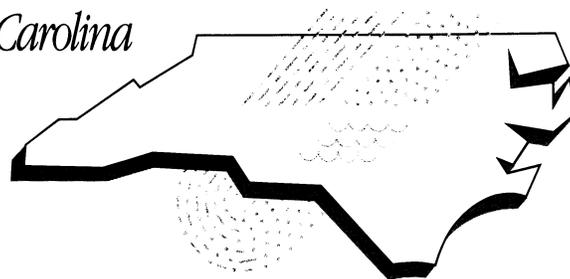


Water Resources Research Institute News

of The University of North Carolina



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Conference presentations address range of basin management issues

At WRRI's annual conference in March, investigators from universities, agencies, industry, and consulting firms presented results of work on topics ranging from agricultural erosion to water demand. Some 300 people participated in the conference. Participants had 48 technical presentations in 3 concurrent sessions from which to choose, as well as 23 technical posters to view. (Booklets of presentation and poster abstracts from the conference are available from WRRI for \$2 to cover postage and handling. See the masthead on page 2 for address and phone number.) Following are some conference highlights:

Clearcutting can increase pollutant-removal effectiveness of forest filter zones

In 1996, Hurricane Fran downed all the trees on one of Dr. Carlyle Franklin's research sites and gave him the opportunity for a before-and-after comparison that produced an important discovery: Forested filter zones beside agricultural fields are much better at removing pollutants from runoff after they've been clearcut.

Franklin is a professor in the Department of Forestry at NC State. More than a decade ago, he placed instrumentation on two small watersheds at NCSU's Oxford Tobacco Research Station in Granville County and began studying how various factors affect the ability of the forested zones in the watersheds to remove sediments and

nutrients from water running off adjoining tobacco fields.

Franklin said that he had hypothesized that one way to improve pollutant removal effectiveness of a forested filter zone would be to remove trees. Removing or thinning the forest canopy lets more light reach the forest floor and stimulates growth of dense ground

vegetation that intercepts runoff, slowing its speed and allowing sediment to be deposited in the zone.

When a microburst from Hurricane Fran took down most of the trees on one of the instrumented watersheds at Oxford, Franklin got the chance to test his hypothesis.

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Director's Forum

TMDLs and the management of North Carolina surface waters

Kenneth H. Reckhow, Director, Water Resources Research Institute

As our National Academy of Sciences committee on the scientific basis of the EPA TMDL program nears completion of its final report to Congress, it is evident to me that changes in the TMDL program are advisable. Our committee examined the entire surface water quality management process—from standard setting, to identifying violations, modeling for TMDL development, and monitoring to assess compliance. At this point, I see that some of the key conclusions are:

- Nature is complex and scientific knowledge is limited; accordingly, scientific uncertainty will never be eliminated. However, it is estimated that 40,000 TMDLs are needed; this translates to 40,000 standard violations that must be addressed. Adaptive management, or “learning by doing,” provides a useful framework to rapidly address these standard violations in the context of scientific uncertainty, by integrating model forecasts with compliance monitoring so that TMDL plans can be adjusted over time to achieve designated uses.
- Water quality standards, which involve a designated use and a criterion intended to assess compliance with the designated use, implicitly or explicitly reflect a balancing of costs and benefits. States should consider the practical limitations of the fishable/swimmable goals for all waters (e.g., urban streams); further, they should consider biological criteria, which are often more closely linked with the designated use (than are chemical criteria).
- Listing a waterbody for standards noncompliance (and hence in need of a TMDL) should be treated as a statistical hypothesis testing exercise with stringent design and analysis criteria. It is likely that current lax listing criteria, and limited state sampling programs, have resulted in a number of

waterbodies being incorrectly listed and a number that are not listed but should be. States should implement a stronger scientific and statistical basis for listing/delisting.

- Modeling for TMDL development must be accompanied by uncertainty analysis. This is essential for determination of the required “margin of safety;” beyond that, uncertainty analysis allows integration of compliance monitoring with modeling for

adaptive management. This monitoring/modeling integration is likely to favor relatively simple, low-cost models that permit uncertainty analysis. Large, detailed models, like that used by EPA in the Neuse and Chesapeake, have not been proven to be more precise than simpler low-cost models; further, these models consume resources, tend to divert attention away from the underlying water quality issues, and are less amenable to uncertainty-weighted

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monitoring/modeling integration for adaptive management.

■ Compliance monitoring is important for addressing scientific uncertainty. In addition, by providing feedback to improve model forecasts over time, compliance monitoring under adaptive management should lead to achievement of the designated uses.

What are the likely effects of these proposed TMDL program changes on North Carolina water quality management? On a positive note, North Carolina's rotating basinwide water quality management program is well suited for adaptive management purposes. TMDLs could be initially set in the active phase, compliance monitoring could occur during "inactive" years, and then monitoring/modeling integration with possible TMDL improvements could occur in the next active phase.

However, surface water quality monitoring in North Carolina, as in many states, does not appear to completely satisfy any single objective including TMDL listing/delisting, due in part to the multiple uses of water quality data. For example, the "305(b)" program for assessing the state of the State's water quality, would best be served by probability sampling. In contrast, the "303(d)" program for TMDL listing would best be served by targeted sampling at suspected problem sites. Limited resources and multiple objectives hamper the surface water quality monitoring program, but these same features suggest that a rigorous re-evaluation of sample site selection and monitoring frequency could yield some gains.

The ongoing determination of the Neuse nitrogen TMDL is useful for illustrating additional points. The Neuse is in many ways a unique case study that illustrates certain good and bad features of the current TMDL program. First, while acknowledging the recent call from some stakeholders that we need more data to make good decisions, the Neuse is actually one of the most data-rich

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WRRRI Annual Conference *continued*

Trees were removed from the site and it was left to nature for two years, during which forest regeneration began. In 1999 under a new grant from WRRRI, Franklin and his co-investigator Dr. Dennis Hazel began collecting pollutant removal data from the clearcut zone to compare with data on performance gathered when the zone was a mature forest.

What they found left little doubt that Franklin's hypothesis is correct. The clearcut zone removed suspended solids (sediments) at twice the rate of the mature forest. It removed organic nitrogen and nitrate at four times the rate and total phosphorous at five times the rate of the mature forest. The clearcut forest zone together with an upslope grassed filter zone removed more than 90 percent of sediments and upwards of 90 percent of nitrogen and phosphorous leaving the tobacco field.

Franklin said that the results of his study have important implications for efforts to remove nutrients from agricultural runoff in the Neuse and Tar-Pamlico river basins. Throughout the Piedmont and Upper Coastal Plain, areas on slopes beside agricultural fields were allowed to revert to forest when modern, mechanized farming methods made planting crops on slopes impractical. These existing forested zones are on upland areas. They are not typically riparian zones—that is they are not along streams or rivers. If farmers managed these upland zones for optimum pollutant removal by removing trees and encouraging dense standing vegetation, the upland filter zones would supplement water quality protection offered by riparian buffers.

"The goal in the Neuse basin is to reduce nitrogen by 30 percent, but we were able to accomplish a 90 percent reduction. Not every forested filter will perform as well as that, but there's still a great opportunity for nutrient reduction out there if farmers could be encouraged by conservation payments to actively

manage their upland forested filter zones for water quality purposes," said Franklin.

Significant price increases or mandatory restrictions are needed to curb water use in North Carolina

Voluntary water conservation programs won't reduce water demand in rapidly growing North Carolina cities with water supply problems. That is one of the findings of a study reported by Dr. Kerry Smith, Director of the NCSU Center for Environmental and Resource Economics Policy, at the WRRRI annual conference.

Smith and his colleagues used existing data to perform an analysis of water demand for 205 municipalities in North Carolina. The analysis takes cities' block rate structure into account and estimates the price elasticity of demand, taking into consideration conservation plumbing ordinances, conservation information programs, as well as use restrictions.

The researchers concluded that it will take fairly dramatic price increases or mandatory restrictions to reduce water demand in fast-growing N.C. cities, particularly Raleigh, where price inelasticity is most pronounced.

Smith said the results of this study are important for future water management since conservation is likely to be a critical alternative to developing new water sources in the state.

**Mark your calendar!
The 2002 WRRRI
Annual Conference
will be held April 9, 2002
at the Jane S. McKimmon
Center in Raleigh.**

A call for abstracts will be issued late this year, probably in November. To make sure you receive the call for abstracts, subscribe to the WRRRI-News list serve. See mast-head on page 2 for instructions on how to subscribe. Or, if you are university faculty not on the WRRRI faculty email distribution list, email Jeri Gray (Jeri_Gray@ncsu.edu).

April, May action of the N.C. Environmental Management Commission

At its regular April meeting, the N.C. Environmental Management Commission (EMC) took the following action:

- Heard from Department of Environment and Natural Resources Secretary Bill Ross that the department has a new plan for dealing with environmental problems of concentrated animal operations. Ross said the department supports development and adoption of environmentally superior waste management technologies, as called for in the "Smithfield agreement." But, he said that in the meantime, animal operations must be managed in an environmentally sound way. Ross said that to achieve sound management, the department will evaluate the status of groundwater near concentrated animal operations using current information, assess the effectiveness of the new odor rules, encourage pilot management programs to minimize nitrogen loss, and investigate ways of utilizing nutrients in animal waste. Ross said the new plan also involves focusing inspections on problem operations rather than requiring annual inspections of all concentrated animal operations and replacing state nondischarge permits with federal NPDES permits at concentrated animal operations. He said legislation to extend the moratorium on new swine farms and to modify inspection requirements will be needed to implement the plan.
- Approved changes to the Neuse River Basin Model Stormwater Program for Nitrogen Control. The changes clarify use of the 1-year, 24-hour storm methodology, allows use of the 2-year storm to approximate the 1-year, 24-hour storm, and clarifies how local governments can exempt underway development from certain requirements.

- Approved temporary amendments to the required minimum management practices for dry-cleaning facilities and to rules for administering the Dry-Cleaning Solvent Cleanup Act Program.
- Initiated emergency rulemaking to amend rules governing wastewater discharges to deem permitted discharges from decontamination facilities operated under declaration of emergency to contain outbreaks of foot-and-mouth disease.
- Approved minor changes to the Central Coastal Plain Capacity Use Area rules to satisfy objections of the Rules Review Commission.
- Approved holding public hearings on regulations governing heavy-duty diesel engines. For information on the rule and hearing check the Division of Air Quality website at <http://daq.state.nc.us/Rules/>.
- Approved holding public hearings on revised draft permanent rules responding to EPA's NOx state implementation plan (SIP) call and to EPA's comments on the previous draft. Hearings are set for May 21 and June 5. For information visit website: <http://daq.state.nc.us/Rules/Hearing/>.
- Affirmed the intent of the EMC that isolated and headwaters wetlands be regulated under the state's wetlands regulations. The request for an interpretive ruling was brought by the staff of the Division of Water Quality acting in the wake of a recent Supreme Court ruling that effectively removed isolated wetlands from Clean Water Act Section 404 regulation. Commissioners Will Fowler and Bob Cook, speaking for agricultural interests, objected to the ruling, saying it would bring farm ponds, springs, and grazing lands under

wetland regulation. Other commissioners disagreed pointing out that agriculture is exempt from wetlands regulation and that state wetlands rules covering isolated wetlands have been in effect since 1996, with no farm ponds or springs having been put off limits to farmers. The commission asked staff to meet with stakeholders and bring recommendations on temporary rules and the EMC's authority to adopt temporary rules on isolated wetlands to the Water Quality Committee in May.

- Approved local nitrogen reduction strategies for agricultural operations in 12 counties devised by Local Advisory Committees under the Neuse River Basin Nutrient Sensitive Waters Management Strategy. The Neuse Basin Oversight Committee (BOC) had approved the strategies, affirming that they will result in a 30% reduction from the 1991-95 baseline nitrogen loading from agricultural operations in these counties. However, five counties (Franklin, Granville, Person, Orange and Wake) have not come up with acceptable strategies for reducing nitrogen loading from agricultural operations by 30%. According to the report from the BOC, in these counties, farms are small, already have extensive riparian buffer coverage, and do not have the full array of BMP choices available in Coastal Plain counties. These five counties will submit revised strategies.
- Delegated to the Water Quality Committee the authority to publish rulemaking subject matter notices. This change will reduce by 30 days the time it takes to move proposals to rulemaking.
- Overturned an Administrative Law Judge's (ALJ) decision to find no violation of the Clean Water Act and to assess no civil penalty against the Town of Wallace for discharge of sewage into Rockfish Creek in 1999. The commission disagreed with the ALJ's interpretation that no violation of

the Clean Water Act occurred because a break in the town's main sewage trunk line was "unforeseeable and unexpected" and the town did not willfully discharge waste to the stream. Commissioner Dan Besse said that agreeing with the ALJ would "throw our enforcement program into disarray." Commissioner Bob Epting said that the Town of Wallace "permitted" the discharge by improper maintenance, and that adopting the ALJ's decision would send a message to municipalities that they don't have to be vigilant about maintenance. Chairman David Moreau said that the issue of intent related to accidental sewage spills will arise again and that there should be a departmental review of policy on fines for sewage spills. The Commission voted to overturn the ALJ's decision but to reduce the civil penalty from \$4,000 to \$2,000.

In May the EMC took the following action:

- Approved more minor changes to the Central Coastal Plain Capacity Use Area permanent rules to satisfy objections of the Rules Review Commission. Division of Water Resources Director John Morris indicated that additional amendments to the rule are likely to clarify how the rules apply to the mining industry. Morris said a General Permit may be developed for mining operations.
- Approved loans from the State Clean Water Revolving Loan Fund for wastewater treatment projects for the Town of Boiling Springs and the City of Goldsboro. Boiling Springs received an emergency loan.
- Approved holding a public hearing on changes to the State's Laboratory Certification rules (15A NCAC 2H .0800). Changes will update techniques and methods references and increase certification fees.
- Approved holding public hearings on several surface water reclassifications: Headwaters of the North Toe River in Avery and Mitchell counties from C Trout to Water Supply V. Reclassification of the Neuse River in Lenoir County from C Nutrient Sensitive Waters to Water Supply IV NSW. Reclassification of the French Broad River in Transylvania, Henderson, Buncombe, and Madison counties for recreation (B, which includes body contact) in addition to current water supply and trout classifications. Reclassification of the Nolichucky River in Mitchell and Yancey counties from C to B for body contact recreation.
- Adopted temporary rules requiring preservation of riparian buffers on the mainstem Catawba River below Lake James and on mainstem reservoirs below Lake James. The temporary rules do not protect buffers on tributaries to the mainstem Catawba and do not apply above Lake James. The process to develop permanent riparian buffer rules for the Catawba Basin continues. Draft permanent rules may be presented to the EMC in September. A threatened protest by residents of McDowell County to the temporary rules did not materialize. For information on the Catawba buffer rules contact Alan Clark with the Division of Water Quality (919) 733-5083 EXT 570.
- Removed from the agenda approval of 2nd round allocations of water from the Jordan Reservoir and approval of an Interbasin Transfer Certificate for the Towns of Cary and Apex. Commissioner Leo Green, chairman of the EMC Water Allocation Committee, said that the hearing officers thought they had reached an agreement with parties involved, but that due to some misunderstandings a couple of major issues remain to be resolved. He said the hearing officers intend to present their recommendations to the EMC in July.

Action of the EMC Water Quality Committee

At its April and May meetings, the Water Quality Committee of the N.C. Environmental Management Commission took the following action:

- Granted a variance from the Neuse River Riparian Area Protection rules for the Plantation Point development at Old Wake Forest Road and Capital Boulevard in Raleigh and for a restaurant, retail, riverwalk development on East Front Street in New Bern.
- Approved a general variance from the Neuse and Tar-Pamlico Riparian Area Protection rules for residential construction meeting certain conditions. For information on the general variance contact Bob Zarzecki with the N.C. Division of Water Quality at (919) 733-9726.
- Approved a Water Supply Watershed Protection ordinance for the Piedmont Triad International Airport in Greensboro. The airport is treated by statute as a municipality and is located within the Reedy Creek and Randleman Reservoir watersheds.
- Approved development of temporary rules for the NPDES Phase II Stormwater Program. Staff of the Division of Water Quality will present rule concepts and take feedback at a series of workshops to be held May 9 - May 29 at locations around the state. For details visit website: <http://h2o.enr.state.nc.us/su/stormwater.html>.
- Approved taking the draft White Oak River Basinwide Water Quality Plan to public meetings. Meetings will be held in July. For information go to website: <http://h2o.enr.state.nc.us/basinwide/index.html> or call Cam McNutt at (919) 733-5083 Ext 575.

Environment-related legislation alive in the N.C. General Assembly

April 26 was "cross over" day in the N.C. General Assembly. That's the date by which all non-finance related bills must pass one chamber in order to remain active. The following environment-related bills were among those that made the cross over deadline. For a more extensive listing together with links to bill text on the General Assembly web server, visit the WRRI News online at <http://www2.ncsu.edu/ncsu/CIL/WRRI/news/329.html>.

H308 (S 1024) AN ACT TO PROVIDE FOR FAIR GEOGRAPHIC REPRESENTATION IN APPOINTING MEMBERS TO THE ENVIRONMENTAL MANAGEMENT COMMISSION.

H 326 (S312) AN ACT TO AMEND THE LAW RELATING TO THE CERTIFICATION OF WELL CONTRACTORS.

H 570 (S 483) AN ACT TO PROVIDE FOR THE IMPLEMENTATION OF THE ADMINISTRATIVE RULE ENTITLED TAR-PAMLICO RIVER BASIN-NUTRIENT SENSITIVE WATERS MANAGEMENT STRATEGY: AGRICULTURAL NUTRIENT CONTROL STRATEGY WITH CERTAIN MODIFICATIONS, TO AUTHORIZE THE ENVIRONMENTAL MANAGEMENT COMMISSION TO INCORPORATE THESE MODIFICATIONS INTO A REVISED ADMINISTRATIVE RULE, AND TO DIRECT THE SOIL AND WATER CONSERVATION COMMISSION TO ADOPT STANDARD BEST MANAGEMENT PRACTICES AND A NUTRIENT LOADING ACCOUNTING METHODOLOGY.

H 609 AN ACT TO SPECIFY THE MINIMUM SEPARATION DISTANCES BETWEEN A WELL SERVING CERTAIN SINGLE-FAMILY DWELLINGS AND CERTAIN OTHER STRUCTURES ON THE SAME LOT AND TO AUTHORIZE THE ENVIRONMENTAL MANAGEMENT COMMISSION TO ADOPT A TEMPORARY RULE TO INCORPORATE THOSE MINIMUM SEPARATION DISTANCES.

H 1008 (S 827) AN ACT TO REPEAL THE SUNSET FOR CERTAIN PROVISIONS REGARDING CLEANUPS OF PETROLEUM FROM LEAKING UNDERGROUND STORAGE TANKS.

H 1009 (S1011) AN ACT TO EXPAND AND MAKE CONSISTENT THE CIRCUMSTANCES UNDER WHICH THE DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES SHALL ALLOW FOR RISK-BASED REMEDIAL ACTIONS.

H1015 (S1078) AN ACT TO IMPROVE AIR QUALITY IN THE STATE BY REQUIRING REDUCTIONS IN THE EMISSIONS OF CERTAIN POLLUTANTS FROM CERTAIN FACILITIES THAT BURN COAL TO GENERATE ELECTRICITY.

H1060 (S955) AN ACT TO PROVIDE THAT ENVIRONMENTAL REMEDIATION AND RESTORATION ACTIVITIES ARE NOT STATE CAPITAL IMPROVEMENT PROJECTS.

H 1061 (S 921) AN ACT TO EXEMPT CERTAIN PUBLIC WATER SYSTEMS THAT RESELL WATER FROM THE NORTH CAROLINA DRINKING WATER ACT.

H1063 (S956) AN ACT TO PROVIDE FOR PERFORMANCE-BASED CLEANUPS OF DISCHARGES OR RELEASES OF PETROLEUM FROM UNDERGROUND STORAGE TANKS.

H1257 AN ACT TO AUTHORIZE THE ENVIRONMENTAL MANAGEMENT COMMISSION TO DELEGATE TO THE DIVISION OF FOREST RESOURCES THE RESPONSIBILITY TO DETERMINE THE PRESENCE OF SURFACE WATERS THAT MAY BE AFFECTED BY SILVICULTURE ACTIVITIES FOR PURPOSES OF THE RIPARIAN BUFFER PROTECTION PROGRAM.

H1301 AN ACT TO DELAY THE SUNSET OF THE EXEMPTION OF CLEANUPS OF PETROLEUM FROM LEAKING UNDERGROUND STORAGE TANKS FROM CERTAIN REQUIREMENTS RELATED TO LAND-USE RESTRICTIONS AND DEED RECORDATION.

H1321 (S1033) AN ACT TO EXTEND THE MORATORIA ON CONSTRUCTION OR EXPANSION OF SWINE FARMS, TO AUTHORIZE THE LEGISLATIVE RESEARCH COMMISSION TO STUDY FUNDING OPTIONS TO IMPROVE ANIMAL WASTE MANAGEMENT SYSTEMS, AND TO DIRECT THE DEPARTMENT OF COMMERCE TO DEVELOP A PLAN TO IDENTIFY AND DEVELOP MARKETS FOR BY-PRODUCTS OF ANIMAL WASTE MANAGEMENT SYSTEMS.

S848 AN ACT TO INCLUDE PUBLIC LIVESTOCK MARKETS WITHIN THE DEFINITION OF ANIMAL OPERATIONS FOR THE PURPOSE OF REGULATING THE ANIMAL WASTE MANAGEMENT SYSTEMS THAT SERVE THESE MARKETS.

Studies

As we announced in the last issue of the WRI News, we are initiating a new department in the newsletter to publish summaries of water research articles and reports sent to us by investigators. Entries in this department will be straightforward summaries, not reviews or critiques. For each article or report, we will indicate the source and level of review provided the original. We aim to provide summaries from many different researchers, and if it becomes necessary, we will limit the number of articles or reports by any one individual that we will accept. We will accept articles and reports from agencies and private entities, but we intend to focus on academic research and will always devote at least half the space in any one issue to university investigators. To submit an article or report for this department, send it to Jeri Gray at the address or email address on page 2.

Study concludes Neuse nitrogen reduction goal should be regarded as moving target

Following a five-year study of the Neuse Estuary which found nitrate loading up but chlorophyll *a* down, Drs. Howard Glasgow and JoAnn Burkholder conclude that decadal data sets are needed to link nitrogen loading and algal production, and say regulators should stand ready to adjust the 30% nitrogen reduction goal at 5- to 10-year intervals—probably upward. An invited, peer-reviewed article detailing their research was published in the August 2000 issue of *Ecological Applications*.

The researchers conducted their study from May 1993 through April 1998 in the mesohaline (generally 5-18 ppt salinity) area of the Neuse Estuary between Flanners Beach and Minnesott Beach. The area includes the wastewater discharge point of the Cherry Point Marine Air Station (mid-way between Flanners Beach and Minnesott Beach), which was a focus of the study. They

established transect, side-channel sampling stations (Flanners Beach – Kennel Beach and Cherry Point—Minnesott Beach) and 33 sampling stations in a radial design centered on the wastewater treatment plant diffuser, with an additional sampling site 750 meters from Beards Creek near the north shore. At six stations (including the transect stations) they took weekly water quality samples, and at 16 (including the six above) they took biweekly samples for a full suite of physical and chemical variables and for chlorophyll *a* (as an indicator of phytoplankton biomass). At all 38 stations they took monthly samples. This monitoring effort produced an extensive data matrix with more than 208,000 observations from which concentrations of total nitrogen, inorganic forms of nitrogen (mainly nitrate), organic forms of nitrogen, total phosphorous, and chlorophyll *a* (*chl**a*) could be statistically analyzed.

At the westernmost edge of the estuary (Mills Branch, New Bern), the researchers used a boat-mounted acoustic Doppler current profiling (ADCP) system to gather shore-to-shore volume-of-flow data. The authors believe that the application of these new tools and technologies, used by scientists in estuaries such as the Chesapeake, can more accurately estimate river discharge into estuarine systems by separating out upriver and downriver estuarine influences. Implementation of this new technology also allows accurate determination of the bottom profile (bathymetry) of the estuary. To calibrate the ADCP data, the researchers gathered volume-of-flow, water height, and bathymetry data on nine dates during spring and summer 1999 when river discharge was at steady state for more than a 72-hour period. They then compared these volume-of-flow data, empirically measured at the beginning (oligohaline edge) of the estuary, to data for volume-of-flow during the same time period in 1999, using the traditional approach that extrapolates from a USGS gaging station at Kinston (26 km upstream from the estuary) down to the estuary at New

Bern. This data comparison indicated that simply extrapolating the Kinston data for the estuary underestimates mass water transport to the estuary at New Bern by, on average, 38%.

The authors then developed a correction factor to adjust the traditionally measured flow data (from the Kinston USGS gaging station) taken during 1993-1998 to estimate corrected flow data, based on their shore-to-shore ADCP measurements at Mills Branch in New Bern. Using the corrected volume-of-flow data and their nutrient data from frequent sampling of the side-channel stations, the researchers calculated total nitrogen, inorganic nitrogen, and total phosphorus loadings to the estuary. They found that at the upstream transect, total nitrogen over the five-year period showed an overall increase of 16%. Inorganic nitrogen (mostly nitrate) loadings increased overall by 38%. Total phosphorus loadings decreased, overall, by 14%.

Detailed statistical analysis using both parametric (Proc ARIMA) and non-parametric (Seasonal Kendall Tau) trend analysis models showed a significant increase in nitrate concentrations, with an average increase of more than 5.5 micrograms per liter per year over the five-year study. The increase in nitrate loading was influenced by the major storms that occurred during year 4 and 5 of the study. The authors noted that in low-flow periods, nitrate was often higher in the area of the wastewater plant diffuser than at the upstream or downstream transects, but that with storms, nitrate often increased uniformly across the study area, indicating significant influence of nonpoint loadings that cannot be accounted for by exclusion of storm data from total nitrogen loading calculations.

Concentrations of chlorophyll *a* were higher in 1993-1995 because of winter blooms of benign dinoflagellates that lasted for up to two months in the study area. Winter blooms did not occur in 1996-97 and 1997-98. The authors

continued next page

pointed out that Hurricane Fran in 1996 likely washed out or buried phytoplankton cysts, and that moderate to severe storms were responsible for reduced chlorophyll *a* concentrations during those years. Thus, the authors reported that in spite of increased nitrogen loading to this generally nitrogen-limited estuary, chlorophyll *a* decreased over the study period. They noted that predictions about estuarine algal blooms on the basis of a five-year data set would have been in error on the basis of increased inorganic nitrogen, alone.

The authors also pointed out that through five years of intensive observations, they repeatedly found that algal blooms generally occurred in side-channel rather than mid-channel areas. Their side-channel, high-frequency sampling consistently showed higher mean chlorophyll *a* levels (on average, 50% higher) than monthly, mid-channel sampling done by the N.C. Department of Environment and Natural Resources and therefore has contributed important insights about phytoplankton production as well as nutrient loading in the mesohaline Neuse. They reported that climatological events control whether and when increased nitrogen will result in increased algal production, and therefore complicate efforts to predict the relationship between N loading and chlorophyll *a*. They strongly suggest that decade-long data sets with sufficient sampling frequency to capture most moderate and major storm events are needed to assess the relationship between nutrient inputs and algal production.

In another part of the study, the researchers predict increasing inputs of nutrients to the Neuse watershed from increased human and animal populations. They noted that, because of these increases, regulators should expect to have to adjust the N reduction target upward to more than 30%, over time. They pointed out that, like several other researchers before them, their study provides evidence that in the spring, the estuary shifts toward co-limitation of phytoplankton growth by both nitrogen and phosphorus, and that future manage-

ment efforts should include strengthened co-management of phosphorus as well as nitrogen.

This summary includes highlights of only parts of the full study. The complete article can be found in *Ecological Applications*, 10(4), 2000, pp 1024-1046, or contact Drs. Howard Glasgow and JoAnn Burkholder, Center for Applied Aquatic Ecology, NC State University, Raleigh, NC 27606 (howard_glasgow@ncsu.edu, telephone 919-515-3421; joann_burkholder@ncsu.edu, telephone 919-515-2726).

Study illuminates unique ecology of Waccamaw River system

In response to concerns of residents of Brunswick and Columbus counties about sedimentation, poor water quality, and biological impairment in the Waccamaw River, the N.C. General Assembly funded a series of studies. In 1995, Dr. Stanley Riggs and associates of East Carolina University in cooperation with the N.C. Department of Environment and Natural Resources initiated studies of the geologic framework, land-use patterns, and sedimentation in the Waccamaw drainage system. A report on the studies has been delivered to the N.C. Division of Water Resources, which has the report under review and has placed it on its website. The report, *The Waccamaw Drainage System: Geology and Dynamics of a Coastal Wetland, Southeastern North Carolina* by S.R. Riggs, D.V. Ames, D.R. Brant, and E.D. Sager of the East Carolina Department of Geology, can be viewed in html format or downloaded in pdf format at <http://www.dwr.ehn.state.nc.us/reports/waccamawintro.htm>

The study was aimed at providing an initial framework for understanding and integrating the complex and diverse regions and physical, chemical and biological components of the Waccamaw drainage system. The researchers began by reviewing all previous studies related

to the Waccamaw system, then moved on to describe the geology of the drainage area. They carried out a two-year field study then a one-year laboratory analysis of field data. To examine land use changes, they also conducted an analysis of old aerial photography of the area. While the study objectives also focused on describing land use changes (primarily ditching and draining of Green Swamp) and identifying sources of sedimentation, geological studies led the investigators to an important discovery that helps explain the system's ecological uniqueness. This summary focuses on that discovery, although it is only part of the full report.

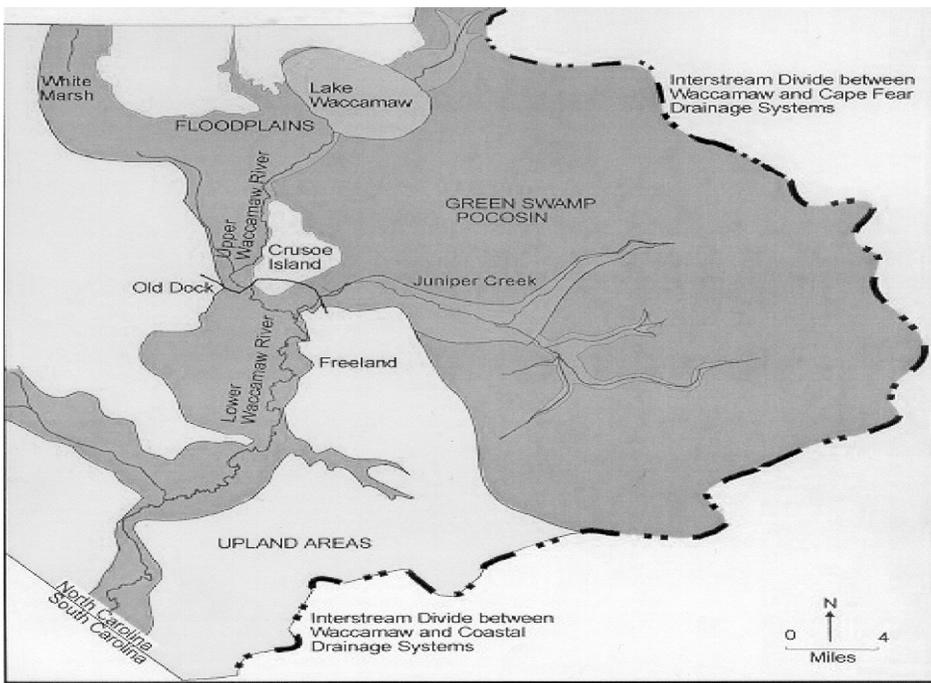
The Waccamaw drainage

The Waccamaw River drainage area is located within the Lumber River Basin, primarily within Brunswick and Columbus counties. It is located on a narrow interstream divide between the Cape Fear River system to the northeast and the Great Pee Dee River system to the southwest (see map).

The upper portion of the Waccamaw drainage system consists of the Green Swamp basin, which includes Lake Waccamaw and the upper Waccamaw River. Most of the Green Swamp is pocosin, or perched wetland. Pocosins are characterized by poor drainage that is initially determined by the large-scale geologic framework. The detailed drainage within any given pocosin is complex, poorly developed, and determined by the paleotopography and composition of underlying sediments.

Green Swamp is like a shallow saucer that is tilted gradually uphill and away from Crusoe Island. The saucer-like basin is dominated by swamps along the entire sloping surface and is broken only by a series of irregular sized and shaped sand ridges or "islands" rising above the Green Swamp wetlands.

Lake Waccamaw is one of the largest natural Carolina bay lakes (NW-SE oriented elliptical depressions) in North Carolina, but it is distinctly different from most bay lakes, having a readily weathered limestone rock bluff shoreline



and a nearly neutral to slightly alkaline pH. Because of the lake's pH, it has a remarkable array of endemic fish and mollusks.

The Green Swamp basin drains into the well-developed riverine system of the lower Waccamaw River. The juncture point of these two systems is south of Crusoe Island where the upper Waccamaw River, White Swamp and Juniper Creek all join to form the lower Waccamaw River. Crusoe Island, which is situated within the lower most portion of the Green Swamp basin, is like a stopper in a vinegar bottle, with well-developed steams flowing along both sides of the island.

Extensive reaches of the lower Waccamaw River are incised into older, underlying sediment units. The incised segments are rock bound on one or more sides and have high sediment banks with no active floodplain. In between the rock-bound stretches are river segments characterized by an actively meandering river channel and floodplain.

Interaction with the Pee Dee Aquifer

Most of Green Swamp, associated streams, and Lake Waccamaw are either underlain by or incised into the Cretaceous Pee Dee Formation, a thick sequence of calcareous cemented

sandstone, sandy moldic limestone, and tight mudstone. The clays of the Pee Dee Formation act as a seal for much of Lake Waccamaw and the surrounding Green Swamp pocosin.

However, investigators on this project found strong evidence that the Pee Dee sandstone and limestone aquifers discharge significant volumes of groundwater into the Waccamaw surface water system. Previous investigators have attributed the higher pH in Lake Waccamaw to weathering of the limestone bluff along the northern shoreline. However, calculations of chemical weathering could account for only about 15 percent of the total lake water alkalinity, leaving the majority of alkalinity within the lake unaccounted for.

Investigators on this study found indications that there is a continuous and major flow of groundwater from the underlying Pee Dee aquifer into Big Creek which drains Friar Swamp into the northeast side of Lake Waccamaw. Although they drain swamps and would be expected to be acidic (with pH of less than 5), Big Creek and its tributaries have pH's of 6.0 to 6.6. Water from the Pee Dee aquifer is alkaline, with pH ranging from about 6.9 to 9.6. A significant amount of Pee Dee groundwater

discharging into Big Creek, the authors say, would account for the elevated pH in Big Creek and Lake Waccamaw. Moreover, they note that varying relative amounts of aquifer discharge and surface water inflow from swamps into Lake Waccamaw would cause the color and pH of the lake to fluctuate, which other investigators have documented.

Throughout its course, the Waccamaw River receives water from the swamps but has a higher than normal pH for a blackwater river, providing additional evidence that the river receives groundwater discharge out of the underlying Cretaceous Pee Dee Formation. The authors also note that springs that flow from Pee Dee outcrops along river banks during low water are direct evidence that this aquifer is discharging into the Waccamaw drainage system. They say that major discharge from the Pee Dee aquifer is the primary reason for development of the unique characteristics of the Waccamaw drainage system. It is why the waters of the Waccamaw have "exceptional water quality" and are a "showcase of biological richness."

However, the authors also say they have evidence that discharge from the Pee Dee into the Waccamaw drainage is declining. Comparison of the precipitation-discharge relationship for the lower Waccamaw for two different time periods (for example, 1946-49 and 1996-1998) shows that while the precipitation pattern was generally uniform, river discharge has become flashier (higher high-flows and lower low-flows), indicating a decrease in base flow. They attribute change in base flow to drainage system modifications (ditching and draining of wetlands) and lowered water tables of both the surficial and deep aquifer systems.

In addition, the authors say that local lore commonly refers to large springs along the Waccamaw River banks that used to be far more extensive than today. Today, there are many small springs that slowly weep from river outcrops of the Pee Dee Formation, suggesting a general decline in the water table.

continued next page

Waccamaw study *continued*

The authors point out that Cretaceous aquifer system, including the Pee Dee aquifer represents an economically important source of groundwater throughout the central portion of the North Carolina Coastal Plain. It is under severe utilization pressure, with the potentiometric surface generally declining at average annual rates up to 1 to 5 meters per year in the major urban areas of Jacksonville, Kinston, Goldsboro, and Greenville. The Pee Dee Aquifer is also under severe pressure in the high growth areas of Wilmington and Myrtle Beach. Brunswick and Columbus counties and the entire Waccamaw drainage system are situated between these two major urban areas that are rapidly sprawling towards each other. This growth will result in ever-increasing pressure on the Pee Dee aquifer for high quality groundwater. Even if there is no major urban growth in Brunswick and Columbus counties, continued development of golf courses, hog farms, and agricultural irrigation are all water intensive operations.

The authors warn that if there is a decline in deep aquifer base flow through time, there will be severe impact upon the river's low-flow dynamics (the number and duration of low-flow events within the streams will continue to increase) and an overall increase in water acidity (low pH) within the lake and river waters. This change in water chemistry will threaten the biological uniqueness of Lake Waccamaw and the Waccamaw River. With time and loss of the Pee Dee input to the base flow, the Waccamaw River system will become just another black-water drainage.

The researchers also identify other threats to the unique Waccamaw system, including "ditching and draining of vast wetlands, replacement of natural, high diversity ecosystems with monoculture pine plantations, and ever-increasing amounts of runoff that contain increasing volumes of sediment, fertilizers and pesticides, and industrial and agricultural waste."

They recommend that to preserve the uniqueness of the system, a detailed basinwide study be conducted to better define the drainage system dynamics and the role of groundwater. They also recommend establishment of a Regional Water Management Council for the Waccamaw Drainage Basin to develop a watershed management plan that will include a water use plan and improvement of land use practices.

WRRRI report available

WRRRI has recently published a peer-reviewed technical completion report on a research project for which it provided funding. Single copies of WRRRI reports are available free to federal/state water resource agencies, state water resources research institutes, and other water exchange agreements have been made. Single copies of publications are available to North Carolina residents at a cost of \$4 per copy prepaid (\$6 per copy if billed) and to nonresidents at a cost of \$8 per copy prepaid (\$10 per copy if billed). Send requests to WRRRI, Box 7912, North Carolina State University, Raleigh, NC 27695-7912 or call (919) 515-2815 or email: water_resources@ncsu.edu.

Benefits of Quality Improvements in North Carolina's Water Resources Report No. 332 March 2001

*Daniel J. Phaneuf, Department of
Agricultural and Resource Economics,
NC State University*

Nearly the entire debate on water quality in North Carolina has focused on costs of implementing various regulations and policies and upon whom costs should fall. Costs, however, represent only half the story. What has received much less attention is benefits, in terms of income equivalents, of water quality improve-

ment stemming from regulation. This study is aimed at filling this void by examining a component—recreational use—of the benefits of water quality improvements at the state level.

This study uses econometric revealed preference methods to assess the monetary benefits to recreation users of water quality improvements in North Carolina. Observed visits to water resources are used to indirectly assess the value to users of the state's waterways. The emphasis is on modeling the impact of conventional nutrient pollution on water recreation site choice.

Specifically, data from a 1994 survey of water recreation use are combined with two sources of quality data to estimate a multinomial logit model of water recreation site choice. Recreation sites for this study are defined to be the 8-digit hydrological units in the state, also known as watersheds. Watersheds are defined to be surface water units that include a common drainage area, such that the characteristics of the watershed are approximately homogeneous across its expanse. Significant variation exists in watershed quality across the state. This choice set uses this variation to capture the effects of water quality on recreation decisions while abstracting from factors affecting the choice of a specific destination within the watershed.

Two structural models are estimated, one relying on water quality data from the EPA's Index of Watershed Indicators web site and the other relying on data from the STORET water quality data repository. A characterization of recreation users' preferences for water quality is estimated. From this an understanding of the importance of different pollutants in the decision process is gained. In each case chemical measures of water quality such as acidity, dissolved oxygen, nitrogen, phosphorous, and chlorophyll a are found to significantly affect recreation site choice, with users choosing to visit watersheds with better water quality.

The preference characterizations can be used to measure the benefits to recreation users of quality improvements.

Benefits are measures in income equivalents and should be interpreted as a budget-constrained willingness to pay for the improvements. For example, reducing levels of ammonia to 0.1 mg/L in surface waters across the state is found to produce a per trip benefit of \$0.24, while raising levels of dissolved oxygen to 5.0 mg/L produced a per trip benefit of \$0.94. Rough calculations of aggregate annual benefits of these policies are \$3.52 million and \$13.8 million, respectively. Still larger aggregate benefits (\$154 million) are found for similar phosphorous reductions.

For the case of improvements in individual river basins, significantly reducing levels of multiple nutrients in the Neuse and Cape Fear basins produce annual aggregate benefits of \$29 million and \$33 million, respectively. These benefits estimates should be interpreted as conservative, since they include only value held by active recreation users of water resources.

Digest

N.C. Environmental Policy Act rule amendment. April 1 was the effective date of an amendment to administrative rule 15A NCAC 1C .0402 which prohibits the N.C. Department of Environment and Natural Resources from acting on applications for permits or other DENR approvals required by a project while preparation and review of environmental documents required under the N.C. Environmental Policy Act (G.S. 113A-100 et seq.) is underway.

Catawba River endangered. American Rivers has listed the Catawba River as the 13th most endangered in the nation. The Catawba rises on the eastern slopes of the Blue Ridge Mountains in North Carolina, flows through the N.C. Piedmont to the North Carolina-South Carolina border near Charlotte, and continues to flow through South Carolina to the Atlantic Ocean. From the foothills of North Carolina to the Midlands of South Carolina, the Catawba has been dammed 11 times by hydropower

projects. According to the N.C. Division of Water Quality's Catawba River Basinwide Water Quality Plan, about half the land in the Catawba basin is forested, and about 23 percent is in urban and developed land use. Between 1982 and 1992, cultivated and uncultivated lands decreased by 26 percent, and urban and developed areas increased by about 35 percent. According to American Rivers, hydropower development, land development resulting in erosion and sedimentation, sewage spills, and water withdrawals are the Catawba's greatest threats. American Rivers says that the impacts of hydropower operations—including degraded water quality, insufficient flow to maintain aquatic habitat, and obstacles to anadromous fishes—are great. The group also says that current "first come, first-served" water allocation policy could well lead to the Southeast's next water war. Duke Energy's license to operate the 13 Catawba River hydropower projects expires in 2008, and a five-year relicensing process will begin in 2003. At that time, many river management issues in the license must be renegotiated. Senators Dan Clodfelter and Fountain Odom have introduced S 982, Catawba-Wateree River Basin Study, in the N.C. General Assembly to authorize creation of a joint interstate commission to study and make recommendations for integrated management of the river basin.

Preliminary reduction target assessment for Neuse River nitrogen TMDL. Under an agreement with the U.S. EPA settling a lawsuit brought by the Neuse River Foundation, the N.C. Division of Water Quality (DWQ) was to have presented for public comment a revised (or phase II) TMDL for nitrogen for the Neuse River Estuary by March 31, 2001. In April, DWQ released a document it says is the first step in the phase II TMDL and said that a new agreement with EPA extends the date for publicly noticing the draft revised TMDL to June 15. The April document, "Preliminary Reduction Target Assessment" addresses only the reduction target and contains no

strategy for allocating reductions among sources of nitrogen in the basin. The document provides descriptions of the two models being developed for producing the Neuse TMDL and predictions from the models as currently calibrated. Based on model predictions, the document says that a 40-45% reduction from the 1991-95 baseline loading of nitrogen to the Neuse Estuary will be needed to meet water quality goals (limited exceedances of the chlorophyll a standard). However, the document says that recent data indicate that flow adjusted concentration of nitrogen at Fort Barnwell decreased by 30% between 1995 and 1998, primarily because of advances in wastewater treatment. This means that some portion of the 40-45% reduction has already been achieved. The document says that the 40-45% reduction is not a final TMDL requirement but a preliminary estimation. Before the final draft revised TMDL is released, additional model review will take place and models will be calibrated to 2000 data. Stakeholder meetings in the Neuse Basin continue, and stakeholder input will be central to development of an allocation strategy. A copy of the Preliminary Reduction Target Assessment of the Neuse Estuary can be obtained from Chris Roessler at (919) 733-5083 Ext 506.

Graywater: How dirty is it? Water conservation enthusiasts are often proponents of using graywater for landscape irrigation. However, according to an article in the Winter 2001 issue of *Small Flows Quarterly*, recent studies show that graywater is not just soapy water. The term "graywater" has no universal definition, but in the few states that allow its reuse it includes only water from bathtubs, showers, bathroom wash basins, and water from clothes washing machines and laundry tubs. Wastewater from kitchen sinks, dishwashers, or laundry water from soiled diapers are considered too contaminated to be reused. Arizona allows the reuse of graywater but regulates the use strictly; consequently, there are few permitted

systems. The state is considering revising graywater regulations to encourage more reuse and recently completed a study of “wildcat” systems to determine the threat to public health from use of untreated graywater for landscape irrigation. Researchers found elevated levels of fecal coliform and E coli in graywater-irrigated soil. However, they concluded that if residents consider the make up of their household (households with children have more fecal coliform bacteria in graywater) and the method of irrigation (avoid areas where people will come into direct contact with the vegetation), use of untreated graywater probably poses no long-term health risks. A study of a permitted graywater system at Desert House, a residential water and energy efficiency demonstration project, found no accumulated effect of irrigation by graywater on plants or the surrounding soil except for a slight increase in boron, probably from soap. According to the article, studies show that graywater does have contaminants but that they are generally more benign than previously thought. In a number of arid states, officials are considering changes to regulations that will make it easier to reuse graywater.

Washing Machine Efficiency Standards. Among the regulations halted by the Bush administration’s January 24 memorandum on regulatory review were new guidelines on washing machine energy and water use efficiency. The rules were mandated by the Energy Policy and Conservation Act, which also set water efficiency standards for toilets, showerheads, and faucets. According to the January-February 2001 *Arizona Water Resource*, the clothes washer standards were expected to cut water use by 10.5 trillion gallons by 2030. The rules, published in the January 12 *Federal Register* would require washing machines to save 4 gallons per load by January 1, 2004, and 18.1 gallons per load by January 1, 2007. The second phase of savings is based on use of horizontal axis machines, the only ones that can achieve such efficiencies.

Poor performing low-consumption toilets. A study by the Water Resources Research Center at the University of Arizona shows that older low-flow toilets that depend on flush valve types that can be altered—such as tank dams and early-close flappers—don’t live up to water savings expectations. The study focused on low-consumption toilets installed under Arizona’s toilet rebate program in 1991-92, thus examining for the first time the effects of aging on low-consumption toilets. Authors of the study say that more than half (57.1%) of homes with 7-year-old toilets supplied through the rebate program had no detectable problems and performed as expected. However, the study revealed that toilets that achieve the 1.6-gallon flush by retaining the 3.5 gallon tank and installing a flush-valve flapper which closes before all water escapes the tank, or a toilet dam which retains water in the tank behind the dam, or a specialized tube and bell flush mechanism, performed worse than pressurized toilets or toilets with a smaller tank, standard flapper, and special bowl design to aid in flushing. Toilets with specialized tube and bell flush mechanisms performed the worst. Pressurized toilets performed the best. High on the list of problems with early-close flappers, tank dams, and specialized tube and bell toilets is replacement by homeowners of proprietary valve mechanisms with standard mechanisms and removal of dams. The report says that water savings projections used by utilities over the expected 20-year life of 1991-92 year low-consumption toilets need to be adjusted downward to incorporate a 24% higher average flush volume and a higher rate of leaks and double flushing. The study recommends that the water industry should not offer rebates or direct install programs which include toilets with alterable designs or with specialized parts for which replacements may not be readily available. It also recommends that the water industry should press through the American Society of Mechanical Engineers/ American National Standards Institute (ASME/ANSI) standards process for

toilet designs which are not alterable. The report can be downloaded in pdf format at web address: http://www.ag.arizona.edu/azwater/toilet/pg1-23_AgingULFT_final.pdf.

Director’s Forum

continued

TMDLs in the United States. Very few of the current 40,000 listed waterbodies will undergo the monitoring and modeling effort supported by the N.C. Division of Water Quality (DWQ) over the last four years. Decisions and actions are needed to address these standard violations; waiting for scientific certainty is fruitless.

The Neuse TMDL is also unusual in that, prior to submittal of the TMDL, EPA Region IV chose to undertake a costly modeling effort on top of the DWQ-supported modeling, while thousands of other TMDL needs currently exist in Region IV. In the Neuse, the early EPA intrusion has at times degenerated into a “dueling models” exercise, which is counterproductive and obscures the underlying water quality issues. The need for wiser use of EPA resources seems evident.

The DWQ-supported modeling has recently resulted in a draft TMDL calling for a 45% nitrogen load reduction from the 1991-95 base level in the Neuse. While there is evidence that some of this reduction may have been achieved by recent point source reductions, continued monitoring and analysis are essential to reduce uncertainties and lead to greater confidence in the scientific inferences.

For too long, we’ve placed undue confidence in one-time scientific studies and overly detailed, untested models. We act as if the conclusions of those studies are truth, effectively close the book, and declare the problem solved.

The adaptive approach proposed as a cornerstone of a new EPA TMDL program has the potential to take us beyond this limited perspective and lead to effective water quality management in the long run.

Erosion and sedimentation control training program targets "earth movers"

A new program aimed at teaching the "people who drive the bulldozers" how to implement North Carolina's Sedimentation Pollution Control Act (SPCA) got off to a big start in the western part of the state in February. Nearly 100 operators of excavators, graders, dozers, backhoes and other earth moving equipment attended training classes at Murphy, Franklin, Waynesville and Boone. They received instruction on requirements of the SPCA, regulations relating to wetlands and stream buffers, installation of erosion control measures, and cost and materials estimating.

The program was the brainchild of Phillip Gibson, a member of the N.C. Sedimentation Control Commission who works with Western North Carolina Tomorrow, and Mike Goodson, assistant regional engineer with the Division of Land Resources of the Department of Environment and Natural Resources (DENR) in the Asheville regional office. It was funded by the N.C. Sedimentation Control Commission.

According to Goodson, the program is an innovation in that it focuses on the earth moving community rather than engineers and other designers of erosion control plans.

Participants received a "Clear Water Contractor" decal to put on their equipment and letterhead, indicating that they have training in erosion and sedimentation control. According to Gibson, lists of those who have received the training will be maintained. The listing of those who attended the first training sessions is posted on the Western North Carolina Tomorrow website at <http://www.wnct.org/clearparticipants.htm>.

In May, the N.C. Sedimentation Control Commission approved funding to expand the training program to the Mooresville and Winston-Salem regions of DENR. For information contact Phillip Gibson at 800-621-0008.

Publications

■ The Southeast Natural Resource Leaders Group, an alliance of senior federal executives in the Southeast, have produced a report that presents some of today's environmental issues in the Southeast against a backdrop of current and past economic and societal trends and highlights some of the promising solutions emerging throughout the region. The report, *Environmental Status and Trends in the Southeast 2000*, uses a set of environmental indicators to explore the status of the region's most important natural resources. Copies of the report are available from Bob Cooper at EPA Region 4 at (404) 562-8281 or Cooper.Robert@epa.gov.

■ "North Carolina needs to be deeply concerned about the potential health impacts of global warming on its population," say Physicians for Social Responsibility in a recent report, *Death by Degrees: The Health Threats of Climate Change in North Carolina*. The reports says that over the next century, temperatures in the state could increase by 3 degrees F and precipitation could increase by 15 percent in parts of the state. Health hazards that would increase as a result of such changes include:

- Decreased air quality due to increased ozone levels leading to more frequent and severe cases of asthma and other respiratory problems.

- More injury from severe storms, hurricanes, tornadoes, lightning and floods.

- Increased allergy problems.

- More heat-related illness and death.

- More contaminated drinking water supplies and related gastrointestinal ailments linked to increased flooding.

- More cases of diseases spread by mosquitoes and ticks, such as West Nile Virus, Lyme Disease and Encephalitis.

The report can be downloaded in pdf format at web address: <http://www.psr.org/northcarolina/index.html>.

■ Harmful algal blooms (HABs) are found in the waters of almost every U.S. coastal state. A growing body of evidence suggests that HABs are increasing worldwide. There are more HAB species, more HAB events, more algal toxins, more areas affected, more fisheries impacted, and higher economic losses today compared to twenty-five years ago. The Harmful Algal Bloom and Hypoxia Research and Control Act (P.L. 105-383) called for an assessment of alternatives for reducing, mitigating, and controlling harmful algal blooms and the social and economic costs and benefits of such alternatives. A recent report by the Task Force on Harmful Bloom and Hypoxia under the National Science and Technology Council Committee on Environment and Natural Resources provides this assessment. *A National Assessment of Harmful Algal Blooms in US Waters* presents a synthesis of current research and management expertise on the causes, consequences and current status of harmful algal blooms nationwide and presents alternatives and recommendations for addressing HABs and their impacts. The report can be downloaded in pdf format at website: <http://www.habhrca.noaa.gov/>.

■ Many people look to growth in aquaculture to relieve pressure on ocean fish stocks and to allow wild populations to recover. However available scientific evidence indicates that by using increasing amounts of wild-caught fish to feed farmed shrimp and salmon and fortify the feed of herbivorous fish, some types of aquaculture are on a destructive path that poses a threat not only to wild fish stocks but also to the industry's own long-term potential. These conclusions are presented in *Effects of Aquaculture on World Fish Supplies* published by the Ecological Society of America in the Winter 2001 *Issues in Ecology*. This issue and others written for the nonscientist are available in pdf format at: <http://esa.sdsc.edu/issues.htm>.

Publications *continued*

■ **Impervious Cover and Land Use in the Chesapeake Bay Watershed.** This new report from the Center for Watershed Protection summarizes a Center study that analyzed 12 suburban land uses in four Chesapeake Bay watershed communities. The study derived impervious cover-land use coefficients that can be used along with land use data to estimate current and future impervious cover in your own watershed. Also included in the report is a method of using these numbers to estimate impervious cover, a detailed study methodology, a review of other methods of estimating impervious cover, and an analysis of research documenting the relationship between impervious cover and stream quality. The publication is available for \$20 from Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043. Phone: 410-461-8323. Fax: 410-461-8324.

■ **Adding It Up: Growth Trends and Policies in North Carolina.** The Z. Smith Reynolds Foundation recently asked the Brookings Institution Center on Urban and Metropolitan Policy to assess the state of research on growth patterns in North Carolina. Center staff made several trips to North Carolina, met with elected officials, researchers, advocates and grassroots organizations, surveyed 100 people knowledgeable about growth issues, and analyzed studies on urban and metropolitan growth in North Carolina. The report on their study summarizes what they found in the analysis of research on growth patterns in North Carolina, discusses findings, outlines an ambitious smart growth policy agenda that North Carolina should consider, and describes the research needed to underpin the implementation of the smart growth strategies suggested. The report can be downloaded in pdf format from website: <http://www.brook.edu/es/urban/ncreport.pdf>.

Conferences and workshops

Onsite Wastewater Systems Conference. June 30 - July 3, 2001. Atlanta, GA. Sponsored by the National Environmental Health Association. 24 hours of NEHA continuing education contact hours available. To download a conference brochure in pdf format go to website: <http://www.neha.org/tracks.html>.

Drinking Water Quality Conference. July 1-2, 2001. Atlanta, GA. Sponsored by the National Environmental Health Association. 12 hours of NEHA continuing education contact hours available. To download a conference brochure in pdf format go to website: <http://www.neha.org/tracks.html>

2001 Annual Meeting of the Alabama Chapter of the Soil and Water conservation Society. **“Our Changing Water-**

North Carolina Precipitation/Water Resources

	March	April
Rainfall (+/- average)		
Asheville	5.00 (+0.37")	1.32" (-2.04")
Charlotte	5.68" (+1.25")	1.18" (-1.50")
Greensboro	5.05" (+1.33")	1.81" (-1.03")
Raleigh	7.11" (+3.34")	1.72" (-0.87")
Wilmington	8.26" (+3.88")	0.91" (-1.96")

Streamflow Index Station (County, Basin)	March mean flow (CFS) (% of long-term median)	April mean flow (CFS) (% of long-term median)
Valley River at Tomotta (Cherokee, Hiwassee)	280 (66%)	191 (57%)
Oconaluftee River at Birdtown (Swain, Tenn)	573 (72%)	508 (70%)
French Broad River at Asheville (Buncombe, FB)	2,010 (69%)	1,630 (64%)
South Fork New near Jefferson (Ashe, New)	351 (61%)	300 (55%)
Elk Creek at Elkville (Wilkes, Yadkin/Pee-Dee)	72.8 (62%)	49 (46%)
Fisher River near Copeland (Surry, Yadkin/Pee-Dee)	135 (59%)	103 (48%)
South Yadkin River near Mocksville (Rowan, Yadkin/PD)	325 (65%)	199 (50%)
Rocky River near Norwood (Stanly, Yadkin/Pee-Dee)	2,000 (67%)	546 (39%)
Deep River near Moncure (Lee, Cape Fear)	2,100 (71%)	1,060 (60%)
Black River near Tomahawk (Sampson, Cape Fear)	883 (62%)	541 (54%)
Trent River near Trenton (Jones, Neuse)	303 (106%)	79.8 (47%)
Lumber River near Boardman (Robeson, Lumber)	1,440 (55%)	1,080 (60%)
Little Fishing Creek near White Oak (Halifax, Pamlico)	323 (108%)	223 (128%)
Potecasi Creek near Union (Hertford, Chowan)	261 (56%)	288 (121%)

Groundwater Index well (Province)	March depth below surface (ft) (departure from average for month)	April depth below surface (ft) (departure from average for month)
Blantyre (Blue Ridge)	35.74 (-5.07)	34.00 (-4.14)
Mocksville (Piedmont)	19.12 (-3.67)	19.24 (-3.66)
Simpson (Coastal Plain)	2.80 (+0.35)	4.60 (-0.70)

Source: U.S. Geological Survey's *Water Resources Conditions in North Carolina* <http://nc.water.usgs.gov/monthly/>

sheds: Issues in the Urban/Rural Interface. June 13-15, 2001, Birmingham, AL. For information go to website": <http://east.al.nrcs.usda.gov/alswcs/01annualmtg.html>

Websites

The **Swat-A-Litterbug Program** is an educational effort administered by the N.C. Department of Transportation's Office of Beautification Programs. Motorists and pedestrians may report incidents of litter law violations by mailing or emailing Swat-A-Litterbug report cards. Owners of vehicles reported receive a note of warning from the Department of Motor Vehicles and the State Highway Patrol reminding them of the penalty for littering and of their civic responsibility to protect the environment. The report card is online at http://www.doh.dot.state.nc.us/operations/dp_chief_eng/roadside/beautification/litterbug/default.html.

2000-2001 Water Resources Research Seminar Series

Presentations take place in the Ground Floor Hearing Room of the Archdale Building in downtown Raleigh or in Room 1132 of Jordan Hall on the N.C. State University campus. This schedule is also posted on the WRRRI website, and any changes will be posted there (<http://www2.ncsu.edu/ncsu/CIL/WRRRI/2000seminars.html>). For additional information contact Associate Director Robert Holman at (919) 515-2815 or Robert_Holman@ncsu.edu.

Presentations begin at 3 pm.

Tuesday, May 22, 2001

Jordan Hall

Technical and Economic Evaluation of Alternative Animal Waste Management

Professor Michael Overcash

Department of Chemical Engineering N.C. State University

North Carolina Progress Board 2020

Draft Goals and Measures. The Progress Board was created in 1995 by the N.C. General Assembly to track the state's progress in eight issue areas, including a sustainable environment. The Board has put its draft goals and measures on its website for citizen comment: <http://theprogressboard.org/>.

Call for Abstracts

The Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds. May 20-23, 2002. Monterey, CA. Deadline July 31, 2001. For instructions on submitting abstracts go to website: <http://www.battelle.org/environment/er/conferences/chlorcon/default.stm>.

Cut along line



WRRRI NEWS SUBSCRIPTION UPDATE (ADD? DELETE? ADDRESS CHANGE?)

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It will help tremendously if you will return changes promptly so that they can be made prior to our next mailing. If we do not hear from you, we will assume your address is correct as shown on the label.

If you know others who would benefit from receiving the WRRRI News, please ask them to send name, affiliation, address and phone number to the address below with a request to be added to the mailing list.

Return to:
Water Resources Research Institute
of The University of North Carolina
Box 7912, N.C. State University
Raleigh, NC 27695-7912

Invitation to Help the NCSU Department of Biological and Agricultural Engineering Plan Distance Learning Opportunities in the Environmental Area

The Department of Biological and Agricultural Engineering at North Carolina State University supports extensive research, extension, and academic programs in environmental engineering. However, we are approaching the limit in what we can offer in the way of workshops, graduate credit courses and programs in this area, given current resources. We are looking for ways to reach more people with our programs using non-traditional delivery methods.

One of the approaches we are considering is distance learning. This

includes workshops and classes offered through interactive, video-based classrooms, video-taped material distributed to the students and/or materials made available on the Internet (Web). In all cases, a real, live instructor will be responsible for establishing the pace, answering questions, and conducting assessments.

To help us determine the need for such programs, we have prepared an on-line survey. The survey enables you to express your interest and give us your opinion on how we should develop this

program. The survey takes less than 10 minutes to complete.

We invite you to participate in our planning process by taking our on-line survey. As an incentive, we are offering a \$10 discount on any of our extension on-line workshops.

The URL for the survey is:

<http://www3.bae.ncsu.edu/dlsurvey/>

If you have any questions about the survey or our programs, please e-mail us via the website.



2000 - 2001 Luncheon and Forum Schedule

September 17, 2001
December 3, 2001

On-Site Wastewater Issues
Flood Plain Management

All luncheon/forums take place at 11:30 am at the Jane S. McKimmon Center on the N.C. State University campus.
For additional information call Robert Holman at WRRRI (919/515-2815)

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