Water Resources Center
Annual Technical Report
FY 2005

Introduction

Delaware Water Resources Center

June 30, 2006

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 2005.

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. Average annual rainfall 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 is 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 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 and floods; (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 Delawares Inland Bays (a national estuary) strongly affects dissolved oxygen levels. In localized areas, large mats of algae accumulate and rot creating "hypoxic and anoxic death zones". Aquatic life such as oyster beds that cannot move can be destroyed by these conditions. Beginning 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; commercial inorganic fertilizers used by farmers, other land managers and homeowners also contribute nutrients to ground and surface waters About 70% of Delaware's cash farm income comes broilers, with annual production ranging from 260 to 280 million, broilers, primarily in Sussex County, the largest broiler producing county in the U.S.

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 Delawares rivers and streams to not fully support the swimming use; 65% do not fully support the fish and wildlife use. Most waters do not meet 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 1980s 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, the presence of brownfield soils in urban areas that had been used as tanneries or other industries, 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.

Recent Initiatives Promoting Delaware Water Quality

Water quality standards for Delaware surface waters in Delaware, revised and adopted effective July 11, 2004 by the Delaware Department of Natural Resources and Environmental Control (DNREC), include amendments to protect swimmers by making bacteria standards consistent with U.S. Environmental Protection Agency guidance and 2000 federal Beaches Environmental Assessment and Coastal Health (BEACH) Act requirements.

To ensure that Delaware waters meet state, regional and national water quality requirements and goals, the State has one of the most extensive water quality monitoring networks in the nation. Our water resources in this State are regularly tested for biological and chemical parameters. The results are reported in even years in the States 305(b) report. Waters that do not meet water quality standards are listed in the States 303 (d) list. Both of these reports are available on the DNREC website at: http://www.dnrec.state.de.us/water2000/Sections/Watershed/TMDL/305and303.htm.

The extensive water quality data has allowed tracking of long term progress made towards improving Delawares water resources.

Delawares non-attainment of Clean Water Act standards as described in the 303 (d) list is addressed by a federal court order requiring the development of total maximum daily load (TMDL) regulations for nearly the entire state, according to a schedule that stretches into 2010. TMDLs establish the maximum amount of pollutants a water body can receive daily without violating water quality standards, allowing the use of these waters for swimming, fishing, and drinking water supplies. TMDLS are being established for PCBs, toxics, nutrients, dissolved oxygen and bacteria. TMDLs were finalized in December 2003 for PCBs in the Delaware Estuary in cooperation with the Delaware River Basin Commission. Information on this effort including monitoring, plan implementation, etc. is found at: http://www.state.nj.us/drbc/toxics_info.htm.

TMDLs for nutrients, dissolved oxygen, and bacteria will be completed by 2007 in all affected watersheds. Completed TMDLs are found on DNRECs website: http://www.dnrec.state.de.us/water2000/Sections/Watershed/TMDL/tmdlinfo.htm.

Additional programs are in place to ensure continued compliance with the court order and to achieve water quality standards. Once TMDLs are in place, Pollution Control Strategies (PCSs) are developed to address how, where and when pollutant loads will be reduced to achieve TMDL levels. The first PCS in the State, developed to address the TMDLs in the Inland Bays has been drafted and is anticipated to be final in the winter of 2007. Final PCSs for the Nanticoke, Murderkill, and Appoquinimink watersheds are also expected to be finalized in 2007. The PCSs generally offer voluntary and regulatory strategies for urban, suburban and agricultural land uses and are developed through a public process where recommendations are made by Tributary Action Teams (TATs), groups of stakeholders formed with the purpose of addressing water quality concerns.

In the Inland Bays, Nanticoke, Murderkill, and Appoquinimink watersheds, the TAT process and the development of a draft PCS has taken up to seven years. However an expedited process has been developed to shorten the PCS development process to 15-18 months in new watersheds where TATs are formed. Since 2005, new TATs have been formed in the Christina, St. Jones, Broadkill, Chester and Choptank watersheds to work on PCSs to address TMDLs in those watersheds. DNREC anticipates having recommendations from those teams by the end of 2007. Teams are expected to be formed in other impacted watersheds over the next several years. To follow progress of the Tributary Action Teams or get more information about them, please visit:
http://www.dnrec.state.de.us/water2000/Sections/Watershed/ws/.

Other DNREC Water Quality Initiatives include:

Sediment and Stormwater: Amended Sediment and Stormwater Regulations became effective in April 2005. The revised regulations require the use of green technology stormwater treatment practices to better address water quality concerns associated with site development. These practices may also include the use of conservation design principles in stormwater management plans. More information on sediment and stormwater program is available at:
http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/StormWater.htm.

Non-point Source (NPS) Pollution: DNREC continues to reduce non-point source pollution through enhanced coordination of the Division of Soil and Water Conservation Cost Share Programs through the USEPAs NPS Management 319 Program and the National Oceanic and Atmospheric Associations (NOAAs) Coastal NPS Management 6217 program along with the Delaware Nutrient Management Commissions (DNMCs) program through the Delaware Department of Agriculture (DDA) and other programs. The effort allows the Department to direct millions of dollars every year toward a comprehensive NPS program to reduce pollutant loads, restore streams and buffers, and install best management practices (BMPs) such as cover crops, nutrient management plans, manure storage structures, manure relocation, and now urban best management practices within impaired watersheds. More information on the NPS 319 program is available at:
http://www.dnrec.state.de.us/dnrec2000/Divisions/Soil/NPS/index.htm; and information on Delawares Coastal Management Program is available at:
http://www.dnrec.state.de.us/dnrec2000/Divisions/Soil/dcmp/index.htm.

Stream and Wetland Restoration: Rehabilitating stream corridors and wetlands, stabilizing stream banks, decreasing erosion, improving biological water quality and providing buffers along the stream for riparian habitat are examples of the types of projects DNREC has implemented to improve water quality in our watersheds. Several projects completed in the last several years including those at Perkins Run in

northern New Castle County, the Three Little Bakers Theater in Pike Creek, and a restoration project at Christ our Teacher Catholic School.

Onsite wastewater treatment systems (Septics): Regulations for the onsite wastewater treatment systems were revised in 2002 and again in April of 2005. Legislation was also passed creating a Class H Licensed Septic Inspector Program. Grant funds have been used during the last few years to implement a septic system pumpout and inspection program and a holding tank inspection and pumpout program in Sussex County. Both programs have been very successful in identifying failing systems and allowing DNREC to provide assistance to system owners in making repairs or replacements as needed. The Department has also been working with the wastewater community to develop new performance standards for onsite wastewater systems. See: http://www.dnrec.state.de.us/water2000/Sections/GroundWat/DWRGrndWat.htm.

Source water assessment and protection: The DNREC Source Water Assessment and Protection Program (SWAPP) provide for the assessment and protection of sources of public drinking water, both surface and ground water. The assessment consists of three critical steps, first-delineation of source water areas; second-identification of existing and potential sources of contamination; and finally assessment of the susceptibility of the source water area to contamination. The Site Index Database identifies the location and status of both existing and potential sources of contamination within the State. Most potential point sources have been mapped and rated.

In 2004, the Source Water Protection Program developed a guidance manual for local governments. This document was updated in 2005. For more information on source water protection, please visit the following website: http://www.wr.udel.edu/swaphome/index.html. Delaware SWAPP is a cooperative effort between DNREC, Delaware Division of Public Health, and the University of Delawares Water Resources Agency. A citizens advisory group (CTAC) was formed to assist DNREC in the development and implementation of the program and to ensure public involvement. SWAPP is a multi-phase program that is expected to be completed in the next few years.

Cooperative efforts: Cooperation among DNREC, residents, other agencies-state and federal, universities, county and municipal governments, conservation districts, and non-governmental organizations (NGOs) helps bring Delaware water goals to fruition. Pollution Control Strategy development and implementation of TMDL regulations is driven by Tributary Action Teams (TATs). The Center for Inland Bays, University of Delaware Cooperative Extension, the Sea Grant Program at the University of Delaware College of Marine Studies, University of Delaware Water Resources Agency, Delaware State Cooperative Extension, the Camden-Wyoming Rotary Club, the state of Delawares Nutrient Management Commission, New Castle, Kent and Sussex County governments, Sierra Club, the county conservation districts, USDA, other DNREC divisions and many others have been vital contributors in the development of PCSs and TATs.

All of the projects implemented in TMDL watersheds to address water quality concerns require a cooperative effort and partnerships to be formed, not just in government interactions, but between members of Tributary Action Teams as well. Finding a solution for cleaner water will require more innovative solutions, greater regulatory control, additional financial resources, and a willingness to make a change by everyone affecting Delawares watersheds, as we are all part of the problem and we must work together to find a reasonable solution for everyone.

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 Delawares Research Office. In 1993, the DWRC was formally moved to the College of Agriculture and Natural Resources (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 14 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 The Nature Conservancy, 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 Universitys 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 Institute for Soil and Environmental Quality at UD, 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 2005 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 6 years, 69 undergraduate internships were made possible via funding from DWRC/USGS, four Colleges within the University of Delaware, and the Department of Agriculture and Natural Resources at Delaware State University. DWRC 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

1. Institute Director:

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3. Abstract of Program and Management Overview:

The Delaware Water Resources Center (DWRC) research, education and information transfer programs focus on issues of state and regional importance to both water quality and water quantity. Long-term priority areas of the DWRC have included nonpoint source pollution of ground and surface waters,

development of ground water supplies, the impact of hydrologic extremes on water supply, and socio-economic factors affecting water supply and water quality. In 2000, the 16-member DWRC Advisory Panel identified five specific areas for near-term DWRC research efforts: (1) Agricultural nutrient management and water quality; (2) Basic and applied research on sources, fate, and transport of water pollutants; (3) Quantifying response of aquatic ecosystems to pollutant inputs; (4) Water supply, demand, and conservation, as affected by changing land uses in Delaware and the mid-Atlantic states; and (5) Management and control of stormwater runoff. The FY05 DWRC public water conservation educational youth program addressed all these issues. DWRCs research program during the same period addressed these concerns by supporting graduate fellowships in water quality, an undergraduate student internship program, and public information forums including an intern research poster session and two statewide water resources conferences.

2005-2006 DWRC Fellowship and Internship Research Program

Two fellowships have been awarded for a third and final year in 2005-2006 based on a review of proposals submitted by potential graduate fellows and their advisors to the DWRC Advisory Panel:

a) Removal and Inactivation of Water-borne Viruses Using Elemental Iron Graduate Fellow: Liping Zhang; Advisors: Yan Jin, Department of Plant and Soil Sciences, College of Agriculture and Natural Resources, University of Delaware; and Pei Chiu, Department of Civil and Environmental Engineering, College of Engineering, University of Delaware.

b) Fate and Transport of Arsenic in Delaware Soils: Impacts on Water Quality Graduate Fellow: Jennifer Seiter; Advisor: Donald Sparks, Department of Plant and Soil Sciences, College of Agriculture and Natural Resources, University of Delaware.

Seventeen internships have been awarded for 2005-2006 based on a review of proposals submitted by potential undergraduate interns and their advisors to the DWRC Advisory Panel:

a) Rain Gardens

Undergraduate Intern: Leslie Carter; Advisor: Susan Barton, Department of Plant and Soil Sciences, College of Agriculture and Natural Resources, University of Delaware.

b) Delaware River Basin State of the Basin Report Card

Undergraduate Intern: Christi M. DeSisto; Advisor: Gerald Kauffman, University of Delaware Water Resources Agency.

c) Hydrogeology of the Near-Surface Aquifers in Sussex County

Undergraduate Intern: Bailey Dugan; Advisors: A.Scott Andres and Andrew Klingbeil, Delaware Geological Survey.

d) The Impact of Predation on the Galerucella Beetle, a Purple Loosestrife Biocontrol Agent

Undergraduate Intern: Jason Graham; Advisor: Judith Hough-Goldstein, Department of Entomology & Wildlife Ecology, College of Agriculture and Natural Resources, University of Delaware.

e) Nutrient Release from Mineralization of Poultry Litter under Simulated Field Conditions

Undergraduate Intern: Leslie Howe; Advisors: Mingxin Guo and Maria Labreveux, Department of Agriculture and Natural Resources, Delaware State University

f) Winter needle conductance rates of Pinus strobus L. (eastern white pine): meteorological conditions and intraspecific variability

Undergraduate Intern: Lydia Leclair; Advisor: Delphis Levia, Department of Geography, College of Arts and Sciences, University of Delaware.

g) Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware

Undergraduate Intern: Matthew Lee; Advisors: Joshua Duke and Rhonda Aull Hyde, Department of Food and Resource Economics, College of Agriculture and Natural Resources, University of Delaware.

h) The Impact of the Solid Waste Decision on Isolated Wetlands In Delaware

Undergraduate Intern: Matthew Loiacono; Advisors: Joshua Duke and Steven Hastings, Department of Food and Resource Economics, College of Agriculture and Natural Resources, University of Delaware.

i) Kinetics Model for Soil

Undergraduate Intern: Jimit Modi; Advisor: Herbert Allen, Department of Civil and Environmental Engineering, College of Engineering, University of Delaware.

j) Biological Control of Purple Loosestrife: Preventing Wetlands Degradation By An Invasive Plant

Undergraduate Intern: Jamie Pool; Advisor: Judith Hough-Goldstein, Department of Entomology & Wildlife Ecology, College of Agriculture and Natural Resources, University of Delaware.

k) Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES)

Undergraduate Intern: Brian Rosen; Advisor: Donald Sparks, Department of Plant and Soil Sciences, College of Agriculture and Natural Resources, University of Delaware.

l) The Effect of Dietary Level and Source of Cu on Broiler Cu Excretion and Movement of Copper (Cu) Through Broiler Excreta Amended Soils

Undergraduate Intern: Carolyn Schnek; Advisors: William Saylor, Michael Persia, and James Skaggs, Department of Animal and Food Sciences, College of Agriculture and Natural Resources, University of Delaware.

m) Sustainable, Low-Impact Methods for Managing Mosquito Populations in Storm Water Ponds

Undergraduate Intern: Nancy McGehee Scott; Advisor: John Gingrich, Department of Entomology & Wildlife Ecology, College of Agriculture and Natural Resources, University of Delaware.

n) Detection of Salmonella in Biosolids using a Combination of Cultural, Molecular and Immunological Methods

Undergraduate Intern: Samantha Smith; Advisor: Diane Herson, Department of Biology, College of Arts and Sciences, University of Delaware.

o) Location and Evaluation of Coastal and Inland Brackish Aquifers for the Support of Halophyte (Kosyteletzkya) Oil Production for Bioidiesel Fuel Conversion

Undergraduate Intern: Maia Tatinclaux; Advisors: John Gallagher and Denise Seliskar, Halophyte Biotechnology Laboratory, College of Marine Studies, University of Delaware.

p) Restoring Coastal Bay Water Quality via Native Eelgrass Micropropagation

Undergraduate Intern: Katherine Tigani; Advisor: John Gallagher, Halophyte Biotechnology Laboratory, College of Marine Studies, University of Delaware.

q) Diversity, Function, and Benefits of Plants Adapted To Flood-Prone and Poorly Drained Environments

Undergraduate Intern: Michael Zuk; Advisor: John Frett, Department of Plant and Soil Science, College of Agriculture and Natural Resources, University of Delaware.

Research Program

REMOVAL AND INACTIVATION OF WATER-BORNE VIRUSES USING PERMEABLE IRON BARRIERS

Basic Information

Title:	REMOVAL AND INACTIVATION OF WATER-BORNE VIRUSES USING PERMEABLE IRON BARRIERS
Project Number:	2003DE30B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Not Applicable
Focus Category:	Water Quality, Toxic Substances, Geochemical Processes
Descriptors:	None
Principal Investigators:	Yan Jin, Pei Chiu

Publication

1. You, Y.; J. Han, Liping Zhang, Pei C. Chiu, Yan Jin, 2006, Removal and Inactivation of Waterborne Viruses Using Zero-Valent Iron, in The 4th International Slow Sand and Alternative Biological Filtration Conference Proceedings, IWW Water Centre, Mulheim an der Ruhr, Germany, 8 pp.
2. Zhang, Liping. Poster Presentation October 21, 2005. Removal and Inactivation of Water-Borne Viruses Using Permeable Iron Barriers, In Proceedings of Fifth Delaware Water Policy Forum, University of Delaware, Newark, Delaware, p 17. http://www.wr.udel.edu/publicservice/WaterForum2005/waterforum05.pdf
3. Zhang, Liping, 2006, Removal and Inactivation of Viruses with Elemental Iron, in proceedings of the 231st American Chemical Society (ACS) National Meeting, Atlanta, GA.

INTRODUCTION AND OBJECTIVES

Microbial pathogens (bacteria, protozoa, and viruses) in drinking waters represent a serious public health problem. Sources of enteric pathogens in source water include septic tanks, landfills, sewage sludge application on land, and wastewater discharge and reuse (Yates, et al., 1985), as well as runoff and infiltration from animal waste-amended fields (McMurry et al., 1998). Among the different microbial pathogens, viruses are particularly problematic because they are highly mobile in soil and groundwater and difficult to remove by filtration due to their small size. Viruses were reported to be responsible for approximately 80% of disease outbreaks for which infectious agents were identifiable (Ryan et al., 2002). The U.S. EPA has promulgated Long Term 1 Enhanced Surface Water Treatment Rule (SWTR) and put forward Long Term 2 Enhanced SWTR (U.S. EPA, 2003) to set treatment requirements to reduce microbial contamination.

Chlorination is the most common process for water and wastewater disinfection. However, chlorine was shown to be less effective against viruses than bacteria (Payment and Armon, 1989, Bull et al., 1990). A recent study (You et al., 2005) demonstrated that in a flow-through column containing Fe(0), two bacteriophages, MS2 and ϕX174, were removed from artificial groundwater with an efficiency of 4-log (99.99%) in an initial pulse test, and more than 5-log (>99.999%) in the second pulse test after passage of 320 pore volumes of artificial groundwater. These authors suggested that the viruses might be removed by iron corrosion products, and that the improved efficiency over time might be due to continued formation of surface iron oxides through corrosion.

In the previous (FY2004) annual progress report to DWRC, we showed results of MS2 and ϕX174 removal by elemental iron after different treatments (as-received, acid-treated, and after anaerobic corrosion). The main findings were that iron as-received effectively removed MS2 and ϕX174 under the experimental conditions, and the removal was mostly due to inactivation rather than adsorption. ϕX174 was inactivated by both acid-treated iron and its corrosion products whereas MS2 was inactivated primarily by iron corrosion products.

X-ray diffraction (XRD) characterization of corroded iron demonstrated that magnetite (Fe_3O_4) was the major oxidation product of anaerobic iron corrosion. We also measured aqueous Fe(II) in batch experiments with 1 g of acid-treated iron and observed increasing Fe(II) concentration over time. We decided to examine the effects of the two corrosion products individually on the removal of the two viruses.

The main objective of our study in 2005 was to evaluate the roles of Fe(0) itself and its anaerobic corrosion products, aqueous Fe(II) and magnetite (Fe_3O_4), on the removal of ϕX174 and MS2 from water.

RESULTS TO DATE (FY04-FY05)

In summary, our experiments show that Fe(0) itself had little effect on either of the MS2 or ϕX174 bacteriophage. Aqueous Fe(II) inactivated ϕX174 to a large extent but had little influence on MS2. Fe_3O_4 adsorbed and inactivated both viruses, although ϕX174 appeared to be more susceptible to inactivation by Fe_3O_4 than MS2. The results suggest

that it was the corrosion products, rather than Fe(0) itself, that were responsible for the observed virus removal and inactivation in Fe(0) systems.

Table 1 summarizes the main results to date, from both FY2004 and FY2005.

Table 1 Summary of batch results

Iron Sample	MS2		ϕX174	
	Removal	BEX recovery	Removal	BEX recovery
1g Fe(0) as-received	93.2% in 4 hr	16.8%	99.5% in 4 hr	0.5%
1g Fe(0) treated with 0.5 M HCl	53.0% in 3 hr	80%	98.7% in 3 hr	1.9%
1g Fe(0) treated with 1 M HCl	No removal	N/A	90.8% in 3 hr	1.0%
1g Acid treated Fe(0) + 3mM citrate	N/A	N/A	No removal	N/A
0.5 mM Fe(II)	No removal	N/A	95.7 % in 12 min	N/A
Fe(II) at four conc.: 0.01, 0.03, 0.1, 0.3mM. Reaction time: 10 min	N/A	N/A	52.4% at 0.01mM 83.6% at 0.03mM 85.8% at 0.1 mM 91.7% at 0.3 mM	N/A
1g Corroded iron	99.4% in 3 hr	53.9%	99.9% in 3 hr	2.5%
1 g Fe_3O_4	99.6% in 3 hr	84.8%	99.9% in 3 hr	22.9%

PLAN FOR FY2006

The objectives and tasks for FY2006 will include (1) to elucidate the mechanisms involved in virus inactivation by aqueous Fe(II) and Fe_3O_4, and (2) to evaluate the effects of common constituents in natural waters, such as natural organic matter, on virus removal efficiency with Fe(0). The long-term goal is to better assess the feasibility and limitations of Fe(0) as a potential virus removal technology for water purification

FATE AND TRANSPORT OF ARSENIC IN POULTRY LITTER AMENDED DELAWARE SOILS: IMPACTS ON WATER QUALITY

Basic Information

Title:	FATE AND TRANSPORT OF ARSENIC IN POULTRY LITTER AMENDED DELAWARE SOILS: IMPACTS ON WATER QUALITY
Project Number:	2003DE32B
Start Date:	3/1/2005
End Date:	2/28/2006
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

Publication

1. Seiter, J., and Donald Sparks, 2006, Fate and transport of arsenic in poultry litter amended Delaware soils: Impacts on water quality, 18th World Congress of Soil Science, Philadelphia, Pennsylvania.
2. Seiter, J., and Donald Sparks, 2005, Fate and transport of arsenic in Delaware soils. Soil Science Society of America Annual Meeting, Salt Lake City, Utah.

INTRODUCTION AND OBJECTIVES

The Delmarva Peninsula is one of the most concentrated areas of poultry production in the United States. In 2000, 620 million broilers were produced, which resulted in manure and poultry litter containing approximately 2.6×10^4 kg of As. Arsenic occurs in poultry litter as a result of the use of 3-nitro-4-hydroxyphenylarsonic acid, roxarsone, a feed additive for prevention of coccidiosis, for increased weight gain, and improved feed efficiency. Through a series of processes the organic roxarsone is transformed into inorganic As species arsenite, As(III), and arsenate, As(V); these species are both more toxic than roxarsone. Arsenic concentrations in poultry litter has been found to vary from 0-77 mg kg^{-1}. The localized nature of poultry farming operations and the cost of transporting litter over long distances has led to limited land areas receiving repeated waste applications. This has raised concerns in the past over P saturation of soils, and similar concerns must also apply to trace element loading.

Phosphate, sulfate and other oxyanions are contained in mass quantities in the litter, and may out-compete arsenic species for adsorption sites on soil components. This competition is likely because phosphate is of similar structure and has the same affinity for oxides and clay minerals as arsenate. The source of sulfate in litter is alum, which is added to the litter in order to reduce soluble P. There is reason to believe that alum may also have an effect on As solubility.
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 soils, the fate and transport 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 are being 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 As status and speciation in poultry litter as a function of roxarsone treatment and time.

KEY FINDINGS IN 2005-2006 (FY05)

1. The basic physicochemical properties of the poultry litter amended and unamended soils were completed.
2. Arsenate sorption onto Delaware soils is highly influenced by pH. It appears that maximum As (V) adsorption occurs around the pH of the soil from pH 5.0-6.0. The adsorption isotherm data are currently being analyzed. Greater amounts of As(V) sorption was seen in the subsurface soils, than the surface soils. The maximum amount of As(V) sorption, as a percent of the total amount added, ranged between 15-25%

3. Data on the poultry litter analyses are included in Table 1. Total As levels range from 2.6 to 15.1 mg/kg. XANES analysis has provided information on As speciation in the poultry litter samples (Figure 1). Preliminary data indicate that there are mixed As species in the litter samples with the primary species being As(V).

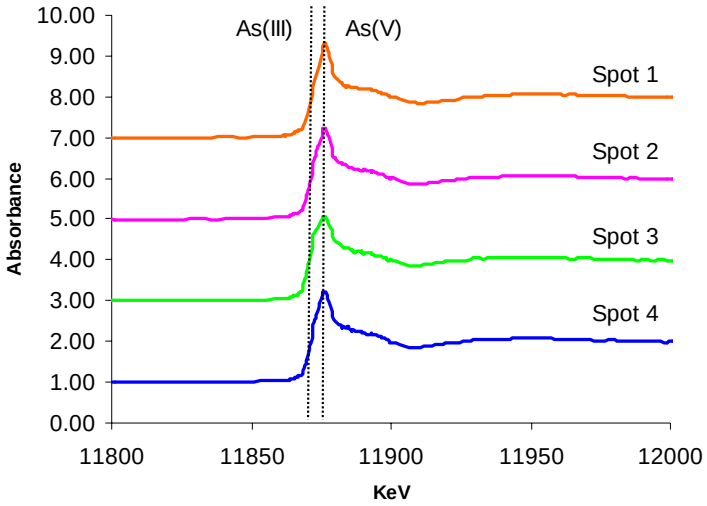
PLANS FOR 2006-2007 (FY06)

Competitive studies will be conducted using a stirred-flow method. Phosphate and arsenate will be the oxyanions of concern. Three different studies will be conducted to assess the ability of As to adhere to soil particles when phosphorus is present. First, As will be sorbed onto the soil, then P will be introduced into the system. The amount of As released from the soil will be monitored. The other study that will be conducted will assess the ability of As to remove P from the soils. Additionally, a study will be conducted where As and P are introduced to the soil together but at varying As:P ratios (1:1, 1:100, 1:1000).

Table 1.
Arsenic Status of Poultry Litter Samples as Affected by Roxarsone Treatment

	----------Feed----------		---------- Litter ----------					
Age (days)	Treatment	ROX (mg/kg)	Total As (mg/kg)	Water Soluble As (mg/L)	Total P	Water Soluble P (mg/L)	pH	Moisture Content %
0-16	Starter	2.7	2.6	0.4	2796.4	557.6	8.4	12.8
17-31	Agristats 1	13.3	12.0	11.8	4258.4	1131.1	8.6	19.5
32-37	Agristats 2	0.6	15.1	7.8	8906.9	1241.4	8.8	14.8
38-44	Agristats 3	0.3	12.8	7.8	8701.2	1719.0	8.8	16.4

Figure 1. XANES analysis of Poultry Litter Sample



Delaware River Basin State of the Basin Report Card

Basic Information

Title:	Delaware River Basin State of the Basin Report Card
Project Number:	2005DE53B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	
Research Category:	Water Quality
Focus Category:	Law, Institutions, and Policy, Non Point Pollution, Education
Descriptors:	
Principal Investigators:	Gerald Kauffman

Publication

1. Kauffman, Gerald, and Christi DeSisto, 2006, Delaware River State of the Basin Report 2006 Development of Environmental Indicators, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 18 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.
3. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 "2005-2006 DWRC Undergraduate Internships News: Spotlight on Three Projects: Spring Internship Winners", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 5.

Undergraduate Internship Project #1 of 17 for FY05

Christi DeSisto researched measurable environmental indicators for a new *"Delaware River Basin State of the Basin Report Card"* in collaboration with researchers at water resources institutes at Cornell, Rutgers, and Penn State. She is shown at the installed wetland at the ***University of Delaware*** Institute for Public Administration Water Resources Agency (***WRA***), where she worked with her advisor Gerald Kauffman. The project was co-sponsored by ***DWRC*** and the ***WRA***.

"This internship has given me the opportunity to apply classroom knowledge to real-world applications. As a Civil Engineering student, I believe this project has opened my eyes to the importance of environmental engineering in today's society." – Christi DeSisto

Abstract

The Delaware Basin is a large basin with many contrasting uses and functions. It covers 13,000 square miles in Delaware, New Jersey, New York, and Pennsylvania and extends 300 miles from its headwaters in the Catskills to its mouth at Cape Henlopen.

Since its creation by the President, Congress, and the four state governors in 1961, the Delaware River Basin Commission (*DRBC*) has sought to balance the interests of economics and the environment for the river with the interests of the public and federal government.

In September 2004, the governors of the four states and the federal representative from the U.S. Army Corps of Engineers approved the Water Resources Plan for the Delaware River Basin, which recommended developing a set of indicators to assess baseline conditions and measure progress toward objectives. The purpose of this report is to describe the condition of water resources and water-related resources throughout the Delaware River Basin to the general public and policy makers. The overall goal is to establish baseline environmental conditions in the basin, and assemble and assess information that would characterize status and trends, and establish environmental-quality indicators in a watershed framework. A draft of the State of the Basin Report is scheduled for submission to *DRBC* by September 2006.

-Excerpt from *Water Matters February 2006* by Jerry Kauffman.

Hydrogeology of the Near-Surface Aquifers in Sussex County

Basic Information

Title:	Hydrogeology of the Near-Surface Aquifers in Sussex County
Project Number:	2005DE54B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Ground-water Flow and Transport
Focus Category:	Hydrogeochemistry, Non Point Pollution, Groundwater
Descriptors:	
Principal Investigators:	Alan Scott Andres, Andrew Klingbeil

Publication

1. Andres, A. Scott, Bailey Dugan, and Andrew Klingbeil, 2006, Hydrogeology of the Near-Surface Aquifers in Sussex County, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 29 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.

Undergraduate Internship Project #2 of 17 for FY05

DWRC and the ***Delaware Geological Survey (DGS)*** co-sponsored ***Bailey Dugan's*** internship evaluating the "*Hydrogeology of the Unconfined Aquifer in Sussex County*". Domestic water use by approximately two-thirds of Delaware's population, water use for self-supplied industry, and water for most of agriculture, Delaware's largest industry, is derived from groundwater sources. Bailey investigated aspects of groundwater found in shallow aquifers susceptible to pollution. Her advisors were A. Scott Andres and Andrew Klingbeil of the ***DGS.***

"I gained experience in field work and research and learned to compile and interpret large amounts of data through the creation of spreadsheets, contour maps, and cross-sections and the use of Geographic Information Systems."
– Bailey Dugan

Abstract

Groundwater, which is in aquifers below the surface of the Earth, is one of the nation's most important natural resources; it is the source of all fresh water used for potable, industrial, commercial, and irrigation purposes in Sussex County, Delaware. The Columbia Aquifer represents the shallowest aquifer of Delaware's groundwater resource. The unconfined portion of the Columbia Aquifer is important in that it supplies water to many agricultural, domestic, industrial, public, and irrigation wells. In some regions, deeper aquifers are in direct contact with the unconfined Columbia Aquifer, and therefore function as part of the unconfined aquifer as well. Detailed information concerning the thickness and water-transmitting (transmissivity) characteristics of the unconfined aquifer is important in the management of the water contained within it.

The identification and description of the geologic units hosting the unconfined aquifer is important in predicting the distribution and water-bearing characteristics of the aquifer, which is necessary information for proper water-use management. The geologic units of importance for examination of the near-surface hydrogeologic framework in Sussex County include the Calvert, Choptank, St. Marys, Cat Hill, Bethany, and Beaverdam Formations, and the Nanticoke, and Delaware Bay Group deposits.

Records obtained from the DGS and the DNREC of descriptive and geophysical logs of drillholes and boreholes throughout Sussex County were examined to produce two cross-sections (one running north to south, one running east to west) and three structure contour maps (illustrating elevations of different formations) to show general characteristics and trends of the county's hydrogeologic framework. Three logs were examined more closely to show more specific details on lithology, gamma log signatures, and thickness of each identified formation and aquifer; transmissivity was also calculated for each of the three logs using a hydraulic conductivity equation.

The boreholes examined in this study possessed a large variation in aquifer thickness. The St. Marys Formation and all overlying units were each found to contain confining beds within the study region. The unconfined aquifer was therefore found to fluctuate highly in thickness and content; sediments contained within the Cat Hill, Bethany, and Beaverdam Formations and the Nanticoke and Delaware Bay Group deposits were found to function as part of the unconfined aquifer in various locations in Sussex County. Of the 23 boreholes used in the 3 cross-sections, the unconfined aquifer was found to range in thickness from 12 to 223 feet. The transmissivity of the unconfined aquifer was also found to be highly variable, ranging from 8,770 to 14,300 feet squared per day; this range shows the inconsistency in thickness and composition of the sediments forming the unconfined aquifer. The variability of these aquifer properties makes it difficult to predict and define thickness and transmissivity without extensive and accurate data.

This study has shown the complexity and variability of the near-surface hydrogeology in Sussex County; it has developed a framework for further definition and better management of Delaware's groundwater resource.

The Impact of Predation on the Galerucella Beetle, a Purple Loosestrife Biocontrol Agent

Basic Information

Title:	The Impact of Predation on the Galerucella Beetle, a Purple Loosestrife Biocontrol Agent
Project Number:	2005DE55B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Biological Sciences
Focus Category:	Wetlands, Acid Deposition, None
Descriptors:	
Principal Investigators:	Judith Hough-Goldstein

Publication

1. Hough-Goldstein, Judith, and Jason Graham, 2006, The Impact of Predation on the Galerucella Beetle, a Purple Loosestrife Biocontrol Agent, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 13 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.

Undergraduate Internship Project #3 of 17 for FY05

Jason Graham's internship was one of two *DWRC / University of Delaware College of Agriculture and Natural Resources* co-sponsored internships, 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, his project was titled "*The Impact of Predation on the* **Galerucella** *Beetle, a Purple Loosestrife Biocontrol Agent*". Jason hopes that beetle biological controls he applied to loosestrife at Flat Pond near the Chesapeake & Delaware canal will reduce these stands significantly.

"It was very rewarding to research in greater depth some of the observations made last summer working with the Purple Loosestrife Project. Our efficiency increased, allowing us to make a greater impact in preserving the biodiversity of the wetlands." -- Jason Graham (pictured above, left)

Abstract

During the summer of 2004, two species of *Galerucella* beetle were released in two distinct ecosystems to control stands of the invasive plant, purple loosestrife. These two species, *G. pusilla* and *G. calmariensis*, are indistinguishable by the unaided eye and were reared and shipped together from the Phillip Alampi Beneficial Insect Laboratory, New Jersey Department of Agriculture.

The ecosystems were distinctly different in that Flat Pond, bordering the C&D canal is a near monoculture of purple loosestrife while the stand of loosestrife at Burrows Run, Ashland Nature Center is mixed with a diverse selection of plants. The *Galerucella* beetles were successful in establishing at Flat Pond, while they were not successful at establishing at Ashland.

These observations led to the hypothesis that the high diversity of plants at Ashland resulted in more arthropod predators as opposed to the less diverse Flat Pond. Therefore the beetles at Ashland were impeded in their establishment by arthropod predators. This hypothesis was tested by sampling the insects at both sites on a weekly basis throughout the summer of 2005.

The sampling consisted of 20 sweeps with a standard insect collection net at five locations at each of the two sites on a weekly basis. The samples were conducted throughout the summer and the specimens collected were keyed to the family level. This enabled the determination of what predators were prevalent during what points in the summer. Predators were present at both sites, yet there were differences in the types of predaceous arthropods present. There was a higher occurrence at the Ashland site of most

predaceous groups. The trend at Ashland shows a higher population of Heteroptera in early June, the same time period that the *Galerucella* beetles were released the year before.

Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware

Basic Information

Title:	Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware
Project Number:	2005DE56B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Social Sciences
Focus Category:	Law, Institutions, and Policy, Non Point Pollution, Water Quality
Descriptors:	
Principal Investigators:	Joshua Duke, Rhonda Aull Hyde

Publication

1. Duke, Joshua, Rhonda Aull Hyde, and Matthew Lee, 2006, Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 15 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.
3. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 "2005-2006 DWRC Undergraduate Internships News: Spotlight on Three Projects: Spring Internship Winners", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 5.

Undergraduate Internship Project #4 of 17 for FY05

Matthew Lee was advised by Dr. Joshua Duke and Dr. Rhonda Aull Hyde of the *University of Delaware* Department of Food and Resource Economics for his *DWRC / Institute of Soil and Environmental Quality at the University of Delaware* co-sponsored internship project "*Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware.*" Matthew surveyed perceptions of policies in order to investigate landowner compliance costs. These costs may suggest making new policies or creating new concepts, goals, or enforcement strategies for existing laws.

"Through my DWRC research project I have become aware of current efforts to protect Delaware and Maryland's surface water quality through federal, state, and county regulations. I have had the opportunity to communicate with environmental agency policy-makers to develop a survey testing landowner's perceptions of these regulations. I feel that understanding these perceptions will help in making future recommendations to policy-makers." -- Matthew Lee

Abstract

The objectives of this project were: (1) to develop a measure of landowners' relative, perceived stringency for the major command-and-control policies affecting surface water quality in Delaware; and (2) to develop a measure of how policy makers think landowners perceive this regulatory environment. Eight relevant policies were identified. A population of landowners owning at least 5 acres in Sussex County, Delaware, was identified and a sample was drawn. A mail survey of 233 landowners resulted in a 45.5% response rate.

The mail survey instrument focused on three aspects of the restrictiveness of water quality policies: (1) landowners level of familiarity with the eight policies; (2) landowners beliefs about which policies apply to their land; and (3) the relative, perceived restrictiveness of the applicable policies. The third type of data was collected so that the Analytic Hierarchy Process could be applied to the data. In addition, a parallel set of data were collected from Delaware policy makers to measure their expert views on landowners' perceptions of the water quality policy environment.

The principal applicability results show that landowners were more likely than policy makers to believe that all policies (except *Nutrient Management*) apply to them. Yet, policy makers correctly predicted that owners were most familiar with *Nutrient Management* and least familiar with *Water Quality Certification*. Additionally, policy makers closely predicted the landowners' quantitative level of familiarity on all policies except *Water Quality Certification* and *Delaware Permit to Impact Water Bodies*. The relative, perceived restrictiveness of each policy was available only for the landowner

survey. Merely a partial ranking—not precise relative restrictiveness measure—was available for policy makers because there were limited data points and a marked lack of disagreement on the restrictiveness of several policies, which prevented the application of the AHP method. The owners reported that *Nutrient Management* and the *Delaware Permit to Impact Water Bodies* were the most restrictive policies and that the *Federal Permit to Impact Wetlands* and *Forest Erosion* were the least restrictive policies. In fact, 48.9% of the owners' perceived restrictiveness was due to three policies; *Nutrient Management*, *Delaware Permit to Impact Water Bodies*, and *Federal Permit to Impact Water Bodies*.

A combined analysis of policy maker rankings data and landowner AHP results on the policy-grouping level shows that landowners perceived *Activities Impacting Crop and Forest Land* policies to be more restrictive than *Activities Impacting Wetland* policies which in turn were about as restrictive as *Activities Impacting Water Body* policies. This did not correspond with the responses of the policy makers who perceived *Activities Impacting Crop and Forest Land* policies to be least restrictive. Within the policy groups, the owners and policy makers tended to rank restrictiveness differently. However, both agreed that *Delaware Permit to Impact Water Bodies* was most restrictive in its group.

Overall, the landowners tend to overestimate the applicability of policies relative to the policy makers. Additionally, policy makers tend to perceive correctly the landowners' level of familiarity. However, for most policies, the owners' perceptions of the restrictiveness of each policy do not align well with the policy makers'. The quantitative difference in these perceptions is unknown.

The Impact of the Solid Waste Decision on Isolated Wetlands in Delaware

Basic Information

Title:	The Impact of the Solid Waste Decision on Isolated Wetlands in Delaware
Project Number:	2005DE57B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Social Sciences
Focus Category:	Wetlands, Law, Institutions, and Policy, Management and Planning
Descriptors:	
Principal Investigators:	Joshua Duke, Steven E. Hastings

Publication

1. Duke, Joshua, Steven Hastings, and Matthew Loiacono, 2006, The Impact of the Solid Waste Decision on Isolated Wetlands in Delaware, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 15 pages.
2. Loiacono, Matthew, 2006, The Impact of the Solid Waste Decision on Isolated Wetlands in Delaware, undergraduate thesis for undergraduate degree with distinction, University of Delaware, Newark, Delaware, 35 pages.
3. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.

Undergraduate Internship Project #5 of 17 for FY05

Matthew Loiacono studied "*The Impact of the* **Solid Waste** *Decision on Isolated Wetlands in Delaware*" in his ***DWRC*** internship, teamed with advisors Dr. Joshua Duke and Dr. Steven Hastings of the ***University of Delaware*** Department of Food and Resource Economics. His project was co-sponsored by the ***DWRC*** and the ***UD College of Agriculture and Natural Resources***.

"This internship has been a great opportunity for me to explore how wetlands work and what they do for the environment. My research over the summer has allowed me to gain better insight into how wetlands are being protected since the 2001* Solid Waste *decision."
– Matthew Loiacono

Abstract

After the U.S. Supreme Court's *Solid Waste* decision, isolated wetlands were left unprotected. Research was conducted to find out how this decision impacted landowners' decision making about wetlands—specifically, the characteristics of the isolated wetlands that remained regulated or were freed from jurisdiction by the U.S. Army Corps of Engineers (Corps). Data were collected from Corps records for the Philadelphia region on the population of landowners seeking jurisdictional determinations following *Solid Waste*. These data were enriched by additional data on the area around these landowners' parcels using GIS data from U.S.G.S. and U.S. Census data. The analysis included descriptive statistics and results of an ordered logit model explaining jurisdictional determinations, the results of which allow several general conclusions about the effect of *Solid Waste* on wetlands and landowner behavior. Without *Solid Waste*, one deduces that only six owners in the region would have had their wetlands freed from jurisdiction. After *Solid Waste*, an estimated 54 additional owners were freed from jurisdiction. The main legal reasons the Corps used to assert jurisdiction were wetlands adjacent to waters of the United States (but not other wetlands) and tributary to a waters of the United States. The major legal reason the Corps freed owners from jurisdiction was isolated, intrastate wetland with no nexus to interstate commerce. In addition, the ordered logit model allows conclusions about the effect of various characteristics of land on the probability of receiving an exemption from jurisdiction. For instance, a 1 percent increase in forest or agriculture within a one mile radius of the parcel increases the chance of getting partial jurisdiction by 20 percent and 19 percent, respectively. Owner decision making also affects jurisdictional determinations. For instance, Delaware owners actively seeking a jurisdictional determination had a 13% increase in probability of moving from partial jurisdiction to full freedom from jurisdiction.

Biological Control of Purple Loosestrife: Preventing Wetlands Degradation By An Invasive Plant

Basic Information

Title:	Biological Control of Purple Loosestrife: Preventing Wetlands Degradation By An Invasive Plant
Project Number:	2005DE58B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Biological Sciences
Focus Category:	Wetlands, Acid Deposition, Management and Planning
Descriptors:	
Principal Investigators:	Judith Hough-Goldstein

Publication

1. Hough-Goldstein, Judith, and Jamie Pool, 2006, Biological Control of Purple Loosestrife: Preventing Wetlands Degradation by an Invasive Plant, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 15 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.

Undergraduate Internship Project #6 of 17 for FY05

Jamie Pool's project was one of two *DWRC / University of Delaware College of Agriculture and Natural Resources* co-sponsored internships, 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, his internship evaluated the "*Biological Control of Purple Loosestrife: Preventing Wetlands Degradation by an Invasive Plant*". Jamie hopes that beetle biological controls he applied to loosestrife at Flat Pond near the Chesapeake & Delaware canal will reduce these stands significantly.

"I feel that this internship has greatly benefited me. It has allowed me to experience first-hand what it is like to work in the field and in an academic research environment. Even more, it has allowed me to do something that I love --- help the environment." -- Jamie Pool (pictured above, right)

Abstract

Purple loosestrife (*Lythrum salicaria*) is a noxious introduced European wetland plant. In the United States, it has become established in wetlands throughout the east coast, where it out-competes native species and creates a monoculture. During the summer of 2005, approximately 50,000 *Galerucella calmariensis* and *Galerucella pusilla* beetles were released at 10 artificial quadrats constructed around Flat Pond, which is about 10 miles south of Newark, DE. This release was a continuation of a pilot release and study conducted during the summer of 2004 designed to reduce the size of the site's purple loosestrife stand. In the weeks after release, it was determined that the beetles caused visible damage to the purple loosestrife around the release quadrats and that some of this damage subsequently prevented plant flowering and reproduction. The overall damage to the purple loosestrife was somewhat less than expected, but because of the magnitude of the 2005 release, it is possible that many more adult *Galerucella* beetles over-wintered at Flat Pond during the winter of 2006. It is possible that the 2005 release will lead to the establishment of a permanent, large *Galerucella* colony that will eventually eradicate Flat Pond's purple loosestrife stand over the next several summers.

Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES)

Basic Information

Title:	Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES)
Project Number:	2005DE59B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Water Quality
Focus Category:	Toxic Substances, Geochemical Processes, Non Point Pollution
Descriptors:	
Principal Investigators:	Donald L. Sparks

Publication

1. Sparks, Donald L., Brian Rosen, and Ryan Tappero, 2006, Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES), Delaware Water Resources Center, University of Delaware, Newark, Delaware, 19 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.

Undergraduate Internship Project #7 of 17 for FY05

"Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES)" is the research topic investigated by ***Brian Rosen*** with his advisor Dr. Donald Sparks of the ***University of Delaware*** Department of Plant and Soil Sciences ***(PLSC).*** The ***DWRC / PLSC*** cosponsored project studied what effect, if any, the use of an acid commonly assumed valuable in environmental pollution testing may have on the accuracy of experiments assessing water contamination.

"My DWRC project allowed me to take an engineering approach to solve for sorption mechanisms. I have learned how to design batch experiments in order to reveal the sorption kinetics of M.E.S (acid) and Nickel to the mineral goethite and have gained experience in using the analytical equipment needed to monitor my experiments." -- Brian Rosen

Abstract

Soil chemists use batch sorption experiments to measure metal and oxyanion retention by soil and soil components to predict their fate and transport in the environment. Solution pH is a master variable influencing the thermodynamics and kinetics of sorption reactions on mineral surfaces, and therefore must be carefully controlled in batch sorption experiments. Buffers offer an effective means to control pH. However, buffers may interact with dissolved species or mineral surfaces. Batch sorption experiments (pH 6.5, 1.0 g/L solid, 500 μ*M* sorbate, 24 - 48 hrs) were conducted to investigate the interaction between a common sulfonic acid buffer MES (2-[N-Morphalino]-ethanesulfonic acid) and goethite (α-FeOOH). Preliminary data indicated MES sorbed to goethite (Γ = 12 μmol/m^2) in low ionic strength conditions (I < 0.005 *M*), but sorption was minimal at higher ionic strengths (I > 0.1 *M*), which indirectly suggested MES formed predominantly an outer-sphere complex. Additional evidence from FTIR flow-cell experiments reinforced the macroscopic batch data. Splitting of a single IR active band (~1050 cm^{-1}) into two IR active bands occurred after exposing dissolved MES buffer (pH = 6.5) to a thin film of α-FeOOH, which indicated an interaction between MES and the mineral surface. However, disappearance of the bands occurred rapidly when the influent flow-cell solution was changed to 0.01 *M* NaCl, suggesting the majority of MES was weakly bound to the α-FeOOH surface. The influence of MES buffer-mineral interactions on Ni sorption kinetics was investigated. Total Ni loading was similar in buffered and unbuffered systems at both low and high ionic strengths (Γ = 1.2 μmol/m^2), which indirectly suggested Ni forms an inner-sphere complex on α-FeOOH. However, the short-term Ni sorption kinetics (< 20 min) were slightly different for the buffered systems at high and low ionic strength and for the buffered and unbuffered system at constant ionic strength, which suggested Ni sorption was influenced by interaction of MES with α-

FeOOH. Results suggest “Better” buffers may not always be considered as inert components in experimental batch systems, and may unexpectedly affect sorption kinetics.

Sustainable, Low-Impact Methods for Managing Mosquito Populations in Storm Water Ponds

Basic Information

Title:	Sustainable, Low-Impact Methods for Managing Mosquito Populations in Storm Water Ponds
Project Number:	2005DE61B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Biological Sciences
Focus Category:	Management and Planning, Surface Water, Wetlands
Descriptors:	
Principal Investigators:	John Gingrich

Publication

1. Gingrich, John, and Nancy McGehee Scott, 2006, Sustainable, Low-Impact Methods for Managing Mosquitoes in Storm Water Ponds, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 11 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.

Undergraduate Internship Project #8 of 17 for FY05

Nancy Scott's "Proposal: Sustainable, Low-Impact Methods for Managing Mosquito Populations in Storm Water Ponds" was advised by Dr. Jack B. Gingrich of *University of Delaware*'s Department of Entomology and Wildlife Conservation. This *DWRC / UD College of Agriculture and Natural Resources* co-sponsored internship was an extension to a previous *DWRC* public health research project studying West Nile virus-carrying mosquito populations in stormwater retention ponds. Nancy searched for mosquito management methods that are environmentally safe and also cost-effective, requiring minimal human resource inputs to implement.

"Our project surveyed the distribution of mosquitoes throughout Delaware and experimented with ways to control their populations in stormwater retention ponds. Through this internship, I am more aware of the complex communities that are a part of these ponds and the impacts that human activities have on them." -- Nancy Scott

Abstract

Storm water retention ponds collect water as runoff from developed and cultivated areas. Such ponds hold water for extended periods of time, usually more than ten days, and create habitats that are ideal for mosquito development. The purpose of this project was to find a low-impact sustainable treatment method to reduce the number of mosquito larvae. Of a total of thirty ponds, six were untreated control ponds, while the other twenty-four were treated in groups of six using various methods to reduce phosphate levels and therefore the amount of food available to growing mosquito larvae. Of the five methods tested, alum, or Bara-Clear, was the most effective treatment method. Alum-treated ponds showed the least amount of increased phosphate over the summer season, and the least amount of mosquito abundance. It is also a more sustainable method for controlling mosquitoes than most traditional pesticides because it generally requires fewer treatments. It also has little effect on other organisms in the pond.

Restoring Coastal Bay Water Quality via Native Eelgrass Micropropagation

Basic Information

Title:	Restoring Coastal Bay Water Quality via Native Eelgrass Micropropagation
Project Number:	2005DE62B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At large
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Ecology, Management and Planning
Descriptors:	
Principal Investigators:	John Gallagher

Publication

1. Gallagher, John L., and Katherine M. Tigani, 2006, Restoring Coastal Bay Water Quality via Native Eelgrass Micropropagation, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 12 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.
3. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 "2005-2006 DWRC Undergraduate Internships News: Spotlight on Three Projects: Spring Internship Winners", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 5.

Undergraduate Internship Project #9 of 17 for FY05

"*Restoring Coastal Bay Water Quality via Native Eelgrass Micropropagation*" was the title of ***Katherine Tigani's*** internship, co-sponsored by the ***DWRC*** and ***University of Delaware*** College of Marine Studies ***(CMS)*** under the advisement of Dr. John L. Gallagher of the ***UD CMS***, Lewes, Delaware. Katherine had worked during the summer of 2004 in the ***UD*** Halophyte Biotechnology Laboratory, Lewes, with plant tissue cultures. In this 2005 project, she used that experience to attempt to devise a methodology that can regenerate eelgrass in volume.

"This DWRC internship has been an amazing experience. Not only has it led to some exciting results in the lab, but the project has developed into a thesis for my Masters degree at the College of Marine Studies. Through the internship I was able to gain valuable contacts in the field and have now arranged to begin field collections along both coasts of the US." -- Katherine Tigani

Abstract

Preliminary advancements were made in the development of a tissue culture protocol for the temperate seagrass species *Zostera marina* (eelgrass) which plays a fundamental role in reducing nutrient load and turbidity in coastal waters. The tissue culture of this submerged macrophyte would provide an abundance of viable transplant material necessary for restoration projects in locations such as the Delaware Inland Bays. Trials for both callus induction and micropropagation were conducted using various media combinations, phytohormones, and environmental factors. Regardless of media, test cultures only survived when incubated at 10˚C. A two-phase solid/liquid MS-based media was developed for *Z. marina*, was successful at supporting culture growth for over six months, and has future implication for growth regulator dosing. Phytohormones (2,4-D, IAA, and KT) in any concentration appear to have a detrimental effect on the plant when absorbed from the water column. A preliminary trial using the algal media ASP-8A have shown substantially positive growth response during seedling development and is now in further trials to determine if this vitamin formula is suited best for callus induction and micropropagation of *Z. marina*.

Rain Gardens

Basic Information

Title:	Rain Gardens
Project Number:	2005DE86B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Water Quality
Focus Category:	Surface Water, Conservation, Education
Descriptors:	
Principal Investigators:	Susan Barton

Publication

1. Barton, Susan, and Leslie Carter, 2006, Rain Gardens, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 7 pages.
2. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 " Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #10 of 17 for FY05

Leslie Carter educated the public about water quality and property value improvements through environmental landscaping in her "*Rain Gardens*" project co-sponsored by the *DWRC* and the *University of Delaware* (*UD*) Department of Plant and Soil Sciences (*PLSC*). Her advisor was Dr. Susan Barton of *UD PLSC*. Leslie's goals were to publish a rain gardens article in a Cooperative Extension periodical, to create a rain gardens page for the Cooperative Extension web site, and to design a rain garden to be installed on the *UD* campus.

" The project was fun and a great experience for me because I had such a wide variety of tasks including researching and writing, traveling around Delaware to meet new people, and getting creative with designing the garden and deciding which plants to use." -- Leslie Carter

Abstract

Rain gardens are an efficient way to handle storm water runoff, but very few people are aware of what they are, how they can be beneficial, and how to build one. The objectives of this project are to publicize this environmental way to control non-point source pollution, erosion, and flooding and to encourage homeowners to build a rain garden on their own property. These goals are approached in a few different ways in this project. Rain gardens are publicized and explained in a newsletter as well as on a website and in a Delaware Nursery and Landscaping presentation scheduled for the end of April 2006. A website on the rain gardens in Delaware was developed and includes a short description, the location and size of the garden, the designers and funding partners of the project, methods of construction, problems encountered during construction, tips from the creators, and contact information for each garden. The website, created by intern Leslie Carter, is hosted on the University of Delaware Cooperative Extension website at http://ag.udel.edu/extension/horticulture/raingarden/index.htm.

Lastly, a rain garden will be constructed on the University of Delaware campus by the newly renovated greenhouse. Not only will this be a demonstration of how to build a rain garden, but a more specific objective for the garden is to deal with a drainage issue that has been a problem in the past. Storm water naturally flows to the head house and floods the basement so with the rain garden hopefully more water will be infiltrated into the ground and flooding will be prevented. This alternative motive to prevent flood damage, as well as the moderate size of this rain garden, minor excavation required, and the exclusive use of hardy, native plants will hopefully encourage homeowners to find affordable ways to construct a functional rain garden of their own. There are possibilities for continued work on rain gardens by making interpretive signage for the rain gardens on campus to further implement the ideas for this environmental method of storm water management.

Nutrient Release from Mineralization of Poultry Litter under Simulated Field Conditions

Basic Information

Title:	Nutrient Release from Mineralization of Poultry Litter under Simulated Field Conditions
Project Number:	2005DE87B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Water Quality
Focus Category:	Nutrients, Agriculture, Water Quality
Descriptors:	
Principal Investigators:	Mingxin Guo, Maria Labreveux

Publication

1. Guo, Mingxin, Maria Labreveux, and Leslie Howe, 2006, Nutrient Release from Mineralization of Poultry Litter under Simulated Field Conditions, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 8 pages.
2. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 " Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #11 of 17 for FY05

Leslie Howe researched aspects of "*Nutrient Release from Mineralization of Poultry Litter under Simulated Field Conditions*" for her *DWRC / Delaware State University (DSU)* co-sponsored project. Her internship advisors were Dr. Mingxin Guo and Dr. Maria Labreveux of *DSU's* Department of Agriculture and Natural Resources. Leslie will study the rate of mineralization, immobilization, and plant availability of nitrogen *(N)* and phosphorus *(P)* in land-applied poultry litter. Her investigation will make possible the creation of more appropriate rates of crop fertilization using poultry litter, in order to improve water quality and agricultural sustainability on the Delmarva Peninsula.

"The DWRC internship has been an interesting experience because I have learned more than I can imagine, from laboratory techniques to communicating well with people. It has been more than a job to me, and I truly appreciate everyone who has helped me with my research." -- Leslie Howe

Abstract

The Delmarva Peninsula has highly concentrated poultry production. Approximately 2,000 poultry producers are in this region and grow more than 11 million chickens each week. About 14% of boilers consumed in the United States are produced on the Delmarva Peninsula. Due to all the poultry production, Delmarva generates more than 700,000 tons of poultry litter each year. The majority of this poultry litter generated on the Delmarva Peninsula is applied to nearby cropland as organic fertilizers. Due to repeated and over-rate application of poultry litter to cropland, there is significant runoff losses of phosphorus and nitrogen nutrients into local water bodies. This causes water eutrophication and quality degradation. Eutrophication is the contamination of water due to excess nutrients. According to the Delaware Department of Natural Resources and Environmental Control, 94% of the rivers and streams and 68% of the ponds and lakes in Delaware are impaired by phosphorus and nitrogen from historic over-application of organic fertilizers to croplands. When the nutrients phosphorus and nitrogen enter natural water bodies, the growth of algae is promoted due to sufficient nutrient availability. Release of toxins into water is possible, inhibiting activities of other aquatic organisms. The algae also will consume most oxygen in the water causing fishes and other water species to be killed.

Research has demonstrated that application rate is the key factor in determining nutrient losses to nearby water bodies from land-applied animal manures. It is of course recommended that land application of poultry litter be conducted at rates not exceeding crop phosphorus requirements, with additional nitrogen applied from other sources to meet crop nitrogen needs. However, this would be the perfect situation. With such massive amounts of poultry litter being produced, excess nutrients are going to subsist.

The objective of our research was to investigate the nutrient release patterns of poultry litter over time. This information was intended to provide information for developing environmental friendly poultry litter application rates. We also tested the nutrient release patterns of poultry litter amended with Alum. Alum (aluminum sulfate) is commonly applied to chicken litter in broiler houses to reduce ammonia emission along with the run off of soluble phosphorus in chicken litter into the soil. Research in Tennessee broiler houses has demonstrated that the use of alum by the poultry industry can significantly reduce the soluble phosphorus and heavy metals in the runoff from land where litter is applied.

Winter needle conductance rates of Pinus strobus L. (eastern white pine): meteorological conditions and intraspecific variability

Basic Information

Title:	Winter needle conductance rates of Pinus strobus L. (eastern white pine): meteorological conditions and intraspecific variability
Project Number:	2005DE88B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Water Quantity, Management and Planning
Descriptors:	
Principal Investigators:	Delphis Levia

Publication

1. Levia, Delphis, and Lydia Leclair, 2006, Winter needle conductance rates of Pinus strobus L. (eastern white pine): meteorological conditions and intraspecific variability, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 9 pages.
2. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 " Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #12 of 17 for FY05

Lydia Leclair's DWRC / University of Delaware (UD) College of Arts & Science cosponsored internship research project *"Winter transpiration rates of* Pinus strobus *L. (eastern white pine): meteorological conditions and intraspecific variability"* was under the advisement of Dr. Delphis F. Levia of the ***UD*** Department of Geography. Knowledge of water consumption and transpiration rates by forests is important for watershed management but is largely lacking with respect to short-term changes in winter weather conditions. Lydia measured transpiration rates for a select number of trees in the Fair Hill (MD) Natural Resources Management Area and collected corresponding meteorological data recorded by a Delaware Environmental Observing System (***DEOS***) station in close proximity to the site.

"***Through my DWRC internship I learned a lot about forest hydrology and the complex interactions of trees and their environment. As an undergraduate it has been a wonderful opportunity to work with Dr. Levia, learning how to conduct field research, analyze data, and think critically and creatively about the results. This is only the beginning for me, and I hope to continue doing research that will allow us to better understand global environmental issues." – Lydia Leclair***

Abstract

The present study was conducted to examine whether or not (1) meteorological conditions had a detectable and considerable effect on winter needle conductance rates from *Pinus strobus*; and (2) there are significant intraspecific differences in winter needle conductance rates from *P. strobus*. Two null hypotheses were tested. First, meteorological conditions will not have a detectable and significant impact on rates of needle conductance and transpiration from *P. strobus*. Second, there will not be statistically significant differences in transpiration among the co-occurring sample trees that are of similar age and health. The fieldwork was conducted at the Fair Hill Natural Resources Management Area in northeastern Maryland (39°42'N, 75°50'W) using a Li-Cor 1600M Steady State Porometer. Meteorological data at the study site were acquired from a continuously recording meteorological station that is part of the DEOS network. Meteorological data were recorded at five minute intervals to ensure that weather conditions could be temporally sequenced with porometer readings. Results of the study indicate that there is general correspondence between mean minimum air temperatures and needle conductance and that there is significant intraspecific variation among co-occurring *P. strobus* trees. The results of the study compel the researchers to reject the two null hypotheses posed. Rejection of the null hypotheses could mean that regional climate change may significantly alter the water balance of mixed forests dominated by *P. strobus*, and that water balance modelers may wish to conduct further work on the intraspecific variation in winter needle conductance and transpiration of *P. strobus*.

Kinetics Model for Soil

Basic Information

Title:	Kinetics Model for Soil
Project Number:	2005DE89B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Not Applicable
Focus Category:	Geochemical Processes, Hydrogeochemistry, Models
Descriptors:	
Principal Investigators:	Herbert Allen

Publication

1. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 " Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #13 of 17 for FY05

Jimit Modi worked with advisor Dr. Herbert E. Allen of the *University of Delaware (UD)* Department of Civil and Environmental Engineering on his *DWRC / UD College of Engineering* cosponsored internship project, "*Kinetics Model for Soil*". Jimit's goal was to investigate and quantify the behavior of trace metals in the soil environment in order to create a predictive model. Some trace metals are essential for plant growth, but others can have negative effects on soil micro-organisms, invertebrates, and water quality. This type of research will lead to a greater understanding of trace metal fates and consequent environmental impacts.

The objective of this research is for us to get a better understanding of the kinetics reactions of trace metals with soils. Since there is limited research done in kinetics reaction of trace metals with soils, a better understanding in this field will be helpful for more accurately predicting metal behavior in the environment. The toxicity of some trace metals has been recognized by many studies, yet some trace metals are essential for growth. Under conditions when trace metals (specifically Cd^{+2}, Co^{+2}, Zn^{+2} and Ni^{+2}) are not at equilibrium with soils, rate of sorption/desorption of the reaction will be studied to create a predictive model.

The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils

Basic Information

Title:	The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils
Project Number:	2005DE90B
Start Date:	6/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Water Quality
Focus Category:	Geochemical Processes, Agriculture, Water Quality
Descriptors:	
Principal Investigators:	William Saylor, Michael Persia, James Skaggs

Publication

1. Schnek, Carolyn J.,James Skaggs, Michael Persia, and William Saylor, 2006, The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 10 pages.
2. Boyd, Amy, ed., 2005, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 1 "DWRC Announces New Undergraduate Interns for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Summer2005.pdf, p. 4-5.
3. Schnek, C. J., J. S. Skaggs, M. E. Persia and W. W. Saylor, 2006, The effect of dietary source and concentration of copper on growth, tissue concentration and copper excretion in broilers, International Poultry Scientific Forum Abstract M22, Atlanta GA, p.7.
4. Schnek, C. J., J. S. Skaggs, M. E. Persia and W. W. Saylor, 2006, The effect of dietary source and concentration of copper on growth, tissue concentration and copper excretion in broilers, Mid-Atlantic Nutrition Conference Proceedings, Timonium, MD
5. Schnek, C. J., J. S. Skaggs, M. E. Persia and W. W. Saylor, 2006, The effect of dietary source and concentration of copper on growth, tissue concentration and copper excretion in broilers, Northeast

Student Affiliate Section of the American Society of Animal Science Meetings, Amherst, MA.

Undergraduate Internship Project #14 of 17 for FY05

Carolyn Schnek's project "*The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils*" was co-sponsored by the ***DWRC*** and the ***University of Delaware (UD) College of Agriculture and Natural Resources.*** The project advisor was Dr. William W. Saylor, joined by additional project investigators Michael Persia and James Skaggs, all of ***UD***'s Department of Animal and Food Science. Carolyn studied the fate and water quality impact of metal nutritional amendments in poultry feed.

"Through my internship with DWRC I have been made aware of the complexities of avian nutrition and management as well as the soil/water interface. I have had the opportunity to participate in a small bird trial as well as a small soil science experiment. This allows me to envision the many aspects of poultry management that affect water quality. Overall, this has been a wonderful learning experience both academically and practically." – Carolyn Schnek

Abstract

An experiment was conducted to determine the effect of Cu source and concentration in a corn-SBM diet fed to straight-run broiler chicks from 1-35d. Diet treatments were: 1) BAS: basal diet (no added Cu) 2) 25IN: basal + 25 mg/kg inorganic Cu (CuSO4 5H2O) 3) 25OR: basal + 25 mg/ kg organic Cu (Bioplex™ Cu 10%) 4) 250IN: basal + 250 mg/kg inorganic Cu; and5) 250OR: basal + 250 mg/kg organic Cu. Two hundred 1-day-old chicks (Ross 308) were assigned to one of the five diets, 8 pens of five chicks per diet until d 7 when numbers, were reduced to 4 birds/ pen,. On d 21, birds were moved to grower batteries; two replicate pens per treatment were combined into one grower pen of 8 birds/pen until d 35. Performance data were collected on d 7, 21, and 35. On d 35 plasma, liver, and duodenal mucosa were collected for mineral analysis. Excreta were collected on d 8-21 and d 29-35 for total and water soluble mineral analysis. Body weight gain for birds fed 250OR averaged 38% lower (P<.05) at 21 and 35 d of age than that of birds fed the other diets. Liver and mucosa Cu in 250OR birds increased 7-fold (P<.001) and plasma Cu increased 1.5 fold (P<.01) above that of birds fed BAS or diets with lower Cu additions. Birds fed 250IN had liver, mucosa and plasma concentrations intermediate to, but not different from, those fed 250OR and the other diets. At 21 d, total Cu in excreta from birds fed 250IN and 250OR was increased (P<.001) 6- and 10-fold, respectively, over that of the other diets, while soluble Cu increased (P<.05) only 2.5-fold in birds fed the 250-supplemented diets compared to the others, regardless of source. By 35 d, total excreta Cu from birds fed 250IN and 250OR was increased (P<.001) 25- and 37-fold, respectively, over that of BAS. In this study high diet Cu fed as an OR form caused severe growth depression not observed in those fed the same concentration as an IN salt. While feed intake was reduced in birds fed 250OR, the reduction did not account fully for the reduction in weight gain.

Detection of Salmonella in Biosolids using a Combination of Cultural, Molecular, and Immunological Methods

Basic Information

Title:	Detection of Salmonella in Biosolids using a Combination of Cultural, Molecular, and Immunological Methods
Project Number:	2005DE91B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Biological Sciences
Focus Category:	Methods, Water Quality, None
Descriptors:	
Principal Investigators:	Diane Herson

Publication

1. Herson, Diane, and Samantha Smith, 2006, Detection of Salmonella in Biosolids using a Combination of Cultural, Molecular, and Immunological Methods, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 14 pages.
2. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 "Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #15 of 17 for FY05

Dr. Diane Herson of the ***University of Delaware (UD)*** Department of Biology advised ***Samantha Smith*** in a ***DWRC / UD College of Arts & Science*** co-sponsored project titled "*Detection of Salmonella in Biosolids using a Combination of Cultural, Molecular, and Immunological Methods*". Until recently, there were no USEPA-approved tests for the detection of the *Salmonella* pathogen in waste water treatment. Samantha compared the effectiveness of a combination of techniques versus the new method proposed by the EPA to detect and count these pathogens in treated biosolids. Accurate assessment of *Salmonella* presence will help determine the suitability of biosolids for land application in compliance with federal monitoring requirements protecting public health and the environment.

"The internship with the DWRC has taught me a variety of skills dealing with the detection of microorganisms that I would not have otherwise been able to experience as an undergraduate, as well as igniting my interest in research." – Samantha Smith

Abstract

Biosolids are produced as byproducts of waste water treatment. Prior to disposal, they are assayed to enumerate the levels of either coliforms or *Salmonella* spp. to determine whether they are Class A and therefore suitable for land application. The presence of *Salmonella* spp. in this material is of concern because of the illnesses caused by these organisms.

Recently, the EPA proposed a new procedure for the detection of *Salmonella* in biosolids. In the newly proposed Method 1682 the initial enrichment and MPN assay are carried out using Trypticase Soy Broth (TSB), a non-selective medium. Selection of *Salmonella* spp. occurs on modified semi-solid Rappaport Vassiliadis (MSRV). This medium contains an antibiotic (novobiocin) and a dye (malachite green) to inhibit non-*Salmonella* species. Method 1682, like previous procedures, takes several days due to the multiple cultural steps involved.

Our studies have focused on developing a molecular method for *Salmonella* spp. detection using standard polymerase chain reaction (PCR) assays. This method takes less time than cultural ones, but since DNA from dead as well as live organisms is amplified, false positive results may be obtained. Other concerns with this method are that the PCR assays may be inhibited by the presence of coliforms or by the initial *Salmonella* enrichment steps.

In the studies presented in this report, we address these issues. In the ones carried out before the proposal of Method 1682, Tetrathionate Broth (TTB) was the recommended initial enrichment medium although other media including Rappaport Vassiliadis (RV)

broth were also used. Our studies tested both TTB and RV as initial enrichment media prior to standard PCR. Our results indicated that an initial enrichment in TTB does interfere with subsequent PCR assays. However, RV enrichment does not have an influence on the outcome of PCR assays.The effect of coliforms on PCR was also tested by using a mixed culture of *Salmonella enterica* and *Escherichia coli* in a 1:1000 ratio.

We found that the presence of the coliform had no effect on the detection of *Salmonella enterica* using either cultural or molecular MPN assays.

With standard PCR there is the added concern about the detection of dead cells. To overcome this problem, two-step enrichment prior to PCR has been recommended. We are attempting to reduce the time required by developing a procedure that has only one enrichment step. To determine if the single enrichment allows for the detection of only living cells, we will need to test our procedure on cultures which have different proportions of living and dead organisms. We are therefore currently determining conditions for the aging of a culture of *Salmonella enterica* by long-term growth at 37^{o} C.

Assays using one or two enrichment steps prior to standard PCR MPN assays will be done and compared to results obtained using Method 1682. If we are successful, our PCR MPN results will be comparable to Method 1682 MPN results.

Location and Evaluation of Coastal and Inland Brackish Aquifers for the Support of Halophyte (Kosyteletzkya) Oil Production for Bioidiesel Fuel Conversion

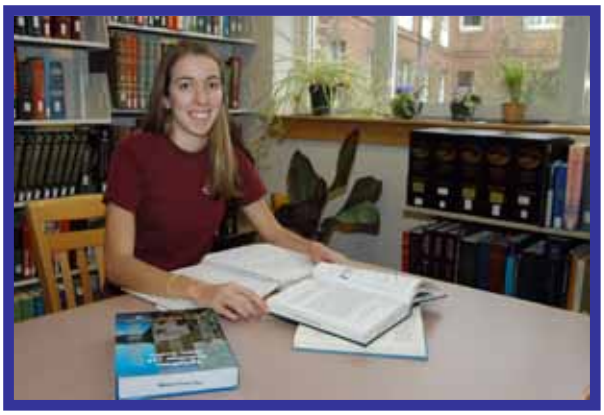
Basic Information

Title:	Location and Evaluation of Coastal and Inland Brackish Aquifers for the Support of Halophyte (Kosyteletzkya) Oil Production for Bioidiesel Fuel Conversion
Project Number:	2005DE92B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Not Applicable
Focus Category:	Water Use, Agriculture, None
Descriptors:	
Principal Investigators:	John Gallagher, Denise Seliskar

Publication

1. Gallagher, John, Denise Seliskar, and Maia Tatinclaux, 2006, Location and Evaluation of Coastal and Inland Brackish Aquifers for the Support of Halophyte (Kosyteletzkya) Oil Production for Bioidiesel Fuel Conversion, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 13 pages.
2. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 "Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #16 of 17 for FY05



Locating suitable brackish aquifers to irrigate crops of seashore mallows as potential sources of biodiesel fuel was the goal of ***Maia Tatinclaux's*** project "*Location and Evaluation of Coastal and Inland Brackish Aquifers for the Support of Halophyte* (Kosyteletzkya) *Oil Production for Biodiesel Fuel Conversion*". She hoped to determine the economic feasibility of inland biodiesel production sites in areas of salinized soils as alternatives to current oil refineries concentrated on the Gulf and Mid-Atlantic coasts that are susceptible to natural disaster. Her advisors were Dr. Jack Gallagher and Dr. Denise Seliskar of the ***University of Delaware*** College of Marine Studies ***(CMS)*** Halophyte Biotechnology Laboratory, Lewes, Delaware, in this ***DWRC / CMS*** co-sponsored internship.

"This internship has been a great opportunity for me to learn more about all aspects of the research process. Designing and planning this project was probably the most valuable part of the experience, and I am glad to have had the chance to participate." – Maia Tatinclaux

Abstract

The rapid depletion of freshwater resources across the United States and world is causing people to consider the potential uses of salt water, an extremely abundant resource. *Kosteletzkya virginica* is a potential halophytic crop that could be cultivated in areas that are too saline for traditional crops to grow. Its high-in-oil-content seeds make it a candidate for biodiesel production. The main objective of this study was to synthesize information concerning different areas of the United States currently dealing with freshwater shortages and salt-affect soils. Three regions were identified each with unique salinity issues: New Mexico, the San Joaquin Valley, and the Delmarva Peninsula. Their salinity-related problems were respectively: fresh water shortages and abundant saline groundwater, salinization of agricultural soils, salt-water intrusion along the Atlantic Coast. New Mexico and the San Joaquin Valley would particularly benefit from the use of salt-tolerant crops, but field studies need to be done to make sure *Kosteletzkya virginica* could grow in these areas.

Diversity, Function, and Benefits of Plants Adapted To Flood-Prone and Poorly Drained Environments

Basic Information

Title:	Diversity, Function, and Benefits of Plants Adapted To Flood-Prone and Poorly Drained Environments
Project Number:	2005DE93B
Start Date:	11/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	At Large
Research Category:	Biological Sciences
Focus Category:	Water Quality, Water Supply, Education
Descriptors:	
Principal Investigators:	John Frett

Publication

1. Frett, John, and Michael Zuk, 2006, Diversity, Function, and Benefits of Plants Adapted To Flood-Prone and Poorly Drained Environments, Delaware Water Resources Center, University of Delaware, Newark, Delaware, 39 pages.
2. Boyd, Amy, ed., 2006, Delaware Water Resources Center WATER NEWS Vol. 6 Issue 2 " Seven Fall DWRC Internship Winners for 2005 2006", http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf, p. 6-7.

Undergraduate Internship Project #17 of 17 for FY05

"*Diversity, Function, and Benefits of Plants Adapted To Flood-Prone and Poorly Drained Environments*" was the title of ***Michael Zuk's*** internship, co-sponsored by the *DWRC* and *University of Delaware (UD)'s* College of Agriculture and Natural Resources Department of Plant and Soil Sciences *(PLSC)*. Advised by Dr. John Frett of *UD PLSC*, Michael inventoried specialized plants that can improve soil drainage in areas of increased land development and impervious cover, thereby reducing pollutant runoff affecting water supply and quality. He further hoped to develop educational literature and signage for the *UD* Botanic Gardens explaining these plants' ability to stabilize streambeds, filter nutrients, and prevent erosion in riparian corridors, rain gardens, and retention ponds.

"The DWRC internship allowed me to experience the process of research first hand and apply classroom knowledge in a self- motivated learning experience that focused on improving our environment." -- Michael Zuk

Abstract

Excess nutrients resulting from excessive agricultural and residential fertilizer applications, copious amounts of toxic chemicals released from industrial plants, pesticides, and pathogens are carried by runoff into Delaware's streams, ponds, rivers, wetlands, and water recharge areas. "More than 90 percent of Delaware's waterways are considered impaired, meaning they do not meet water-quality standards for their designated uses, such as recreation, fishing, or drinking because they are suffering from excess nutrients, low dissolved oxygen, toxins, bacteria, heat, or any combination of these problems. The state's list of impaired waters, filed with the EPA, includes 377 bodies of water that suffer from 11 different impairments, the most common of which are pathogens and nutrients (DNREC 2002-2004)." Delaware has a significant number of impaired bodies of water, therefore the objective of this research was to identify the diversity, environmental functions, and benefits of plant species that are adapted to fluctuating and flooding water conditions, therefore able to cope with anaerobic stress and continue to carry out their metabolic and physiological functions. Short and long term water level changes impact reproduction, roots, hormones, photosynthesis, and growth of plants. Flood-tolerant plants have adapted various morphological, physiological, and metabolic mechanisms by which they are able to carry out their life cycles. Such adaptations include development of large intercellular spaces, root regeneration, and hypertrophy of lenticels (Kozlowski 1984). It is critical to preserve Delaware's water resources for ourselves and future generations. Riparian restoration

projects and bioengineered retention areas are two places where flood-tolerant plants are used to help improve soil conditions, drainage, and water quality. Plants adapted to fluctuationg water conditions that are natural environmental buffers can help improve the fragile conditions of the state’s waterways.

Information Transfer Program

Delaware Water Resources Center FY05 Information Transfer Activities

Basic Information

Title:	Delaware Water Resources Center FY05 Information Transfer Activities
Project Number:	2005DE94B
Start Date:	3/1/2005
End Date:	2/28/2006
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 all Delaware Water Resources Center information transfer activities during FY05, consolidating reporting into a single project **#2005DE94B**. All activities from the DWRC's FY04 Information Transfer project **(#2004DE66B)** continued into this year. New additions to the program for FY05 include a new lecture series and also researcher poster and/or platform presentations.

The FY05 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 and training booths at University of Delaware "AG DAY", Newark, Delaware (2003 – present)
- Delaware Water Resources Center co-sponsored lecture series (March – April 2006).
- Delaware Water Resource Center researcher poster and / or platform presentations (March 2005 – present)

Basic Information:
Delaware Water Resources Center Print Publication WATER NEWS

Title:	"WATER NEWS"
NIWR Project No.:	**#2005DE94B** , formerly NIWR #2000DE107B for FY00, FY01, FY02, #2003DE57B for FY03, and #2004DE66B for FY04.
Issues during FY05:	Volume 6 Issues 1 and 2 (Summer 2005 and Fall 2005 /Winter 2006)
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 over 900 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 2005 topics included:

- Highlights from the April 14, 2005 White Clay Creek Conference
- Save the Date: Oct. 21, 2005 State Water Forum
- Welcome Martha Corrozi to DWRC Advisory Panel
- DWRC Trains Girl and Boy Scouts at Ag Day 2005
- Ten new DWRC 2005-2006 Interns Selected
- DWRC Annual Meeting and Poster Session
- Water News You Can Use:
    - *Upcoming water resources events*
    - *Delaware State University water news*
    - *New USGS Online Report*
    - *DWRC thanks Advisory Panel retiring members Dworsky, Isaacs, Solberg, and Vanderwende*
- DWRC History, Goals, Advisory Panel, Contacts

Fall 2005 / Winter 2006 topics included:

- Highlights from 5th Statewide Water Forum Oct. 21, 2005
- DWRC Fellow Jen Seiter researches arsenic fate
- DWRC Water News You Can Use:
    - *Competitive Grants, Fellowships, Meeting, Internships*
    - *Liping Zhang poster presentation*
- Legates, Rohrer, Seliskar Join DWRC Advisory Panel
- Spotlight on Three DWRC 2005-2006 Interns: Katherine Tigani, Christi DeSisto, Matthew Lee
- DWRC Announces Seven New 2005-2006 Interns
- DWRC History, Goals, Advisory Panel, Contacts

Basic Information: Delaware Water Resources Center Website

Title:	Web site http://ag.udel.edu/dwrc
NIWR Project No.:	**#2005DE94B.** Formerly NIWR #2004DE66B for FY04, #2003DE57B and #1996DE104B for FY96 – FY03
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.:	**#2005DE94B.** Formerly NIWR #2004DE66B for FY04, #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 approximately 250 as of June 2006.

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

Title:	"WATER E-NEWS"
NIWR Project No.:	**#2005DE94B.** Formerly NIWR #2004DE66B (FY04), #2003DE57B (FY03), #2002DE105B (FY02)
Issues during FY04:	**Vol. 4 Issues 1,2, 3; Vol. 5 Issue 1.** **March '05, September '05, December '05, Febuary '06.**
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 250 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 Sessions / Annual Advisory Panel Meetings

Title:	University of Delaware 2005 and 2006 Undergraduate Research Scholars Poster Sessions with DWRC Advisory Panel Meetings
NIWR Project No.:	**#2005DE94B.** Formerly NIWR #2004DE66B (FY04), #2003DE57B (FY03), #2001DE106B (FY01 and FY02)
Date:	4/22/2005 and 4/28/2006
Description:	Undergraduate Interns presented their 2004-2005 and 2005-2006 DWRC-funded projects following annual meeting of the DWRC Advisory Panel.
Lead Institute:	University of Delaware Undergraduate Research Program Co−Sponsors: Delaware Water Resources Center, Northeast Chemical Association, Howard Hughes Medical Institute, Howard Hughes Medical Institute, National Science Foundation, Delaware Biotechnology Institute, Beckman Foundation, University of Delaware Research Foundation, Charles Peter White Fellowship, HHMI/Arts and Sciences Dean's Special Scholar Award, Center for Composite Materials, UNIDEL Foundation – David Roselle Scholarship.
Principal Investigators:	Joan Bennett, Director, UD Undergraduate Research Program (jbennett@udel.edu), J. Thomas Sims, Director, Delaware Water Resources Center (jtsims@udel.edu)

On April 22, 2005, seven of the nine undergraduate student interns who had been funded in 2004-2005 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 11-member *DWRC Advisory Panel* also convened 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 2005-2006 with regard to research funding and public education outreach efforts such as statewide water forums and **UD** Ag Day water conservation training.

Poster Presentations by 2004-2005 DWRC Undergraduate Interns – April 22, 2005

1) Carlson, Carol. Poster Presentation April 22, 2005. Monitoring and Assessing the Nutrient Status and Overall Health of Freshwater Wetlands. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

2) DeSanctis, Matthew. Poster Presentation April 22, 2005. An Evaluation of Water Supply Security in the State of Delaware After September 11, 2001. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

3) Ernst, Steven. Poster Presentation April 22, 2005. An Evaluation of the Economic, Social, Environmental, and Recreational Benefits of the Christina Basin. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

4) Graham, Jason. Poster Presentation April 22, 2005. Biological Control of Purple Loosestrife at Flat Pond: Reclaiming a Freshwater Pond near the C&D Canal. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

5) Knight, Trevor. Poster Presentation April 22, 2005. Assessing the Feasibility of Using Fish Assemblages as Indicators of Water Quality in Delaware Streams. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

6) Pool, Jamie. Poster Presentation April 22, 2005. Biological Control of Purple Loosestrife: Preventing Wetlands Degradation by an Invasive Plant. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

7) Revis, Alicia. Poster Presentation April 22, 2005. Assisting Small and Underserved Farmers in Meeting Water Quality Objectives. 2005 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

On April 28, 2006, sixteen of the seventeen undergraduate student interns who had been funded in 2005-2006 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. Fourteen ***DWRC Advisory Panel*** members also convened 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 2006-2007 with regard to research funding and new public education outreach efforts such as public lectures and a proposed event dedicated to Scout water conservation training, as well as ongoing public water forums .

Poster Presentations by 2005-2006 DWRC Undergraduate Interns – April 28, 2006

1) Carter, Leslie. Poster Presentation April 28, 2006. Rain Gardens. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

2) DeSisto, Christi. Poster Presentation April 28, 2006. Delaware River Basin State of the Basin Report Card. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

3) Dugan, Bailey. Poster Presentation April 28, 2006. Hydrogeology of the Near-Surface Aquifers in Sussex County. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

4) Graham, Jason. Poster Presentation April 28, 2006. The Impact of Predation on the *Galerucella* Beetle, a Purple Loosestrife Biocontrol Agent. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

5) Howe, Leslie. Poster Presentation April 28, 2006. Nutrient Release from Mineralization of Poultry Litter under Simulated Field Conditions. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

6) Leclair, Lydia. Poster Presentation April 28, 2006. Winter transpiration rates of *Pinus strobus* L. (eastern white pine) in relation to meteorological conditions. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

7) Lee, Matthew. Poster Presentation April 28, 2006. Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

8) Loiacono, Matthew. Poster Presentation April 28, 2006. The Impact of the *Solid Waste* Decision on Isolated Wetlands in Delaware. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

9) Pool, Jamie. Poster Presentation April 28, 2006. Biological Control of Purple Loosestrife: Preventing Wetlands Degradation By An Invasive Plant. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

10) Rosen, Brian. Poster Presentation April 28, 2006. Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES). 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

11) Schnek, Carolyn. Poster Presentation April 28, 2006. The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

12) Scott, Nancy McGehee. Poster Presentation April 28, 2006. Sustainable, Low-Impact Methods for Managing Mosquito Populations in Storm Water Ponds. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

13) Smith, Samantha. Poster Presentation April 28, 2006. Detection of Salmonella in Biosolids using a Combination of Cultural, Molecular and Immunological Methods. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

14) Tatinclaux, Maia. Poster Presentation April 28, 2006. Location and Evaluation of Coastal and Inland Brackish Aquifers for the Support of Halophyte (*Kosyteletzkya*) Oil Production for Biodiesel Fuel Conversion. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

15) Tigani, Katherine. Poster Presentation April 28, 2006. Restoring Coastal Bay Water Quality via Native Eelgrass Micropropagation. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

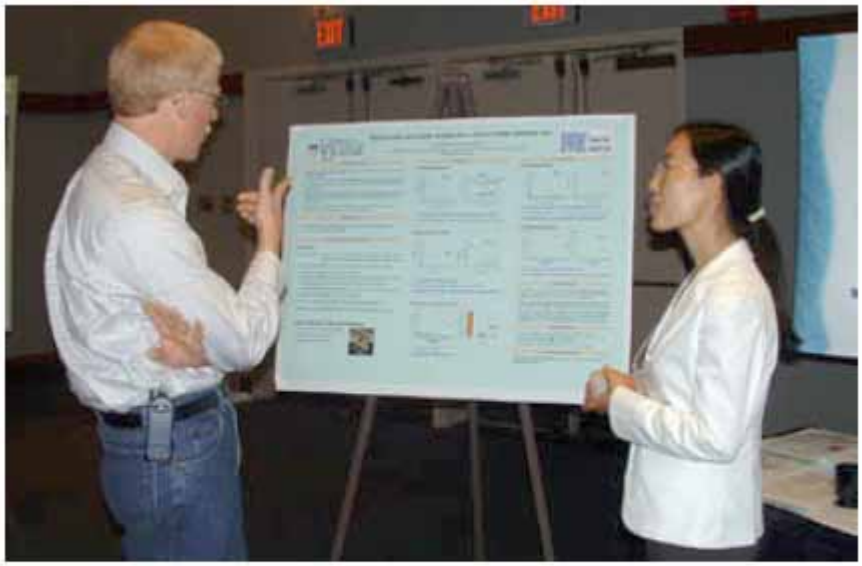
16) Zuk, Michael. Poster Presentation April 28, 2006. Diversity, fundtion, and benefits of specialized plants in poorly drained environments. 2006 University of Delaware Undergraduate Research Scholars Poster Session, University of Delaware, Newark, Delaware.

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

Title:	Fifth Annual Delaware Statewide Water Policy Forum: "Water-Friendly Landscape Design: A Prescription for Healthy Watersheds"
NIWR Project No.:	**#2005DE94B.** Formerly NIWR #2004DE66B for FY04, #2003DE57B for FY03, #2002DE48B, #2002DE125B for FY02
Date:	Oct. 21, 2005
Description:	Presentation of DWRC recent accomplishments and program goals; DWRC information booth; Poster display by DWRC graduate fellow Liping Zhang. Forum brochure / agenda / proceedings for the 2005 event may be found on the web at: http://www.wr.udel.edu/publicservice/WaterForum2005/WaterForum2005_Proceedings.pdf Complete article is found in DWRC Fall 2005 – Winter 2006 WATER NEWS at http://ag.udel.edu/dwrc/newsletters/Fall 2005 - Winter 2006.pdf Pages 1 – 3.
Lead Institute:	Co-sponsored by the Delaware Water Resources Center, University of Delaware Institute for Public Administration, Water Resources Agency, Longwood Graduate Program in Public Horticulture, and Delaware Department of Natural Resources and Environmental Control.
Principal Investigators:	J. Thomas Sims, Director, Delaware Water Resources Center (jtsims@udel.edu); Jerome Lewis, Director, University of Delaware Institute for Public Administration (jlewis@udel.edu); Gerald Kauffman, Director of Watershed Policy, University of Delaware Institute for Public Administration Water Resources Agency (jerryk@udel.edu); Robert Lyons, Coordinator, Longwood Graduate Program in Public Horticulture (rlyons@udel.edu); Kevin Donnelly, Director, Division of Water Resources, Delaware Department of Natural Resources and Environmental Control (kevin.donnelly@state.de.us)

The fifth annual Delaware Policy Forum titled "Water-Friendly Landscape Design: A Prescription for Healthy Watersheds" was held for about 135 visitors from Delaware government, water agencies, academia, and the public, on October 21, 2005 at Clayton Hall on the University of Delaware campus in Newark, Delaware. This was the fifth annual statewide water resources forum in recent years, and the fourth co-sponsored by the Delaware Water Resources Center. Expert speakers discussed how private citizens, city and state planners, subdivision and campus engineers, and groups of private and government agencies can work together toward better water quality and supply in Delaware using wetlands, subdivision design, rain gardens, and more. The Forum's presentations, materials, and poster session were free of charge, courtesy the co-sponsors: Delaware Water Resources Center, University of Delaware Institute for Public Administration, Water Resources Agency, Longwood Graduate Program in Public Horticulture at the University of Delaware, and Delaware Department of Natural Resources and Environmental Control.

Delaware Water Resources Center graduate fellow Liping Zhang presented a poster at the event. (Below)



DWRC's graduate fellow, Liping Zhang, shown here speaking with City of Newark Water and Wastewater Director, Roy A. Simonson, about her research and the possibility of elemental iron barrier removal and inactivation of waterborne viruses in Newark's water system.

The Delaware Water Resources Center had previously co-sponsored the state forums *"The Historic Christina Basin"* Oct. 13, 2004 attended by 200 visitors, *"Land Use Change and Water Quality: Assessing the Impacts and Planning for the Future"* held for over 150 participants on October 2, 2003, and "*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.:	**#2005DE94B.** Formerly NIWR #2004DE66B (FY04).
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 (riveradministrator@whiteclay.org) Amy Boyd, Program Coordinator, Delaware Water Resources Center www.udel.edu/dwrc/ (aboyd@udel.edu) 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
2005 and 2006 University of Delaware "AG DAY", Newark, DE

Title:	DWRC "Ag Day" public Water Conservation information / training booths
Dates:	April 29, 2006 and Apr. 30, 2005
NIWR Project No.:	**#2005DE94B.** Formerly NIWR #2004DE66B (FY04 event), #2003DE57B (FY03 event).
Description:	Public education outreach. Visit http://ag.udel.edu/dwrc/publications.html and click "Public Programs" link for highlights and photos.
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 (aboyd@udel.edu), and Maria Pautler, Program Coordinator, Institute of Soil and Environmental Quality (ISEQ) at the University of Delaware (mpautler@udel.edu), presenters. Displays support was provided by Delaware Department of Natural Resources and Environmental Control, the Water Resources Agency, University of Delaware Institute for Public Administration, University of Delaware College of Agriculture and Natural Resources, and the Delaware Geological Survey. Additional staff for the 2006 event included University of Delaware graduate students Jennifer Gilbert, Jen Seiter, Amy Sprinkle, Brandon Lafferty, and Sheila Gardner, and Laura Boyer of the Delaware Department of Natural Resources and Environmental Control (DNREC). Additional staff for the 2005 event included University of Delaware graduate students 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 29 area Boy Scouts and 17 area Girl Scouts, all grades 6-12, by **DWRC** and **UD** Institute of Soil and Environmental Quality (ISEQ) staff at **UD Ag Day April 29, 2006.** Now in its third year, the program has trained 86 boys and 35 girls to date in topics of soil and water conservation. Estimated attendance at the overall 2006 public outdoor event was between 3,000 and 4,000. 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 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. DWRC and ISEQ provided a free soil and water conservation literature table (contents listed below).

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.

Boy Scout Soil and Water Conservation Merit Badge Training and **Girl Scout Eco-Action Interest Project Training** was also provided to 25 area Boy Scouts and 18 area Girl Scouts, all grades 6-12, by **DWRC** and **ISEQ** staff at **UD Ag Day April 30, 2005.** Due to inclement weather, the event was held indoors. The first **Boy Scout Soil and Water Conservation Merit Badge Training** was provided to 32 area Boy Scouts by **DWRC** and **ISEQ** staff at **UD Ag Day April 24, 2004.** Estimated attendance at the overall 2004 outdoor public event was between 3,000 and 4,000. 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.

Basic Information:
Delaware Water Resources Center-supported 2006 lecture series

Title:	DWRC co-sponsored 2006 lecture series
Dates:	March 16, 2006: "The Wild and Scenic White Clay Creek: Pennsylvania and Delaware's Threatened Treasure" and April 25, 2006: "Healing a Wounded Stream: Pike Creek Restoration"
NIWR Project No.:	**#2005DE94B**
Description:	Series of free public presentations on the White Clay Watershed
Lead Institute:	**Sponsored by:** White Clay Wild and Scenic Program (Linda Stapleford, River Administrator lstaplef@msn.com) **Coordinated by:** the Delaware Nature Society (Ginger North, Stream Watch Coordinator ginger@delawarenaturesociety.org) **Supported by:** Delaware Department of Natural Resources and Environmental Control **Delaware Water Resources Center** National Park Service Partnership for the Delaware Estuary Stroud Water Research Center University of Delaware Water Resources Agency White Clay Watershed Association White Clay Wild and Scenic Program

Basic Information:
Additional Delaware Water Resources Center researcher presentations

Title:	Additional Delaware Water Resources Center researcher presentations
NIWR Project No.:	**#2005DE94B.**
Description:	Presentations at conferences without proceedings, and upcoming presentations, by graduate fellows and / or undergraduate interns and their advisors on DWRC-funded research
Lead Institute:	Delaware Water Resources Center

Liping Zhang, September 2005, [2003-2006 Fellowship Presentation] Sorption and Inactivation of Water-borne Viruses Using Elemental Iron, University of Delaware Department of Plant and Soil Sciences Third Annual Graduate Student Symposium, Clayton Hall, University of Delaware.

Schnek, Carolyn, 2006, [2005-2006 Internship Presentation] The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils, 27th Annual Southern Poultry Science Society Meeting, Atlanta, GA.

Schnek, Carolyn, 2006, [2005-2006 Internship Poster Presentation] The Effect of Dietary Level and Source of Copper (Cu) on Broiler Cu Excretion and Movement of Cu Through Broiler Excreta Amended Soils, 4th Mid-Atlantic Nutrition Conference, Timonium, MD.

Upcoming:
Rosen, Brian, July 9-15, 2006, [2005-2006 Internship Presentation] Nickel Sorption Kinetics at the Goethite/Water Interface: Effects of Ionic Strength and 2-[N-Morphalino]-ethanesulfonic acid (MES), 18th World Congress of Soil Science, Philadelphia, Pennsylvania.

Lee, Matthew, and Joshua Duke, July 11, 2006, [2005-2006 Internship Presentation] Landowner Perceptions of the Stringency of Water Quality Regulations in Delaware, Full Commission Meeting of the Delaware Nutrient Management Commission, Dover, Delaware.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	17	0	1	0	18
Masters	0	0	0	0	0
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	19	0	1	0	20

Notable Awards and Achievements

Research Program: The Delaware Water Resources Center (DWRC) has funded twenty research grant projects during March 2005 through February 2006 that address state water resources priorities identified by the DWRCs 14-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. One is a USGS summer intern project creating computerized water data access systems. The remaining seventeen projects are undergraduate internships. Topics researched include: water-friendly landscaping education, watershed assessment, groundwater characteristics mapping, impacts of and biological controls of invasive freshwater plants, nutrient transport and water quality, water transport and watershed management, water quality regulations perceptions, wetlands legislation impacts, soil metals and water quality, water testing accuracy, poultry feed effects on water quality, water quality effect of mosquito controls, wastewater pathogen detection, brackish aquifers for alternative biodiesel fuel crops, coastal bay water quality restoration methods, and the use of plants for better water quality and supply.

Nine additional undergraduate internships have been awarded by the DWRC for the period March 2006 through February 2007. Topics under investigation include: 1) effects of proposed climatic warming on the hydrological cycle, 2) pollutant biodegradation using electrodes, 3) predators of biocontrol agents for freshwater invasive plants, 4) measurement of groundwater discharge to Delawares Inland Bays, 5)a method to detect salmonella in biosolids, 6)study of oyster aquaculture farm impacts, 7) sustainable mosquito control for stormwater ponds, 8) copper transport in broiler excretion and in broiler excreta-amended soils, and 9) hydraulic properties of the unconfined aquifer in southern New Castle County, Delaware.

DWRC public education programs train area 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 35 area teen Girl Scouts at UD Ag Day programs in April 2005 and again in April 2006. The DWRCs companion Boy Scout Soil and Water Conservation Merit Badge program, offered at the event for three consecutive years to boys in grades 6-12, brought to 86 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 2004-2006 events. 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.

Two DWRC-co-sponsored statewide Water Forums address watershed water resources issues: A new DWRC-co-sponsored multi-state conference addressed water issues in the Wild and Scenic White Clay Creek Watershed. **"Water and Our Changing Landscape: Perspectives from the Wild & Scenic White Clay Creek Watershed"** was held at the University of Delaware (UD), Newark, Delaware 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. The fifth annual Delaware Water Policy Forum titled **"Water-Friendly Landscape Design: A Prescription for Healthy Watersheds"** was attended by nearly 150 visitors from government, academia, industry, non-profit organizations, and the general public October 21, 2005 at the same location. The event offered a variety of expert presentations, materials, and poster session free of charge, courtesy the co-sponsors: Delaware Water Resources Center (DWRC), UD Institute for Public Administration (UD IPA), Water Resources Agency (WRA), Longwood Graduate Program for Public Horticulture at the University of Delaware, and Delaware Department of Natural Resources and Environmental Control (DNREC).

Delaware Water Resources Center undergraduate intern Carolyn Schnek has won first place in the original research presentation category judged at the Northeast Student Affiliate Section meeting of the American Society of Animal Science, Feb. 24-26, 2006, in Amherst, MA. Schnek's research project titled "The effect of dietary source and concentration of copper on growth, tissue concentration and copper excretion in broilers" increases our understanding of water quality impacts of copper fate and transport in regions of intensive poultry raising. Project advisors included James Skaggs, Michael Persia, and William Saylor at the University of Delaware.

Publications from Prior Projects

1. 2002DE37B ("Understanding the Mechanisms of the Spread of Phragmites: For Better or for Worse") - Articles in Refereed Scientific Journals - League, M.T., E.P. Colbert, D.M. Seliskar, J.L. Gallagher, 2006, Comparison of the rhizome growth dynamics of native and exotic haplotypes of Phragmites australis (common reed), Estuaries 29(2): 269-276.
2. 2002DE37B ("Understanding the Mechanisms of the Spread of Phragmites: For Better or for Worse") - Articles in Refereed Scientific Journals - League, M.T., D.M. Seliskar, J.L. Gallagher, 2006, Predicting the effectiveness of Phragmites control measures using rhizome growth potential bioassay, Wetlands Ecology and Management, in press.
3. 2002DE37B ("Understanding the Mechanisms of the Spread of Phragmites: For Better or for Worse") - Conference Proceedings - League, M.T., D.M. Seliskar, J.L. Gallagher, 2005, Poster Presentation: Dr. Jekyll and Mr. Hyde: Comparing the Rhizome Growth Dynamics of Native and Non-Native Populations of Phragmites australis, in Proceedings of the Delaware Estuary Science Conference,

Partnership for the Delaware Estuary, Cape May, NJ, p.17. http://www.delawareestuary.org/pdf/Proceedingsofthe2005DelawareEstuaryScienceConference.pdf

4. 2002DE1B ("Graduate Fellowship in Water Quality: Baseflow and Storm Discharges of Nutrients to Delaware's Inland Bays") - Conference Proceedings - Volk, Jennifer A., K.B. Savidge, J.R. Scudlark, A.S. Andres, and W.J. Ullman, 2005, Nutrient Loadings to Rehoboth Bay, Delaware, from Baseflow, Stormflow, Underflow, Atmospheric and Point Sources, Estuarine Research Federation Conference, Norfolk, Virginia.
5. 2002DE1B ("Graduate Fellowship in Water Quality: Baseflow and Storm Discharges of Nutrients to Delaware's Inland Bays") - Conference Proceedings - Ullman, W.J., J.R. Scudlark, J.A. Volk, K.B. Savidge, 2005, Is Atmospheric Deposition a Significant Source of Phosphorus to Coastal-Plain Estuaries?, Estuarine Research Federation Conference, Norfolk, Virginia.
6. 2002DE1B ("Graduate Fellowship in Water Quality: Baseflow and Storm Discharges of Nutrients to Delaware's Inland Bays") - Articles in Refereed Scientific Journals - Volk, J.A., K.B. Savidge, J.R. Scudlark, A.S. Andres, and W.J. Ullman, in press, Nitrogen Loads through Baseflow, Stormflow, and Underflow to Rehoboth Bay, Delaware, Journal of Environmental Quality.