Water Resources Center
Annual Technical Report
FY 2004

Introduction

The Delaware Water Resources Center receives an annual Federal matching grant as authorized by section 104 of the Water Resources Research Act of 1984 (Public Law 98-242) as amended by Public Law 101-397, Public Law 104-147, and Public Law 106-374. The U.S. Geological Survey (USGS), Department of the Interior, administers the provisions of the Act. This annual evaluation report describes, in the format prescribed by the USGS, the research, training, and information transfer activities supported by the section 104 grants and required matching funds during fiscal year 2004.

Introduction

Understanding the nature of the water quality and water supply problems faced in Delaware, historically and today, requires knowledge of the physiographic nature of the state, its climate, and major land uses. Geologically, Delaware is comprised of the Piedmont and Atlantic Coastal Plain Provinces. Only the northernmost 6% of the state is within the Piedmont, a region created of very old igneous and metamorphic rock. Soils range from well-drained, highly productive silt loams in the Piedmont to well- and excessively well-drained sandy loams and loamy sands in the Coastal Plain. Significant areas of poorly drained soils are also present, particularly in southeastern Delaware. Erosion and surface runoff are the main concerns in the Piedmont, while leaching of contaminants to shallow ground waters is the main water quality problem in the Coastal Plain. Rainfall as of 2000 is plentiful (45 in/yr) and rather constant, averaging 3 to 4 in/month in winter and spring and 4 to 5 in/month in summer. Precipitation typically exceeds evapotranspiration by 12 to 18 in/yr, providing 10 to 12 in/yr of groundwater infiltration. Surface water is the main water supply source in the Piedmont, although the Cockeysville Formation is an important local aquifer of fractured marble and dolomite. This province is dominated by the Christina River Basin, fed by rivers that first flow extensively through Pennsylvania and Maryland. Water quality of the White Clay and Red Clay Creeks and Brandywine River are strongly affected by land use and point sources of pollution in neighboring states. Those rivers flow into the Christina River which, in turn, flows into the Delaware River. Ground water is the major water supply source for the Atlantic Coastal Plain, a province of southeastwardly thickening unconsolidated and semi-consolidated sediments over crystalline basement rock. A primary aquifer in this province for water supply, stream base flow, and confined aquifer recharge is the unconfined Columbia aquifer. In a southwardly expanding wedge, the western portion of this area flows to the Chesapeake Bay through headwaters of the rivers and creeks of the Delmarva Peninsula's eastern shore. The mideast section of the province flows to the Delaware Estuary, fed by the watersheds of 15 creek and river systems. The southwest portion of the state flows into the Inland Bays of Delaware and Maryland and the Atlantic Ocean. The major land use in Delaware as of 2000, as in the past, is agriculture (526,070 acres; 41% of the 1.28 million acres in the state), which is dominated by a large, geographically concentrated poultry industry. Other main land uses are urban (19%), wetlands (19%), forests (15%), open water (4%), and barren land (1%). Delaware has 2509 miles of streams and rivers, 2954 acres of lakes/reservoirs/ponds, 841 square miles of estuarine waters, and 25 miles of ocean coastline. Approximately 2/3 of the state's wetlands are freshwater, and 1/3 is tidal. Protection of the quality and quantity of the State's surface waters and aquifers is a major concern to all

agencies and individuals responsible for water resource management in Delaware. Groundwater protection is particularly important given the increasing reliance on this resource for drinking water. In general, the key priority water resource issues today are (not prioritized): (1) enhanced management and control of stormwater runoff, erosion and sediment; (2) improved understanding of sources, transport, fate, and remediation of toxic organics and trace elements; (3) comprehensive management of agricultural nutrients; (4) identifying sources of pathogenic organisms and preventing human health impacts; (5) increased understanding of the response of aquatic systems to pollutants; (6) identification and protection of wellheads and aquifer recharge areas; (7) better management of water supply and demand and development of a systematic means to deal with droughts; (8) treatment and disposal of on-site sewage; (9) protection and restoration of wetlands; and (10) prevention of saltwater intrusion to potable water supplies.

The Water Resource Problems of Delaware

Surface Water Quality: Delaware has a number of serious, documented surface water quality problems. Many can be traced back to point source pollution problems in past decades; others reflect ongoing anthropogenic activities that degrade surface water quality. Water quality is a major state environmental priority and improvements have occurred, particularly since the 1970's, due to the use of state and federal regulatory and funding means to address "end-of-pipe" point sources of surface water pollution. Much of this improvement was due to aggressive use of federal funding, available in the late 1970's and early 1980's under the Clean Water Act and combined with local funding, to expand and improve municipal wastewater treatment systems.

The National Pollution Discharge and Elimination System (NPDES) Program in Delaware has reduced the number of "point sources" from over 200 in the 1970's to 59 as of 2000 . Major reductions in oxygen demanding materials and toxics in surface waters were achieved. Today, however, large federal investments in the infrastructure needed to reduce point source pollution are more difficult to obtain. This raises the question of whether or not it is reasonable to expect additional major improvements in water quality due to increased control of point source pollution. Reductions in point source pollution of surface waters have drawn attention to the need to control nonpoint pollution. The consensus among state and federal agencies is that Delaware's main water quality challenge today is to manage diffuse sources of pollution from urban, suburban, and rural landscapes. The major surface water quality problems in Delaware include:

Urbanization: A rapidly expanding urban population is increasing pressures on Delaware's surface waters. Rivers and streams are being affected by elevated temperature and low dissolved oxygen levels that can result from degradation of streambanks and stream channels. In residential and urban areas, increases in impervious surface have resulted in greater and flashier stormwater runoff, leading, in turn, to erosion, sedimentation, shallower water levels and destabilization of stream channels. Biological and habitat quality are also being affected by removal of stream buffers and stream bank "hardening" through use of riprap and concrete.

Drainage: Extensive drainage systems have been installed throughout the state, especially in coastal plain areas. Most were constructed in the 1930's and 1940's by the Civilian Conservation Corps and the Works Progress Administration. At that time, building a drainage ditch system involved channelizing and straightening headwaters of existing natural streams, then constructing ditches out and back from the channelized stream. Upland wetlands were often drained to reduce mosquito populations. A state "tax

ditch program" is re-constructing ditches and in doing so wetlands are protected or augmented and management practices are used to minimize impacts to habitat. The effects on the biological and habitat quality of the waterway once it is stabilized are unknown. Another trend today, is the proliferation of public ditch projects instead of tax ditches. Public funding makes the choice by landowners to tax themselves for reconstruction and maintenance of ditches less compelling. Public ditch projects are typically smaller (a few hundred feet) in scope and take place in the upper reaches of streams (typical bottom width is 3 feet) to augment mostly residential and some agricultural drainage. These projects are often carried out by the Conservation Districts. Nothing is known about the impacts to water quality or ecology from such projects. This lack of information may be important since protection of small headwater streams is critical to watershed health. Few streams in Delaware are unaffected by current or historic drainage projects that modify watershed drainage, natural stream channel configuration, buffers, and nutrient transport.

Nutrients are a leading cause of water quality degradation in Delaware. Nutrient effects can be seen especially in lakes, ponds, bays, and estuaries that receive nutrients conveyed by rivers, streams, and ground water. According to the State of Delaware's Feb. 5, 2005 305(b) report, Delaware waters are generally considered to suffer from eutrophication and low dissolved oxygen related to nutrient enrichment. Excessive macroalgae production in the inland bays strongly affects dissolved oxygen levels. In localized areas, large mats of algae accumulate and rot creating "hypoxic and anoxic death zones" as noted in the state Division of Water Resource's 2000 Annual Report. Aquatic life such as oyster beds that cannot move can be destroyed by these conditions. In 2000, plantings for a seagrass re-establishment project were not implemented due to extensive macroalgae growth in the Indian River system. Thirty-four fishkills were investigated in 2000 and 23 in 2001 by the state Division of Fish and Wildlife, some in dead-end lagoons and some in open waters. Many of the incidences are thought to be related to low dissolved oxygen. Though toxic organisms including Pfiesteria have been present in some cases those organisms cannot be directly linked as a cause of any kills. There were 17 fish kills each in 2002 and 2003. Of the fishkills in 2003, 4 were from natural causes, 4 of unknown cause, and 9 were from low dissolved oxygen. Two of those kills were compounded by large phytoplankton blooms.

Primary land-based sources of nutrients in Delaware are agricultural practices, septic systems, and urban runoff. About 41% of Delaware's land area is devoted to agricultural activities and 19% to urbanized uses. Delaware's agricultural industry has a strong broiler industry component that heavily influences the state's overall agricultural nutrient balance and has long created nutrient management problems because of the large amount of manure that must be land applied. About 70% of Delaware's cash farm income was from broilers in 2001, with production of 257,700,000 broilers. Delaware's southern most county ranked first among counties nationally in broiler production.

Other problems: Toxics have affected Delaware waters resulting in fish consumption advisories for 5 lakes/ponds and portions of 12 rivers in 2002. The primary pollutant is polychlorinated biphenyl (PCB). Chlorinated pesticides, dioxins, and mercury have also been identified. Though PCB's have long been banned they are persistent in the environment and are transported from land to waters through runoff to settle in waterbody sediments where they enter the aquatic food chain.

New designated uses and surface water quality standards as amended on July 11,2004 indicate that pathogenic organisms in surface waters have negatively affected shellfish harvesting and caused 94% of Delaware's rivers and streams to not fully support the swimming use; 65% do not fully support the fish and wildlife use. Most of these waters do not meet the standards because of nonpoint source pollution

impacts.

Groundwater Quality: The domestic needs of approximately two-thirds of the State's population are met with ground water provided by both public and private wells. Most of the water used for agriculture, Delaware's largest industry, and self-supplied industrial use, is also derived from ground-water sources. A shallow water table and high permeability soils make Delaware's ground water vulnerable to pollution. Shallow unconfined aquifers are especially vulnerable, though deeper confined aquifers are susceptible as well because they subcrop beneath and are recharged by unconfined aquifers.

Major groundwater quality problems in Delaware today are:

Nutrients: Nitrates from agriculture and septic systems are, by far, the major contaminant in Delaware's ground water. There are also some concerns about dissolved phosphorus transport to surface waters by shallow ground water flow in parts of the state where shallow water tables are interconnected with surface waters by ditches and/or tiles.

Organics: Hydrocarbons have also been found as have pesticides, though not at levels which cause alarm. A major source of hydrocarbons, such as MBTE, is leaking underground storage tanks (USTs) while agricultural activities are the source of pesticides. There are 12,050 regulated underground storage tanks in the State; 9,651 have been properly abandoned and 2,399 are still in use. Since the 1980's 314,040 releases to ground water have been confirmed and 2,800 of those (USTs) have been closed. Over the period 2002-2003, 142 sites had confirmed releases with 30 confirmed ground water releases.

Salt water intrusion: Problems with private wells occur sporadically from seasonal salt water intrusion along the Delaware River and the Inland Bays/Atlantic Ocean coastal areas. No major problems have occurred and only one public well in Lewes required abandonment.

Trace elements: Though not considered a health threat, iron concentrations are a widespread problem in Delaware for cosmetic reasons. Many public water supplies have treatment systems to remove iron. Thirty-four percent of 561 raw groundwater samples analyzed by Delaware's Office of Drinking Water in 2002 exceeded the secondary contaminant level standard of 0.3 mg/L. Concerns are emerging about arsenic in ground waters because of the long-term application of this element in poultry manure to soils overlying shallow drinking water aquifers, and the lowered drinking water standard for As.

Wetlands Quality: A watershed study of nontidal wetlands is currently under way that will provide information regarding overall condition of wetlands and identify major stressors affecting wetland function. For now, the primary evaluation of wetlands lies in determining trends, primarily rate of loss. About 2000 acres of vegetated wetlands were lost statewide between 1981/2 and 1992, predominantly palustrine vegetated wetlands (1890 acres). Of the palustrine vegetated wetlands, the greatest loss was of palustrine forested wetlands (1505 acres). Agricultural activities are considered the primary cause of loss (954 acres) and residential activities had the second greatest impact (436 acres). Estuarine wetlands were destroyed to a much smaller extent (106 acres), mainly due to saltwater impoundments and filling.

Water Supply: Half of Delaware's population is located in the Piedmont (6% of land area) and uses surface water for drinking water. The other 50% of the population relies on ground water and is spread throughout the remaining 94% of the State. With regard to the amount of water used, ground and surface water are of equal importance; with regard to area served, ground water is overwhelmingly dominant. Capacity concerns are important north of the Christina River due to population concentration and the

reliance on surface water. For the rest of the state, the reliance on abundant ground water and a diffuse pattern of development suggest that the supply of potable water is not currently a problem. Recent drought emergencies have brought water supply demand in northern Delaware into conflict with the need to maintain minimum pass-through flows in streams for protection of aquatic resources. Benthic organisms, the foundation of the aquatic food chain, cannot move to avoid dry stream bed conditions. This suggests that not maintaining pass-through flows at all times would be detrimental to stream aquatic life. Required pass-through flows can be high; the need to ensure those flows can result in practices or structures such as reservoirs that are economically inhibitory or may cause as much or greater environmental degradation as occasional dry stream bed periods.

Delaware Water Resources Center: An Overview

The Delaware Water Resources Center (DWRC) has been a part of the University of Delaware since 1965. From 1965 until 1993 the DWRC was located in the University of Delaware's Research Office. In 1993, the DWRC was moved to the College of Agriculture and Natural Resource (CANR) where, since 1997, Dr. Tom Sims, Associate Dean for Academic Programs and Research, has served as DWRC Director. The DWRC works with all organizations and agencies in Delaware with an interest or responsibility in water resources. We have a 13 member Advisory Panel representing a wide variety of water resource backgrounds. We regularly cooperate with the Delaware Water Resources Agency, Delaware Geological Survey, Delaware Department of Natural Resources and Environmental Control, Center for the Inland Bays, the Delaware Nutrient Management Commission, Delaware State University, USDA Natural Resources Conservation Service, Delaware Nature Society, and Sierra Club, to name but a few. The DWRC has always supported a wide range of water resource related research, education, and information transfer programs. We cooperate with many academic departments and units that conduct water-related research at Delaware State University's Department of Agriculture and Natural Resources and the University of Delaware (UD), including the UD Water Resources Agency in the Institute for Public Administration, the UD Departments of Biology, Bioresources Engineering, Chemistry, Civil Engineering, Geography, Geology, and Plant and Soil Sciences, as well as the UD Colleges of Agriculture and Natural Resources, Arts and Science, Engineering, Human Services, Education and Public Policy, and Marine Studies. Close communication is maintained between the DWRC and State natural resource agency representatives and water officials to address priority water quality and water quantity concerns in the State. Through efforts such as these, the DWRC has provided key stakeholders a forum for discussion and an opportunity for education regarding water resources.

Section 104 Objectives

The DWRC has defined a two-fold mission to meet the goals of the Water Resources Research Act:

(1) To support research, education, and public outreach programs on water supply, water quality, and water management, issues of major importance to Delaware citizens; and

(2) To support training and education programs for future water scientists, engineers, managers, and policymakers who will lead water resources research, planning, and management efforts in the future.

To meet these goals we have focused our efforts during 2004 into three major areas:

(1) Graduate Fellowship Program: A competitive graduate fellowship program supports graduate fellows on a 3-year cycle. The two Ph.D. graduate fellows supported during the period of this report are both in the University of Delaware College of Agriculture &Natural Resources. They are researching water quality topics of virus deactivation/removal and arsenic transport / fate;

(2) Undergraduate Internship Program: We initiated a highly successful undergraduate internship program in 2000. In the first 5 years we funded 42 undergraduate interns from four Colleges within the University of Delaware and the Department of Agriculture and Natural Resources at Delaware State University. Interns work with faculty to conduct research, prepare a written project report, and present their findings at an annual poster conference;

(3) Information Transfer: The DWRC web site and newsletters (print and electronic) are sources of up-to-date information on DWRC activities and water-related issues of importance to Delaware and the region. Our web site provides information on water resources problems, links to water-related organizations, internship and job opportunities in the water resources, a calendar of upcoming events, and a Kids Zone for teachers and parents. We also co-sponsor state-wide conferences on water resource topics of current interest.

Delaware Water Resources Center Program Goals and Priorities

The primary goal of the Delaware Water Resources Center is to support research that will provide solutions to the State’s priority water problems.

A secondary goal is to promote the training and education of future water scientists and engineers.

A third goal is to serve as a source of information to water researchers, decision makers, natural resource protection agency personnel, and to the public through technology transfer projects.

Research Program

Graduate Fellowship: Removal And Inactivation Of Water-Borne Viruses Using Elemental Iron

Basic Information

Title:	Graduate Fellowship: Removal And Inactivation Of Water-Borne Viruses Using Elemental Iron
Project Number:	2003DE30B
Start Date:	7/1/2003
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At large
Research Category:	Not Applicable
Focus Category:	Water Quality, Toxic Substances, Geochemical Processes
Descriptors:	
Principal Investigators:	Yan Jin, Pei Chiu, Liping Zhang

Publication

1. Boyd, Amy, Ed., Spring 2004, Delaware Water Resources Center WATER NEWS Vol. 5 Issue 1, "Removal and Inactivation of Water-borne Viruses Using Elemental Iron", http://ag.udel.edu/dwrc/newsletters/Spring2004.pdf, pp. 6-7.
2. Boyd, Amy, Ed., Fall 2003 Delaware Water Resources Center WATER NEWS Vol. 4 Issue 2, "DWRC Awards Two New Graduate Fellowships", http://ag.udel.edu/dwrc/newsletters/fall2003.pdf p.6.
3. Jin, Yan, Pei Chiu and Liping Zhang, 2005, Removal and Inactivation of Water-borne Viruses Using Permeable Iron Barriers, Fellowship Progress Report to the Delaware Water Resources Center, Newark, Delaware, 5 pages.

Delaware Water Resources Center (DWRC) Fellowship Project 2003-2005
"Removal and Inactivation of Water-borne Viruses Using Elemental Iron"
Liping Zhang, DWRC 2003-2005 fellow
Advisors at the University of Delaware (UD):
Dr. Yan Jin, Plant & Soil Sciences
Dr. Pei Chiu, Civil & Environmental Engineering

Drinking water safety and the growing demand for potable water are two critical water resource issues facing Delaware. The mission of **DWRC** includes supporting research, education, and outreach programs that focus on water supply, water management, and water quality. The research of **DWRC** fellow Liping Zhang, advised by Dr. Yan Jin of the **UD** Department of Plant and Soil Sciences and Dr. Pei Chiu of the **UD** Department of Civil and Environmental Engineering, will evaluate the feasibility of using elemental iron to remove and inactivate waterborne viruses. The purpose of this research is to ultimately develop an effective and economical technology that can be used to remove pathogens from water.

Ms. Zhang received her M.S. in environmental science and engineering and has two and half years of experience in water quality research. She has a keen interest in her Ph.D. project, stating, "Dr. Jin and Dr. Chiu are creative persons and have extensive experience in virus fate and transport in porous media and using elemental iron to treat environmental pollutants. Under their direction, I hope to provide a scientific understanding of the interactions between viruses and elemental iron and iron oxides and the factors that influence these interactions." Liping is very excited about her research, which she hopes to yield an innovative, effective, robust, and low-cost technology that can be used to remove viruses (and potentially other pathogens) in drinking water, wastewater, and groundwater, and ultimately contribute to Delaware's water quality. Other potential benefits of the iron technology may include lower disinfectant dosage and cost and reduction in disinfection by-product formation.

Abstract

Microbiological contamination of drinking water continues to be one of the greatest challenges in public health risk management in the 21st century. Among the different classes of microbial pathogens, viruses are of particular importance as they are smaller than bacteria and protozoa, far more mobile in subsurface environments, and also more resistant to the currently available water treatment technologies. The United States Environmental Protection Agency (USEPA) in the proposed Ground Water Rule (GWR) identifies viruses as the target organisms because they are responsible for approximately 80% of water-borne disease outbreaks for which infectious agents were identified.

The proposed research will evaluate the feasibility of using elemental iron in a continuous-flow treatment barrier to remove and inactivate waterborne viruses. ***We hypothesize that iron can be used to remove viruses from water because elemental iron can continuously generate and renew the surface iron oxides and oxyhydroxides through corrosion in water, and iron oxides and oxyhydroxides have been shown to inactivate viruses***. A preliminary column test we conducted recently shows that a very thin layer (3 mm) of iron filings in the flow path of virus-contaminated groundwater (8.8 min residence time) resulted in approximately 2-log (99%) removal of two viruses over 40 pore volumes, and 90% of the removal was due to inactivation rather than reversible sorption. We propose to conduct a series of column experiments to further evaluate the effectiveness of iron to remove two bacteriophages and an avian virus and to investigate the effects of the variables and medium conditions that are relevant to water treatment, including iron type and age, pH, and dissolved oxygen.

The specific objectives are:

1. To test the effectiveness of elemental iron to continuously remove and inactivate viruses from contaminated water,
2. To investigate the effects of important parameters (e.g., residence time, iron type and age, virus type) and medium conditions (pH, dissolved oxygen) on the efficacy of virus removal, and
3. To identify the types of Fe oxides/oxyhydroxides involved in virus removal and inactivation.

The proposed study represents the first attempt to evaluate elemental iron for removing pathogens from water. Although elemental iron has been used in permeable reactive barriers (PRBs) to remove chemical contaminants in groundwater for almost a decade, it has never been shown to remove viruses. The proposed study will help determine whether iron PRBs can potentially be a feasible technology for removing waterborne viruses. The research will also provide information regarding the interactions between virus particles and iron mineral surfaces involved in virus removal. This information will form the basis for elucidating, in our subsequent studies, the mechanisms for virus inactivation and sorption by iron oxides - a process that is important in both natural and treatment systems.

Upon successful completion of the proposed project, we will seek longer-term funding to (1) study the mechanisms via which virus sorption and inactivation by iron oxides occur and (2) establish partnerships with water and wastewater treatment companies and organizations to conduct pilot-scale studies. The proposed research and subsequent studies are expected to yield innovative, effective, robust, and low-cost technologies that can be used to remove viruses (and potentially other pathogens) in drinking water, wastewater, and groundwater. Other potential benefits of the iron technology may include lower disinfectant dosage and cost and reduction in disinfection by-product formation. Such technologies are urgently needed to alleviate increasing public concerns about drinking water safety and to meet the growing demand for potable water – two critical water resource issues facing Delaware.

Significance and Potential Impact of the Proposed Study:

It has been estimated that 76 million cases of acute gastrointestinal illnesses per year in the U.S. is foodborne (Mead et al., 1999) and 10-40% of these cases may be associated with drinking water (Payment et al., 1991, 1997). Groundwater contaminated with pathogenic microorganisms has been implied in more than 80% of all waterborne disease outbreaks in the U.S. (Ryan et al., 2002). These outbreaks continue to occur despite improvements in water treatment practices and regulations. Among the different classes of pathogens, viruses pose a particular threat to public health due to its high mobility in groundwater. If our hypothesis is proven, iron can perceivably be used in subsurface barriers or above-ground treatment systems to remove and inactivate waterborne viruses. Such iron-based "virus filters" can be either a stand-alone process or added onto an existing water and/or wastewater treatment system to enhance the overall removal efficiency of viruses and possibly other pathogens. Iron filings are relatively inexpensive and have been used in groundwater PRBs for the past decade. The proposed iron treatment process is passive, continuous, and long-lasting, and involves minimal startup, maintenance, and operation costs. The iron treatment can also potentially decrease the disinfectant dosage required, minimize the formation of toxic disinfection by- products, while achieving reduction of the numbers of pathogens in treated water.

Graduate Fellowship: Fate and Transport of Arsenic in Poultry Litter Amended Delaware Soils: Impacts on Water Quality

Basic Information

Title:	Graduate Fellowship: Fate and Transport of Arsenic in Poultry Litter Amended Delaware Soils: Impacts on Water Quality
Project Number:	2003DE32B
Start Date:	7/1/2003
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At large
Research Category:	Not Applicable
Focus Category:	Water Quality, Geochemical Processes, Toxic Substances
Descriptors:	
Principal Investigators:	Donald L. Sparks, Jen Seiter

Publication

1. Boyd, Amy, Ed., Fall 2003 Delaware Water Resources Center WATER NEWS Vol. 4 Issue 2, "DWRC Awards Two New Graduate Fellowships", http://ag.udel.edu/dwrc/newsletters/fall2003.pdf p.6.
2. Sparks, Donald, and Jennifer Seiter, 2005, Fate And Transport Of Arsenic In Poultry Litter Amended Delaware Soils: Impacts On Water Quality, Fellowship Progress Report to the Delaware Water Resources Center, University of Delaware, Newark, Delaware, 5 pages.

Delaware Water Resources Center (DWRC) Fellowship Project 2003-2005
"Fate and Transport of Arsenic in Poultry Litter Amended Delaware Soils: Impacts on Water Quality"
Jen Seiter, DWRC 2003-2005 fellow
Advisor at the University of Delaware (UD):
Dr. Donald Sparks, Plant & Soil Sciences

Abstract:

There are increasing concerns about surface and ground water quality in the Mid-Atlantic Region of the USA. The primary pollutants of concern on the Delmarva Peninsula have been nutrients such as N and P, but there are ever increasing concerns about trace metals derived from industrial, municipal, and particularly, agricultural sources. Arsenic (As) is a ubiquitous metalloid in soil/water environments due to natural geological processes and anthropogenic inputs. Over the past few decades, environmental health has been jeopardized by As contaminating soil and water in the U.S. because of its high carcinogenic, phytotoxic and biotoxic characteristics. Arsenic is a major concern for the health of plants and crops, microorganisms, farm animals, wildlife, and humans. Long-term human exposure to As in drinking water can result in bladder, lung, skin, kidney, immunological, neurological, and endocrine effects. The USEPA announced that it was lowering the maximum contaminant level (MCL) for As in drinking water from 50 ppb to 10 ppb, and all water systems must comply by January 2006 (USEPA, 2001a). This will necessitate an ever vigilant monitoring of water quality to ensure that human health is not deleteriously impacted. Recent data show that there is still an unacceptable level of risk at the EPA's newly adopted 10 ppb MCL. It has been shown that the consumption of only 3 ppb of As creates risk of bladder and lung cancer in 4 to 10 people per 10,000 people (National Research Council, 2001). This risk level exceeds EPA's maximum acceptable level of risk of 1 in 1,000,000 people by 1000-fold.

The Delmarva Peninsula is one of the most concentrated poultry production areas in the US. In 2000, 620 million broilers were produced, which resulted in manure and poultry litter (PL, a mixture of bedding such as wood shavings or sawdust and manure) containing approximately 2.6 X 104 kg of As (Poultry and Value Summary, 2000; Garbarino et al., 2003). Poultry litter is generally applied at the rate of 8.96-20.16 Mg ha-1 on agricultural lands, and its total annual As inputs on the Delmarva Peninsula are estimated between 20 and 50 metric tons of total As (Christen, 2001a). The As in the PL is initially primarily organic (3-nitro-4-hydroxy-phenl-arsonic acid, Roxarsone, abbreviated ROX), which is the form fed to the poultry to control coccidiosis disease, to enhance growth and to improve feed conversion. The quantity of roxarsone that is excreted by a single broiler when fed the 45.4 g ton-1 formulation is estimated to be 150 mg over the typical growth period of 42 days for the chicken (Garbarino et al., 2003). Feed spillage and digested materials have increased the mean total As concentration in the PL to 14-76 mg kg-1 (Moore et al., 1998). Assuming that PL is applied at a rate of at least 5 metric tons per hectare, about 60-250 g of As per hectare could be introduced with each PL application. Annual total metal(oid) inputs on agricultural lands via PL amendments are not specifically regulated at either the federal or state levels, and continuous PL amendment effects on As contamination in Mid-Atlantic soil and water environments are not known. Moreover, the effects of PL amendments on trace element contamination, e.g., from As, in soils have not been considered in current nutrient management programs.

The As in PL is water soluble, which suggests that after land application, it could be readily mobile in water environments. Limited data have shown ground water from agricultural fields of the Pocomoke River Basin in MD and DE having total dissolved As concentrations as high as 23 μg L-1 (Hancock et al., 2003). There is evidence that the organic As transforms to inorganic As,

primarily As (V), after land application. The As (V) is much more toxic than ROX. Data are needed to understand the impacts that PL amendments have on the fate and transport of As in sandy, Mid-Atlantic soils and resultant effects on water quality. However, there are very limited data on the speciation and distribution of As in long-term PL amended Delaware soils, the fate and transport of As in these soils, and how competing ions such as phosphate, which is also found in large quantities in PL and in Delaware soils, affect As retention and release. Such studies will be conducted in this research and will be invaluable in understanding the fate and transport of As in soils that are quite fragile due to their sandy texture, low organic matter, clay, and metal oxide contents, and the often high water tables.

Accordingly, the objectives of this study are:

1) To determine the As status, retention, and release in Delaware soils that have been amended and unamended with poultry litter (PL) and the effects of competitive sorbates such as phosphate.

2) To determine the transport of As in PL amended and unamended soils as it impacts water quality.

Undergraduate Internship: Assisting Small and Underserved Farmers in Meeting Water Quality Objectives

Basic Information

Title:	Undergraduate Internship: Assisting Small and Underserved Farmers in Meeting Water Quality Objectives
Project Number:	2004DE39B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Not Applicable
Focus Category:	Water Quality, Non Point Pollution, Law, Institutions, and Policy
Descriptors:	
Principal Investigators:	Dennis McIntosh

Publication

1. McIntosh, Dennis, and Alicia Revis, 2005, Assisting Small and Underserved Farmers in Meeting Water Quality Objectives, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 19 Pages.
2. Boyd, Amy, ed., Spring 2004, Delaware Water Resources Center WATER NEWS Vol. 4 Issue 2 "Two from Delaware State University Win DWRC 2004 2005 Internships", http://ag.udel.edu/dwrc/newsletters/Spring2004.pdf, p. 3 and 5.
3. Revis, Alicia. Poster Presentation October 13, 2004. Assisting Small and Underserved Farmers in Meeting Water Quality Objectives. Fourth Delaware Water Policy Forum, University of Delaware, Newark, Delaware.
4. McIntosh, Dennis, Alicia Revis, and Andrew Lloyd. Poster Presentation February 7-9, 2005. Assisting Small and Underserved Farmers in Meeting Water Quality Objectives. National Integrated Water Quality Program (NIWQP) Conference, San Diego, California.

Undergraduate Internship Project #1 of 9 for FY04

"Assisting Small and Underserved Farmers in Meeting Water Quality Objectives" is the research topic for Alicia Revis' project, sponsored by the DWRC. Her advisor is Dr. Dennis McIntosh of the Delaware State University (DSU) Department of Agriculture and Natural Resources. Alicia will evaluate farm drinking water samples for possible contaminants, then report results and explain assistance programs available to address any water quality problems identified.

"I am working with a number of people, including extension agents and a microbiologist, and learning the value of patience and persistence in gathering data. I am glad to have this opportunity to rise to the challenge of working in the public arena on water quality issues." -- Alicia Revis

Abstract:

From years past, there has slowly been a decline in the number of small farms. As a result, these smaller farms become more isolated and consequently, less unaware of their eligibility for government assistance. Another problem facing these farms is a lack of understanding available information on protecting their water resources. Due to limited education and a use of inadequate operational practices these underserved farms may not be well protected from various contaminants that could adversely affect their health and the quality of their farmland.

Different areas across the world (cities, communities, and rural areas) rely on water that is safe, reliable, and healthy for human consumption. According to the EPA (2002), the United States has one of the safest water supplies in the world. However, the statistics do not indicate what is specifically coming out of each individual tap. Although the EPA regulates drinking water, it does not regulate the drinking water from private wells, which is one major reason for conducting this study.

About 15 percent of all Americans have their own source of drinking water. However, unlike public or city drinking water, they do no have professionals testing their water on a regular basis. Checking drinking water regularly is the only way to ensure that the water being supplied through private drinking water systems is safe for human consumption (EPA, 2002).

Ground water is a natural resource found under the earth's surface. It may naturally contain some impurities and contaminants, without outside sources. These impurities and contaminants can come from many different areas through the waters travels. Water moving through rocks and soil may contain magnesium, calcium, and chlorides. Some water may also contain arsenic, boron, selenium, or radon. Aside from natural contamination, water may also become polluted by human activities (EPA, 2002).

The majority of the United States' groundwater is safe for human consumption. However, groundwater contamination has been found in all 50 states. This statistic gives

well owners a reason to be vigilant about protecting their water sources. They need to become aware of the potential health risks and test their water regularly to maintain their wells and protect their family's well being (EPA, 2002).

The objective of this project is to assist underserved farmers that may have existing water quality problems. By identifying the location and the demographics of the farms, resources can be located that may provide help protecting water quality within their communities. This project will also build upon existing USDA "Small Farms" programs providing information in community workshops and sharing strategies to meet state/federal water quality compliance requirements.

Undergraduate Internship: Monitoring and Assessing the Nutrient Status and Overall Health of Freshwater Wetlands

Basic Information

Title:	Undergraduate Internship: Monitoring and Assessing the Nutrient Status and Overall Health of Freshwater Wetlands
Project Number:	2004DE40B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	AT-large
Research Category:	Water Quality
Focus Category:	Wetlands, Water Quality, Nutrients
Descriptors:	
Principal Investigators:	Bruce L Vasilas

Publication

1. Vasilas, Bruce; Carol Carlson, 2005, Monitoring and Assessing the Nutrient Status and Overall Health of Freshwater Wetlands, Delaware Water Resources Center, University of Delaware, Newark, DE 9 pages.

Undergraduate Internship Project #2 of 9 for FY04

Carol Carlson's project is "Monitoring and Assessing the Nutrient Status and Overall Health of Freshwater Wetlands". Her advisor is Dr. Bruce Vasilas of the University of Delaware (**UD**) Department of Plant and Soil Sciences, and the project is co-sponsored by the **UD Department of Plant and Soil Sciences** and the **Delaware Water Resources Center**.

"Through my internship with DWRC I have been made aware of the different aspects of monitoring and assessing wetlands. I have had the opportunity to participate in soil descriptions at sites that differed in topography, land use, and surrounding geography. I have also been involved in collecting water samples to measure phosphorous and nitrogen levels as well as used equipment to measure soil water temperature and dissolved oxygen. It has been a great learning experience." – Carol Carlson

Abstract

Under the Clean Water Act, states are required to monitor waters including wetlands for purposes of compliance with water quality standards. Our objectives were as follows: (I) to establish baseline levels for nitrogen and phosphorous (N,P), (II) to determine the relationship between disturbance and nutrient enrichment, (III) to determine the relationship between water quality, and biotic and abiotic characteristics of wetlands, and (IV) to identify robust indicators of nutrient enrichment and overall ecological health for potential rapid assessment procedures.

These objectives are being carried out over a three-year period. Six Piedmont freshwater slope wetlands were selected to include a range of hydrologic conditions and anthropogenic disturbances. Sampling wells were placed in the wetland and readings for dissolved oxygen and temperature were taken bimonthly from February - July and monthly from August - January. The wetland samples were filtered and tested for N and P levels. Bio-assessment and rapid assessment procedures in and surrounding the wetlands were implemented as well. Based on these data and information previously collected from hydroperiods of representative sites, our results show: Dissolved oxygen levels followed the expected trend of lower levels at warmer water temperatures and higher levels at cooler water temperatures. Expected species of salamanders were found at four of the sites with the greatest number and frequency at the Willis Farm site and the fewest number and frequency at the Stroud site. Hydroperiods did not always follow the expected pattern of a lower water table during the growing season and a higher water table in the winter months. Many factors are involved in the water table level such as topography, presence of seeps, piled up plant matter, pooling, infiltration rates, and soil texture and structure, all of which influence water table level. Nitrogen levels also did not follow expected trends of lower values in the growing season and higher values in the winter months for many of the same reasons listed above as well as effects from surrounding land use.

Undergraduate Internship: A Water Resource Threat Analysis for Delaware

Basic Information

Title:	Undergraduate Internship: A Water Resource Threat Analysis for Delaware
Project Number:	2004DE41B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Not Applicable
Focus Category:	Law, Institutions, and Policy, Water Supply, Toxic Substances
Descriptors:	
Principal Investigators:	Janet B. Johnson

Publication

1. Johnson, Janet, Matthew DeSanctis, 2005, A Water Resource Threat Analysis for Delaware, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 29 Pages.

Undergraduate Internship Project #3 of 9 for FY04

The Delaware Water Resources Center and the **University of Delaware College of Arts and Science** co-sponsored **Matthew DeSanctis'** internship evaluating "A Water Resource Threat Analysis for Delaware". Matthew is investigating Delaware water supply protection security measures and standards and is assessing current risk. His advisor is Dr. Janet Johnson, **UD** Department of Political Science.

"My DWRC research project has allowed me to pursue a topic that has long fascinated me. Exploring water security in Delaware has been a challenging undertaking, but I feel understanding the complexities of this issue will help in making recommendations in the future." -- Matthew DeSanctis

Abstract:

In the days, weeks, and years following September 11, 2001 a variety of complicated security issues emerged and have captured the attention of our nation. While issues such as foreign military operation and airport security garner an impressive amount of attention from both media and the general public, perhaps even more important issues remain to be addressed. Consequently, the issue of our nation's water supply security is a concern that cannot be ignored.

The availability of a safe and secure water supply is among civilization's most fundamental needs. America has long enjoyed one of the world's safest supplies of water, yet, after the tragic events of September 11th the permanent availability of this resource could no longer be guaranteed or taken for granted. While the federal government has taken steps to secure our water resources, the states must also address their own distinct needs while simultaneously implementing federal standards.

Discussion of water supply security reveals a multitude of actors, agencies, organizations, and various forms of legislation, illustrating the complexity of the issue. While certainly acknowledging that water supply security, like any other topic surrounding such a critical field, possesses an inherent amount of sensitive information; delineating the information that is available to the public could effectively address this critical issue. In preliminary investigation of the available data pertaining to the subject, no succinct source of aggregate information could be found specific to Delaware. Thus, the scope of this paper is to effectively evaluate the state of water supply security in Delaware post 9/11 allowing for a full and complete review of all involved actors, in both the public and private sectors, relevant legislation (at the state and federal level) and the various contributions they afford to the safety of the water supply in Delaware.

Undergraduate Internship: Evaluating Land Application of Wastewater as a Nutrient Reduction Control Strategy for the Chesapeake Bay

Basic Information

Title:	Undergraduate Internship: Evaluating Land Application of Wastewater as a Nutrient Reduction Control Strategy for the Chesapeake Bay
Project Number:	2004DE42B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Water Quality
Focus Category:	Water Quality, Nutrients, Non Point Pollution
Descriptors:	
Principal Investigators:	William F. Ritter

Publication

1. Ritter, William, and Erin Zimich, 2005, Evaluating Land Application of Wastewater as a Nutrient Reduction Control Strategy for the Chesapeake Bay, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 23 Pages.

Undergraduate Internship Project #4 of 9 for FY04

Erin Zimich's project "Evaluating Land Application of Wastewater as a Nutrient Reduction Strategy for the Chesapeake Bay" is co-sponsored by the DWRC and the UD College of Engineering. Dr. Bill Ritter of UD's Department of Civil and Environmental Engineering is the project advisor. Erin will inventory current and prospective land application sites and will consider the costs of additional application facilities for potential further nutrient reduction.

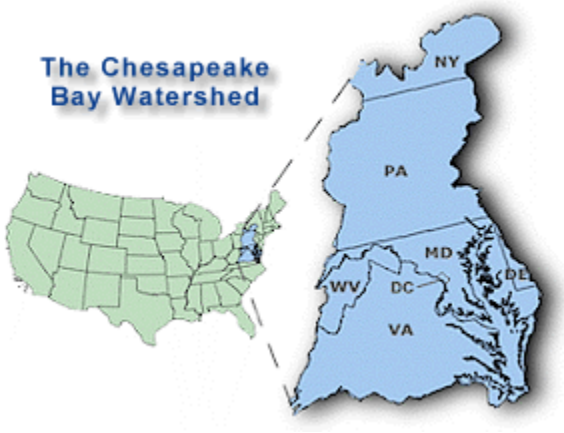
"My internship has given me perspective on the state of water quality in the Chesapeake Bay and made me realize that, in order to maintain this precious resource, drastic measures must be taken." --Erin Zimich

Abstract

The Chesapeake Bay, which is the largest estuary of its kind and provides habitat for vast numbers of species as well as a revenue source for human commercial interests, receives wastewater discharges from six states and the District of Columbia. Two billion gallons of treated effluent reach the Bay waters each day; this wastewater, though treated, is leading to a nitrogen loading of almost 60 million pounds yearly.

Nitrogen is one of the Bay's biggest current pollution problem. Excess nitrogen causes algae blooms that affect the Chesapeake in two major ways. First, large living populations of algae drift thickly through the water and decrease the amount of sunlight that reaches bottom-dwelling grasses, causing some grasses to die and those that survive to be less productive in absorbing CO2 and releasing oxygen. Second, as algae dies, the decaying process removes oxygen from the water. This one-two punch, reducing new oxygen production from plants and wasting oxygen already present in the system, has a serious adverse effect upon the Bay. Fish kills are probably the most visible result of this phenomenon, but nitrogen originated problems are also a large contributor to the current ¾ reduction in Bay productivity.

There are four main sources of nitrogen pollution in the Chesapeake: agriculture, sewage treatment plants, urban storm water, and air pollution. Sewage treatment plants are the second largest contributor of Bay pollution, and constitute for 22% of the nitrogen load. Though nationwide standards regulate the amount of nutrients that are discharged into the Bay, they have proven to be insufficient. Due to the Chesapeake Bay's extreme importance to industry, many states are working together to adopt stricter nutrient reduction standards.



Federal regulations encourage states to reduce effluent discharges into sensitive waters such as the Chesapeake Bay by using wastewater for some purpose other than mere discharge. Land application of wastewater, also called land treatment, is one of the successful methods of reducing nutrient loading into waterways. By applying partially treated wastewater at a

prescribed application rate to soils, instead of water, the nutrient loads can be more easily controlled. Land application offers benefits that are not achieved by simple discharge: nutrients are used in a controlled and beneficial manner, water is conserved, and the costs of saleable crops can be reduced. When effluent is discharged into water the nutrients that it contains may travel hundreds of miles to affect unexpected areas in unexpected ways. Applying wastewater to land in a controlled fashion eliminates this guessing game. Simply, land application uses as fertilizer nutrients that would otherwise act as pollutants.

Perhaps the biggest hurdle that spray irrigation must overcome is public perception that it is unsafe. This "fear of becoming Mexico" is simply unfounded; land application of waste is not at all a new technology and has in fact worked successfully in the US and elsewhere for hundreds of years. The practice was first documented in Germany in 1531, but it is believed to have been in existence long before. Land application was widely used in the United States until the 1960's and was once considered the safest and most reliable form of waste treatment. Several factors precipitated its fall from favor: germ theory of the transmission of disease, improper management of facilities that led to the overloading of application sites, and the development of farmland for other uses. None of these reasons, however, is insurmountable. Provided that there are proper engineering controls in place, land treatment of waste is still the most reliable and environmentally efficient method available. It is certainly feasible to use it more often in the United States.

The question thus becomes, "Is land application a good option for reducing the pollution load into the Chesapeake Bay?" To answer, this study is accessing the potential of each treatment plant that discharges into the Bay. This report summarizes an analysis of the present land application sites in the watershed and an analysis of the Pennsylvania wastewater treatment plants potential to convert to land application.

Undergraduate Internship: Biological Control of Purple Loosestrife at Flat Pond: Reclaiming a Freshwater Pond near the C&D Canal

Basic Information

Title:	Undergraduate Internship: Biological Control of Purple Loosestrife at Flat Pond: Reclaiming a Freshwater Pond near the C&D Canal
Project Number:	2004DE45B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Biological Sciences
Focus Category:	Wetlands, Ecology, None
Descriptors:	
Principal Investigators:	Judith Hough-Goldstein

Publication

1. Hough-Goldstein, Judith, and Jason Graham, 2005, Biological Control of Purple Loosestrife at Flat Pond: Reclaiming a Freshwater Pond near the C&D Canal, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 9 Pages.
2. Boyd, Amy, ed., Fall 2004, Delaware Water Resources Center WATER NEWS Vol. 5 Issue 1 "DWRC 2004 Internship Update: Beneficial Insect Control For Wetland Restoration", http://ag.udel.edu/dwrc/newsletters/Fall2004-P4-8.pdf, p. 7.
3. Baldwin, Susan Morse, ed., 2005, University of Delaware Messenger Vol. 13 No. 2, "Connections to the Colleges: Chewing through a problem"
4. Baldwin, Susan Morse, ed., Dec. 2004, University of Delaware College of Agriculture and Natural Resources Horizons "Loosestrife Menace to Local Pond Combatted With Bio-control", http://ag.udel.edu/Horizons/Dec04/LoosestrifeMenace.htm.
5. Hough-Goldstein, Judith, 2004, Biological Control of Invasive Weeds, in Joint Meeting of the Entomological Society of Pennsylvania and the American Entomological Society, Oct. 20, 2004, University of Delaware.

Undergraduate Internship Project #5 of 9 for FY04

In FY04, the ***Delaware Water Resources Center and University of Delaware College of Agriculture and Natural Resources*** co-sponsored two internships together, both advised by Dr. Judith Hough-Goldstein of the ***UD*** Department of Entomology and Wildlife Ecology**,** dealing with purple loosestrife, an invasive plant clogging Delaware freshwater ponds.

Jason Graham is studying the "Biological Control of Purple Loosestrife at Flat Pond: Reclaiming a Freshwater Pond near the C&D Canal."

"I learned this is the type of work I would like to do after graduate school. It was an exciting opportunity to use fieldwork and scientific research to make a positive difference in the control of an invasive species." -- Jason Graham

Abstract:

Within the past several decades purple loosestrife (Lythrum salicaria), have invaded and degraded freshwater habitats across North America. These plants are establishing a strong presence along the Chesapeake and Delaware Canal bordering Delaware and Maryland.

A nearby pond ("Flat Pond") was infested with purple loosestrife, and determined to be beyond labor intensive means of control. As a perennial plant which produces thousands of seeds, efforts to control purple loosestrife by chemical or mechanical means have proven ineffective in the past.

The Del Bay Retriever Club with its partner the University of Delaware and the support of the Delaware Division of Fish and Wildlife and the U.S. Corps of Engineers sought to reduce, if not eliminate, the presence of purple loosestrife at Flat Pond by use of two species of Galerucella , pusilla and calmieris –which are purple loosestrife specific herbivorous beetles.

A similar study was conducted by Jamie Poole, another student intern for the Delaware Water Resources Center at Barrow's Run, part of Ashland Nature Center during the same time frame.

Forty-three ten-foot PVC pipe poles ¾ inch diameter and 4 PVC connectors ¾ inch diameter were purchased. The poles were cut to designate twenty square-meter quadrats at Flat Pond and to create two square meter quadrat markers to be placed over the marking poles for each quadrat. The final average height of the designators (two per each quadrat in diagonal corners) was approximately 6.5 feet above the soil.

On June 7th 2004, At Flat Pond, five quadrats were chosen on the west side of the pond for release while five quadrats were chosen on the east side of the pond for a control site. The monitoring sessions were conducted in the morning (between 9:00 AM and 11:30 AM) once a week throughout the summer. The true release point was at Quadrat 1 on the western side of Flat Pond, in the center of Quadrats 2 and 4. Each quadrat was placed ten meters away from each other with the furthest "release-side" quadrats 20 meters away from Quadrat 1.

5,000 beetles were received from the Phillip Alampi Beneficial Insect Laboratory, New Jersey Department of Agriculture. On June 10th, 2004 under the direction of Dr. Judith-Hough Goldstein, of the Entomology and Wildlife Ecology

Department at University of Delaware, the beetles were released at Flat Pond. The site was monitored for signs of damage and to count the beetles in their various life stages.

The methods followed for monitoring were taken from Bernd Blossey's Purple Loosestrife Monitoring Protocol found at: http:// www.invasiveplants.net. Form 2: Purple Loosestrife Biocontrol Monitoring (Spring) was taken from the above website and used for the Flat Pond site. At the end of the Summer, an additional survey was conducted using Form 3: Purple Loosestrife Biocontrol Monitoring (Fall) found on the same website.

Undergraduate Internship: Design and Field Testing of Advanced Surveillance Systems for Delaware's Shallow Depth Estuaries

Basic Information

Title:	Undergraduate Internship: Design and Field Testing of Advanced Surveillance Systems for Delaware's Shallow Depth Estuaries
Project Number:	2004DE46B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Engineering
Focus Category:	Water Quality, Hydrogeochemistry, Ecology
Descriptors:	
Principal Investigators:	James Lawrence Glancey

Publication

1. Glancey, James, Matthew King, 2005, Design and Field Testing of Advanced Surveillance Systems for Delaware's Shallow Depth Estuaries, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 3 Pages.

Undergraduate Internship Project #6 of 9 for FY04

Matt King is studying the "Design and Field Testing of Advanced Surveillance Systems for Delaware's Shallow Depth Estuaries" in his internship co-sponsored by DWRC and the Delaware Department of Natural Resources and Environmental Control (DNREC). His advisor is Dr. James Glancey of the University of Delaware Departments of Bioresources Engineering and Mechanical Engineering in the Colleges of Agriculture and Natural Resources and Engineering

"My efforts have been iterative and evolving, and I learned that a project of this scope is a real challenge. I look forward to passing on what I have learned with the goal of continued improvement of the design of this water quality monitoring system." -- Matt King

Abstract:

A cooperative effort between the University of Delaware and DNREC has led to the development of a low cost monitoring station that is capable of measuring whole water column water quality data throughout the entire depth of a water body. The device utilizes the data sondes currently in owned by DNREC. As configured, the monitoring station following parameters can be measured: water quality variables [water temperature, pH, dissolved oxygen, and turbidity] and meteorological variables (air temperature, relative humidity, barometric pressure, incident solar radiation, wind speed and direction, rain gauge). The resulting information provides a complete snapshot of important water quality data – over a period of time, the data provides a comprehensive understanding of water quality changes in a body of water throughout the entire depth. In addition, the monitoring station is equipped with cellular telemetry which transmits the data to a host computer that can broadcast the data on the web in real time; data can also be processed and sent to a list of scientists and other personnel for further analysis.

This technology provides a unique and effective means to monitor estuarine waters with high temporal resolution, which is critical for an effective Harmful Algal Bloom (HAB) detection. The goal of this project is to deploy a monitoring station for extended testing in the Inland Bays and to begin to understand, in cooperation with DNREC's Environmental Laboratory, water quality dynamics throughout the entire water column during critical periods of the 2004 summer season. The continuously recorded results from the monitoring station will promote a better understanding of the influences of nutrient enrichment on HAB dynamics, assist in determining the temporal relationships between HABs and shellfish health/toxin contamination, and provide an early warning system for the detection of HABs in one of Delaware's prime recreational waters.

Project Objectives:

1) Deploy and fully support the prototype whole water column monitoring station from June through September, 2004, in cooperation with DNREC. The site location will be chosen by DNREC, and if possible, will accommodate whole-water column testing.
2) Design and field test a small DGPS-guided, self-propelled, mobile water craft that utilizes the technology already developed for whole-water column sampling.
3) Complete a Degree with Distinction Thesis using the data collected during the summer as well as the design and testing of the mobile water craft sampling device.

Project Methods:

The first goal of this project is to conduct the first set of extended field tests with the exiting fixed dock monitoring station. To accomplish this, the prototype monitoring system will be deployed at a location in the Delaware Inland Bays chosen by personnel at DNREC based on data that demonstrates recent algae bloom activity, fish kills, oxygen deficits, and a potential threat to Delaware's recreational approved shellfish areas. Throughout the test period from June though September, data will be available from the monitoring station to complement current HAB monitoring programs. During this time period, design improvements for the station will be incorporated, both for the hardware and software. By the end of the test period in September, the goal is for personnel at both DNREC and U of D to develop sufficient confidence in this new method of monitoring so that a more extensive sampling program can be implemented in 2005. To accomplish this, regularly scheduled review meetings during the summer will be conducted at DNREC. The purpose of these monthly meeting will be to review the performance of the monitoring station, compare data collected with the station to data from other sampling activities by DNREC, and re-evaluate and update the plan for the remainder of the sampling season. In addition to the meetings, at least one field demonstration will be conducted at the sampling site for DNREC personnel. To reduce the potential for damage or theft during the sampling season, a 'dummy' monitoring station will be fabricated in May. The dummy device will be deployed at the testing site until the actual monitoring station is installed at the beginning of June.

A second goal of the project is the design and testing of a mobile sampling platform capable of automatic guidance within a water body. The primary advantage of this system will be to provide improved spatial resolution of several key water quality variables, not only throughout the water column, but also with respect to length and width of a creek, pond, river or bay. This attribute will be very important in understanding why and how some water bodies are prone to fish kills. For example, the mobile sampling platform will provide the ability to monitor several creeks within the Inland Bays Watershed that are know to have highly variable water depths – unlike the stationary fixed dock platform, the mobile sampler will allow researchers to examine how, for example, dissolved oxygen dynamics are influenced by varying water depth within a water body. By using the mobile sampler to traverse and sample a water body over time, the spatial variations and temporal changes can be quantified for the first time in Delaware.

To achieve this second goal, work will begin the latter part of the summer to design a small DGPS-guided, self-propelled, mobile water craft. The current technology developed for the fixed dock sampler (described previously) will be integrated into the water craft. The on-board microprocessor will be used for guidance control, with the addition of a DGPS receiver. Two different navigation strategies will be examined: 1) teach-and-play and 2) fixed-path trajectory using predefined GPS way points. In the teach-and-play mode, an operator would "teach" the device the path it is to follow by using a remote control. While being navigated through this path, the mobile water craft will record GPS points along the way – after completing the path one time, the device can then follow the path and operate on its own without a user. In the fixed-path trajectory approach, a handheld GPS receiver can be used to create a path using known "waypoints" – the set of waypoints can then be downloaded into the mobile sampling craft, and the device can traverse the path on it own. With either approach, once a path has been defined, the mobile water craft will be programmed remotely to traverse the path a regular intervals, both night and day. The device will stop at the predefined sampling locations along the path and record whole water column as well as meteorological data. Data will be transmitted via the on-board cellular modem once the system has traversed the entire path. The near real-time data will be displayed on a U of D website for DNREC and other personnel to review.

Undergraduate Internship: An Evaluation of the Economic, Social, Environmental, and Recreational Benefits of the Christina Basin

Basic Information

Title:	Undergraduate Internship: An Evaluation of the Economic, Social, Environmental, and Recreational Benefits of the Christina Basin
Project Number:	2004DE47B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Social Sciences
Focus Category:	Law, Institutions, and Policy, Water Quality, Non Point Pollution
Descriptors:	
Principal Investigators:	Steven E. Hastings, Gerald Kauffman

Publication

1. Hastings, Steven E., Gerald Kauffman, Steven T. Ernst, 2005, An Evaluation of the Economic, Social, Environmental, and Recreational Benefits of the Christina Basin, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 25 Pages.
2. Boyd, Amy, ed., Fall 2004, Delaware Water Resources Center WATER NEWS Vol. 5 Issue 1 "DWRC 2004 Internship Update: Christina Basin Governance Analysis", http://ag.udel.edu/dwrc/newsletters/Fall2004-P4-8.pdf, p. 7.

Undergraduate Internship Project #7 of 9 for FY04

Steven Ernst's project explores water resources governance practices and related benefits for the Christina Basin, home to more than half of Delaware's population. His **Delaware Water Resources Center / University of Delaware Institute for Public Administration Water Resources Agency (WRA)** co-sponsored internship is entitled "An Evaluation of the Economic, Social, Environmental, and Recreation Benefits of the Christina Basin." **UD** Department of Food and Resource Economics**'** Dr. Steve Hastings and the **WRA's** Gerald Kauffman are the project advisors.

"My goal is for Christina Basin residents to experience more effectively coordinated stewardship of their watershed resources. I will recommend approaches to help shareholders best succeed with their proposed conservation programs and policies." -- Steve Ernst

Abstract

Managing transboundary resources, particularly water, is one of the greatest challenges facing experts in the field of natural resource management. The various agencies and organizations involved in any given region make decision-making and consensus building very difficult. In the past, different water agencies were delegated authority over separate areas of water policy; however, in the last 20 years there has been a movement toward watershed based management strategies. This movement resulted in the creation of the Christina Basin Water Quality Management Committee, later renamed the Christina Basin Clean Water Partnership.

The Christina Basin Clean Water Partnership was created with the objective of bringing together local watershed groups and organizations to improve the Basin's water quality. In the ten years since the Partnership's creation, water quality has greatly improved and coordination within groups has increased. However, the Partnership is now at a point where it must decide whether to grow in size and influence or stagnate and risk missing an opportunity to further improve the watershed.

Organizations that manage transboundary resources come in many different forms; the goal of this paper is to find the form that would best suit the future goals of the Partnership. Much has changed since the first interstate water agreements were created nearly 300 years ago, but many of the problems these plans worked to improve, like pollution control and funding, were the same then as they are now.

The most common transboundary governance structures include authorities, consolidated districts, commissions, partnerships, and partnerships with coordinators. Each of these structures has advantages, disadvantages, and information we can use to find the structure that best suits the Christina Basin. Upon analyzing the attributes of each option, the partnership with coordinator structure best fits the current and future needs of the Basin.

The coordinator would handle the day to day business of the Partnership and would act as the contact person between the group and the community. The Partnership would also benefit from more secure funding in the form of a state line item. These improvements would allow the Partnership to spend less time handling administrative

tasks and creating grant proposals, and provide more time to work on meaningful policy objectives within the Basin.

The Christina Basin Clean Water Partnership has made great progress in the last ten years and will continue to do so in the future. The current arrangement of the organization has served the Basin's needs well, however, a few changes will greatly increase the effectiveness of the Partnership. By making these improvements, the Partnership can insure that it will continue to play an increasingly important role in the conservation and protection of the Christina Basin's valuable water resources.

Undergraduate Internship: Fish communities as indicators of water quality: quantifying the response of aquatic systems to pollutant inputs in Delaware headwaters

Basic Information

Title:	Undergraduate Internship: Fish communities as indicators of water quality: quantifying the response of aquatic systems to pollutant inputs in Delaware headwaters
Project Number:	2004DE49B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Biological Sciences
Focus Category:	Water Quality, Non Point Pollution, Management and Planning
Descriptors:	
Principal Investigators:	Dewayne Fox, Maria Labreveux

Publication

1. Fox, Dewayne A., Maria Labreveux, Trevor Knight, 2005, Fish Communities and Indicators of Water Quality: Quantifying the Response of Aquatic Systems to Pollutant Inputs in Delaware Headwaters, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 25 Pages.
2. Boyd, Amy, ed., Spring 2004, Delaware Water Resources Center WATER NEWS Vol. 4 Issue 2 "Two from Delaware State University Win DWRC 2004 2005 Internships", http://ag.udel.edu/dwrc/newsletters/Spring2004.pdf, p. 3 and 5.
3. Knight, Trevor. Poster Presentation October 13, 2004. Fish Communities and Indicators of Water Quality: Quantifying the Response of Aquatic Systems to Pollutant Inputs in Delaware Headwaters. Fourth Delaware Water Policy Forum, University of Delaware, Newark, Delaware.

Undergraduate Internship Project #8 of 9 for FY04

Trevor Knight is studying "Fish Communities and Indicators of Water Quality: Quantifying the Response of Aquatic Systems to Pollutant Inputs in Delaware Headwaters" in his DWRC internship, teamed with advisors Dr. Dewayne Fox and Dr. Maria Labreveux of Delaware State University (DSU) Department of Agriculture and Natural Resources. Trevor hopes to measure fish health for water quality assessments in all three Delaware counties.

"This project has given me a better understanding of fish communities in small streams and has allowed me to work with water pollution response in fishes I have never seen before." – Trevor Knight

Abstract

Monitoring of surface water degradation and further remediation to comply with the 1972 Clean Water Act can be both a challenging and expensive task for regional and local governments. Through the use of an Index of Biotic Integrity (IBI) resource managers can frequently monitor water quality in a cost effective manner. Presently, the State of Delaware lacks a standardized IBI that resource managers can utilize. To this end, we explored the suitability of an IBI developed for the Coastal Region of Maryland for use in documenting faunal response to human induced changes in water quality. Three Delaware watersheds (Blackbird Creek: forested, St. Jones River: urbanized, and Broad Creek: agricultural) were selected based on published land use patterns. Within watersheds, fish sampling was conducted three times at randomly selected sites. During each sampling event, three seine passes were made in an attempt to collect all fishes. Fish sampled were identified to species, measured for total length, fin clipped, and released. Prior to fish collection, physical parameters and a water sample were collected for quantification of water quality parameters. A total of 932 fishes were collected during sampling which represented 10 families and 24 species along with one hybrid. Watershed IBI scores classified Blackbird Creek as Poor, St. Jones River as Poor, and Broad Creek as Very Poor. As a result of Delaware's rapid development in recent years, it is crucial that resource managers adopt a biological monitoring program to compliment chemical and physical monitoring. There is promise that the use of an IBI will provide a simple and inexpensive means of monitoring water quality in Delaware streams based on current analysis.

Undergraduate Internship: Biological Control of Purple Loosestrife at Burrows Run: Preventing Wetlands Degradation by an Invasive Plant

Basic Information

Title:	Undergraduate Internship: Biological Control of Purple Loosestrife at Burrows Run: Preventing Wetlands Degradation by an Invasive Plant
Project Number:	2004DE64B
Start Date:	6/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At-large
Research Category:	Biological Sciences
Focus Category:	Wetlands, Non Point Pollution, Management and Planning
Descriptors:	
Principal Investigators:	Judith Hough-Goldstein

Publication

1. Hough-Goldstein, Judith, and Jamie Pool, 2005, Biological Control of Purple Loosestrife at Burrows Run: Preventing Wetlands Degradation by an Invasive Plant, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 6 Pages.
2. Boyd, Amy, ed., Fall 2004, Delaware Water Resources Center WATER NEWS Vol. 5 Issue 1 "DWRC 2004 Internship Update: Beneficial Insect Control For Wetland Restoration", http://ag.udel.edu/dwrc/newsletters/Fall2004-P4-8.pdf, p. 7.
3. Baldwin, Susan Morse, ed., 2005, University of Delaware Messenger Vol. 13 No. 2, "Connections to the Colleges: Chewing through a problem"
4. Baldwin, Susan Morse, ed., Dec. 2004, University of Delaware College of Agriculture and Natural Resources Horizons "Loosestrife Menace to Local Pond Combatted With Bio-control", http://ag.udel.edu/Horizons/Dec04/LoosestrifeMenace.htm.
5. Hough-Goldstein, Judith, 2004, Biological Control of Invasive Weeds, in Joint Meeting of the Entomological Society of Pennsylvania and the American Entomological Society, Oct. 20, 2004, University of Delaware.

Undergraduate Internship Project #9 of 9 for FY04

In FY04, the Delaware Water Resources Center and University of Delaware College of Agriculture and Natural Resources co-sponsored two internships together, both advised by Dr. Judith Hough-Goldstein of the UD Department of Entomology and Wildlife Ecology, dealing with purple loosestrife, an invasive plant clogging Delaware freshwater ponds.

Jamie Pool is evaluating the "Biological Control of Purple Loosestrife at Burrows Run: Preventing Wetlands Degradation by an Invasive Plant."

"This project has opened my eyes to the aspects of field research, and it has given me a greater sense of responsibility and diligence." -- Jamie Pool

Abstract:
During the summer of 2004, approximately 3,000 Galerucella calmariensis and Galerucella pusilla beetles were released at the Burrow's Run site of Ashland Nature Center. The objective at Burrow's Run was to use the beetles to reduce the flowering of the purple loosestrife stand. By reducing the plants' flowering, loosestrife reproduction could be limited, and the stand would not spread as fast as it would if left unchecked. 5 control quadrats were constructed in a small grove of purple loosestrife at Ashland Nature Center, and 5 release quadrats were constructed at Burrow's Run. The Galerucella beetles were released at the central quadrat at Burrow's Run. Over the next several weeks, the quadrats were observed in order to determine the number of Galerucella adults, larvae, and eggs and any noticeable damage to the purple loosestrife. Damage was observed in a one-meter radius around the release point one week after the release, but no Galerucella adults, larvae, or eggs were found. Over the next two weeks worth of monitoring, there was no further damage to the purple loosestrife, and no Galerucella adults, larvae, or eggs were observed. After the initial three weeks of monitoring, the original damage to the purple loosestrife around the release point was reversed by continued plant growth.

Unfortunately, the Galerucella beetles apparently did not become established at Burrow's Run. Had they become established, the Galerucella beetles might have damaged the purple loosestrife to a point where plant reproduction could have been limited. Because the project at Ashland Nature Center and Burrow's Run was unsuccessful during the summer of 2004, the managers of the center may wish to make another attempt. The previous Galerucella release at Ashland Nature Center several years ago was a success, and there is no reason why it cannot be successful at Burrow's Run as well. Should the project at Ashland continue in the summer of 2005, hypotheses based on the differences between Burrow's Run and Flat Pond (the lack of loosestrife monoculture at Burrow's Run and subsequent greater variety of insect predators) can be tested and accommodated in future Galerucella beetle releases.

Information Transfer Program

Delaware Water Resources Center FY04 Information Transfer Activities

Basic Information

Title:	Delaware Water Resources Center FY04 Information Transfer Activities
Project Number:	2004DE66B
Start Date:	3/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	At Large
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	
Principal Investigators:	J. Thomas Sims

Publication

Information Transfer Program

The following section describes the Delaware Water Resources Center's information transfer activities during FY04, grouped together as a single project **#2004DE66B.** All activities listed are continuations of elements of project #**2003DE57B** established in 2003, however, some additional elements of that project did not continue into FY04.

The FY04 DWRC Information Transfer Activities include:

- Delaware Water Resources Center Print Publication WATER NEWS (2000 - present)
- Delaware Water Resources Center Website (updated 2001 – present)
- Delaware Water Resources Center E-group /Courses Link (2002 – present)
- Delaware Water Resources Center Electronic Newsletter WATER E-NEWS (2002 – present)
- Delaware Water Resources Center Intern Project Poster Session / Advisory Panel Annual Meeting (2001 – present)
- Delaware Statewide Water Forum Co-Sponsor & Participant (2001 – present)
- Delaware Water Resources Center information booths at University of Delaware "AG DAY", Newark, Delaware (2003 – present)

Basic Information:
Delaware Water Resources Center Print Publication WATER NEWS

Title:	"WATER NEWS"
NIWR Project No.:	#**2004DE66B,** formerly NIWR #2000DE107B for FY00, FY01, FY02, and #2003DE57B for FY03.
Issues during FY04:	Volume 5 Issues 1 and 2 (Spring/Summer and Fall/Winter 2004)
Description:	Newsletter published biannually by the University of Delaware Water Resources Center
Lead Institute:	DE Water Resources Center
Principal Investigators:	Dr. J. Thomas Sims, Director, Amy Boyd, Editor

WATER NEWS is received by nearly 800 recipients in Delaware water-related academia, government, public and private agencies, agriculture and industry. It may be accessed via the Delaware Water Resources Center web site at: http://ag.udel.edu/dwrc/news.html.

Spring 2004 topics included:

- Statewide Water Forum Oct. 13, 2004 Clayton Hall
- Annual DWRC Meeting and Poster Session
- Spotlight on DSU Water Resources Educ. / Research
- Two DSU Undergrads Win 2004 DWRC Internships
- DWRC Fellow Liping Zhang and Virus Removal
- Water News You Can Use
    - *Free "Smartyards" in the Appoquinimink Watershed*
    - *Boy Scout Soil and Water Conservation Merit Badge Training*
    - *Upcoming Local Water Conferences*
    - *New Reports from U.S. / DE Geological Surveys*
- 2004 DWRC Undergraduate Interns Announced
- DWRC History, Goals, Advisory Panel, Contacts

Fall 2004 topics included:

- Highlights from 4th Statewide Water Forum Oct. 13
- Hands Across the Watershed: Christina Nonprofits
- One Year Later: Sept. 28-29, 2004 Tropical Storm Jeanne / Red Clay Creek Flooding
- Fellowships, Grants, Internships for 2005
- Water News You Can Use
    - *CUAHSI*
    - *New AWRA chapter*
    - *Conservation Security Program*
    - *Jobs and Grants*
    - *Intern News*
- DWRC Thanks: McDermott, Richards, Spagnolo
- DWRC 2004 Internship Update
- DWRC History, Goals, Advisory Panel, Contacts

Basic Information: Delaware Water Resources Center Website

Title:	Web site http://ag.udel.edu/dwrc
NIWR Project No.:	**#2004DE66B.** Formerly NIWR #2003DE57B and #1996DE104B since FY96
Start Date:	Second edition, since 12/2001
End Date:	Ongoing
Description:	Comprehensive site serving Delaware water resources community
Lead Institute:	DE Water Resources Center
Principal Investigators:	Dr. J. Thomas Sims, director, Amy Boyd, administrator

Site contains:

- **Delaware Water Resources Center (DWRC) and Director's News:** Latest updates on DWRC activities and information on the DWRC's mission, history, and role in the National Institute of Water Resources (NIWR).
- **Delaware Water Concerns:** Summary of the major areas of concern related to Delaware's ground and surface waters, with links to key organizations and agencies responsible for water quality and quantity.
- **Projects and Publications:** Descriptions of DWRC's undergraduate internship and graduate fellows programs, annual conference proceedings, and project publications dating back to 1993.
- **Advisory Panel:** Purpose, contact information and e-mail links for the DWRC's Advisory Panel.
- **Request for Proposals and Application Forms:** For undergraduate interns, graduate fellowships and other funding opportunities available through the DWRC.
- **Internships and Job Opportunities:** Information on undergraduate and graduate internships from a wide variety of local, regional, and national sources along with current job opportunities in water resource areas.
- **Water Courses and Faculty:** Link to search engine for current list of University of Delaware water resource courses. List of researchers at Delaware universities with an interest in water resources research; also, science and natural resource curricula links.
- **Water Resources Contacts:** Links to local, regional, and national water resource agencies and organizations categorized as government, academia, non-profit, and US Water Resource Centers.
- **Calendar:** Upcoming local, regional, and national water resources events sponsored by the DWRC and other agencies, such as conferences, seminars, meetings, and training opportunities.
- **Newsletters:** Access to DWRC newsletters dating back to 1993.
- **Annual and 5-year Reports:** DWRC annual and 5-year reports, dating to 1993.
- **KIDS' Zone:** Water Resources Activities and Information for Kids and Teachers

Basic Information: Delaware Water Resources Center E-group /Courses Link

Title:	Delaware Water Resources Center / Water Resources Agency Egroup, originating from the online listing of Delaware water teachers and researchers found on the DWRC site: http://ag.udel.edu/dwrc/faculty.html
NIWR Project No.:	**#2004DE66B.** Formerly NIWR #2003D57B and #2001DE112B (FY03, FY02, FY01)
Start Date:	Since 12/2001
End Date:	**Ongoing**
Description:	E-group and link to university water resources courses taught, serving Delaware water resources community
Lead Institute:	DE Water Resources Center
Principal Investigators:	J. Thomas Sims, director, Amy Boyd, administrator

The online listing of approximately 70 researchers at the University of Delaware, Delaware State University, and Wesley College found on the Delaware Water Resources Center web site at http://ag.udel.edu/dwrc/faculty.html forms the foundation for a broader egroup list maintained by the Center reaching additional academic, public, private, and government water community contacts, who are notified via a monthly email newsletter of events and job postings of interest in water resources.

The web site also links to a search engine and site for water-related courses currently offered by the researchers.

The total list of e-group members numbered almost 200 as of June 2005.

Basic Information:
Delaware Water Resources Center Electronic Newsletter WATER E-NEWS

Title:	"WATER E-NEWS"
NIWR Project No.:	**#2004DE66B.** Formerly NIWR #2003DE57B (FY03), #2002DE105B (FY02)
Issues during FY04:	**Vol. 3 Issues 2, 3, 4; Vol. 4 Issue 1.** **September '04, October '04, November – December '04** **March '05**
Description:	Online newsletter published periodically and emailed to center's water resources e-group by the University of Delaware Water Resources Center
Lead Institute:	DE Water Resources Center
Principal Investigators:	J. Thomas Sims, Director, Amy Boyd, Editor

WATER E-NEWS is now received by nearly 200 recipients in Delaware water-related academia, government, public and private agencies, agriculture and industry. The current issue and back issues dating to its July 2002 inception may be accessed via the Delaware Water Resources Center web site at: http://ag.udel.edu/dwrc/news.html.

Featured in each issue of Water E-News are:

I. Undergraduate Internships and Jobs in Water Resources from DWRC and more;
II. Graduate Fellowships, plus post-doc and professional opportunities;
III. Project funding and awards programs;
IV. Upcoming seminars and conferences; and
V. New information and training sources in water resources.

Basic Information:
Delaware Water Resources Center Intern Project Poster Session / Annual Advisory Panel Meeting

Title:	University of Delaware 2004 Undergraduate Research Scholars Poster Session
NIWR Project No.:	**#2004DE66B**. Formerly NIWR #2003DE57B (FY03), #2001DE106B (FY01 and FY02)
Date:	4/23/2004
Description:	Undergraduate Interns presented their 2003-2004 DWRC-funded projects.
Lead Institute:	UD Undergraduate Research Program, DE Water Resources Center
Principal Investigators:	Joan Bennett, Director, UD Undergraduate Research Program, J. Thomas Sims, Director, Delaware Water Resources Center

On April 23, 2004, nine undergraduate student interns who had been funded over the past year by the Delaware Water Resources Center (DWRC) presented the results of their research accompanied by their advisors at an informal poster session sponsored by the University of Delaware Undergraduate Research Program. Over one hundred UD Science and Engineering Scholars joined the ***DWRC*** interns to present to a crowd of over 500 visitors.

The 16-member ***DWRC*** *Advisory Panel* also convened on April 23, 2004 for lunch with the interns and their advisors and then held their annual meeting prior to the poster session. **DWRC** Director Tom Sims described the Center's plans for 2004 with regard to research funding and new public education outreach efforts such as statewide water forums and **UD** Ag Day water conservation training. The Center's 5-year report covering its activities spanning 1998-2002 is complete and will be posted at http://ag.udel.edu/dwrc/reports.html.

Poster Presentations

1) Bielawa, Megan. Poster Presentation April 23, 2004. Factors Affecting West Nile Virus Transmission from Water Retention Ponds and Constructed Wetlands. University of Delaware Undergraduate Research Scholars Poster Session.

2) Cormier, Kathleen. Poster Presentation April 23, 2004. Field Measurements of Non Point Source Pollutant Removal Efficiencies of Stormwater BMPs at the UD Experimental Watershed. University of Delaware Undergraduate Research Scholars Poster Session.

3) Glier, Justin. Poster Presentation April 23, 2004. Role of Urea as the Soil Nitrogen Source in the Uptake of Nickel in Allysum Hyper-accumulating Species. University of Delaware Undergraduate Research Scholars Poster Session.

4) Joslyn, Andrew. Poster Presentation April 23, 2004. Enhanced Pollutant Biodegradation by Electrode Use. University of Delaware Undergraduate Research Scholars Poster Session.

5) McDermott, Alice. Poster Presentation April 23, 2004. Biological and Enzymatic Treatment of a Food Processing Wastewater. University of Delaware Undergraduate Research Scholars Poster Session.

6) Neimeister, Mark. Poster Presentation April 23, 2004. Nanticoke Watershed Total Maximum Daily Load (TMDL) Project. University of Delaware Undergraduate Research Scholars Poster Session.

7) Sentoff, Kristen. Poster Presentation April 23, 2004. Fairfield Run: An Evaluation of Stream Habitat Restoration at the UD Experimental Watershed. University of Delaware Undergraduate Research Scholars Poster Session.

8) Simon, Matthew. Poster Presentation April 23, 2004. Characterization of Autochthonous Viral Communities in Estuarine Waters. University of Delaware Undergraduate Research Scholars Poster Session.

9) Walker, Judith. Poster Presentation April 23, 2004. Blue Hen Creek: An Evaluation of Stream Habitat Restoration at the UD Experimental Watershed. University of Delaware Undergraduate Research Scholars Poster Session.

Basic Information:
Delaware Statewide Water Forum Co-Sponsor & Participant

Title:	Annual Delaware Statewide Water Policy Forum
NIWR Project No.:	#**2004DE66B.** Formerly NIWR #2003DE57B for FY03, #2002DE48B, #2002DE125B for FY02
Date:	Oct. 13, 2004
Description:	Presentation of DWRC recent accomplishments and program goals; DWRC information booth; Poster display by two DWRC undergraduate interns. Forum brochure / agenda / proceedings for the 2004 event may be found on the web at: http://www.wr.udel.edu/publicservice/WaterForum2004/WaterForum04Proceedings.html. Complete article is found in DWRC Fall 2004 WATER NEWS at http://ag.udel.edu/dwrc/newsletters/Fall2004-P1-3.pdf.
Lead Institute:	Co-sponsored by the Delaware Water Resources Center, University of Delaware Institute for Public Administration, Water Resources Agency, Delaware Geological Survey, and Delaware Department of Natural Resources and Environmental Control. http://www.wr.udel.edu/publicservice/WaterForum2004/WaterForum04Sponsors.html.
Principal Investigators:	J. Thomas Sims, Director, Delaware Water Resources Center; Jerome Lewis, Director, University of Delaware Institute for Public Administration; Gerald Kauffman, State Water Coordinator, University of Delaware Institute for Public Administration Delaware Water Resources Agency; John Talley, Director, Delaware Geological Survey; Kevin Donnelly, Director, Division of Water Resources, Delaware Department of Natural Resources and Environmental Control

The fourth annual Delaware Policy Forum titled "*The Historic Christina Basin: Delaware's First Watershed*" was held for over 200 visitors from Delaware government, water agencies, academia, and the public, on October 13, 2004 at Clayton Hall on the University of Delaware campus in Newark, Delaware. This was the fourth annual statewide water resources forum in recent years, and the third co-sponsored by the **Delaware Water Resources Center**. Nineteen water resources advocates presented water policy and historic water resources concerns in the Christina Basin, comprised of the Brandywine Creek, Red Clay Creek, White Clay Creek, and Christina Creek watersheds. The Christina contains 6 trout streams and numerous endangered species, is home to more than half of Delaware's population, and is the largest source of drinking water supply in the state of Delaware. The Forum's presentations, materials, and poster session were free of charge, courtesy the co-sponsors: Delaware Water Resources Center **(DWRC)**, UD Institute for Public Administration (UD IPA), Water Resources Agency (WRA), Delaware Geological Survey, and Delaware Department of Natural Resources and Environmental Control (DNREC).

Posters presented by Delaware Water Resources Center undergraduate interns at the event included:

1) Knight, Trevor. Poster Presentation October 13, 2004. Fish Communities and Indicators of Water Quality: Quantifying the Response of Aquatic Systems to Pollutant Inputs in Delaware Headwaters. Fourth Delaware Water Policy Forum, University of Delaware, Newark, Delaware.
2) Revis, Alicia. Poster Presentation October 13, 2004. Assisting Small and Underserved Farmers in Meeting Water Quality Objectives. Fourth Delaware Water Policy Forum, University of Delaware, Newark, Delaware.

The Delaware Water Resources Center had previously co-sponsored the state forum *"Land Use Change and Water Quality: Assessing the Impacts and Planning for the Future"* held for over 150 visitors on October 2, 2003, and also the state forum "*Drought.02: A Debate and Panel Discussion Concerning Water Supply Policy in Delaware*" held October 9, 2002 for nearly one hundred attendees.

Basic Information: Delaware Water Resources Center Information Booth at 2005 White Clay Creek Conference, Newark, DE

Title:	DWRC information booth at 2005 White Clay Creek Conference "Water and Our Changing Landscape: Perspectives from the Wild & Scenic White Clay Creek Watershed", University of Delaware Clayton Hall, Newark, Delaware
NIWR Project No.:	#**2004DE66B**
Date:	April 14, 2005
Description:	Information booth of DWRC current programs and publications, with newsletter signups.
Lead Institute:	DE Water Resources Center.
Principal Investigators:	Linda Stapleford, River Administrator, White Clay Watershed Association, www.whiteclay.org Amy Boyd, Program Coordinator, Delaware Water Resources Center www.udel.edu/dwrc/ Chester County Conservation District http://www.chesco.org/conserve.html Delaware Department of Natural Resources and Environmental Control (DNREC) http://www.dnrec.state.de.us/dnrec2000/ Delaware Department of Transportation (DelDOT) http://www.deldot.net/index.shtml Partnership for the Delaware Estuary, Inc. http://www.greentreks.org/delawareestuary/index.htm United Water Delaware and Water Bethel, subsidiaries of United Water Resources http://www.unitedwater.com/ Water Resources Agency (WRA), University of Delaware Institute for Public Administration (IPA) http://www.wr.udel.edu/ Contributors: Artesian Water Company, Chester Water Authority (PA), City of Newark (DE), Delaware Nature Society, Kennett, London Grove, and Penn Townships (PA), New Castle County (DE) Conservation District, Stroud Water Research Center (PA)

"*Water and Our Changing Landscape: Perspectives from the Wild & Scenic White Clay Creek Watershed",* the White Clay Creek Conference held University of Delaware Clayton Hall, Newark, Delaware Thursday April 14, 2005, featured Rick Darke, landscape designer, author, and photographer as keynote speaker, an address by Dr. Bernard Sweeney, Director of Stroud Water Research Center, a report by the White Clay Creek Watershed Management Committee, luncheon roundtables, and a stormwater management panel The nearly 200 participants received a new DWRC brochure prominently displayed in their conference packet and had an opportunity to visit the Center's information table, which featured:

1. DWRC Poster display featuring current research projects of fellows and interns
2. Brochures describing the DWRC Internship program for 2005-2006
3. Copies of /signups for DWRC's newsletters "Water News" and "Water E-News".

Basic Information:
Delaware Water Resources Center information booths at
2004 and 2005 University of Delaware "AG DAY", Newark, DE

Title:	DWRC "Ag Day" public Water Conservation information / training booths
Dates:	Apr. 30, 2005, and Apr. 24, 2004
NIWR Project No.:	**#2004DE66B** (previously #2003DE57B for FY03 event).
Description:	Public education outreach
Lead Institute:	DE Water Resources Center, Institute of Soil and Environmental Quality at the University of Delaware
Principal Investigators:	Amy Boyd, Program Coordinator, Delaware Water Resources Center, and Maria Pautler, Program Coordinator, Institute of Soil and Environmental Quality (ISEQ) at the University of Delaware, presenters. Displays support was provided by the Water Resources Agency, University of Delaware Institute for Public Administration. Additional University of Delaware graduate student staff for the 2005 event included: Jennifer Gilbert, Amy Sprinkle, Jen Seiter, Kristin Staats, Laura Boyer, Sheila Gardner, and Tiffany Thomas.

Boy Scout Soil and Water Conservation Merit Badge Training and **Girl Scout Eco-Action Interest Project Training** were provided to 25 area Boy Scouts and 18 area Girl Scouts, all grades 6-12, by **DWRC** and **UD** Institute of Soil and Environmental Quality staff at **UD Ag Day April 30, 2005.** Due to inclement weather, the event was held indoors. A large public information display of watershed and contour maps and aerial photos were provided by the University of Delaware Institute for Public Administration Water Resources Agency.

Boy Scout Soil and Water Conservation Merit Badge Training was provided to 32 area Boy Scouts by **DWRC** and **UD** Institute of Soil and Environmental Quality staff at **UD Ag Day April 24, 2004.** Visit http://ag.udel.edu/dwrc/publications.html and click "Public Programs" link for highlights and photos.

Estimated attendance at the overall 2004 public event was between 3,000 and 4,000. A large public information display of watershed and contour maps was provided by the University of Delaware Institute for Public Administration Water Resources Agency and Delaware Geological Survey. The public could also pick out Newark area water features on an aerial map provided by the UD College of Agriculture and Natural Resources and the Water Resources Agency. This public training program expanded the DWRC's education outreach efforts at this annual event. A free soil and water conservation literature table (contents listed below). At the **previous Ag Day on April 27, 2003**, attended indoors on a rainy day by an estimated 2,000 people, the Center's presence was the information table only.

Literature table contents:
1. Brochures describing the DWRC and its Internship program
2. Copies of DWRC newsletters "Water News" and printed "Water E-News"
3. Signups to receive these free periodic newsletters.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	9	0	2	0	11
Masters	2	0	0	0	2
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	11	0	2	0	13

Notable Awards and Achievements

Research Program: The Delaware Water Resources Center (DWRC) has funded thirteen research grant projects during March 2004 through February 2005 that address state water resources priorities identified by the DWRC's 13-member Advisory Panel. Two of these projects are graduate fellowships investigating the impact of soil arsenic on water quality and the removal of water-borne viruses; two are USGS summer intern projects mapping aquifers and creating computerized water data access systems. The remaining nine projects are undergraduate internships researching freshwater wetlands nutrient status, water supply security, watershed governance, freshwater invasive plants biological controls, water quality test system design, fish communities as water quality indicators, small farm water quality assessment and assistance education, and wastewater land application for nutrient reduction in the Chesapeake Bay.

Ten additional undergraduate internships have been awarded by the DWRC for the period March 2005 through February 2006. Topics under investigation include: 1) a water "report card" for the Delaware River Basin, 2) an aquifer hydrogeology study, 3 and 4) freshwater invasive plants biological controls (two projects), 5) landowner attitudes toward water quality regulations, 6) solid waste regulation impacts on wetlands, 7) use of more environmentally-friendly acids to treat "hard" water, 8) fate and water quality impact of metal (copper) nutritional amendments in poultry feed, 9) self-sustaining, ecological mosquito management methods for stormwater ponds, and 10) restoring coastal Bay water quality via native eelgrass micropropagation.

New DWRC public education program trains area Girl Scouts in conservation issues: The DWRC and Institute of Soil and Environmental Quality (ISEQ) at the University of Delaware (UD) staff provided new Eco-Action Interest Project training to 18 area Girl Scouts at UD Ag Day April 30, 2005. The DWRC's companion Boy Scout Soil and Water Conservation Merit Badge program, offered at the event for the second year to the same age group in grades 6-12, brought to 57 the number of area Boy Scouts trained to date by the DWRC and ISEQ. Visit ag.udel.edu/dwrc/publications.html and click "Public Programs" link for highlights and photos of the 2004 event. Free soil and water conservation literature were also made available, and a large public information display of watershed and contour maps and aerial photos was provided by the DWRC with assistance from the UD Institute for Public Adminstration Water Resources Agency, UD College of Agriculture and Natural Resources, and the Delaware Geological Survey.

DWRC-co-sponsored statewide Water Forum addresses watershed water resources issues: The Delaware Policy Forum titled "The Historic Christina Basin: Delaware's First Watershed" was attended by over 200 visitors from government, academia, industry, non-profit organizations, and the general public on October 13, 2004 at the University of Delaware's (UD) Clayton Hall. Fourth in an annual series examining statewide water policy issues, this year's event explored historic water resources concerns in the Christina Basin. Nineteen water resources advocates presented water policy and historic water resources concerns in the Christina Basin, comprised of the Brandywine Creek, Red Clay Creek, White Clay Creek, and Christina Creek watersheds in its Delaware portion. The Christina contains 6 trout streams and numerous endangered species, is home to more than half of Delaware's population, and is the largest source of drinking water supply in the state of Delaware. DWRC interns presented posters on their current research topics. The Forum's presentations, materials, and poster session were free of charge, courtesy the co-sponsors: Delaware Water Resources Center (DWRC), UD Institute for Public Administration (UD IPA), Water Resources Agency (WRA), Delaware Geological Survey, and Delaware Department of Natural Resources and Environmental Control (DNREC).

New DWRC-co-sponsored multi-state conference address water issues in Wild and Scenic White Clay Creek Watershed. "Water and Our Changing Landscape: Perspectives from the Wild & Scenic White Clay Creek Watershed", a new DWRC co-sponsored conference, was held at the University of Delaware (UD), Newark, Delaware Thursday April 14, 2005 for nearly 200 participants. The agenda included historical, scientific, and governance perspectives presented by representatives from the National Park Service, White Clay Creek Watershed Management Committee, watershed water purveyors, and consultants from nonprofits, private engineering firms, and government. Featured were keynote speaker Rick Darke, landscape designer, author, and photographer; Dr. Bernard Sweeney, Director of Stroud Water Research Center; a report by the White Clay Creek Watershed Management Committee; luncheon roundtables; and a stormwater management panel.

Publications from Prior Projects

1. 2002DE4B ("Graduate Fellowship in Water Quality: Mechanisms of Phosphorus Stabilization in the Soil Environment: A Molecular Scale Evaluation") - Articles in Refereed Scientific Journals - Hunger,Stefan, H. Cho, J. T. Sims, and D. L. Sparks, 2004, Direct speciation of phosphorus in alum-amended poultry litter: Solid-state 31P-NMR investigation, Environmental Science and Technology, Volume 38, 674-681.
2. 2002DE4B ("Graduate Fellowship in Water Quality: Mechanisms of Phosphorus Stabilization in the Soil Environment: A Molecular Scale Evaluation") - Articles in Refereed Scientific Journals - Hunger,Stefan, J.T. Sims,and D. L. Sparks, 2005. How accurate is the assessment of phosphorus pools in poultry litter by sequential extraction? Journal of Environmental Quality, Volume 34, 392-398.
3. 2003DE25B ("Characterization of autochthonous viral communities in estuarine waters") - Conference Proceedings - Simon, Matthew. Poster presentation, June 6, 2005, American Society of Microbiology Annual Meeting, Atlanta Georgia.