and the environment has recently been published. *Texas Water and Environmental Guide* is a 130- page handbook that focuses on water and wastewater treatment, and the management of solid and hazardous wastes.

The guide includes organizational charts and descriptions of activities of state and federal government agencies including the Environmental Protection Agency, the Texas Water Commission, the Texas Air Control Board, the Texas Department of Health and others.

The book also reviews the 1986 community "right to know" legislation, lists information on environmental associations and university research groups, and includes a business yellow pages. Perhaps the most important part of the book is a listing of the addresses, phone numbers, and managers of water districts throughout the state.

The report costs \$16.95. To order a copy, contact: Austin Publishing, Inc., 9600 Great Hills Trail, Suite 150W, Austin, TX, 78759, or call 512- 343- 1218.

Options for Financing Wellhead Protection Efforts Outlined in EPA Report

The U.S. Environmental Protection Agency has recently published a report titled *Local Financing for Wellhead Protection (EPA 440/6-89-001)* that contains information about a variety of financing approaches available to support wellhead protection initiatives.

The guide is aimed at meeting the needs of state agencies and local managers of water quality and water supply districts who are attempting to fund wellhead protection programs.

The book outlines wellhead protection initiatives such as land acquisition and regulatory measures; sources of funds, including local taxes and fees; institutional options, ranging from public enterprise to special districts created by referendum, and case studies.

For details, contact EPA, Office of Groundwater Protection, 410 M Street SW (WH-550G), Washington, DC, or call 202- 382- 7077

New Freshwater Foundation Study Links Groundwater Pollution, Real Estate Values

A study by the Freshwater Foundation may shed some light on how groundwater pollution affects property values. The study, *Economic Impacts of Groundwater Contamination to Companies and Cities*, profiled direct and indirect costs of groundwater pollution to cities and companies by surveying city officials, utility managers, industry representatives, and agency personnel.

The study suggests that Minnesota suffered losses of more than \$67 million because of 35 incidents of groundwater pollution. Costs to cities were placed at roughly \$24 million while business losses were more than \$43 million. The report includes 21 case studies.

Major costs linked to groundwater pollution were identified as the loss to the tax base because of real estate devaluations and lack of business development due to groundwater pollution, according to the study. Other major costs included construction of new water treatment plants and remediation efforts.

To order a copy, contact: Freshwater Foundation, 2500 Shadywood Road, Box 90, Navarre, MN 55392. The phone number is 612- 471- 8407.

Ed the Armadillo, Lupe the Turtle, to Educate Students About Guadalupe River

Journey Through the Guadalupe River Basin is the title of a new educational packet offered by the Guadalupe River Basin Authority (GBRA). The GBRA, with the aid of two fourth grade teachers, developed this kit especially for grade school students living in area serviced by GBRA.

The teaching kit consists of a teacher's guide, filmstrip, program record sheet, pre- tests and post- tests, student workbooks, and GBRA stickers. Lessons deal with such topics as uses of water and water regulation.

Students will take their journey with "Edward A. Armadillo" and his friend "Lupe the Turtle." Student workbook activities include wordfinding games, crossword puzzles, and riddles. Skills in the areas of social studies, language arts, science, and math are also tested.

For further information regarding the kit or the GBRA, contact: Guadalupe Blanco River Authority, P.O. Box 271, Seguin, TX, 78155 or call 512- 379- 5822.

Effects of Global Warming Explained in NRDC Reports

Three publications by the Natural Resources Defense Council discuss global warming and its effects on farming, the ozone layer and the environment, and responses to curb climate change.

The Challenge of Global Warming, edited by D.E. Abrahamson, describes global warming and its effects on physical and biological systems. It looks at patterns in greenhouse gases such as methane and chlorofluorocarbons (CFCs), and outlines options for regulating production of these gases. The book describes policy responses to the global warming issue that may be necessary to ensure a healthy planet in the future.

To order a copy, contact: Island Press, Suite 300, 1718 Connecticut Avenue NW, Washington, D.C. 20009.

Cooling the Greenhouse: Vital First Steps to Combat Global Warming, describes the greenhouse effect and its impact on the climate. The book describes U.S. and international policies to reduce the production of greenhouse gases and to adapt to global warming.

Farming in the Greenhouse: What Global Warming Means for American Agriculture addresses the problems of farming in a hotter climate and adapting to that climate. Although climate change may devastate some crops, additional CO₂ may benefit others. The publication lists what farmers can do to combat global warming such as establishing forests on marginal cropland, and conserving soil and water.

For a copy of *Cooling the Greenhouse* or *Farming in the Greenhouse*, contact: Natural Resources Defense Council, 1350 New York Avenue NW, Suite 300, Washington D.C. 20005 or call 202- 783- 7800.

Mobile Irrigation Planting System Developed by TAES

A new system that utilizes moving irrigation units to plant seeds in rows has been developed by researchers with the Texas Agricultural Experiment Station (TAES) at Lubbock- Halfway.

Bill Lyle and Jim Bordovsky were instrumental in designing the Mobile Irrigation Planting System (MIPS). The new technology is an expansion of LEPA (Low Energy Precision Application) irrigation systems that were developed by TAES researchers. LEPA applies water and chemicals in small amounts and at precise locations where they will do the crops the most good.

"The impact of MIPS is that it provides an all inclusive agricultural production system Lyle said. "No other machinery is required except those implements needed for harvesting."

MIPS plants seeds in rows by excavating the proper amount of soil with a jet of water. It then places the seeds in the furrow and covers them. MIPS consists of a seed germination facility (where seeds are primed and mixed with a gel that protects them as they move through the system), a transfer and injection system, and a seed distribution and planting unit.

The research was featured in an article titled "Planting Row Crops with Moving Irrigation Systems" (ASAE Paper 89- 2687) that was presented at the 1989 winter meeting of the American Society of Agricultural Engineers meeting.

For more information about MIPS, contact: Bill Lyle, Texas A&M University Agricultural Research and Extension Center, Route 3, Box 219, Lubbock, TX 79401 or call 806- 746- 6101.

UH Scientists Say Isotope Analysis Useful in Choosing Landfill Sites

One of the main concerns in safely locating landfills is making sure that pollutants don't leak into shallow groundwaters beneath the site.

Scientists with the University of Houston believe areas where excessive infiltration into soils and groundwater systems may take place can be identified by analyzing chemical isotopes from selected sites.

James Lawrence of the Geosciences Department of the University of Houston is measuring hydrogen and oxygen isotopes from water in rainfall and aquifers. Because rainfall and groundwater often have distinct isotopic signatures, the amount of rainfall that eventually makes its way into aquifers can be identified. Studies are now underway to measure how isotope levels change before and after rainfall events.

Results could be useful to safely locate future landfills or in evaluating the amount of pollutants that percolate down into and contaminate aquifers from existing facilities.

For more information, contact: James Lawrence, Geosciences Department, University of Houston, 4800 Calhoun, Houston, TX, or call 713- 749- 1817.

Lamar Researchers Study Tactics to Resolve Environmental Disputes

James Esser and Richard Marriott of the Psychology Department at Lamar University are studying strategies used by third parties to resolve disputes of environmental issues such as industrial pollution and hazardous wastes.

Esser and Marriott point out that settlement of such disputes usually requires costly and timeconsuming court action. Other types of litigated disputes, such as divorces, child custody cases, and labor relations have been settled by arbitration and mediation. The researchers believe that these same tactics may prove successful as a cost- efficient way to settle the growing number of environmental disputes.

Esser and Marriott plan to conduct several laboratory experiments to simulate situations where environmental issues are causing conflicts of differing priorities to each party. Students will play the roles of experimenter, mediator, and arbitrator. The experiments will initially combine mediation with arbitration and additional mediation tactics will be examined in follow- up studies.

For details about this study, contact James K. Esser, Department of Psychology, Lamar University, Beaumont, TX, 77710 or call 409880- 8285.

Texas Tech Develops Mobile Lab to Study Acid Rain

Scientists at Texas Tech University will be taking to the road this year in an effort to learn more about the causes and effects of acid rain in the state.

Purnendu Dasgupta of Texas Tech is now developing a mobile lab called the Texas Tech University Mobile Atmospheric Research Laboratory (TTU MARL- 1) which will measure the sulfur emissions from oil and natural gas production fields and determine the nature and distribution of the different sulfur compounds in surrounding areas.

Other planned uses of the mobile lab will include studies of the effects of cattle on levels of airborne ammonia near dairies and feedlots and an assessment of how increased concentrations of ammonium sulfate may have reduced visibility in such pristine and remote locations as Big Bend National Park.

"Just because Texas doesn't have much acid rain doesn't mean that we are immune to sulfur contamination," says Dasgupta. "In fact, Texas is a net exporter of atmospheric sulfur."

The lab will be equipped to measure sulfur compounds as well as hydrogen peroxide, ozone, formaldehyde, nitric acid and other chemicals.

For more information, contact: Purnendu K. Dasgupta, Department of Chemistry and Biochemistry, Texas Tech University, Lubbock, TX 79406 or call 806- 742- 3064.

Archaeological Dig Near Lake Ray Roberts Being Analyzed by University of North Texas Scientists

Archaeologists with the University of North Texas are helping analyze remnants gathered from a site near Lake Ray Roberts along the Elm Fork of the Trinity River in Denton. The site may be the oldest, best dated and best preserved example of the Clovis people who populated the southern plains roughly 12,000 years ago.

Reid Ferring of the UNT Geography Department actually discovered the site (which is 25 to 30 feet below the ground surface) in December of 1988 when he was out collecting fossils with his son. Since that time, he has been analyzing artifacts including flint artwork and spear points, knives, flint blades and other tools (the discovery of flint is particularly interesting because the nearest sources of flint are 200 miles away). Bones of animals including bison, woolly mammoths, turtles, snakes and alligators and sites where food was cooked were also located. The studies may yield clues into the life of the Clovis people who are believed to have been some of the first inhabitants of North America.

Technical information was contained in an article entitled "The Aubrey Clovis Site: A Paleoindian Locality in the Upper Trinity River Basin of Texas" which appeared in the Fall 1989 issue of *Current Research in the Pleistocene*. For details, write: Reid Ferring, Archaeology Dept., PO Box 13078, University of North Texas, 76203 or call 817- 565- 2694.

UT Pan American Scientists to Measure Oyster Reefs Using Aerial Infrared Photography

Mapping the distribution of oyster reefs in Texas bays used to be slow, expensive, and laborintensive. Typically, bays had to be surveyed by hand with a sextant and locations had to be plotted onto topographic maps.

Those old methods may become obsolete, however, if a study by scientists with the University of Texas- Pan American proves successful. The study, being led by Frank Judd of Pan American's Coastal Studies Laboratory on South Padre Island, involves using color infrared aerial photography to measure the number and locations of oyster reefs in South Bay in Cameron County, TX.

In the study, Judd hopes to determine the necessary altitudes to compute accurate aerial measurements and to provide cost estimates for surveying all the oyster reefs along the Texas coast. The accuracy of hand surveying and aerial photography will be compared in the investigations.

For more information, contact: Frank Judd, Coastal Studies Laboratory, University of TexasPan American, PO Box 2591, South Padre Island, TX 78957 or call 512761- 2644.

Protecting Endangered Species in San Marcos River Target of SW Texas Plan

Researchers at Southwest Texas State University have received a grant from the U.S. Fish and Wildlife Service to develop a river management plan to protect endangered aquatic plants and animals in the San Marcos River.

Jane Maler of SWT's Edwards Aquifer Research and Data Center is leading the study. She says the study will first determine which sections of the river are most often utilized for recreation and other uses. That data will be merged with information on erosion and which sections of the river provide habitat for endangered fish species such as gambusia, amphibians such as the San Marcos salamander, and plants including Texas wild rice.

Ultimately, the study will result in the development of a comprehensive river management plan.

For additional details, contact: Jane Maler, Edwards Aquifer Research and Data Center, SW Texas State University, San Marcos, TX 78666 or call 512245- 2329.

Texas Tech Investigate Bubbles, Pores, Biology of Interfacial Water

A research project at Texas Tech University is attempting to understand how interfacial water (a thin layer of water in different phases such as air, bubbles, gases and other forms) is chemically, physically and biologically different from ordinary water.

G. Wils Robinson of the Subpicosecond and Quantum Radiation Laboratory at Tech is leading the study. He believes that interfacial water occurs in many situations such as

bubbles, clouds, oceans, and when liquid water is in molecular contact with surfaces of ice, quartz, oil, metals and semiconductors.

In the study, Robinson hopes to measure the amount of interfacial water that is present in a welldefined system using fluorescent probes to distinguish interfacial water from bulk water. He also hopes to study differences in how interfacial water reacts to a repulsive oily surface and a hydrogen bonding surface like ice.

Other experiments will measure how interfacial water plays a part in the development of bubbles. Supercomputers will be used to simulate many of these processes.

Earlier research on this topic was featured in an article entitled "Chemically Stiff Water: Ions, Surfaces, Pores, Bubbles, and Biology," that appeared in the September 22, 1989 issue of *Chemical Physics Newsletters*. For more information, contact: G.W. Robinson, Director, Subpicosecond and Quantum Radiation Laboratory, Texas Tech University, P.O. Box 4260, Lubbock, TX, 79409 or call 806742- 3884.

TAES Temple Scientists Refining Computer Models to Study Water Quality

Computer simulation models which could ultimately predict the ability of specific agricultural chemicals to enter surface and groundwater supplies are being developed by scientists with the Texas Agricultural Experiment Station (TAES) at Temple.

TAES researchers such as Ray Griggs are currently refining the PRZM (the Pesticide Root Zone Model) and GLEAMS (the Groundwater Loading Effects of Agricultural Management Systems). They want to determine if the models can be adapted to more accurately reflect Texas conditions such as soil pH, moisture, mineralogy, and temperature which influence how chemicals are degraded.

The improved models could help chemical manufacturers get an early idea of the potential impact of new agricultural pesticides and herbicides on the environment while still in the early screening stages.

PRZM was developed by the U.S. Environmental Protection Agency, while GLEAMS was developed by the U.S. Department of Agriculture/ Agricultural Research Service. Both models simulate the movement of pesticides from surface water runoff, soil erosion, and leaching through the root zone.

For details, contact: Ray Griggs, Blacklands Research Center, TAES, 808 E. Blackland Rd., Temple, TX, 76502 or call 817- 770- 6601.

UT Engineers Say Bacteria Thrive on Methane, May Degrade Pollutants

Gerald Speitel Jr. of the Civil Engineering Department and George Georgiou of the Chemical Engineering Department are developing treatment processes to biologically degrade a complex class of chemicals called chlorinated aliphatic solvents. The chemicals

have been involved in many instances of groundwater pollution and are believed to be cancer causing.

The engineers are exploring the use of bacteria which grow on methane called methylotrophs to degrade trichloroethylene (TCE). They believe that a specific methylotroph called *Methylosinus trichosporium OB3b* may degrade TCE much more rapidly than other organisms.

The research includes characterizing the ideal environment for the organism and developing a process to stimulate the production of a specific enzyme (methane monooxygenase) which allows the methylotroph to effectively degrade TCE.

The studies could lead to a treatment process where the time required for methylotrophs to degrade pollutants like TCE could be reduced.

For more information on this project, contact: Gerald Speitel Jr., Civil Engineering Department, University of Texas at Austin, 8.6 Cockrell Hall, Austin, TX 78712 or call 512471 - 4996.