

What are the experts saying about effects of climate change on rainfall and streamflow in North Carolina?

by Dr. David H. Moreau, WRRRI Director

What are the experts saying about effects of climate change on water resources in North Carolina? More specifically, what are they saying about effects on rainfall and streamflow? Possibly the most important and predictable water related impacts of climate change on North Carolina is rising sea level. Here we focus on the less well understood impacts on rainfall and streamflow on which much of our water supplies for urban areas, industry, agriculture, ecosystems, and energy production are dependent. To predict these kinds of effects, scientists are relying on more than 30 general circulation models that cover the globe with a set of interconnected grid cells. Because those cells cover portions of several states in the Southeast, the best we can do at this time is to review what is being predicted for the Southeast in general.

A recent report on “**The Physical Science Basis**” for the 2007 report on climate change by the Intergovernmental Panel on Climate Change (IPCC) will be incorporated in IPCC’s Fourth Assessment Report “Climate Change 2007”. That report represents a consensus of scientists appointed by the World Meteorological Organization and the United Nations Environment Programme. That group examined predictions using results from 21 climate models based on common scenarios of future greenhouse emissions. Aver-



From WRRRI Archives: Men studying water level at Orange County Reservoir, July 1986. Photo by Jim Page, NC Department of Natural Resources and Community Development

age values predicted for the period 2080-2099 were compared to baseline values for 1980-1999. About half of those models predicted a wetter future and the other half predicted a drier future for a one part of the Southeast. Predictions for the other part are more heavily skewed toward a wetter climate, but some models show little to no change in precipitation. It is noteworthy what they had to say about changes in precipitation in other parts of North America, namely that “Annual mean precipitation is very likely to increase in Canada and the northeast USA, and likely to decrease in the southwest USA.” The mixed outcomes of predictions for the Southeast led the Working Group to remain silent about this region.

Another recent report was produced by a group at the Joint Global Change Research Institute of Pacific Northwest National Laboratory. That report chose two models at the two ends of the

continued on page 2

In this issue

July-August 2007

	Page
Environment-related Legislation Passed by the NC General Assembly	3
People	4
North Carolina Water Resources Association 2007 Board Members	4
WRRRI-funded Proposals for FY 2007-2008	5
WRRRI-sponsored Research Reports	6
Upcoming Events	9

Experts Saying *continued from page 1*

spectrum on effects of climate change. Changes in temperature and precipitation for these two models were then routed through a watershed model to estimate effects on streamflow in each of the 18 major river basins in the country. The “drier” model, one constructed by an Australian research group, predicted a reduction of 9-10 percent in annual rainfall in the South Atlantic-Gulf area for a 1°C rise in global temperature. For that same scenario, a model built by the University of Illinois Urbana-Champaign (UIUC) predicted increases in annual rainfall of about 5-6 percent increase. When those changes were routed through watershed models, effects on streamflow were somewhat less. Changes in temperature and rainfall predicted by the Australian model led to a reduction in streamflow of 3-6 percent, while the UIUC changes resulted in a 2-5 percent increase in flow.

A third major analysis reported similar results. The Water Sector Assessment Team (WSAT), part of the National Assessment of the Consequences of the Potential Consequences of Climate Change and Variability, delivered its report to the President and Congress in November 2000. That team used a Canadian and a British model for their analysis, both of which were based on business-as-usual scenarios that assumed carbon dioxide would increase at the rate of one percent each year and that sulfur emissions would double by 2100. Potential consequences were predicted for six broadly defined geographical regions that cover the coterminous United States. The Canadian model predicted a decline of 13 percent in precipitation for the Southeast by 2095 while the British model predicted a 22 percent increase. While the two models resulted in somewhat different percentage changes for each of the six regions, the Southeast was the only one of the six for which the two models predicted different directions of change.

It is clear from the several reports covered in this brief review that predicting water resource implications in the Southeast is subject to considerable uncertainty. That general statement could be made about other regions of the United States, but, if judgments by the IPCC are accepted, it is more applicable to the Southeast. The Working Group made relatively strong statements about changes in precipitation in other parts of the country, but the evidence about precipitation change in the Southeast is weak. Analyses by the Pacific Northwest National Laboratory and WSAT show potential effects on the Southeast that range from drier to wetter. Their results are generally consistent with those of IPCC’s working group in the sense that there is less confidence in the direction of change in the Southeast than in other parts of the country.

It would seem that for the present, water planners in the Southeast will have to live with uncertainties about the future.

Editor’s Note: To read the full paper written by Dr. David H. Moreau, please download a copy from the WRRRI web site at:

http://www.ncsu.edu/wrri/publications/SEClimate_August2007.pdf



ISSN 0549-799X

Number 358

July-August 2007

This newsletter is financed in part by the Department of the Interior, U.S. Geological Survey, as authorized by the Water Resources Research Act of 1984. This newsletter is an electronic document that is distributed through the wrri-news listserv.

WRRRI offices are located at 1131 Jordan Hall on the North Carolina State University campus. Mailing address: Box 7912, NCSU, Raleigh, NC 27695-7912

General Telephone: (919) 515-2815

Email: water_resources@ncsu.edu

URL: <http://www.ncsu.edu/wrri/>

WRRRI STAFF CONTACT INFORMATION

David H. Moreau (David_Moreau@ncsu.edu)

Director, 919/513-1144

Upton Hatch (Upton_Hatch@ncsu.edu)

Associate Director, 919/513-1145

Kelly Porter (Kelly_Porter@ncsu.edu)

Environmental Ed. & Comm. Coordinator, 919/513-1152

Lynne Bridger (Lynne_Bridger@ncsu.edu)

Business and Administrative Officer,

919/513-1216

Gerry Cheney (Gerry_Cheney@ncsu.edu)

Accounting Technician, 919/513-7321

Angela Morgan (angela_morgan@ncsu.edu)

Program Coordinator, 919/513-1203

Nancy Simpson (nancy_simpson@ncsu.edu)

Workshop Assistant

SUBSCRIBE TO THE WRRRI-NEWS LIST

Anyone with email can subscribe to the WRRRI-News electronic list. This service is used to disseminate the electronic version of the WRRRI News information about WRRRI seminars, workshops, conferences, NCWRA forums, and other pertinent information. To subscribe, send an email to mj2@lists.ncsu.edu. The subject line should be blank and in the body section, type: subscribe WRRRI-News. Please send correspondence regarding the WRRRI News or the wrri-news electronic list to Kelly_Porter@ncsu.edu.

Environment-related Legislation Passed by the NC General Assembly

The House and Senate adjourned on August 2, 2007 from their long session. They will reconvene for the short session on May 13, 2008. The following are some of the environment-related legislation that was passed by the General Assembly during the 2007 long session:

H 810 AN ACT TO: (1) CLARIFY THE TRAINING AND QUALIFICATION REQUIREMENTS APPLICABLE TO ANIMAL WASTE MANAGEMENT TECHNICAL SPECIALISTS IN THE PROVISION OF SERVICES RELATED TO THE DEVELOPMENT, IMPLEMENTATION, OR OPERATION OF AN ANIMAL WASTE MANAGEMENT PLAN OR ANIMAL WASTE MANAGEMENT SYSTEM, AS RECOMMENDED BY THE ENVIRONMENTAL REVIEW COMMISSION; (2) EXTEND THE PILOT PROGRAM FOR INSPECTION OF ANIMAL WASTE MANAGEMENT SYSTEMS; AND (3) CLARIFY THE APPLICABILITY OF THE WATER QUALITY ENFORCEMENT PROVISIONS IN ARTICLE 21 OF CHAPTER 143 OF THE GENERAL STATUTES.

H 820 AN ACT TO DIRECT THE ENVIRONMENTAL REVIEW COMMISSION TO STUDY ISSUES RELATED TO THE TRANSFER OF WATER FROM ONE RIVER BASIN TO ANOTHER RIVER BASIN AND THE ALLOCATION OF SURFACE WATER RESOURCES AND TO AMEND THE LAWS GOVERNING THE TRANSFER OF WATER FROM ONE RIVER BASIN TO ANOTHER RIVER BASIN.

H 859 AN ACT TO ESTABLISH TRANSITIONAL NUTRIENT OFFSET PAYMENTS AND TO DIRECT THE DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES TO DEVELOP AND IMPLEMENT A PLAN TO TRANSITION THE NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM NUTRIENT OFFSET PROGRAM FROM A FEE-BASED PROGRAM TO A PROGRAM BASED ON THE ACTUAL COSTS OF PROVIDING NUTRIENT CREDITS.
The nutrient offset payment for nitrogen in the Neuse River Basin will be \$28.35 per pound of nitrogen; for nitrogen in the Tar-Pamlico River Basin it will be \$21.67 per pound of nitrogen; and for phosphorus in the Tar-Pamlico River Basin the payment will be \$28.62 per tenth of a pound of phosphorus.

H 862 AN ACT TO AMEND THE PLANT PROTECTION AND CONSERVATION ACT.

H 1370 AN ACT TO CLARIFY THAT THE HIGH UNIT COST THRESHOLD DOES NOT APPLY TO PLANNING GRANTS AND TECHNICAL ASSISTANCE GRANTS MADE BY THE CLEAN WATER MANAGEMENT TRUST FUND FOR WASTEWATER COLLECTION SYSTEMS AND WASTEWATER

TER TREATMENT WORKS.

H 1646 AN ACT TO INCREASE THE PENALTIES FOR VIOLATIONS OF LAWS TO PROTECT AIR QUALITY.

S 844 AN ACT TO AMEND CERTAIN ENVIRONMENTAL AND NATURAL RESOURCES LAWS TO PROVIDE THAT: (1) AN APPLICATION FOR A CONSTRUCTION PERMIT FOR A PRIVATE DRINKING WATER WELL THAT IS TO BE LOCATED ON A SITE ON WHICH A WASTEWATER SYSTEM IS LOCATED MAY BE ACCOMPANIED BY A SITE PLAN RATHER THAN A PLAT; (2) PROOF OF COMPLETION OF ANY REQUIRED PROFESSIONAL DEVELOPMENT IS REQUIRED FOR RENEWAL OF A WELL CONTRACTOR CERTIFICATE; (3) THE TRANSPLANT OF SEED CLAMS AND SEED OYSTERS OF A CERTAIN SIZE THAT ORIGINATE FROM AN AQUACULTURE OPERATION PERMITTED BY THE SECRETARY OF ENVIRONMENT AND NATURAL RESOURCES IS LAWFUL; (4) MEMBERS OF THE ADVISORY COMMISSION FOR THE NORTH CAROLINA STATE MUSEUM OF NATURAL SCIENCES SHALL SERVE FOUR-YEAR STAGGERED TERMS; (5) TO EXTEND THE EXEMPTION FOR CERTAIN WELL CONTRACTORS FROM CONTINUING EDUCATION REQUIREMENTS FOR TWO YEARS; (6) DRAFT FISHERY MANAGEMENT PLANS ARE NOT SUBMITTED FOR REVIEW TO THE ENVIRONMENTAL REVIEW COMMISSION; (7) TO MAKE CLARIFYING, CONFORMING, AND TECHNICAL AMENDMENTS TO VARIOUS LAWS RELATED TO THE ENVIRONMENT AND NATURAL RESOURCES; AND (8) TO AMEND OR REPEAL VARIOUS ENVIRONMENTAL REPORTING REQUIREMENTS.

S 1465 AN ACT TO (1) CODIFY AND MAKE PERMANENT THE SWINE FARM ANIMAL WASTE MANAGEMENT SYSTEM PERFORMANCE STANDARDS THAT THE GENERAL ASSEMBLY ENACTED IN 1998, (2) PROVIDE FOR THE REPLACEMENT OF A LAGOON THAT IS AN IMMEDIATE HAZARD, (3) ASSIST FARMERS TO VOLUNTARILY CONVERT TO INNOVATIVE ANIMAL WASTE MANAGEMENT SYSTEMS, AND (4) ESTABLISH THE SWINE FARM METHANE CAPTURE PILOT PROGRAM.

S 1468 AN ACT TO PROMOTE INNOVATIVE STORMWATER MANAGEMENT AND WATER QUALITY PROTECTION EFFORTS.

S 1492 AN ACT TO: (1) CLARIFY THE CIRCUMSTANCES UNDER WHICH AN APPLICATION FOR A SOLID WASTE

People

Sullins Named DWQ Director

On June 1, Coleen H. Sullins began serving as director of the NC Division of Water Quality (DWQ). Former Director Alan Klimek retired on May 31. The Division of Water Quality is responsible for all aspects of water quality protection including rules development, standards setting, monitoring, planning, permitting and compliance activities. Sullins has worked at the Department of Environment and Natural Resources for 17 years, and has been deputy director of the Division of Water Quality since 2003. In this position, she assisted the director in the administration and management of division programs. More information is available at <http://h2o.enr.state.nc.us/admin/pubinfo/documents/SullinsNamed.doc>.

Klimek Retires After 33 Years of Service

Alan Klimek retired as director of the NC Division of Water Quality after serving 33 years in the North Carolina Department of Environment and Natural Resources. Klimek has helped to streamline the division's business processes, resulting in more effective use of resources to provide widespread water quality protections. More information is available at <http://h2o.enr.state.nc.us/admin/pubinfo/documents/KlimekRetiresfinal.doc>.

WRRI Program Coordinator Takes Promotion

Angela Morgan has served for two years as program coordinator. She will be an executive assistant for another department on the NC State University campus. As program coordinator, Morgan maintained the institute schedule for the annual call for proposals and report completion process, and administered the registration and other logistics for WRRI conferences and workshops.

Two WRRI Staff Recognized for Years of Service

Gerry Cheney, WRRI accounting technician, and Lynne Bridger, WRRI business administrator, have served at NC State University for 30 and 25 years, respectively. Cheney has served with WRRI for seven years and Bridger for six years. They will be honored at an NC State University Employee Recognition Luncheon on August 29.

North Carolina Water Resources Association 2007 Board Members

The following are the 2007 North Carolina Water Resources Association board members:

Position	Name	Affiliation
President	Ken Carper	WK Dickson (Raleigh)
President Elect	Sandra Slayton	Carter Burgess (Raleigh)
Past President	Todd Kennedy	Tetra Tech, Inc.
Vice President	Robert Patterson	Criser, Troutman, Tanner Consulting Engineers
Treasurer	Jean Spooner	NC State University Water Quality Group
Secretary	Phil Fragapane	NC DENR Division of Water Resources
Permanent Member	Kelly Porter	Water Resources Research Institute
Member At Large	Sydney Miller	Triangle J Council of Government
Member At Large	Patricia D'Arconte	Town of Chapel Hill Stormwater Management Program
Member At Large	Michael Burkhard	Mecklenburg County Water Quality Program
Member At Large	Virginia Hodges	City of Charlotte Engineering and Property Management - Land Development Division
Member At Large	Jay Wilson	City of Charlotte Engineering and Property Management - Land Development Division

The next NCWRA Forum and Luncheon will be taking place on Monday, September 10, 2007 at 11:30 AM at the McKimmon Center at NC State University. Ryan Boyles, PhD, State Climatologist, State Climate Office of North Carolina, NC State University, will be speaking on "Using the Best Climate Information Technology for Managing Water Resources." You may download a registration form for the NCWRA Forum via the WRRI web site at http://www.ncsu.edu/wrri/events/NCWRA_Sept2007.pdf.

If you would like to learn more about NCWRA please visit the web site: <http://www.ncsu.edu/ncwra/>. If you would like to become a member please fill out the form on the NCWRA web site and mail it in with payment to the Water Resources Research Institute. If you have questions about NCWRA membership or upcoming forums please email WRRI at water_resources@ncsu.edu or call 919-515-2815.

WRRI-funded Proposals for FY 2007-2008

These are proposals that were awarded funding for the fiscal year 2007-2008.

Principal Investigator	Project
Derek Aday NC State University	Exploring Mercury Transport Mechanisms in Aquatic Systems: A Statewide Assessment of Factors Affecting Methylmercury Contamination of Food Webs and Fish
Emily Bernhardt Duke University	Water Quality Impacts of North Carolina's Largest Wetlands Mitigation Bank
Michael Burchell NC State University	Reducing Bacterial Loads from Ocean Outfalls Using Dune Infiltration Systems
Alexandria Graves NC State University	Antibiotic Resistance and Water Quality: Land Application of Swine Lagoon Effluent as a Potential Source of Antibiotic Resistant Genes in Surface Water
Detlef Knappe NC State University	Protecting Receiving Waters: Removal of Biochemically Active Compounds from Wastewater by Sequential Photochemical and Biological Oxidation Processes
Michael O'Driscoll East Carolina University	Stable Isotope Tracers to Quantify Impervious Area Effects on Baseflow to Coastal Plain Streams

General Assembly *continued from page 3*

MANAGEMENT PERMIT MAY BE DENIED; (2) PROVIDE THAT SOLID WASTE MANAGEMENT PERMITS ARE NOT TRANSFERABLE WITHOUT THE APPROVAL OF THE DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES; (3) INCREASE THE PENALTIES THAT MAY BE IMPOSED FOR SOLID WASTE VIOLATIONS; (4) REQUIRE THAT AN APPLICANT FOR A PERMIT AND A PERMIT HOLDER ESTABLISH FINANCIAL RESPONSIBILITY TO ENSURE THE AVAILABILITY OF SUFFICIENT FUNDS FOR PROPER DESIGN, CONSTRUCTION, OPERATION, MAINTENANCE, CLOSURE, AND POST-CLOSURE MONITORING AND MAINTENANCE OF A SOLID WASTE MANAGEMENT FACILITY; (5) REQUIRE THAT AN OWNER OR OPERATOR OF A SANITARY LANDFILL ESTABLISH FINANCIAL ASSURANCE SUFFICIENT TO COVER A MINIMUM OF THREE MILLION DOLLARS IN COSTS FOR POTENTIAL ASSESSMENT AND CORRECTIVE ACTION AT THE FACILITY, IN ADDITION TO OTHER FINANCIAL RESPONSIBILITY REQUIREMENTS; (6) CLARIFY AND EXPAND THE SCOPE OF ENVIRONMENTAL COMPLIANCE REVIEW REQUIREMENTS; (7) CLARIFY THAT A PARENT, SUBSIDIARY, OR OTHER AFFILIATE OF THE APPLICANT OR PARENT, INCLUDING ANY BUSINESS ENTITY OR JOINT VENTURER WITH A DIRECT OR INDIRECT INTEREST IN THE APPLICANT IS SUBJECT TO FINANCIAL RESPONSIBILITY AND ENVIRONMENTAL COMPLIANCE REVIEW; (8) PROVIDE FOR SITING OF COMBUSTION PRODUCTS LANDFILLS IN AREAS THAT HAVE BEEN FORMERLY USED FOR THE STORAGE OR DISPOSAL OF COMBUSTION PRODUCTS FROM COAL-FIRED GENERATING UNITS AT THE SAME FACILITY THAT GENERATED THE COMBUSTION PRODUCTS, AND TECHNICAL REQUIREMENTS FOR THESE LANDFILLS; (9) SPECIFY ADDITIONAL TECHNICAL

REQUIREMENTS FOR SOLID WASTE MANAGEMENT FACILITIES; (10) REQUIRE THAT ALL APPLICANTS FOR PERMITS FOR SANITARY LANDFILLS CONDUCT AN ENVIRONMENTAL IMPACT STUDY; (11) REQUIRE THAT CERTAIN APPLICANTS FOR SOLID WASTE MANAGEMENT FACILITY PERMITS CONDUCT A TRAFFIC STUDY; (12) CLARIFY THE CIRCUMSTANCES UNDER WHICH A UNIT OF LOCAL GOVERNMENT MAY COLLECT A SOLID WASTE AVAILABILITY FEE; (13) AUTHORIZE UNITS OF LOCAL GOVERNMENT TO HIRE LANDFILL LIAISONS; (14) ESTABLISH FEES APPLICABLE TO PERMITS FOR SOLID WASTE MANAGEMENT FACILITIES TO SUPPORT THE SOLID WASTE MANAGEMENT PROGRAM; (15) ESTABLISH A SOLID WASTE DISPOSAL TAX TO BE IMPOSED ON THE DISPOSAL OF MUNICIPAL SOLID WASTE IN LANDFILLS IN THE STATE AND ON THE TRANSFER OF MUNICIPAL SOLID WASTE FOR DISPOSAL OUTSIDE THE STATE IN ORDER TO PROVIDE FUNDS FOR THE ASSESSMENT AND REMEDIATION OF PRE-1983 LANDFILLS AND FOR OTHER PURPOSES; (16) ESTABLISH A COMPUTER EQUIPMENT MANAGEMENT PROGRAM; (17) DIRECT THE DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES TO DEVELOP A PROPOSED RECYCLING PROGRAM FOR FLUORESCENT LAMPS; (18) DIRECT THE ENVIRONMENT REVIEW COMMISSION TO STUDY ISSUES RELATED TO THE FRANCHISE OF SOLID WASTE MANAGEMENT FACILITIES BY UNITS OF LOCAL GOVERNMENT AND THE TRANSPORTATION OF SOLID WASTE BY RAIL AND BARGE; AND (19) MAKE RELATED CLARIFYING, CONFORMING, AND TECHNICAL CHANGES.

Visit the NC General Assembly web site to learn more about these new laws at <http://www.ncleg.net/>.

WRRR-sponsored Research Reports

WRRR no longer prints copies of the WRRR research reports. They will eventually be available on our web site to download. If you would like an electronic copy of the following WRRR reports please contact WRRR at water_resources@ncsu.edu or call 919-515-2815.

Method Development for the Occurrence of Residual Antibiotics in Drinking Water **Report 356 February 2004**

Howard S. Weinberg, Zhengqi Ye, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill, Chapel Hill, NC, and Michael T. Meyer, US Geological Survey, Lawrence, Kansas

As pharmaceutical compounds are currently not regulated as contaminants in water supplies, there is much interest in their presence in surface water and groundwater. Many compounds have similar chemical functional groups to pesticides and appear to not be efficiently removed by conventional water treatment processes. Antibiotics are of particular concern because of the development of antibiotic-resistant bacteria and potential immunosuppressant properties. This raises concern, not only that pharmaceutical compounds will find their way into our water systems and survive drinking water treatment processes, but also that they may have detrimental effects on ecological and human health. The objective of this study was to evaluate whether pharmaceutical compounds persisted in North Carolina drinking water.

After extensive development, evaluation, and validation of analytical methodologies for the quantitation of antibiotics in environmental waters, samples of raw (source) and finished water from several drinking water plants within the North Carolina Urban Water Consortium (NCUWC) were analyzed for 22 antibiotic residues. Quantitation limits down to 10 ng/L for some of the target antibiotics enabled some preliminary evaluation of the effectiveness of conventional treatment on their apparent removal. Overall, fluoroquinolones were the most frequently detected in source waters, followed by sulfonamides, lincomycin, tetracyclines, and macrolides. Although the detection of ciprofloxacin, which is used only in human medication, seems to indicate impact from human wastewater discharges, the possibility of contamination from animal sources should not be excluded, as the veterinary fluoroquinolone enrofloxacin can, under certain conditions, be metabolized to ciprofloxacin. The levels of antibiotics found in raw-water intakes at the drinking water plants of NCUWC members suggest that these drugs are in the aquatic environment as a result of inadequate wastewater treatment and/or nonpoint source runoff from agricultural operations such as confined animal feeding operations.

In most treatment plants, finished waters were either chlori-

nated or chloraminated and showed either no detectable antibiotic residues or very much reduced levels. However, it is not known whether these compounds were physically removed during treatment, such as by adsorption to filters or precipitation in coagulation basins, or were merely chemically converted during disinfection processes. The trends for each treatment plant indicate that removal is not always consistent and that conventional treatment may not protect the consumer against daily exposure to low levels of these and other so-called "emerging" contaminants. The long-term health implications of these exposures are unknown, but there are some initial, though controversial, suggestions that their occurrence in the aquatic environment could contribute to the growth of antibiotic-resistant bacteria that could threaten human and animal life in the future.

Ongoing research is investigating the use of alternative wastewater and drinking water treatments for the removal of the activity of the chemicals. It is recommended that NCUWC members participate in as many of these studies as possible, so that they can prepare themselves to soon make either subtle or significant changes to their treatment processes. The next steps in this process could be twofold: (1) evaluate pilot-scale operations using modifications to existing treatment to control the fate of the contaminants using surrogate chemicals, and (2) use the preliminary data from this study and a follow-up study as suggested in (1) to permit a tailored collaboration through a larger agency with more resources to support the unique needs of North Carolina utilities.

Effectiveness of Three "Best Management Practices" for Reducing Non-Point Source Pollution from Piedmont Tobacco Fields **Report 357 February 2003**

E. Carlyle Franklin, Dennis W. Hazel, Kathleen T. Summitt, Department of Forestry, and Gregory D. Jennings, Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, NC

Non-point source pollution (NPSP) from agricultural runoff is a major concern regarding water quality throughout the state of North Carolina, the southeastern region and the nation. Farmers are being encouraged to adopt best management practices (BMPs) to conserve soils and reduce NPSP. For example, conservation tillage and vegetated filter zones are frequently recommended. However, there is little research documenting the effectiveness of a complete system consisting of no-till, grassed and forested filter zones.

This purpose of this project was to evaluate the effectiveness of three BMPs for tobacco production: no-till (NT) versus

continued on page 7

Reports continued from page 6

conventional tillage (CT), grassed field-side filter zones (GFZs), and forested filter zones (FFZs) for two years. Level spreaders were installed within FFZs and GFZs zones to convert channelized runoff into sheet flow. The primary objective was to test the three BMPs in series to determine the total reduction in suspended solids and nutrients as runoff exited the lower flumes of the FFZs. A secondary objective was to compare yield and quality of tobacco from NT versus CT. Another secondary objective was to compare the effectiveness of the same FFZ first with a mature stand of pines and hardwoods, and later with vegetation following clear cutting. The study was conducted on the Oxford Tobacco Research Station in Granville County, North Carolina.

GFZs functioned very well in retaining solids and nutrients in early summer, but seemed to overload during late summer, probably due to limited infiltration capacity. Forested filter zones with their higher infiltration capacity, were able to back up the GFZs when they overloaded and exported sediment and nutrients to the FFZs. In combination, GFZs and FFZs retained 80-95% of all sediment and nutrients entering the zones, proving to be an extremely effective combination.

Total suspended solids leaving tobacco fields were reduced by 70-90% by use of NT compared to CT. Although, there was a slight tendency toward more nutrient release from NT than from CT fields, nutrient discharge from both field types was so low that no clear trends were seen.

Dense ground vegetation in the cut-over FFZ more than doubled its capacity to effectively detain sediments and nutrients, compared to the effectiveness of the same FFZ when it was covered by a stand of mature mixed pine-hardwood. Detention rates jumped from 32% with a mature forest to 72% with dense ground vegetation which followed the clear cut. As found in our previous studies, a small number of major events each year accounted for at least 80% of all sediments and nutrients exported from the fields.

In both crop years, yield was lower and grade was slightly lower for tobacco from NT compared to that from CT. In the first year, yields from NT and CT were below the regional average. In the second year, yields from NT and CT were higher than the regional average.

Some form of conservation tillage for tobacco and other tilled crops and the use of grassed and forested filter zones with level spreaders are recommended to effectively minimize delivery of sediment to receiving waters. Indications were that yields from no-till are lower than from conventional tillage, thus cost-share payments may be appropriate to supplement the practice. On the other hand, retention of so much soil in farm fields, which under conventional tillage was routinely lost, should eventually help to increase yields and/or lower costs of crop production.

Grassed filter zones should be used for the first phase of reduction of sediments and nutrients in agricultural runoff. However, the use of forested filter zones is also recommended, since

grassed zones are typically low in infiltration capacity because of sod compaction due to equipment use, and since they are typically inadequate to handle the large events which deliver most of the yearly non-point source pollution. Vegetation in all zones should be managed to encourage growth of dense, woody ground vegetation, except in the upper portions of the grassed zone. In some cases this would mean forested, brushy and grassed filter zones should be planted adjacent to agricultural fields, or, if available forested zones are too small or otherwise only partially functional, overstory removal should greatly improve performance of the filter zone. Level spreaders should be used in grassed zones when they would improve the utilization of available area, and in the upper end of forest zones if topography or hydrologic engineering concentrate runoff.

Improving Dewatering of Wastewater Biosolids Using Innovative Approaches Report 358 July 2005

*Francis L. de los Reyes III and Matthew B. Skidmore,
Department of Civil, Construction, and Environmental Engineering,
North Carolina State University, Raleigh, NC*

During wastewater treatment processes, the removal of excess moisture in sludge can lead to considerable reductions in disposal costs; thus, sludge dewatering has become a highly important operation for many wastewater treatment plants (WWTP) looking to reduce operational costs. The goal of this project was to increase the dewatered solids content of biosolids (sludges) by incorporating various treatments with traditional dewatering processes using the moisture distribution in sludge as a theoretical framework. The specific objectives of the project were: (1) to determine the inherent dewaterability of various types of biosolids, including developing a centrifuge test for predicting dewaterability; and (2) to determine the effects of various biosolids pretreatments on dewaterability.

A centrifugal dewatering test was developed that would measure biosolids dewaterability based on moisture distribution. The test is based on the idea that as centrifugal forces approach infinity, only bound water will remain in the solid pellet. The test consisted of centrifugation at ~150,000 x g for a period of 30 minutes. Significant correlations between test results and full-scale plant dewaterability results were obtained. The centrifuge test is able to predict trends in biosolids dewaterability in advance of solids handling (digestion, thickening, and conditioning) and dewatering equipment (centrifuges, belt-filter presses, and plate-and-frame press). This suggests that the centrifugal dewatering test can be used by wastewater treatment plants as a tool for optimizing or monitoring changes in dewaterability.

Sonication as a cellular disruption technique caused a

continued on page 8

Reports *continued from page 7*

change in the distribution of water as measured by dilatometry, and emerged as the best method for increasing dewaterability in this study. Addition of divalent cations alone and at low levels (< 15 meq) significantly altered the dewaterability of sludge, as measured by the centrifugation technique. However, heat treatment alone did not lead to increased dewaterability. A combination of cation addition and cell disruption techniques did not increase dewaterability beyond that of the disruption technique alone. A variety of possible mechanisms are suggested in this study to explain these results. In particular, the nature of EPS, changes in floc sizes, and the effect of cations can potentially explain why no significant increases in dewaterability were obtained. These results show the complex nature of biological sludges, and emphasize the difficulty in increasing dewaterability.

The concept of dewaterability testing based on moisture distribution shows promise and merits further testing. The centrifugation technique developed in this study should be applied to a several WWTPs over longer time periods to demonstrate its use as a dewatering monitoring and optimization tool. The concept of measuring the upper limits of sludge dewaterability needs to be explored further. From a research standpoint, the finding that bound water and dewaterability may not be related as previously thought (that a decrease in bound water is associated with an increase in dewaterability) suggests that measures of dewaterability should always be related to actual plant dewatering performance. The usefulness and optimization of these centrifugation methods and other possible dewatering methods at particular plants should be further explored based on the specific characteristics of individual WWTP biosolids, such as the percentage of the maximum dewaterability.

Trophic Basis for Restoration of Fish Fauna in Restored Urban Streams

Report 359 September 2005

Anne E. Hershey and Robert Northington, Department of Biology; University of North Carolina at Greensboro, Greensboro, NC

Past studies have shown that terrestrial subsidies from riparian zones can be important to aquatic communities in pristine, non-urban systems, yet urban streams typically lack these forested buffer zones. The purpose of this project was to evaluate the importance of terrestrial subsidies to fish populations in streams affected by urbanization including unrestored reaches, reaches with restored riparian zones and some channel restoration, and forested reaches that were below waste water treatment plants (WWTPs). Specific objectives were to (1) evaluate the effectiveness of stream restoration in restoring abundance and richness of stream fish communities compared to unrestored and waste-water influenced forested streams; (2) assess availability of

aquatic food resources and terrestrial subsidies in each of the stream reaches; and (3) evaluate the importance of terrestrial subsidies from riparian zones in supporting fish diets and growth in restored versus unrestored and forested streams. The latter objectives were met by examining using stable isotopes of N and C, and using gut analyses of fishes.

Restored sites had significantly higher species richness for fish, as well as terrestrial and aquatic invertebrates. Total abundance of fish showed no significant difference overall, although there was a strong trend toward more fish in the restored sites. Abundance and taxa richness of terrestrial and aquatic macroinvertebrates were not significantly different between sites, although there was a trend for higher richness and abundance at restored sites.

Fish were significantly more depleted in $\delta^{13}\text{C}$ and enriched in $\delta^{15}\text{N}$ at restored sites than at unrestored sites, which is most likely due to increased use of detrital resources by aquatic macroinvertebrates, which were the most important component of fish diets. Seston and FBOM had significantly higher $\delta^{15}\text{N}$ in the forested compared to the restored and unrestored sites. Both isotope mixing models and gut content analysis supported the conclusion that most fish were relying primarily on aquatic resources.

At sites below sewage treatment plants, much of the carbon in fish tissue is derived from sewage. Isotope data showed that the fish at these sites were slightly enriched in $\delta^{13}\text{C}$, and that all fish as well as aquatic invertebrates were enriched in ^{15}N . Because all of the sites below WWTPs were in forested reaches of their watersheds, one would expect terrestrial inputs to be important. However, the large quantity of treated sewage entering the stream, in the form of seston and dissolved organic carbon, apparently overwhelmed the signal of terrestrial detritus in the food web.

These trends at restored sites (improved species abundance and richness) suggests that the improved habitat and water quality at these sites is beginning to show a long-term benefit to the aquatic biota because of a shift toward greater utilization of terrestrial detrital resources by the stream biota. This methods used in this study should be useful to managers for anticipating the time course required for restoration of the stream biota and for evaluating the degree to which stream restoration has been successful in restoring the ecological function in urban streams. For example, because the $\delta^{13}\text{C}$ value of periphyton and leaf litter are distinct in these streams, analysis of stable isotopes of carbon provides an economical monitoring tool for detecting an increase in the use of detrital material as a basal food source. This method could be used to replace or enhance more traditional monitoring efforts that involve a large investment in sample processing and a high level of taxonomic expertise.

Upcoming Events

September 10, 2007

11:30 am

NCWRA Forum and Luncheon

McKimmon Center, NC State University

Topic: "Using the Best Climate Information Technology for Managing Water Resources"

Speaker: Dr. Ryan Boyles, State Climatologist, State Climate Office of North Carolina, NC State University,

Web: <http://www.ncsu.edu/wrri/events/>

September 16-18, 2007

2007 NC APWA Water Resources Conference

Blockade Runner

Wrightsville Beach, NC

Web: http://www.apwa.net/documents/chapters/2007_Conference_Brochure.pdf

September 25-26, 2007

Erosion and Sedimentation Control Planning and Design Workshop

City Hotel & Bistro

Greenville, NC

Web: <http://www.ncsu.edu/wrri/erosionworkshops.html>

October 15, 2007

4:00 pm

Progress Energy Water Resources Seminar

McKimmon Center, NC State University

Speaker: Dr. Upmanu Lall, Columbia University

October 30-31, 2007

Erosion and Sedimentation Control Planning and Design Workshop

Holiday Inn Select

Hickory, NC

Web: <http://www.ncsu.edu/wrri/erosionworkshops.html>

December 5, 2007

11:30 am

NCWRA Forum and Luncheon

McKimmon Center, NC State University