DIVINING ROD

NEW MEXICO WATER RESOURCES RESEARCH INSTITUTE

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New Mexico Tech undergraduate students Karen Karen (left) and Patricia Frisch collect river samples from the Rio Grande near Escondida. The samples were tested for arsenic concentrations.

Arsenic monitoring conducted along Rio Grande

Graduate students at New Mexico Tech have been joined by high school students and their teachers in collecting river samples along the Rio Grande and San Juan River to determine arsenic concentrations. The group effort is part of the educational component of a WRRI-funded project under the direction of NM Tech Professor David Norman.

Arsenic, a known class A human carcinogen, is toxic when ingested or inhaled. Over the past decade, evidence has accumulated that indicates arsenic at low levels in drinking water will seriously affect health. Increased rates of skin cancer, heart disease, infant mortality, and birth defects are related to arsenic. This has prompted the U.S. Environmental Protection Agency (EPA) to re-examine limits of arsenic in drinking water supplies currently set at 50 ppb. In the last days of the Clinton Administration, EPA lowered arsenic standards to 10 ppb but the Bush Administration has indicated it wants to withdraw the new standard until more research is conducted.

Albuquerque and increasingly Las Cruces and El Paso will be using Rio Grande water for municipal drinking water supplies. The Rio Grande has reported arsenic concentrations of 2 to 13 ppb. Tributaries and water treatment plant discharges have 12 to 40 ppb arsenic. Dr. Norman and his students have monitored Rio Grande arsenic at Socorro and have recorded concentrations of 2 to 16 ppb that show seasonal variability.

This project, *Arsenic and Arsenic Species in the Rio Grande, and the Effect on Irrigated Lands,* will monitor arsenic concentrations and arsenic speciation at three places along the Rio Grande weekly. The team of researchers has been monitoring the Rio Grande in Corrales and at two locations in San Acacia. Thus far,

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arsenic monitoring

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Rio Grande water shows dissolved arsenic concentrations of 1 to 3 ppb. Total arsenic including dissolved suspended load ranges from river concentration of 3.4 ppb to drainage concentrations up to 1.5 ppb. Two sets of samples were taken from the San Juan River in Farmington that show virtually no detectable arsenic.

Prior to this study, no one had studied Rio Grande diurnal arsenic variations that in other rivers show concentrations changing by a factor of two. Dr. Norman and crew are measuring diurnal variations in arsenic species and concentrations at the monitoring sites during each season and measurements are taken every three hours. The team has found no significant changes in arsenic concentration during diurnal sampling. All other parameters such as Eh, pH, conductivity, and alkalinity show variability, but no trends are apparent yet.

Another objective of the research is to study the consequences of Rio Grande arsenic on irrigated fields. It has been the opinion of many that arsenic will be trapped in soils. The 2 to 16 ppb ranges in arsenic concentrations along the length of the Rio Grande suggest that arsenic may be trapped or is being added to the river. Ratios of Cl in irrigation and drain water indicate about 95% of arsenic in irrigation water remains in soils. Arsenic could be lost to sediment trapped behind dams. In either case, the trapped arsenic may be a time bomb waiting to be released by a change in chemical conditions, according to Dr. Norman. Preliminary measurements of irrigated soils show that they have 2 to 5 ppm of absorbed arsenic.

Thus far, Dr. Norman's research indicates that irrigation waters in the Middle Rio Grande Valley are consistently lower in arsenic concentrations both for dissolved arsenic and suspended load arsenic. Irrigation water is significantly higher in bicarbonate and has higher conductivity than river water.

Data collected during this project will be preliminary. Dr. Norman intends to use the information from this research to study the phenomena in detail, including investigations to decide the mechanisms involved, and the nature of the variations along

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Doctoral candidate develops arsenic test kit

story and photo by George Zamora, New Mexico Tech

In the course of field work conducted for his geochemistry dissertation, New Mexico Tech doctoral candidate Greg Miller has developed a low-cost, easy-to-use analytical kit which may soon provide researchers and technicians with a better method of differentiating the various species of arsenic detected in groundwater and other sources of drinking water.

Miller has applied for a patent for his arsenic speciation test kit and should hear soon as to whether he can begin marketing the device. Meanwhile, the U.S. Environmental Protection Agency (EPA) will be conducting a testing program for Miller's method of arsenic analysis. EPA wants to ensure that laboratories using the method will obtain arsenic data of the quality they require. Certification by EPA may take a year or so.

The method of using the portable arsenic test kit–which is about the size of a shoe box–was developed in the course of field research conducted by Miller, who used mathematical equations and computer programs to "model"

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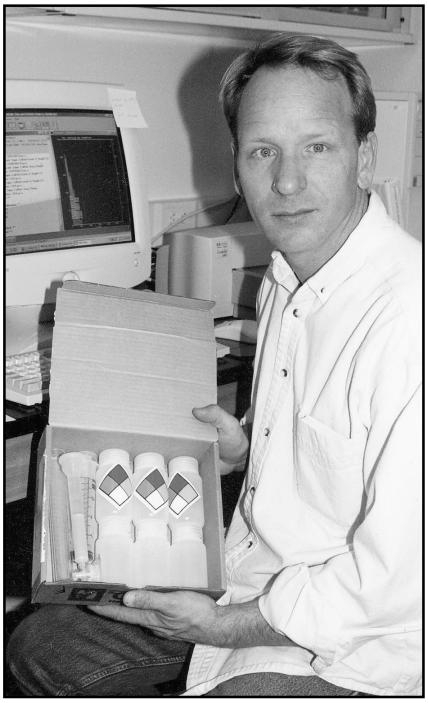

NMTech geologist invents low-cost, low-tech arsenic filter

story by George Zamora, New Mexico Tech

David Norman, a professor of geochemistry at New Mexico Tech, recently was awarded a $25,000 grant from the Conrad N. Hilton Foundation to further develop his new "low-tech" method of removing arsenic from drinking water.

The simple filtering device Norman has invented consists entirely of a five-gallon bucket with a hole on the bottom, filled with crushed and screened laterite–a weathered reddish-brown material composed primarily of hardened clumps of iron oxide, which occurs naturally in some soils.

Through the Hilton Foundation grant, Norman will adapt his bucket-filter technology for use in villages in Ghana where villagers are often subjected to high arsenic levels in their drinking water, which is typically drawn from communal wells.

"In our field studies in Ghana, we came across water with so much arsenic that drinking it will result in skin problems and cancer," Norman relates. "But after we ran it through the bucket filter, you could safely drink the stuff...These types of filters are awesomely efficient."

Once instructed on how to make bucket filters, Ghanaians would have little trouble constructing their own arsenic filtering devices, Norman maintains, since most of the required materials–discarded plastic buckets, window screens, and laterite-rich soil–are readily available throughout Ghana and other neighboring African countries.

Norman's research also has shown that buckets filled with ground-up laterite can be used to filter out high concentrations of iron from drinking water.

"Basically, that's iron taking out iron," the Tech geochemist points out. "And, we really don't know why this is happening...We just know that it works just as well."

Laterite deposits also occur in soils found in some of our own country's north-central states, including Michigan, Wisconsin, and Minnesota, Norman explains, and, as such, the bucket-filter technology might also have applications for residents of those states where high-iron content in their water poses problems with hard-water stains.

"It might eventually be possible to develop a smaller, cartridge-type filter filled with laterite as an active ingredient to effectively remove most of the iron out straight from the tap," Norman says.

With the grant from the Hilton Foundation, the bucket-filter technology, which is more technically described as a "continuous sorption column," also will be adapted to a larger-scale, square-meter-sized, concrete-encased filtering system which will be employed in larger Ghanaian villages for their communal wells.

World Vision, a nonprofit international organization which is committed to advocacy for children, has also pledged to assist Norman and his fellow researchers by providing them with trucks to transport people and equipment in Ghana as they set up various water-filtering systems.

arsenic test kit

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the movement of various forms of arsenic in the environment.

Miller found it impractical to take expensive analytical equipment out into the field to measure low levels of arsenic and, at the same time, found it confounding that certain arsenic compounds rapidly change into other forms of arsenic, sometimes before they can be sent to a commercial laboratory for analysis.

With a prototype of his newly developed kit, Miller can now determine on-site if the specimens he is collecting contain organic forms of arsenic or the more toxic inorganic forms.

In addition, the invention allows for rapid differentiation in the field between arsenic (III), or "arsenite," and arsenic (V), or "arsenate."

"Arsenic (III) is widely acknowledged as being the most nefarious form of arsenic, as far as having deleterious health effects on humans," Miller points out.

Arsenic occurs naturally in the environment and is actually the twentieth most common element in the Earth's crust and the twelfth most common element found in the human body.

However, scientific evidence has long linked long-term exposure to high arsenic levels with an increase in occurrences of cancer.

In the last days of the Clinton administration, the arsenic standard was lowered from 50 parts per billion to 10 parts per billion. Recently, the EPA has indicated it wants to withdraw the standard and to conduct further

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Meet the Researcher

Dr. David I. Norman

Geochemist and Professor, Department of Earth and Environmental Science, Geochemistry Program, New Mexico Tech in Socorro since 1992.

Research focuses on geothermal systems, ore deposits, and arsenic in ground and surface waters.

Education:
Ph.D. in Geology, University of Minnesota, 1976
Columbia Teachers College, Peace Corps Training, 1966
B.S. in Physics, Institute of Technology, University of Minnesota, 1963

Dissertation:
Geology and Geochemistry of the Tribag Breccia Pipe Deposits, Batchawana Bay, Ontario

Advising:
14 Ph.D. students completed
47 M.S. students completed
currently advising 3 Ph.D. and 2 M.S. students

Teaching:
Undergraduate courses in Environmental Geology
Graduate level courses in Genesis of Ore Deposits; Exploration and Environmental Inorganic Geochemistry; Geochemistry of Geothermal Systems; New Mexico Volcanoes

Current Research:
Current projects of Professor Norman's students and himself include the study of arsenic in the Middle Rio Grande watershed and irrigated fields; the study of arsenic in Ghana groundwaters; development of an iron arsenic filter using natural materials; study of gas geochemistry in geothermal systems at Coso, California, Awibengkok, Indonesia, and elsewhere; and the study of ore deposits in Mexico, Nevada, Kurdistan, and Sweden.

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test kit

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research on how much arsenic is acceptable in drinking water supplies. Miller indicated that, "the review of the EPA ruling may well show that arsenic speciation is an important part of the mix in assessing human and ecological risk."

"If EPA decides it's important to also consider what specific forms of arsenic are present in our drinking water as part of its revised regulations, then it becomes very important to have an inexpensive, portable kit available which will test for different arsenic species," Miller maintains. "Although health researchers consider it important, I must admit that speciation of arsenic has not been a major concern for EPA in the past."

Miller estimates that at the outset of EPA's establishing new standards for arsenic levels in groundwater, demand for his test kit may range anywhere from 1,000 kits per year to over 10,000 units sold each year, largely depending on which course the new regulations take and, even more so, on whether the agency gives its official stamp of approval to the new testing method.

Norman

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Norman, D.I. and F.J. Sawkins. 1987. Analysis of fluid inclusions by mass spectrometer. *J. Chem. Geol*. 61:1-10.

Water Experts Prove Themselves a Hearty Bunch

At last year's WRRI Water Conference, the bus that took folks on a tour of the Santa Ana Pueblo Restoration Project became stuck in sand. With a bit of cooperation and coordination led by John Hawley (not seen in this picture), the group was soon on its way.

arsenic monitoring

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the New Mexico reach of the Rio Grande. Further study will involve an integrated effort by several researchers including geochemists, soil geologists, vadose zone hydrologists, and surface and groundwater hydrologists. The current study will be completed early this summer and a final report on its findings available from the WRRI by the end of the year.

Upcoming Conferences

Symposium on Model Validation, Geological Society of America - April 29-May 2, 2001, Albuquerque, NM (dsalvato@dbstephens.com)

Water Quality, Monitoring, and Modeling, AWRA's spring specialty conference - April 30-May 2, 2001, San Antonio, TX (www.awra.org)

Science and Technology in the New Administration, American Association for the Advancement of Science - May 3-4, 2001, Washington, DC (www.aaas.org/spp/r&d)

Land Use Law, CLE International - May 3-4, 2001, Santa Fe, NM (www.cle.com)

Workshop on Fate, Transport, and Transformation of Mercury in Aquatic and Terrestrial Environments, U.S. EPA - May 8-10, 2001, West Palm Beach, FL (www.epa.gov/ttbnrmrl)

The Law of the Colorado River, CLE International - June 7-8, 2001, San Diego, CA (www.cle.com)

Two Decades of Water Law and Policy Reform: A Retrospective and Agenda for the Future, University of Colorado School of Law, 22nd Summer Conference - June 13-15, 2001, Boulder, CO (nrlc@spot.colorado.edu)

Decision Support Systems for Water Resources Management, Joint AWRA/UCOWR conference - June 27-30, 2001, Snowbird, Utah (www.awra.org)

Wetlands and Remediation, Second International Conference - September 5-6, Burlington, VT (conferencegroup@compuserve.com)

Water Resources Management 2001 - September 24-26, 2001, Halkidiki, Greece (www.wessex.ac.uk/conferences/2001/wrm01/)

Enviro-Pro Expo/Tecomex 2001 - September 25-28, 2001, Mexico City, Mexico (leonardo@ejkrause.com)

New Mexico Environmental Health Conference 2001 - October 29-31, 2001, Albuquerque Convention Center (www.nmehc.org)

National Water Resources Administration's Annual Conference - October 29-November 1, 2001, Salt Lake City, Utah (www.nwra.org)

New Mexico Watershed Management: Restoration Utilization and Protection, NM 46th Annual Water Conference - November 5-7, 2001, La Fonda, Santa Fe, NM (wrri.nmsu.edu)

2001 American Water Resources Administration Annual Water Resources Conference, November 12-15, 2001, Albuquerque, NM (www.awra.org)

WRRI welcomes Peggy Risner

This February, Peggy Risner joined the WRRI staff as Administrative Secretary. Peggy replaced Ellie Maese Duran, who retired in December. Peggy is a native to New Mexico, living most of her life in Las Cruces. She has worked at New Mexico State University for over 20 years and is now enjoying learning about water issues at the WRRI. Peggy spends much of her free time with Bob, her husband of 17 years. They enjoy hunting, fishing, 4-wheeling (their new hobby), and traveling. Her favorite destinations include Seward, Alaska, Acapulco, and New Orleans. Peggy loves animals–she has two Cocker Spaniels and four cats with very distinct personalities. She enjoys playing computer games, and seeing movies, and having lunch with her friends. An avid reader, Peggy writes short stories and poetry, and is an accomplished photographer. She also is working on an English degree. Peggy has two stepdaughters, Michelle and Tammy, and one grand-baby, Paige, who she adores. The institute is very pleased to have such a capable and enthusiastic person on its staff.

Recently published WRRI technical reports

The WRRI recently has published several reports as part of the institute's Technical Completion Report Series. Each research project funded through the WRRI culminates in a report that describes the project's objective, methods, and results. Hard copies of these reports are available at no cost as long as supplies last. We are now making complete reports available on the Internet via the our home page at http://wrri.nmsu.edu

Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin - F.A. Ward, R. Young, R. Lacewell, J.P. King, M. Frasier, J.T. McGuckin, C. DuMars, J. Booker, J. Ellis, and R. Srinivasan (Technical Report No. 317)

This multi-year project was a collaborative effort with the Water Resources Research Institutes and Agricultural Experiment Stations in New Mexico, Colorado and Texas. A research team consisting of economists, hydrologists and a lawyer were assembled to test the hypothesis of whether new institutions for interstate coordination of surface water withdrawal and reservoir operations could reduce economic losses resulting from water shortfalls in periods of severe and sustained drought.

The researchers developed a hydrologic-economic model for the Rio Grande Basin from Colorado through New Mexico to Ft. Quitman, Texas, based on an earlier model developed for the Colorado River Basin. The objective of the model was to identify hydrological and economic impacts of possible changes in institutional structure for coping with drought. The report contains the model on CD-ROM.

This study will be highlighted in the next issue of the *Divining Rod*.

Efficient and Predictable Recovery of Viruses and *Cryptosporidium Parvum* Oocysts from Water by Ultrafiltration Systems - K.H. Oshima (Technical Report No. 316)

Concentrating and detecting viral pathogens in surface, ground and drinking water is difficult from a technical and practical standpoint as well as being expensive. New Mexico State University biology professor Kevin Oshima explored the feasibility of two ultrafiltration systems to concentrate waterborne viruses under controlled laboratory conditions. Experiments were conducted using two small-scale (2 liter) and two large-scale (100 liter) ultrafiltration systems (hollow fiber and tangential flow) with viruses suspended in reagent grade water, tap, ground, and surface waters.

Recovery experiments were done with three viruses: bacteriophage PP7 and T1, poliovirus, and protozoan parasite (*Cryptosporidium parvum* oocysts) to compare, characterize and optimize the recovery with the two ultrafiltration systems. Pretreating the ultrafilters with blocking agents (fetal bovine serum or other proteinaeous solutions) and the use of elution agents served to prevent viral adsorption to the filter surface or to elute bound virus and keep viral agents suspended in the retentate. Blocking the membrane also improved in *C. parvum* recovery. The use of a blocking and an elution step efficiently concentrated (>60% recovery) viruses and *C. parvum* oocysts from widely varying water qualities including surface waters. Both ultrafiltration systems appear to be able to recover viruses efficiently;

46th Annual New Mexico Water Conference

New Mexico Watershed Management: Restoration, Utilization and Protection

November 5-7, 2001
La Fonda, Santa Fe

however, the hollow fiber system provided slightly better and more consistent results in the 2L and 100L volumes tested.

These results indicate that the hollow fiber ultrafiltraton system can efficiently and reproducibly recover viruses and *C. parvum* from small- and large-scale systems and from widely varying water qualities. Both ultrafiltration systems can provide efficient recovery of viruses from water.

The Impact of Heterogeneous Consumer Response on Water Conservation Goals - J.M. Chermak and K. Krause (Technical Report No. 315)

University of New Mexico economists Janie Chermak and Kate Krause designed and employed an experimental game that simulated water consumption from a potentially exhaustible source. The game was a means by which to study significant, observable consumer characteristics that are factors in demand for water. The researchers then econometrically modeled water demand incorporating these characteristics, which allowed the researchers to segment consumer groups. The model was used to design a conservation incentive program that allows individuals to choose their own best conservation alternatives, while still achieving conservation program goals.

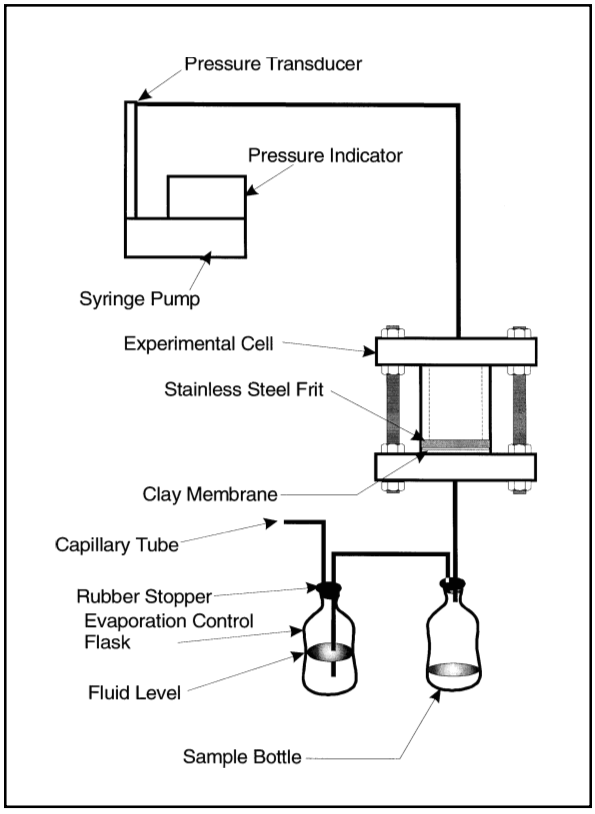
A total of 114 subjects took part in a series of six experiments. Forty-two of the participants were students at the University of New Mexico, while seventy-two of the participants were members of communities from various areas in New Mexico.

Chermak and Krause found heterogeneous demand for water, including differences between student and community participants. There were also consumption differences between members of the community who identify themselves as part of the active workforce and those who identify themselves as retired. Specifically, they found that while consumption levels are a function of price, consumption levels are also impacted by a variety of social and cultural factors. Among these are age, gender, ethnicity, political affiliation, religious affiliation, and risk preferences. While all these factors are not significant characteristics across all three groups (students, work-force or retirees), they are significant in at least one of the three groups.

The study was able to show that by disaggregating demand, a menu of price systems can achieve conservation goals with less loss of consumer welfare than can alternative policies. These systems provide each consumer an incentive to choose the one that is most beneficial given his or her unique demand, minimizing enforcement costs.

Hyperfiltration-Induced Precipitation of Sodium Chloride - T.M. Whitworth and C. Gu (Technical Report No. 314)

In previous WRRI-funded research, former New Mexico Tech professor Michael Whitworth (now with the University of Missouri-Rolla) demonstrated that heavy metals including copper, cobalt, and lead, could be successfully precipitated from initially undersaturated chloride solutions forced through clay membranes, a process referred to as “hyperfiltration.” Those metals were quite soluble but not as soluble as sodium chloride, a common constituent of almost all waters. However, theoretical calculations suggested that it is not only possible to precipitate sodium chloride from an initially undersaturated solution



Experimental setup for hyperfiltration experiments conducted by T.M. Whitworth and C. Gu as reported in WRRI Technical Completion Report 314.

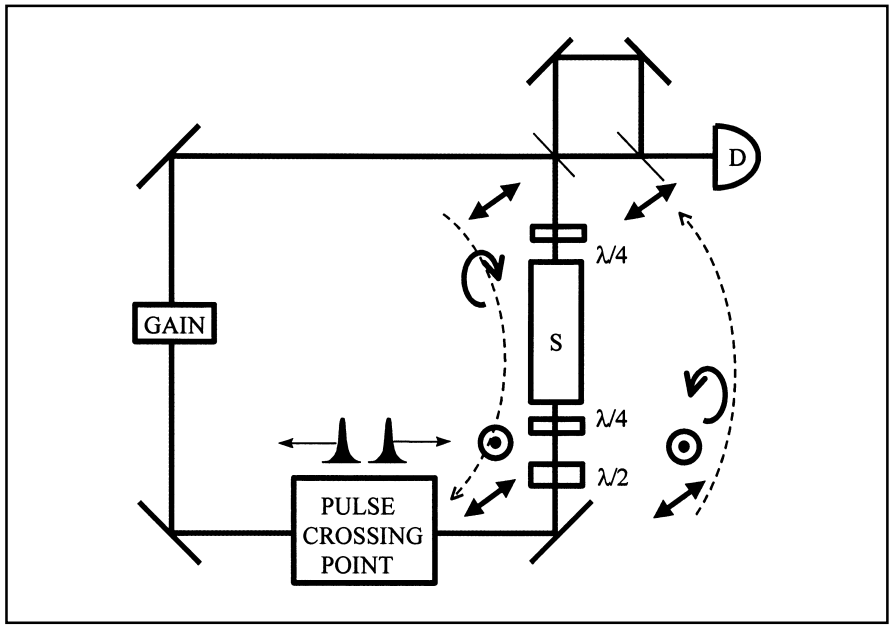
passing through a clay membrane, but that it can be done at fluid pressures of less than 400 psi– pressures, significantly less than those used in most reverse osmosis systems.

Therefore, the researchers tested the concept that clay membranes can concentrate and precipitate NaCl in a series of hyperfiltration experiments. Some experiments resulted in formation of sodium chloride crystals on the surface of the membrane when undersaturated NaCl solutions were forced through the membranes. Bentonite and kaolinite clay membranes were used in these experiments. They discovered that ethanol, which is commonly used to displace water, forms an azeotrope when mixed with water and this results in NaCl precipitation when NaCl concentrations are high enough. To avoid this problem, Whitworth displaced the water in the experimental cells and membranes with cooking oil before examining the clay membranes for the presence of NaCl crystals. Consequently, they did observe NaCl precipitation when undersaturated solutions were passed through both kaolinite and bentonite membranes. Thus, the initial concept appears to be valid. Further work will be required to develop this into a commercial application.

Detection of Groundwater Through Ultra-Sensitive Magnetic Measurements with Ultra-Short Pulse Lasers - J-C. Diels (Technical Report No. 313)

The goal of this research was to develop instruments to detect sources of groundwater and/or monitor the growth and decay of large aquifer layers through changes in magnetic susceptibility. University of New Mexico physicist Jean-Claude Diels took two approaches: developing instrumentation capable of detecting minute changes in the vertical component of the earth's magnetic field, averaged over large distances; and instrumentation capable of directly measuring changes in magnetic susceptibility.

The common thread in both these instruments is the use of ultra-short pulse ring lasers as differential phase spectrometers. The basic principle is to translate a differential phase shift into a frequency difference between the two output beams of a ring laser. Magnetic field changes are translated into phase shifts when the intracavity beams traverse a resonant atomic vapor inside the cavity. New stabilization techniques had to be developed to stabilize the pulsed laser to a narrow atomic transition. A Ti: sapphire laser was used to perform basic stabilization research. Optical parametric oscillators and solid-state diode pumped lasers were developed in order to lead to a practical instrument that could be used in the field. Professor Diels also describes progress on fiber laser research that will lead to the development of a magnetic susceptibility detector.



Pictoral of magnetic field monitoring with a pulsed ring laser. *S* designates a material producing differential phase shift for left- and right-circularly polarized beams, proportional to the component of a magnetic field along the propagation direction of the beam. From WRRI Technical Completion Report 313 by Jean-Claude Diels.

High school students forecast our water future

In conjunction with last year's Annual Water Conference, the WRRI sponsored the Water Essay 2000 Contest. High school students from throughout New Mexico were encouraged to participate by writing a 1,500 word essay on the following scenario:

The year is 2020, the era of the "water card." Individuals must have water cards that allow them to use only a certain amount of water every day. When people have consumed their allotment, alarms go off and the water card no longer activates faucets, toilets, water fountains, washing machines, and so on. Describe your life in the year 2020, using your knowledge of water concepts to write a brief science fiction thriller.

Essays were judged in two categories: grades 9 and 10; and grades 11 and 12. First place in each category received $300 and second place received $200. Six essays in each category were also given Honorable Mention certificates.

The WRRI received 66 essays and assembled a committee of 6 judges to score the essays. Award-winning essays were read by students during the luncheon banquet at the Annual New Mexico Water Conference, where students also received their prizes.

In this issue of the *Divining Rod* we are publishing the second place essays in each category. The newsletter's next issue will contain the first place essays.

Our congratulations to all students who participated in the competition. The WRRI hopes to continue sponsoring the contest in the years to come.

Second Place - Senior Division

Paul Rossman
Deming High School

Hydroman

The changes brought on during 2020 were significant. Most people regarded the "water card" as a necessary evil. On one hand water was needed but the government overstepped itself with control. Some people did without, selling their water card privileges to others. Needless to say they died a slow death. Others bartered away water card rights. Most people learned to deal with less, a lot less. The scene was all too common. A person putting in their water card only to have the Hydro Agents remind people of their water limits. Sometimes people were jailed. Paul Rossman didn't mind the fact that he was facing the HA today. He had forgotten just how much water he had consumed. Today would be a reminder, no ticket, no jail and no additional water. Paul laughed to himself after the encounter, if only they knew.

All those years in college had paid off. Paul had spent time researching water quality issues since high school. College brought no new surprises. But buying a large tract of land with a small inheritance near Animas, New Mexico proved to be a gold of sorts. Getting the rest of the capital was much more challenging. Several prominent citizens, mainly politicians, invested in the venture and Paul's company was off and running. Using specific state run agencies and vehicles, Paul had tapped into systems throughout the Southwest. It started with Deming and Silver City. Once the profits rolled in, it became a game. Soon trucks were bringing deliveries from Las Cruces and Albuquerque. Next on the list of targeted cities were El Paso and Tucson. Their precious cargo was the unthinkable, sewage. The "water cards" only made the game more interesting for Paul. The people he worked with on a daily basis knew him as "Hydroman." The risk was increasing with each shipment. The trucks rolled in, sometimes three and four times a day. The trucks rolled out too. But producing the product took time. Ten years ago Paul developed a municipal plant that used cutting edge technology while keeping costs and maintenance low.

Through the use of water pond plants and natural filtering systems, sewage was treated. To make the water potable and drinkable, Paul experimented with various coagulants until he had the system down pat. One particular coagulant that proved to be quite effective was a chemical called Alum. Coagulants are mixed with water samples. They then clump up all the undesirable wastes in the water. This can later be filtered out using something as simple as sand. To make his illegal business run, water hyacinths and other pond plants were incorporated in the final filtering process. Selling the plants was irrelevant because Paul made cattle feed out of them and sold them to area ranchers. It was evident why he was no

longer an engineer of municipal plants. His plans were too cost effective. The water game had gone high tech and expensive. People like Paul were crushed by many of the larger chemical companies. Needless to say who was laughing now. Near Animas, Paul had constructed an underground municipal plant. Above ground were small ponds filled with different plants. Most people had no idea that 'Hydroman' even existed. The water cards became a complication. Paul had been making money but he never dreamed that the government would restrict people's consumption of water. Now he was drawn into an ethical and moral predicament. He was stealing the sewage to make money but he never felt that was a problem. His dilemma was that now people were dying because they did not have water. Could he help? Should he help? Inside Paul knew what his answer was, he could not allow people to die when he was capable of helping them.

The regular deliveries of water to the Governor's mansion would go unnoticed. The plan required that the cleaned water be bottled and placed on milk trucks. All of the jugs were a white plastic that could not be seen through. Paul knew in his heart that what he was doing would help many people, including children. He bought an additional milk truck with his own profits. Beginning tomorrow morning he would drop 'milk' shipments off at poor income neighborhoods. This was the right thing to do. The real question was would his business partners notice a slight drop off in production and profits? His palms were warm with sweat as he drove the milk truck across the railroad tracks to the area known as 'Wasteland.' Many of the men in this part of town had sold their 'water cards' and were trying to get by sharing water with their families. Stopping the truck in front of the rundown homes "Hydroman" went public. The deliveries were greeted with skepticism because there was no payment. They were somewhat ignored because people thought the product was milk. This was the beginning. The following day Paul repeated the process. Trying to be discrete was a priority. If he was discovered giving away the hydro he could be killed. The milk was accepted in the same manner as the day before. Today, people's eyes acknowledged the gift. They said nothing verbally but the warmth on their faces was all Paul needed to feel. Comforted by their approval he would continue his routine.

Martha and her family didn't know who "Hydroman" was but they needed him. Without those last two jugs of water it was likely that her two-year old son would have died. John and Esther needed him too. Esther had been extremely ill and dehydrated. They both thought the water they drank at the hospital had been tainted. At least "Hydroman's" water was safe. Six months later the call came. It was the Governor of New Mexico. A private meeting was already arranged for Paul and all of his business partners. They knew. Paul couldn't help but wonder what they were going to do to him. One thing was certain, they needed him to continue cleaning up the sewage for them. He knew they had grown dependant on his additional supplies of water. Without him they had nothing. They had been following him for four months. In fact they knew his routine better than he did. What started as a small operation had turned into a rather large affair. The deliveries were throughout the city of Deming. Who could imagine that he would be using twenty trucks a day to provide free water to citizens. Pictures told a story of a man bent on destroying a very profitable game. They could not allow this behavior to go on as if they knew nothing. Governor Johnson had already hired a scientist to replace Paul but he was untested in this particular area. Could Dr. Goodgame ever truly understand the municipal plant currently being run by Dr. Rossman?

WRRI Director Karl Wood presents a certificate and cash award to Paul Rossman while his grandmother, Betty Smith, and his mother, Claudia Rossman look on proudly.

The meeting began with a large glass of water. They drank it like it was the finest champagne on earth. The water itself was clear, cold and appetizing. After taking their seats at the table they acknowledged all of the hard work and dedication that Paul had put into the secret plant. Next, they were ready to expand the plant even more. This was a

total surprise for Paul. He had expected to come in and be confronted with accusations of stealing, not this. They were planning on making a big move, the city of Phoenix. Because of the expansion, Paul would need additional help. Then they dropped the bombshell on him. They had hired Dr. Goodgame to run the plant. Paul was in disbelief. They actually expected him to train his replacement.

"Hydroman" had less than two days to expedite his plan before Dr. Goodgame would arrive. Knowing that people trusted him, he slipped a former city worker a note in an empty milk jug. A meeting was arranged with Paul and Casey Dodson. At midnight Paul asked for help from Casey. Taking all of his profits out of the bank and giving the money to Casey was the easy thing to do for Paul. He had to continue helping people who needed water.

The explosion could be seen and heard for miles. What was out in the desert that could cause such a commotion? The following day everyone knew that "Hydroman" was dead. His body was never found. The obituary was simple yet heartwarming. People were going to miss him. Paul made the ultimate sacrifice; he chose to help people in need. Two months later Deming engineers began to wonder if they had a sewage leak. The municipal plant's intake was down by ten percent. The logbooks reflected this but nothing was ever said. Across the tracks at the "Wasteland" several homes were having sewer problems. Lines were dug up everywhere. As the days and weeks progressed the milk deliveries continued.

Second Place - Junior Division

Daniel Bowman
Socorro High School

The Last Flood

The members of the Socorro County Water Committee met for the last time on September 21, 2020. The handful of men and women present were all that was left in the valley of what used to be the Rio Grande. All the rest of the farmers were gone, having left long ago in search of better land, land that wasn't cracked and dry.

They sat down in old, rusty folding chairs at a table that had seen better days, at the old Socorro County Fair. Wind blew dust and trash in the open door of Kelly Hall, threatening a storm that would never give rain. It was still hot inside even with the door open, and the swamp cooler was long since rusted through.

"This meeting is called to order on September 21, 2020 by the Water Committee to discuss the new system proposed by our friends in Albuquerque," said President Cody Smith. Secretary Alan Gonzales read the minutes, and the meeting began in earnest. "Ladies and gentlemen, I believe you all know why we are here. Our counterparts in Albuquerque have proposed a new system called the 'water card' for the rest of the state. Cochiti Dam is full, so I guess we might get a little water.

"Every person will have an attachment to his or her ditch port and water meter, which will monitor both total water usage and water flow. If either exceeds a limit, then your water is cut off for the rest of the month. In order for you to have water for the entire month you must not use more than 24 gallons per day for household use. You will only be allowed to irrigate once every six weeks. That's our situation, folks," said Mr. Smith.

Mr. Smith waited for the rest of the angry growls and mutters to cease, and then began speaking again. "We have a couple options as I see it. We can sue and take this to the Supreme Court. We all know what happened to southern Arizona when they tried to do that in 2018. Now Arizona is the equivalent of a third world country in terms of percent of the populace in poverty.

"We could try to pump water from the aquifers again, but even that probably won't work, since the valley has been sucked dry and there isn't enough water even for Socorro from the springs on the mountain. When we pumped before, the USGS measured a subsidence of over 20 feet in places. Pumping in the desert would be pointless, as it wouldn't even leave us

enough water to drink, let alone irrigate with."

"Wait a minute," interjected Mr. Stevens. "Why is Albuquerque allowed to have as much water as they can pay for, when we only get 24 gallons and still have to pay?"

"Because we don't have 2.5 million people in our water district," said a farmer angrily, "and we're nothing but farmers."

A chair crashed over as yet another member of the audience shouted, this time standing, "I'm tired of this. I say we fix that dam and protect our water like we did in San Acacia in '01!"

"We can't sabotage any ditch valves this time, Mr. Armijo," said Stevens coldly.

"I say we take that dam out!" said yet another irate farmer. Her proposal met with roars of approval. Soon a body of determined farmers addressed Mr. Smith.

"Mr. President, I move that we take matters into our own hands." The statement met with roars of "I second that!"

I was totally stunned. In this dusty hall, the seeds of revolution seemed to have been planted. Mr. Smith was overwhelmed with proposals. He seemed to be shifting towards revolution himself.

Junior Daniel Bowman receives his award from WRRI Director Karl Wood. Daniel's parents, Rob and Karen, attended the luncheon where Daniel read his winning essay.

Every member in the hall knew that what had been born in Socorro on September 21, 2020 would be taught to generations of New Mexico schoolchildren. They also felt the futility of the endeavor. There was no way it could succeed. Perhaps these brave men and women were tired of the fall into decadence of every system involving water for irrigators. That fall had begun with the Silvery Minnow water shortage in '00 and ended in an anarchist southern half of the state 20 years later.

Several days later, work began to commence on the San Acacia Dam. A visitor from Albuquerque would have been surprised to see the massive concrete and dirt structure taking shape between Indian Hill and the mesa on the east side of the river, but no one from Albuquerque ever visited. A pity. The entire town of Socorro pitched in on this great structure. The county treasury was exhausted, then all of our personal accounts. However, it was a labor of vengeance. Not one of us begrudged the money, and not one of us came home each night (those of us that had houses) without an aching back.

I slept out on the dam when the weather was good. At 35, I was reasonably strong, but I mostly drove dump trucks and backhoes. I watched the full 135-foot dam take shape with pride and bitterness.

I had been raised here, back in 1988, when my parents and I moved from Arizona. I had seen the beginning of the Silvery Minnow crisis, and I will always remember the first year the Rio Grande never ran. Then, as I looked across the great arroyo that is the Rio Grande, and remembered the days when Pablo and I could set out the decoys in the mist and still have a duck for dinner, I felt the resolve to see the river flow one last time.

Finally, the last breakfast of bacon, eggs, and tortillas was cooked on the great hill that was the New and Improved San Acacia Dam. The last load of desert gravel was dumped. The last cement form was removed. A mass of humanity 10,000 strong stood before the dam, as the sand in the bed of the Rio Grande swirled and blew, and as the wind whistled mournfully through the burned and desiccated remains of the bosque they roared their defiance of the water-hoarders one last time.

An old, scratched, rusty, white truck lurched and backfired up the old I-25 freeway to Albuquerque. It entered the beeping hordes of drivers, those irate motorists that never on their life would let anyone pass them. But when they saw the sunglassed, grinning man in the old, sweat stained Stetson hat with the Hayduke Lives! bumper sticker on his windshield, they thought twice about not letting him pass. Who knows what such a person might do.

The truck weaved its way up the now newly paved freeway and entered the Bernalillo Metropolitan Area. The driver watched the great dam looming over the houses that came right up to its base. He crossed the cement ditch holding the ghost of the Rio Grande and caught the Jemez Freeway. The highway curved west and zigzagged up the cement face of Cochiti Dam.

The old, rusty truck stuttered to a stop at the viewpoint at the middle of the dam. The sunglassed man walked over to the north side, peered at the cobalt blue lake, crossed the pedestrian bridge, and faced the 300 foot drop-off. He pulled a Coors Light out of his leather jacket, savored it, and pitched the bottle off the face of the dam. It hit the Rio Grande ditch and shattered with a noise like a gunshot. Some bystanders stared curiously. One reached for her cell phone.

The sunglassed man unloaded the ATV from the back of his truck and drove off. The sound of his passage faded into silence.

He got off the dam, onto the freeway, off the freeway, and onto the cement floor of the Rio Grande Floodway. And he raced the wrath of the river. A great roar shattered the silence. Cracks raced down and sideways. Slabs of concrete exploded outward from the force of the C-6 in the pickup. And then came the water, no longer blue and placid, but white and vengeful. The man in the Stetson hat had fulfilled his quest. He had released the river.

The people of Socorro County stood below Indian Hill, the wall of the San Acacia dam at their backs, and the empty bed of the river before them. A wall of steaming, foaming, brown water surged down the bed. No one moved, not a single one out of 10,000. It was their destiny, and they would go out full of life, not slowly dying of thirst. And the water came, and they knew no more.

So I sit here, wearing my old, sweat stained Stetson hat, camped out among the willows, and I am happy to be alive. A little bit longer and the mist will rise, and I will get my duck for dinner. But until then I am content to sit here by the campfire, writing this, the one who got away.

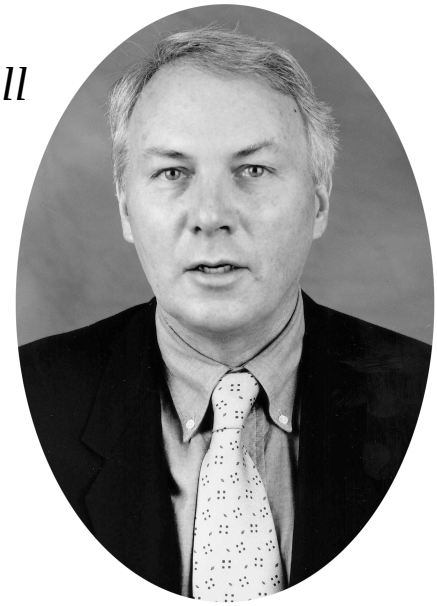
Albert E. Utton Memorial Water Lecture

featuring

Dan Tarlock

Distinguished Professor of Law
Chicago - Kent College of Law

Professor Tarlock will speak on western water in the 21st century in conjunction with an article he is preparing for the Natural Resources Journal.



to be given at the

46th Annual New Mexico Water Conference
November 6, 2001
6:30-8:30 pm, La Fonda, Santa Fe

Reports available

USGS reports

The U.S. Geological Survey has recently published several New Mexico related publications and national reports of interest to our area. Copies are available for inspection at the USGS District Office in Albuquerque (5338 Montgomery Blvd NE, Suite 400). The Water Resources Research Institute library also has the reports on file. They may be ordered from the USGS, Federal Center, Box 25286, MS 517, Denver, CO 80225. You may call 1-888-ASK-USGS for price information.

Estimates of Mountain-Front Streamflow Available for Potential Recharge to the Tularosa Basin, New Mexico - by Scott D. Waltemeyer. Prepared in cooperation with the City of Alamogordo and the Department of the Air Force, (Water-Resources Investigations Report 01-4013)

Water-Quality and Ground-Water-Level Trends, 1990-99, and Data Collected from 1995 Through 1999, East Mountain Area, Bernalillo County, central New Mexico - by Dale R. Rankin. Prepared in cooperation with the Bernalillo County Environmental Health Department (Open-File Report 00-476)

Use of Air-Pressurized Slug Tests to Estimate Hydraulic Conductivity at Selected Piezometers Completed in the Santa Fe Group Aquifer System, Albuquerque Area, New Mexico - by Carole L. Thomas and Condé R. Thorn. Prepared in cooperation with the City of Albuquerque Public Works Department, Water Resources Management (Water-Resources Investigations Report 00-4253)

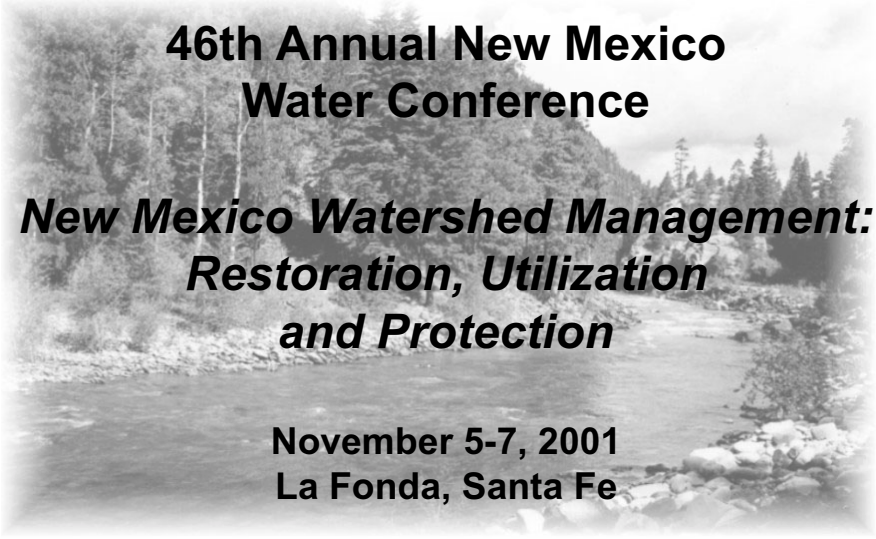
Predevelopment Water-Level Map of the Santa Fe Group Aquifer System in the Middle Rio Grande Basin between Cochiti Lake and San Acacia, New Mexico - Prepared in cooperation with the City of Albuquerque (Water-Resources Investigations Report 00-4249)

Other reports of interest

1999 Report of the Rio Grande Compact to the Governors of Colorado, New Mexico and Texas - available from the New Mexico Interstate Stream Commission, Bataan Memorial Building, Room 101, State Capitol, P.O. Box 25102, Santa Fe, NM 87504-5102 (505-827-6160)

A Primer on Climatic Variability and Change in the Southwest - This 28-page primer is aimed at a range of decision-makers, stakeholders, and other interested citizens and provides, in nontechnical language, answers to a number of questions: what do we know about the Southwest's past, present, and future climate; what are the status and trends of key social, economic, and environmental conditions in the region and how do these relate to climate; how do changes in climate affect agriculture, ranching, urban water demand, energy use, natural ecosystems, and other sectors; and what actions, taken by whom, might help minimize potential or likely adverse impacts of climatic variability and change? A printed version of the primer is available from the Udall Center (contact Jen McCormack at jenmack@email.arizona.edu). A pdf version is available at udallcenter.arizona.edu.

Water - The Potential Consequences of Climate Variability and Change. A report of the National Water Assessment Group for the U.S. Global Change Research Program. Lead author: Peter H. Gleick, Pacific Institute for Studies in Development, Environment, and Security. The report was issued September 2000. Printed copies available from the U.S. Geological Survey (703-648-5743). The report is also available on the web at www.gcrio.org/nationalassessment/water/ and at www.pacinst.org.



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