

Delaware Water Resources Center Initiates Programs for 2000

The Delaware Water Resources Center (DWRC) has a number of new projects underway for 2000.

The DWRC approved three **new research projects** for funding this year (see article on page 2). Additionally, **the DWRC will be supporting an undergraduate internship program this year.** Each intern will work with a faculty advisor to conduct a research or education project related to an area of interest to the DWRC. For more details on the internship program, visit the DWRC homepage at: <http://bluehen.ags.udel.edu/dewrc/index.htm>

A **DWRC advisory panel** has been established with representation from numerous organizations in the State which have significant expertise and interest in water resource research, management and education. Panel members are from environmental, natural resource and agricultural agencies, the farming community, academia, and non-profit organizations (see back page for membership list).

The DWRC advisory panel serves many crucial functions, including peer review and ranking of research proposals, planning of annual conferences, promoting the interaction of the DWRC with other agencies, and advising the Director on State priority water resource focal areas as well as the best ways to accomplish the Center's mission.

A **DWRC sponsored conference** will be held in the Spring of 2001 to provide an opportunity for DWRC research project results to be presented to the public. It is anticipated that the conference will also provide a forum for input regarding the Center's mission, as well as time for discussion on the status of critical water resource issues facing Delaware.

Request for Proposals: Water Resources Research National Competitive Grants Program

A request for proposals (RFP) for matching grants to support research on nonpoint source water pollution and water use is issued by the U.S. Geological Survey, in cooperation with the National Institutes for Water Resources and the Kentucky Water Resources Research Institute. A total of \$1-million is being made available for research under this program. At least \$500,000 is to be spent on topics addressing nonpoint source pollution. The remaining funds are to be focused on research in the area of water use. Any investigator at an institution of higher learning in the United States is eligible to apply for a grant through a Water Research Institute or Center established under the provisions of the Water Resources Research Act. Proposals involving substantial collaboration between the USGS and university scientists are encouraged, especially on proposals addressing nonpoint source pollution. Proposals may be for projects of 1 to 3 years in duration and shall not request total federal funds exceeding \$250,000 per project. Successful applicants must match each dollar of the federal grant with one dollar from non-federal sources.

Proposals must be filed on the Internet at <http://www.niwr.org/> by 11:59 PM, eastern standard time, March 24, 2000 and must be approved for submission to the National Competitive Grants Program not later than 11:59 PM, eastern standard time, April 3, 2000 by the Institute or Center through which they were submitted. Contact: Dr. Tom Sims, Director, Delaware Water Resources Center (jtsims@udel.edu).



Delaware Water Resources Center Funds Three New Research Projects

In the fall of 1999 the Delaware Water Resources Center (DWRC) issued a request for proposals for graduate fellowships in water quality. A major goal of these fellowships is to provide scientific support to the ongoing efforts of the Delaware Nutrient Management Commission (DNMC) to develop a State nutrient management program, as required by Delaware's 1999 Nutrient Management Act (see page 4 for details on the DNMC). Based on a review by the DWRC advisory panel in December of 1999, each of the following three fellowships has been approved for funding in the amount of \$16,000 per year for up to three years:

Mechanisms of Phosphorus Stabilization in the Soil Environment: A Molecular Scale Evaluation

Dr. Donald Sparks and Mr. Stefan Hunger
Department of Plant and Soil Sciences
University of Delaware

Many of the soils in the Mid-Atlantic region, especially in areas where intensive animal agriculture is practiced, contain excessive amounts of phosphorus (P) relative to crop needs. Over-application of P in manure and commercial fertilizers has contributed to the buildup of P in soils. It is well known that soil P losses to surface waters through erosion, runoff, and leaching also contribute to the degradation of water quality.

The first DWRC research project will evaluate the retention and release of P from soil minerals to better determine the factors which control the fate of P in soils and affect soil P loss to waters. State-of-the-art molecular scale spectroscopic methods, including x-ray absorption near edge spectroscopy (XANES) and nuclear magnetic resonance spectroscopy (NMR) will be used to elucidate the mechanisms by which P reacts in soils.

The results of the research will be used to improve predictions about the stability, release and availability of phosphorus in soils with and without the addition of fertilizers, manure and chemically-amended poultry litter. Research results are expected to improve predictive capabilities regarding P fate and mobility, the cornerstone of an effective strategy for enhancing agricultural management of P to protect water quality.

Baseflow and Stormwater Discharges of Nutrients to Delaware's Inland Bays

Dr. William J. Ullman and Mr. Joseph R. Scudlark
College of Marine Studies
University of Delaware

The second DWRC funded project will build upon existing research being conducted by the University of Delaware's College of Marine Studies, Delaware Department of Natural Resources and Environmental Control (DNREC) and the US Environmental Protection Agency (USEPA) Coastal Intensive Site Network (CISnet) program. Under the existing project, baseflow and storm event nutrient discharges to Delaware's Inland Bays are being monitored.

Nutrient over-enrichment has been identified as the primary cause of water quality and ecosystem impairment of the Inland Bays watershed. DNREC has set targets for allowable point and nonpoint source discharges of nutrients to the Inland Bays. The targets were developed based on a Hydrodynamic/ Water Quality Model that, to a large extent does not take into account the predictable seasonal variations in nutrient discharges nor the effects of unpredictable storms and storm-related discharge of water and nutrients. Furthermore, although land use information is used to establish the discharge limits, very little research has been conducted in the Mid-Atlantic region on the impact of different land uses on nutrient discharges. In addition, the model and resulting allowable targets currently used by DNREC managers are based on average annual flow conditions and average annual nutrient loadings.

The principal focus of the DWRC graduate fellowship project will be the conceptual analysis of the baseflow, stormflow and land use data which is being collected, and the development of a conceptual model that can be coupled with the existing Hydrodynamic/Water Quality Model. Results will be used to help set technically defensible nutrient discharge limits for determining the Inland Bays Total Maximum Daily Load (TMDL) allocations. (For more information on TMDLs, see page 6).

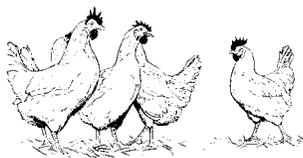


Environmental Policies for a Sustainable Poultry Industry in Sussex County, Delaware

***Dr. William F. Ritter, Bioresources Engineering
Dr. John Byrne and Dr. Young-Doo Wang,
Center for Energy and Environmental Policy
University of Delaware***

Poultry production in Sussex County, Delaware, the most concentrated area of broiler production in the nation, generates close to 300,000 wet tons of poultry litter each year. There is a pressing need today for economic and environmentally sound uses for this potentially valuable by-product of the poultry industry. The third DWRC research project will evaluate and rank various options for poultry litter use, treatment and disposal to determine the best mechanisms for reducing the nutrient imbalance in Sussex County and reducing nitrogen and phosphorus loads to surface and ground water in the Nanticoke and Inland Bays watersheds. Relative costs and predicted environmental impacts of the following options will be evaluated:

- Land application of poultry litter as a fertilizer.
- Drying and pelletizing the manure for use as a fertilizer outside the region.
- Composting the manure for use as a horticultural product in the Northeast and Mid-Atlantic States.
- Use of the poultry litter as a component of animal feed in the Delmarva region and elsewhere.
- Use of poultry litter as a fuel for combustion to generate heat, biogas, and electricity.
- Utilizing the phytase enzyme in feed, and feeding low phytate corn to reduce the phosphorus content of manure.
- Addition of alum to litter to reduce phosphorus transport in runoff waters.



Preliminary results from all three projects are to be presented at the DWRC Annual Conference in the Spring of 2001



Delaware's Nutrient Management Act

In June of 1999 the Delaware General Assembly passed, and Governor Thomas Carper signed into law, Delaware's Nutrient Management Law (title 3, Delaware Code chapter 22). The impetus for the legislation's passage originates from a history of ground and surface water quality impairment in Delaware due to excess nutrients, as well as lawsuits and policy changes at a national level aimed at mandating stricter controls on the management of animal manure.

To address the nutrient management issue, Governor Carper appointed an Agricultural Industry Advisory Committee on Nutrient Management (AIACNM) in 1998 to formulate recommendations which ultimately led to the development of the new nutrient management legislation. The University of Delaware also formed a nutrient management and water quality advisory committee in 1998, under the leadership of Dr. Tom Sims, Director of the Delaware Water Resources Center (DWRC). The task force provided technical input to the AIACNM based on the results of phosphorus and nitrogen management research conducted through the College of Agriculture and Natural Resources and the DWRC (see related article on page 5).

The final 1999 Delaware Nutrient Management Law establishes a 15-member Delaware Nutrient Management Commission (see membership on page 4) that must "...develop, review, approve, and enforce regulations governing the certification of individuals engaged in the business of land application of nutrients and the development of nutrient management plans..."

Nutrient Management Plans (NMPs) are required for all animal feeding operations with greater than eight animal units or for any property in excess of 10 acres upon which nutrients are applied.

The first deadline established by the act is July 1, 2000, when all commercial processors must file plans with the DNMC. All nutrient handlers must be certified by January 1, 2004 and all nutrient management plans must be reviewed and fully implemented by the year 2007.

For more information on Delaware's Nutrient Management Law, contact the Delaware Department of Agriculture (phone: 1-800-282-8685) or visit the State of Delaware's legislation website at:

www.state.de.us/research/assembly.htm

Delaware Nutrient Management Commission

William Vanderwende, Sussex County Dairy Producer, Chairman
David Baker, New Castle County Grain Industry, Vice Chairman
Edwin Brown, Golf/lawn Care Industry
Steve Corazza, New Castle County Poultry Producer
David Devine, Nursery Industry
Carlton Fifer, Kent County Vegetable Industry
Jeremy Homer, Kent County Public Citizen
John Hughes, Director, Division of Soil and Water, DNREC
David Jones, Environmental Advocacy Group
Tony Keen, Nutrient Consultant
Connie Larimore, Kent County Poultry Producer
Dale Ockels, Sussex County Swine Producer
Brian Schilling, Commercial Applicator
Carl Solberg, Environmental Advocacy Group
Charles West II, Sussex County Poultry Producer

Ex-officio Members:

Hon. Nicholas A. DiPasquale, Secretary, Department of Natural Resources and Environmental Control (DNREC)

Hon. Gregg Sylvester, Secretary, Department of Health and Social Services (DHSS)

Hon. John F. Tarburton, Secretary, Delaware Department of Agriculture (DDA)

Nutrient Management Program Administrator:

William Rohrer, Program Administrator,
Delaware Department of Agriculture
2320 S. DuPont Highway
Dover, DE 19901
phone: 1-800-282-8685 or 302-739-4811



Information on Nutrient Management and Water Quality

(Phone numbers are area code 302 unless otherwise noted)

Department of Natural Resources and Environmental Control (DNREC):

website: <http://www.dnrec.state.de.us>
Division of Water Resources, phone: 739-4860
Division of Soil and Water, phone: 739-4411

Delaware Geological Survey (DGS), phone: 831-2833

website: <http://www.udel.edu/dgs/dgs.html>

Delmarva Poultry Industry, Inc. (DPI), phone: 856-9037

US Department of Agriculture; Natural Resources and Conservation Service (NRCS), Dover, DE 678-4160,
<http://www.nhq.nrcs.usda.gov/BCS/nutri/management.html>

USDA National Extension Service

website: <http://hermes.ecn.purdue.edu/water/>

New Castle County Cooperative Extension, 831-2506,

website: <http://bluehen.ags.udel.edu/ncc/>

Kent County Cooperative Extension, 697-4000

Sussex County Cooperative Extension, 856-7303

Delaware Association of Conservation Districts,
Dover, DE, phone: 739-4411

Department of Health and Social Services (DHSS), Dover, DE, phone: 739-5264, website:

<http://www.state.de.us/dhss/dph/dphhome.htm>

US Environmental Protection Agency (EPA) - Region III, Philadelphia, PA, phone: (215) 814-2900,

website: www.epa.gov/owow/ (and [/OGWDW](http://www.epa.gov/ogwdw/))

US Geological Survey (USGS), Dover, DE,

phone: 734-2506, website: www.usgs.gov

Water Resources Agency for New Castle County, Newark, DE, phone: 831-4928

website: <http://www.wr.udel.edu/index.html>

Center for the Inland Bays, Nassau, DE, 645-7325,

website: <http://www.udel.edu/CIB>

Delaware Nature Education Society (DNS),

Hockessin, DE, phone: 239-2334

website: <http://www.delawarenaturesociety.org/>

Sierra Club, <http://members.dca.net/sierrade/>

Chesapeake Bay Foundation, Laurel, DE

website: <http://www.savethebay.cbf.org/>

Delaware State University, Dover, DE, 857-6400

website: <http://www.dsc.edu>

University of Delaware:

Department of Plant and Soil Sciences, 831-2534

website: <http://bluehen.ags.udel.edu/plsc>

Department of Bioresources Engineering, 831-2468

website: <http://bluehen.ags.udel.edu/breg/>

Department of Civil and Environmental Engineering,

831-4457, website: <http://www.ce.udel.edu>

College of Marine Studies, Lewes, DE, 645-4346

website: <http://www.ocean.udel.edu>

UD Research and Education Center, phone: 856-1997

Current DWRC Research

Three DWRC projects funded in 1996 are now nearing completion. Brief summaries of these projects are given below. More information about these studies can be found by visiting the DWRC homepage at: <http://bluehen.ags.udel.edu/dewrc/index.htm>. Final results will be presented at the next annual DWRC conference scheduled for the Spring of 2001.

Geochemistry, Geostatistics and Hydrology of Phosphorus Losses in Agricultural Drainage

Dr. Tom Sims and Dr. Don Sparks, Department of Plant and Soil Sciences, and Scott Andres, Delaware Geological Survey University of Delaware

The impacts of excess nutrients on water quality in the Delmarva region, as well as other Atlantic Coastal Plain areas dominated by animal based agriculture, prompted a DWRC study initiated in the Fall of 1996, to better understand the processes controlling the release and transport of phosphorus to surface water.

A major objective of the study was to develop an accurate, fundamental understanding of the soil and geochemical processes that control the release of phosphorus to drainage waters and to surface runoff. Initial research results identify an optimum pH range of 6.0 to 7.0 for maximum phosphorus sorption. In addition, a high correlation was found between phosphorus released, and the soil phosphorus $\text{NH}_4\text{Ox-P}$ and $\text{NH}_4\text{F-P}$. It is encouraging that preliminary research results suggest that these two extractants have value in evaluating the risk of phosphorus loss to waterbodies, particularly since NH_4Ox has been used to characterize the degree of phosphorus saturation (and thus potential for loss in runoff and leaching) and NH_4F is a constituent of two major routine soil tests which have been proposed to predict potential for phosphorus loss from soils.

Finally, research results suggest a threshold of 60 mg/kg of phosphorus, using agronomic soil test P (STP), as a maximum concentration for Mid-Atlantic soils. Soil phosphorus concentrations above this threshold resulted in an increased potential for loss of soluble and bioavailable phosphorus to surface waters.

Hydrologic modeling is also being conducted to estimate phosphorus exports from agricultural fields via drainage ditches in the watershed.

The research results should help prioritize areas and improve phosphorus management practices in the Inland Bays watershed as well as other areas in the Atlantic Coastal Plain faced with similar water quality problems.

Groundwater Remediation Using Biosurfactants

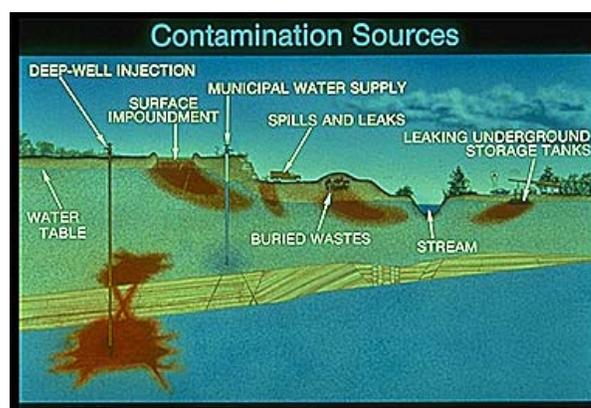
Dr. Mark Radosevich, Department of Plant and Soil Sciences, and Dr. Dan Cha, Department of Civil and Environmental Engineering University of Delaware

Many of the sites in Delaware and other areas of the Northeastern region where hazardous substances have been released to soils and subsurface environments are located where there are predominantly shallow water tables and permeable soils. At sites such as these, the groundwater is very susceptible to contamination. Although the capacity of soils to detoxify waste has been well documented, natural detoxification processes often require years to restore impacted sites. Economical and efficient ground water remediation techniques are needed.

A DWRC funded research project was initiated in the Fall of 1997 to assess the effects of various biosurfactants (derived from bacteria and plants) on the desorption and biodegradation of sorbed organic pollutants. Additionally, the potential of surfactants produced in situ to enhance the transport and degradation of sorbed phenanthrene was evaluated.

While substantial research has been conducted on the use of synthetic surfactants to mobilize contaminants for groundwater remediation techniques, additional research is needed to better understand the effectiveness of biologically derived surfactants. Biosurfactants have several advantages which make them superior candidates to synthetic surfactants in bioremediation schemes. Biosurfactants are biodegradable, pose no additional pollution threat, and are generally non-toxic to microorganisms. In addition, biosurfactant production is less expensive, and can be easily achieved on-site.

All surfactants tested increased the solubility of phenanthrene, and enhanced the release of sorbed phenanthrene from soil. It is anticipated that the research results will provide sufficient information to ultimately lead to the development of improved bioremediation strategies.



**Total Maximum Daily Load Allocations
for the Christina River Basin:
Installation and Operation of a
Permanent Stream Sampling Site**

**Dr. Carmine Balascio, Department of Bioresources
Engineering, and Gerald Kauffman,
Water Resources Agency
University of Delaware**

Total Maximum Daily Loads (TMDLs) are currently being developed for waterbodies in the State which have the most severe water quality problems. A TMDL establishes the maximum amount of pollutants a waterbody can receive without violating water quality standards, thereby allowing use goals, such as swimming, fishing and drinking water supply to be met. (For more information on TMDLs in Delaware, please visit the DNREC website: <http://www.dnrec.state.de.us>.)

To help support TMDL development, a DWRC funded research project was initiated in 1996 to obtain flow and water quality data for the Christina River Basin. The Christina Basin is made up of four watersheds: the Brandywine, Red Clay, and White Clay Creeks, in addition to the Christina River. The streams of the Christina River Basin provide 75% of the drinking water supply for New Castle County, and include the only designated put-and-take trout streams in Delaware.

A permanent stream sampling station has been established in the Christina Basin, making it possible to gather flow data for a range of different storm events, as well as for low flow dry periods. The data are being used to calibrate the hydrology and water quality model HSPF, which will be used to calculate the TMDL allocations for the Christina River Basin.

The full TMDL process will determine the pollutants causing water quality impairments, identify maximum permissible loading capacities for water quality limited segments of the Christina River, and for each relevant pollutant, assign load allocations to each of the different sources, point and nonpoint, in the watershed. The DWRC project, which is part of a large interstate effort between Delaware and Pennsylvania, will help support the ultimate objective of the TMDL: to restore the waters of the Christina Basin to fishable and swimmable status.



**DWRC Research
Project Publications
and Fact Sheets**



Balascio, C.C. , D.J. Palmeri, and H. Gao. 1998. "Use of a genetic algorithm and multi-objective programming for calibration of a hydrologic model" in TRANSACTIONS of the ASAE, 41(3), Minneapolis, MN, pages: 615-619.

Vadas, P. A. and J. T. Sims. 1998. Redox status, poultry litter, and phosphorus solubility in Atlantic Coastal Plain soils. Soil Science Society of America Journal 62:1025-1034.

Sims, J. T. and P. A. Vadas. 1997. Nutrient management strategies for the profitable, environmentally sound use of phosphorus. Fact Sheet ST-08. College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

Sims, J. T. and P. A. Vadas. 1997. Soil test phosphorus status and trends in Delaware. Fact Sheet ST-09. College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

Sims, J. T. and P. A. Vadas. 1997. Use of phytase and low-phytate corn to increase phosphorus availability in poultry feed. Fact Sheet ST-10. College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

Sims, J. T. and P. A. Vadas. 1997. Nutrient management planning for poultry-grain agriculture. Fact Sheet ST-11. College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

Sims, J. T. and P. A. Vadas. 1997. Value added products from poultry wastes: Alternatives to land application. Fact Sheet ST-12. College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

Chang, J.S., D.K. Cha, M. Radosevich, and Y.Jin. 1999. "Mineralization of phenanthrene in the presence of biosurfactants produced by Rhodococcus erythropolis". In Hazardous and Industrial Wastes, 31st Mid-Atlantic Industrial and Hazardous Waste Conference Proceedings.

Leytem, A.B. and J.T. Sims, 1999, "Nutrient Management for Delaware Agriculture, Developing a Comprehensive Nutrient Management Plan" Fact Sheet NM-02, College of Agriculture and Natural Resources, University of Delaware, Newark, DE.

To view the DWRC Five Year and Annual Reports, visit the DWRC homepage at the following address:
<http://bluehen.ags.udel.edu/dewrc/index.htm>

Past DWRC Conferences and Research Presentations

Biosolids Survey Results: The DWRC conducted a national survey to determine what States have restrictions on phosphorus in their land application of biosolids programs. The results were presented at the American Society of Agronomy (ASA), Crop Science Society of America (CSSA) and Soil Science Society (SSSA) of America annual meetings held in Baltimore, Maryland from October 18 - 22, 1998.

AFO Strategy: DWRC co-sponsored a conference held November 12, 1998 to discuss the USDA and EPA Unified National Strategy for Animal Feeding Operations. Proposed Permitting Guidance for Concentrated Animal Feeding Operations (CAFOs) can be reviewed at the following website: <http://www.epa.gov/owm/afoguide.htm>.

Nutrient Management Training Session:

In January of 1999, DWRC co-sponsored a four-day educational and training program entitled, "Nutrient Management for Water Quality Protection". Participants were provided a forum for discussion and education regarding animal waste and nutrient management issues impacting Delaware. The Nutrient Management Handbook for Delaware (Sims, J.T. and Gartley, K.L., April 1996) and a new slide module were utilized at the training session.

Installation and Operation of a Permanent Stream Sampling Site for the Christina River Basin: Results of Carmine Balascio and Gerald Kauffman's research were presented at the conference "Interstate Initiatives for Clean Water in the Christina Basin" which was held on June 17, 1999 at the Delaware Nature Society in Ashland, Delaware.

The Effect of Biosurfactants on the Fate and Transport of Nonpolar Organic Contaminants in Porous Media: At the 1999 Mid-Atlantic Industrial and Hazardous Waste Conference, a presentation entitled, "Mineralization of Phenanthrene in the Presence of Biosurfactants Produced by *Rhodococcus Erythropolis*", was given based on the results of research by Mark Radosevich, Yan Jin and Daniel Cha. The research was also presented at the 1998 Soil Science Society of America meeting, the 1999 American Society for Microbiology meeting and at DuPont's Stine-Haskell Center.

Modeling and Improved Management of Phosphorus: Presentations were given in 1998 on "Modeling Agricultural Phosphorus Exports from an Atlantic Coastal Plain Watershed in the United States" at the International Conference on Practical and Innovative Measures for the Control of Agricultural Phosphorus Losses to Water, Belfast, Northern Ireland and at the ASA Annual Meeting, Baltimore.

Upcoming Conferences in 2000



1. Managing Nutrients and Pathogens from Animal Agriculture; March 28-30, Camp Hill, PA, Natural Resource, Agriculture and Engineering Service (NRAES) Website: <http://www.nraes.org/>
2. The New Millennium: Where Will the Water Come From? April 26-27, Matamoras, PA, AWRA Regional Conference, contact Raymond Zabihach,(973)829-8120.
3. National Water Quality Monitoring Council: Monitoring for the Millennium; April 25-27, Austin TX. Website: <http://nwqmc.site.net>
4. Nutrient Management Planning 2000: Perspectives for Crop Advisors, June 21, Clayton Hall (contact: Karen Gartley, 831-1392), to be held in conjunction with Northeast Branch of the American Society of Agronomy and Soil Science Society of America Annual Meeting, June 18-21, Clayton Hall, Newark, DE. Website: <http://www.asa-cssa-sssa.org/branch/ne/>
5. Watershed 2000: July 9-13, Vancouver, British Columbia, Water Environment Federation (WEF) Conference. Website: <http://www.wef.org>
6. Living Downstream in the Next Millennium: Reconciling Watershed Concerns with Basin Management; July 31-August 4, New Orleans, LA, Universities Council on Water Resources, <http://www.uwin.siu.edu>
7. International Conference on Riparian Ecology and Management in Multi-Land Use Watersheds; August 27-31, Portland, Oregon, American Water Resources Association (AWRA), <http://www.awra.org/>
8. International Symposium on Animal, Agricultural and Food Processing Waste, October 7-11, Des Moines, IA e-mail: moore@asae.org
9. AIH Annual Meeting and International Conference on Atmosphere, Surface and Subsurface Hydrology and Interactions, November, 5-8, Research Triangle Park, NC. Website: www.aihydro.org
10. For additional listings on water resource courses and conferences, browse the websites listed above, as well as the National Groundwater Association's (NGWA) Website: <http://www.ngwa.org/education/>

***The Delaware Water
Resources Center***

The Delaware Water Resources Center (DWRC), established in 1965, is part of a network of 54 Water Resources Research Institutes throughout the nation. The DWRC receives funding through Section 104 of the Water Resources Research Act of 1984. The U.S. Geological Survey administers the provisions of the Act and provides oversight of the nation's Water Resources Centers. The primary goals of the DWRC are to: support research that will provide solutions to Delaware's priority water problems, disseminate research results to water managers and the public, and to promote the training and education of future water scientists and engineers.

***Delaware Water
Resources Center
Advisory Panel***

Chris Brown
Steven K. Dentel
Judith Denver
Kevin Donnelly
Bernard Dworsky
Mark Isaacs
Ed Jones
Ken Lomax
Jenny McDermott
Dorothy Miller
Paul Petrichenko
Kent Price
Bruce Richards
Bill Saylor
Carl Solberg
William Vanderwende

The ***Water News*** is published biannually by the University of Delaware Water Resources Center

Dr. J. Thomas Sims - Director

Cynthia Kranz Greene - Editor

Tammy Allston Kater - Graphics

The *Water News* welcomes materials for publication, including news articles and letters to the editor. If you have material to submit or if you would like to be placed on our mailing list to receive future issues of *Water News* please address your correspondence to:

Cynthia Greene

Delaware Water Resources Center

College of Agriculture and

Natural Resources

University of Delaware

Townsend Hall

Newark, DE 19717-1303

E-mail: cgreene@udel.edu

Phone: (302) 831-1392

Delaware Water Resources Center
College of Agriculture and Natural
Resources
University of Delaware
Townsend Hall
Newark, DE
19717-1303