

N.C. URBAN WATER CONSORTIUM

The North Carolina Urban Water Consortium is a research partnership between The University of North Carolina Water Resources Research Institute and cooperating municipalities and special districts in North Carolina.

NEWS

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UNC-Charlotte researcher will compare processes for removing nutrients from wastewater

Concern about nutrient enrichment of waterbodies is growing, and, across North Carolina, wastewater treatment plants are facing stringent limits on concentrations of nutrients in effluent. To meet these limits numerous plants must add nutrient removal tertiary treatment capabilities. Before selecting a technology, wastewater managers would like to know which of several processes for removing nutrients from wastewater is most cost effective, but information on long-term steady-state operation and maintenance costs associated with nutrient removal tertiary treatment is not currently available.

Thanks to recent developments within facilities of the Charlotte-Mecklenburg Utility (CMU), the opportunity exists to develop that information.

The CMU McDowell Creek wastewater treatment plant discharges effluent to the nutrient sensitive waters of Mountain Island Lake, one of the city's drinking water supplies. The plant's latest National Pollutant Discharge Elimination System (NPDES) permit limits total nitrogen in the effluent to 10.0 milligrams per liter (mg/L) and total phosphorous to 1.0 mg/L. To meet the discharge limits, CMU has modified the plant to allow for chemical phosphorous removal and biological nutrient removal (BNR) by three different processes. In cooperation with CMU and operators at the McDowell Creek plant, a researcher and students from UNC-Charlotte and a private consultant will assess costs and performance for the various nutrient-removal configurations

possible at the plant and determine the least-cost mode for nutrient removal.

The research will be conducted in five phases, during which each biological nutrient-removal configuration (three-stage BNR, University of Cape Town/Virginia Initiative Plant Process, and Charlotte, NC Process) will be maintained at steady-state operation for six months and the chemical phosphorous removal process will be operated in conjunction with a nitrification scheme for two months. Influent and effluent levels of total nitrogen and total phosphorous will be monitored to determine the overall removal efficiency of each configuration. Power consumption related to mixing, aeration and pumping will be monitored and materials, repair, and personnel costs will be tracked for each phase.

The information on performance and operations and maintenance costs will be evaluated together to identify the least-cost mode of biological nutrient removal method for maintaining compliance with discharge permit limits at the McDowell Creek plant. By comparing these methods at one single plant, variables that might confound comparative results, such as differences in influent source and environmental factors, will not be a major source of error.

Performance and cost data from the McDowell Creek plant studies will then be compared to performance and operation and maintenance costs of nutrient removal at treatment plants operated by the City of Raleigh, City of

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Removing nutrients from wastewater

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Durham, Orange Water and Sewer Authority, and City of Greensboro. The comparisons will provide assistance to other plants in evaluating their nutrient removal processes.

Comparison of Performance and Operations and Maintenance Costs for Three Biological Nutrient Removal Schemes at a Full-Scale Wastewater Treatment Plant (50244)

Karl G. Linden, Department of Civil Engineering, University of North Carolina at Charlotte

September 1, 1998, to August 31, 1999
Funded by the N.C. Urban Water Consortium

Impacts of Diminished Water Quality on Municipal Water Treatment Costs

Results of a recent study in Texas revealed that when regional raw water contamination is present, the chemical cost of water treatment increases from a base of \$75 per million gallons (mg) to \$95 per mg. A one percent increase in turbidity was shown to raise chemical treatment costs by 0.25%.

Researchers in Nebraska, Texas, and Oregon collaborated on the study to provide information on how the volume of pollutants affect the marginal costs of treating municipal water supplies. They used three years' worth of data on 12 Texas water treatment plants that treat surface water to estimate the cost of municipal water treatment as a function of raw surface water quality. Sediment was utilized as a primary indicator of water quality. Fertilizers and pesticide levels were also measured because they attach to sediments.

For information on the study and publications resulting from it contact Dr. Bruce A. McCarl, Department of Agricultural Economics, Texas A&M University (409) 845-1706 or mccarl@scout.tamu.edu.

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Views expressed are not necessarily those of members of the Urban Water Consortium.

THE URBAN WATER CONSORTIUM

In 1985, The University of North Carolina Water Resources Research Institute in cooperation with several of North Carolina's larger cities established the Urban Water Consortium to provide a program of research and development and technology transfer on water problems that urban areas share.

Through this partnership, WRRRI and the State of North Carolina help individual facilities and regions solve problems related to local environmental or regulatory circumstances.

The Consortium program is administered by the Institute. Participant support the program through annual dues and enhancement funds and guide the program through representation on an advisory board, selection of research topics, participation in design of requests for proposals, and review of proposals.

Membership in the consortium is limited to cities or special districts in North Carolina.

Benefits of membership in the Urban Water Consortium:

- N Independent scientific research by university experts that can address specific water and wastewater problems.
- N Technology transfer through one-on-one discussions with researchers, group presentations by researchers, and peer-reviewed published technical reports.
- N Waived overhead that otherwise would consume one-third of total project costs.
- N Literature reviews of research on policy, management, and scientific topics, as requested by the Consortium.
- N Information on legislative and regulatory actions at the state and federal levels through an annual newsletter, the *Urban Water Consortium News*.
- N Opportunity for discussion of problems and issues with other municipal water and wastewater managers at regularly scheduled meetings.

Members of the N.C. Urban Water Consortium:

City of Burlington

City of Durham

City of Greensboro

City of High Point

City of Winston-Salem

City of Charlotte

City of Fayetteville

City of Greenville

City of Raleigh

Orange Water & Sewer Authority

For additional information on the Urban Water Consortium contact
Robert E. Holman, Associate Director of WRRRI at (919) 515-2815.

UNC-Chapel Hill scientist will develop model to predict bacterial regrowth in drinking water distribution systems

When drinking water leaves municipal water treatment plants, it is largely free of microbiological contaminants and is of generally high quality. However, between the time that drinking water leaves the plant and the time it flows from the consumer's tap, its quality may have declined significantly. The deterioration of drinking water quality in the distribution system is often attributed to the age and condition of pipes. Insides of water pipes may be pitted by corrosion, and the deposition of oxides of iron and other metals may line pipes with "growths." These rough surfaces are ideal places for microbes to attach themselves and form biofilms, which can then slough off bacteria that end up in tap water.

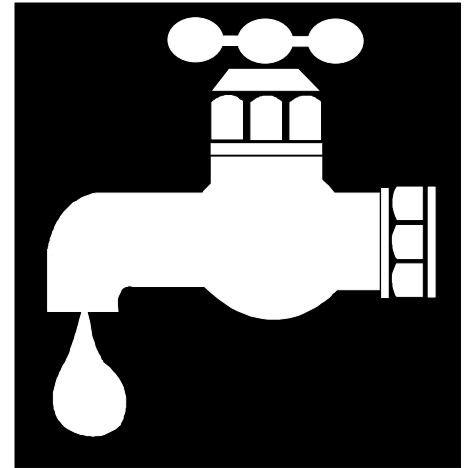
Water systems add disinfectants (chlorine or chloramine) to distribution lines at various points to try to inhibit the regrowth of bacteria in disinfected water and formations of biofilms on the pipes. However, residual chlorine in drinking water must be kept below certain levels because of concerns about formation within the distribution system of disinfection by-products, which may be carcinogenic. Therefore the amount of disinfectant that water systems typically add to distribution lines may not be sufficient to kill bacteria and prevent biofilm formation, particularly if much of the disinfectant is used up by oxidizing pipe interiors.

In addition to age and condition of pipes and level of residual chlorine, other factors have been shown to influence the growth of biofilms in distribution systems: natural organic matter content of water, nutrient concentrations, temperature, pH of water, velocity at which water flows through distribution lines, and the length of time that water may stand in an area of the system, such

as dead-end lines. In fact, research has shown that in some water systems there is a stronger relationship between the appearance of bacteria in tap water and some of these factors than between bacteria and residual chlorine levels. Because each water system is unique and because water differs from region to region across the country, it is impossible to develop guidelines for preventing bacterial and biofilm regrowth that apply to all systems. Therefore, individual water system managers need help in determining what to do to prevent growth of biofilms in their specific distribution systems and thereby protect consumers from the possibility of bacterially contaminated drinking water.

In an effort to provide this help to water systems in North Carolina, researchers at UNC-Chapel Hill have, for two years, been conducting water sampling and analysis and biofilm sampling and analysis throughout the distribution systems of the City of Durham and the City of Raleigh. The goal of their sampling has been to identify the factors most important in causing biofilm growth in these systems. Although data collection will continue for another year to provide ample data for testing a model, researchers are now performing detailed regression analyses of earlier data to determine which system and water quality factors correlate strongly with bacterial regrowth. Results of this work will feed into a new phase by helping researchers decide which variables to include in modeling efforts.

In the current project, work will focus on developing a bacterial regrowth model capable of predicting bacterial counts, disinfectant residual, and natural organic matter concentrations at locations within a distribution system. The



researcher believes that a mechanistic biofilm model that simulates the cumulative result of processes occurring "upstream" in a distribution system and accounts for uncertainty in biofilm growth, disinfection efficiency, and water velocity may be the best predictive tool. Instead of a specific value for bacterial number concentration and disinfection residual at any location, the model would provide a frequency distribution based on analysis of uncertainty. Such a model could be calibrated and verified with water quality data collected in the earlier project. The model could be used to optimize the location of sites for monitoring bacterial regrowth and disinfection residuals, to predict the effects of line flushing, and to determine the changes in water treatment practices that would improve water quality within the distribution system.

Data Collection to Support a Simplified Regrowth Model for Distribution Systems Incorporating Uncertainty Analysis (50245)

Francis A. DiGiano,
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Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill
September 1, 1998, to August 31, 1999
Funded by the N.C. Urban Water Consortium

NCSU researcher will recommend design changes for better stormwater treatment ponds



The recently adopted Neuse River Basin Nutrient Sensitive Waters Management Strategy requires that ten cities and five counties in the basin develop stormwater management plans that maintain nitrogen loading from new development at 70% or less of the 1995 loading from the previous land use (assumed to be agricultural and forest lands with an area-weighted loading rate of 3.6 pounds per acre per year), or offset loadings by paying into the N.C. Wetland Restoration Fund. As a consequence, there is a tremendous need for reliable, cost-effective measures to control nutrients in stormwater runoff from urban areas in the basin.

Wet detention ponds are the most common best management practices for reducing nitrogen and phosphorous in stormwater runoff. Wet ponds maintain a permanent pool of water and remove suspended solids and adsorbed pollutants (phosphorous among other things) by sedimentation during quiescent periods between rainfall events. In addition, dissolved nutrients (nitrogen and phosphorous) may be removed through algal uptake, growth, and subsequent settling. However, research has shown

that current wet detention pond designs often achieve less than the 30% nitrogen reduction that will be required of urban areas in the Neuse Basin. A recent survey of research on wet pond removal efficiency revealed that total nitrogen removal efficiency varied in ponds studied from minus 12% to 85%.

In previous work, NCSU researchers monitored a series of regional wet detention ponds in High Point and used the results to evaluate current wet detention pond design practices. They believe that they have identified major weaknesses in current pond design and areas where nutrient removal efficiency could be increased with little additional cost.

In this project, a researcher involved in the previous work will use a one-dimensional reservoir water quality model, CE-QUAL-R1, to help identify the major design parameters controlling nutrient removal in wet detention ponds and develop reliable, cost-effective modifications to existing designs to enhance removal. He will use the model to simulate thermal stratification, sedimentation, algal growth and nutrient uptake, and pollutant removal in wet

detention ponds, calibrating the model with data from previous studies at the High Point ponds. He will then use model to evaluate changes to primary design variables such as hydraulic detention time, hydraulic overflow rate, normal pool volume, normal pool depth, ration of mean to maximum depth, temporary pool volume, temporary pool discharge rate, and physical configuration of outlet structure. He will evaluate these changes using inflows with high nutrient loading and a lower nutrient loading in an effort to develop designs that perform well across a range of conditions. Results of these analyses will then be used to develop recommendations for increasing wet detention pond removal efficiency at the lowest cost. For example, if the analyses show that the volume of the temporary pool has minimal influence on removal efficiency, the investigator will examine whether it may be possible to increase removal efficiency by converting a portion of the temporary pool storage to permanent storage. Finally, analyses will be conducted to evaluate the effect that parameter uncertainty has on the most efficient pond configuration identified and to evaluate uncertainty in predicted removal efficiency.

Once preliminary recommendations are developed, they will be presented to State regulators and design engineers to get input on the practical application of proposed changes.

Optimization of Wet Detention Ponds for Phosphorous and Nitrogen Removal (50243)

Robert C. Borden, Department of Civil Engineering, North Carolina State University

July 1, 1998, to June 30, 1999

Funded by the N.C. Urban Water Consortium

Duke researchers will study sediment problems in Greensboro's Lake Jeanette

Lake Jeanette is a privately owned reservoir in northeast Greensboro, completed in 1943 by Cone Mills Corporation. While the reservoir contributes flow to Lake Townsend, one of Greensboro's water supply reservoirs, it is not classified for water supply. Over the last five years, areas in the lake's 7.5 square-mile watershed have been sold to residential developers, and single-family, multi-family, and commercial development has increased significantly. In spite of zoning restrictions similar to those in water supply watersheds, Lake Jeanette seems to be suffering from sedimentation and possibly nutrient enrichment.

In response to concerns from lakeshore homeowners and others, the City of Greensboro wants an objective study of sources of sediment, rates of sedimentation, and any resulting water quality problems in Lake Jeanette. This information will help develop appropriate erosion and sediment and stormwater controls not only for Lake Jeanette but also for other lakes and reservoirs in the city.

In this project, researchers will assess the extent of sedimentation in Lake Jeanette, the potential for additional sedimentation, and the current water quality and potential trophic status of the reservoir. The researchers will first conduct a preliminary analysis to determine how much sediment could have plausibly been deposited in Lake Jeanette since its construction. Using data and maps of the original area and capacity of the reservoir and sediment loading calculated using the empirical area-reduction method, they will project a range of possible sediment deposition profiles in the reservoir.

They will also directly assess current sedimentation in Lake Jeanette



and its effect on reservoir storage capacity by mapping the reservoir bottom topography using a depth sounder and global positioning system. To determine when existing sediment loads were deposited and past rates of sedimentation, they will take sediment cores and use radioisotopic dating to determine the age of the sediment profile.

To project how much sedimentation might be occurring presently and how much might occur in the future, they will survey physical characteristics, land uses, and conservation practices in the watershed and incorporate this information into a geographic information system (GIS). They will use the GIS information in conjunction with the Universal Soil Loss Equation (USLE) to estimate sedimentation potential and to compare relative sedimentation potential of existing land uses. To more directly assess sediment delivery to the lake, they will also monitor suspended solids and

flow in the main tributary, Richland Creek, and develop an empirical model to estimate sediment loading.

To assess water quality in the reservoir they will conduct summer-long monitoring of standard water quality parameters including secchi depth, suspended solids, turbidity, phosphorus, nitrogen, pH, dissolved oxygen and chlorophyll a. They will also sample twice for metals of concern for drinking water supplies. To project future water quality in the reservoir, they will incorporate data from the summer monitoring study and the erosion potential estimates from the land use assessment into Eutromod, a spreadsheet model calibrated for reservoirs in the Southeast. This model will predict a plausible range for in-lake nitrogen, phosphorus, and chlorophyll concentrations, as well as secchi depth.

At the completion of the study, the researchers will prepare a public education brochure to inform residents of the watershed of the causes and likely consequences of sediment problems in Lake Jeanette and measures that can be taken to mitigate the problems.

An Erosion and Sedimentation Study of Lake Jeanette and the Lake Jeanette Watershed, Greensboro, North Carolina (50241)

*Craig A. Stow and Sherri Cooper,
Nicholas School of the Environment,
Duke University*

June 1, 1998, to October 31, 1999
Funded by the City of Greensboro
through the N.C. Urban Water Consortium

CONTINUING RESEARCH

Assessment of metals in wastewater effluent continues

Drs. Philip C. Singer and Howard S. Wienberg of the University of North Carolina at Chapel Hill found that strictly following recommended protocol and implementing quality assurance for wastewater effluent sample collection, handling and analysis will substantially reduce the number of instances of noncompliance with standards for mercury and cadmium. They found that following protocol and enforcing quality assurance will reduce noncompliance for cyanide for most plants. However, they also found that a few plants continue to show apparent high levels of cyanide in their effluents in spite of tight protocol and quality assurance. As this project concludes, the scientists are using a new analysis system and new methodology to investigate whether the current analytical methods employed for measuring cyanide are adequate and whether chlorination/dechlorination of wastewater may produce compounds that interfere with accurate measurement of cyanide in treatment plant effluent.

Assessment of Trace Element Concentrations in Municipal Wastewater Treatment Plant Discharges in North Carolina (50210) September 1, 1995, to December 31, 1998—Funded by the N.C. Urban Water Consortium

Monitoring and evaluation of wet detention ponds continue

Drs. Robert C. Borden and Sarah K. Liehr of North Carolina State University continue to monitor and compare pollutant loadings and treatment efficiencies of two conventional wet detention ponds in watersheds with differing land uses and an artificial wetland. They are also comparing mathematical model predictions of treatment efficiencies of the structures with actual removal

efficiencies.

Evaluation of Ponds and Wetlands for the Protection of Public Water Supplies Continuation (50211)

January 1, 1996, to December 31, 1998—Funded by the N.C. Urban Water Consortium and the City of High Point

Investigation of pesticides in water supplies continues

For nearly two years, Dr. Robert E. Holman of WRRI and Dr. Ross B. Leidy of NCSU have collected samples in water supply watersheds and conducted analyses for 11 pesticides: acetochlor, alachlor, aldicarb, atrazine, carbaryl, carbofuran, chlorothalonil, chlorpyrifos, methomyl, metolachlor, and 2,4-D. In more than 5,000 samples, the investigators found no traces of five of the targeted pesticides: acetochlor, alachlor, carbaryl, carbofuran, and methomyl. The only pesticide detected in raw water above the level that EPA has set for finished drinking water was atrazine. In phase II of the study, the investigators attempted to further isolate the sources of atrazine through intensive water column and sediment monitoring during the spring. Bench-scale powdered activated carbon (PAC) studies are being conducted to determine what levels of PAC are needed to reduce pesticides such as atrazine to below detection levels in treated water.

Evaluation of Pesticides in Water Supply Watersheds (50218/33)

April 1, 1997, to December 31, 1998—Funded by the N.C. Urban Water Consortium

Demonstration of biosolids uses continues

Dr. James E. Shelton of North Carolina State University concludes his four-year project to identify and promote appropriate uses for compost made with wastewater "biosolids" by conducting demonstra-

tion and education activities for farmers, Cooperative Extension agents, and others.

Evaluation of Wastewater Biosolids Compost for Production of Agronomic and Horticultural Crops (50193)

January 1, 1994, to December 31, 1998—Funded by the Charlotte-Mecklenburg Utility through the N.C. Urban Water Consortium

Manual for biosolids uses being developed

Dr. James E. Shelton continues the effort to promote agricultural and horticultural use of composted biosolids by developing and producing a manual of use guidelines to be made available to producers through the Cooperative Extension Service and trade groups. **Manual for Best Management Practices for Compost Utilization** (50227) March 1, 1997, to August 31, 1998. Funded by the Charlotte-Mecklenburg Utility through the N.C. Urban Water Consortium

Investigation continues of effects of algae on drinking water treatment

Drs. Detlef Knappe, Sarah Liehr, and JoAnn Burkholder of NCSU continue their efforts to find the best ways to treat—for drinking water purposes—raw water that contains algae, to determine what can be done to control algae in reservoirs, and to determine whether toxic forms of algae could threaten water supplies in Piedmont North Carolina. A survey of water treatment plants in the state has suggested that a majority experience problems with algae and that unpleasant taste and odor, filter clogging, increased chlorine demand, and increased coagulant demand are the problems most often associated with algae blooms. The survey also indicates that the most problematic alga is *Ana-*

baena. An evaluation of in-vivo fluorometry (IVF) has shown that the technique is suitable for monitoring chlorophyll *a* concentrations at levels commonly observed in drinking water sources. Jar tests have shown that ferric sulfate in combination with an anionic polymer is highly effective for algae removal under sweep floc conditions (pH 7.5). As the project continues, the scientists will examine the effect of potassium permanganate, an algicide, on cell lysis and release of intracellular compounds; evaluate dissolved air flotation and the ACTIFLO Process for the removal of algae; conduct pilot scale testing of various methods for removal of algae; verify the results of bench- and pilot-scale studies with full-scale measurements at three water treatment plants; conduct a survey of reservoir water quality and algae control practices at participating utilities; and perform bench-scale experiments to evaluate the effect of nutrients on production of algal toxins.

Optimization of Treatment to Mitigate Impacts of Algae and Algae Control on Finished Water Quality (50215/7)

December 1, 1996, to May 31, 1999
Funded by the N.C. Urban Water Consortium and the American Water Works Association Research Foundation

Investigation continues of causes of bacterial regrowth in distribution systems

Drs. Francis A. DiGiano and Donald E. Francisco of UNC-Chapel Hill continue sampling and analyzing water and biofilms from tappings from the City of Raleigh and City of Durham water systems to identify the factors most important in causing bacterial regrowth in small- and medium- sized water distribution systems in the Southeast.

Bacterial Regrowth in Drinking Water Distribution Systems: A Comparison of Durham and Raleigh (50212)

July 1, 1996, to August 31, 1998.
Funded by the Urban Water Consortium

AWWARF reports on study of conservation programs

A report recently published by the American Water Works Association Research Foundation (AWWARF) indicates that water demand is much more price-inelastic than has been suggested in other studies and that managing water demand by pricing requires new strategies.

The study was sponsored by AWWARF and Water Resources Research Institutes in western states. It was designed to discover how residential consumers respond to water conservation efforts by municipal water suppliers and if consumers in different cities respond similarly.

The study looked at both price programs (i.e. increases in price levels and/or rate structures where costs increase with amount consumed) and nonprice programs (i.e. education, rebate/retrofit, drought ordinances, plumbing codes). Utilities nationwide are increasingly using both kinds of programs in efforts to reduce residential demand. By 1994 the number of water providers using declining rate had dropped from a 1986 high of 60 to 40 percent and the number using inclining rate structures had increased from a 1986 low of 8 percent to 22 percent. Nonprice programs are used as substitutes for or in addition to price conservation programs.

Investigators collected, evaluated and compared information on the effects of price and nonprice programs on residential consumption in seven different urban areas of the southwestern United States. They developed three water demand models to investigate consumer response: (1) one to investigate whether consumers in a region respond similarly; (2) one to investigate seasonal variations in response across a region; and (3) one to investigate whether consumer response is city and season specific. Although all three models predicted demand with a high degree of

accuracy, the city/season-specific model was statistically a "better fit," indicating that the conservation program that works in one city may not necessarily be effective elsewhere.

The statistical modeling also showed that while water price has a significant and negative impact on water use, water demand is very price-inelastic. The highest elasticity (about -0.20) was for summer use. This indicates that water utilities could double their water rates and expect at most a 20-percent decrease in water use during the peak season.

Statistical tests to determine whether consumers perceive and respond to marginal prices or average prices were inconclusive. The authors say that consumers appear to respond to some kind of combination of marginal and average prices, making it difficult to design effective rate structures. They say the mixed response is, in part, a result of the use of fixed service charges along with uniform or block rate structures which keep average prices declining as consumption increases, even when marginal prices are rising. According to the authors, the results indicate that utilities interested in using price to encourage conservation should re-examine the incentive provided by their rate structures and, specifically, focus on reducing or even eliminating the fixed charge component.

The study showed that nonprice conservation programs appear to be effective if the water utility achieves a "critical mass" of programs. However, an overall lack of information about implementation of nonprice programs and the resulting changes in demand makes it inadvisable to simply apply approaches developed by one city in another city. The report, *Effectiveness of Residential Water Conservation Price and Nonprice Programs*, is available from AWWARF.

Utilities should anticipate increasing problems with affordability of water and sewer service

Through surveys, the U.S. EPA has determined that 4 percent of gross income is an affordable amount for a household to spend on water and sewer service combined. According to this standard, a four-person household in North Carolina earning the median income of \$3,558 a month could afford a water/sewer bill of \$142 a month. Few North Carolinians face water and sewer bills this high. In fact, EPA says that average-user median-income households across the country spend only 1.1 percent of monthly income on combined water and sewer bills.

However, in many municipalities in North Carolina, a family supported by a single minimum-wage earner—which would be considered living below the poverty line—could easily see its monthly water and sewer bill demand 4 percent or more of its monthly income of \$708. Families relying on Aid to Families with Dependent Children could pay 10 percent or more of their assistance income for water and sewer service.

There are now more U.S. households living in poverty than at any time in the past 20 years. In 1995, 12.6 percent of North Carolinians, or about 935,550 people, were living below the poverty line.

At the same time, water and sewer rates have risen. According to the Raftelis Group's 1998 Water and Wastewater Rate Survey, between 1995 and 1997 the median increase in bills for an average residential customer using 1,000 cubic feet of water per month was 12.3 percent, and the increase for wastewater service was 3.5 percent. In some municipalities in North Carolina, the increase has been much greater.

Moreover, environmental and health regulations, the need to repair and replace aging infrastructure, and inflation will see to it that water and sewer costs continue to rise.

This set of facts should alert utilities to the possibility that increasing numbers of low-income customers will be unable to pay utility bills on a timely basis, according to a recent report from the American Water Works Association Research Foundation. The report points out that water utilities have not historically had to contend with the complex socioeconomic situation facing their low-income customers because in most places water has been a relatively inexpensive commodity for many decades.

However, says the report, utility managers must understand the various consequences of the widening gap between water bills and low-income households' ability to pay—including, increased collection costs, rising levels of arrearages and numbers of accounts with arrearages, an increased number of terminations of water service, and swelling criticism from various sectors of the community. As the rate crisis spreads to more and more communities, managers should prepare themselves and their constituencies for an orderly, rational introduction of measures to address the problem of unaffordability of basic water and sewer services.

To help utility managers cope with the gap between water rates and the ability of low-income households to pay water bills, AWWARF conducted a survey of methods of rate design, billing and collection that can be used to reduce arrearages and address the needs of low-income customers. The results of the study are published in the report *Water Affordability Programs*.

The report includes a "Quiz for Water Utility Managers," which managers can use to determine if a system's rates are unaffordable to a significant portion of the customer base. It then presents affordability models that can be used to maximize a utility's total revenue.

Presented are five different rate structures that can be considered affordability plans:

- 1) Waiving the customer service charge on low-income customers' bills
- 2) Offering a discount on the usage charge to low-income customers so that they pay a lower rate per unit of water usage
- 3) Providing low-income customers with a discount on the entire water bill
- 4) Charging eligible customers on a block rate—the first block, a discounted essential amount of water based on average household size; the second block, usage above the essential amount charged at the regular rate
- 5) Same as 4 except basing the essential amount on the actual household size

The report evaluates (1) how effective each of the five models may be in making water/sewer affordable for low-income households, (2) what detrimental effects each model might have on some portions of the low-income population, and (3) what might be the increased costs to the utility.

Also explored are other ways to help make water affordable including: (1) monthly billing, (2) budget billing, (3) appropriate charges (such as late charges and dis/re-connect charges) (4) arrearage management plans, (5) conservation assistance, (6) sewer rate structures, and (7) sources of assistance (such as customer-based funds and government and charitable assistance).

The report also looks at cross-subsidization issues, the legality of water affordability programs, and eligibility issues. It is available free to members of AWWARF and for a fee to others. Contact AWWARF at (303) 347-6100 and ask for publication number 1P-3C-90732-7/98-CM.

NEWS

a digest of recent and relevant events

Floodplain management authority. On Sept 23, the N.C. General Assembly passed HB 1260, An act to restore the authority of local governments to adopt floodplain management ordinances. The act amends G.S. 143-138(e) to provide that local governments may adopt floodplain management regulations within their jurisdictions regardless of whether the N.C. State Building Code has approved the localities' floodplain building codes. The act says that "Local floodplain regulations may regulate all types and uses of building or structures located in flood hazard areas identified by local, State, and federal agencies, and include provisions governing substantial improvement, substantial damage, cumulative substantial improvements, lowest floor elevation, protection of mechanical and electrical systems, foundation construction, anchorage, acceptable flood resistant materials, and other measures the political subdivision deems necessary considering the characteristics of its flood hazards and vulnerability."

Durham stormwater suit. In July the N.C. Supreme Court upheld the City of Durham's authority to impose fees to operate its stormwater program, reversing a decision by the State Court of Appeals. The suit was brought by Smith Chapel Baptist Church, Fellowship Baptist Church, Layman's Chapel Baptist Church and Calvary Baptist Church of Durham. These plaintiffs contested the program established by the City of Durham to comply with the Clean Water Act NPDES stormwater permitting program. The City of Durham adopted an ordinance and created the Durham Stormwater Utility to receive fees, based on the impervious areas of assessed lands, to operate a stormwater program. The plaintiffs alleged that the city did not have the authority to impose fees to operate its stormwater program, that the

method by which fees were to be calculated is unlawful, that the rates set by the city were discriminatory, and that a fee for utility service must be commensurate with services rendered while evidence showed there was virtually no benefit to them. With Lake and Orr dissenting, the Justices rejected all the plaintiffs' arguments and remanded the case for entry of a judgment for the defendant. In the slip decision, the court found that it is not discriminatory to set fees based on the amount of pollution caused by a lot and that it is not arbitrary and capricious to require those who cause a stormwater problem to pay for it. The slip decision can be read on the Supreme Court of North Carolina web site. Direct address is <http://www.aoc.state.nc.us/www/public/sc/slip/slip98/250-97-1.htm>

Raleigh total nitrogen reduction. The Neuse River Basin Nutrient Sensitive Waters Management rules require the City of Raleigh's wastewater treatment plant to reduce the nitrogen it discharges to the Neuse River by 49% by 2003. However, Raleigh expects to meet its reduction goal by 1999. In 1996, the Raleigh City Council approved an \$8 million denitrification facility for the Neuse River Wastewater Treatment Plant (NRWTP). Work on the facility is scheduled to be finished by November, but, as of July, phasing in of the facility had already decreased Raleigh's year-to-date total mass nitrogen loading by 11% from the same period in 1995, which is the year the State uses to benchmark the reductions required. This total loading reduction has taken place at the same time the plant has been treating more and more wastewater. In 1998, the NRWTP treated 5.2 million gallons per day more than it had the year before and 6.4 million gallons per day more than it did in 1995. As of August, the plant's mass loading was 69% less than it

had been in August 1995. Based on recent performance, Raleigh Public Utilities Director Dale Crisp projects that the plant will discharge a total of about 955,000 pounds of total nitrogen in all of 1998. This would represent a 27% reduction from the 1995 total of 1,317,067 pounds of total nitrogen.

Water reuse projects in North Carolina. In August, the City of Raleigh announced that it will initiate a water reuse project to reduce the volume of treated wastewater it discharges into the Neuse River. A water pumping station and distribution pipeline extension will be built at the Neuse River Wastewater Treatment Plant, and treated wastewater will be pumped to a nearby golf course to be used for irrigation. In addition, the city will irrigate 1,000 acres of city-owned and leased land with wastewater effluent. The project will cost \$376,000, \$200,000 of which is being provided by an appropriation from the N.C. General Assembly through a grant from the Lower Neuse Basin Association. When the project comes on line in April 1999, it will initially pump 800,000 gallons of water for reuse, but the City of Raleigh has committed another \$1.5 million for additional pumps and distribution lines to boost reuse to 5 million. In Charlotte, the Charlotte-Mecklenburg Utility expected to see its first water reuse project activated the week of October 8. Treated wastewater will be pumped 5 miles from the Mallard Creek Wastewater Treatment Plant to the Tradition Golf Course, a private facility built on land leased from the county. The golf course will use about 400,000 gallons per day for irrigation. Later, the county will also use treated wastewater to irrigate recreational fields now under development at the nearby park. CMU has developed this reuse project at a total cost of about \$3 million.

Draft plan for N.C. Source Water Assessment Program to be available soon

The 1996 amendments to the Safe Drinking Water Act require states to conduct assessments of the vulnerability of all public water supply sources to contamination and to make the results available to the public. However, states must first develop a plan for conducting their Source Water Assessment Programs (SWAP) and submit plans to the U.S. Environmental Protection Agency by February 6, 1999.

Each state SWAP plan is required to detail how the state will:

- N Delineate source water protection areas
- N Inventory significant contaminants in these areas, and
- N Determine the susceptibility of each public water supply to contamination.

Each plan must contain four sections:

- N A description of the approach the state will take to implement a Source Water Assessment Program, including goals for the plan consistent with national goals of protecting and benefitting public water supplies.
- N A description of how the state achieved public participation in developing its plan.
- N A description of how the state will make the results of assessments available to the public.
- N A description of how the state will implement its chosen approach to the SWAP.

With help from a citizens and technical advisory committee, the N.C. Public Water Supply Section has been developing North Carolina's required plan for the State's Source Water Assessment Program (SWAP). In two day-long meetings state staff and the advisory committee have discussed and agreed upon:

N Methods for delineating source water protection areas for surface water sources and groundwater sources.

N Methods for completing the required contaminant inventory for each source area.

N A plan for public participation in the SWAP.

N Plans for public dissemination of results of source water assessments.

At the time this article was written (early October), complete consensus had not been reached on methods for assessing the susceptibility of each public water supply source to contamination, but subcommittees were continuing to meet to work out differences.

The draft plan that will result from these development sessions will be sent to the SWAP Technical and Citizens' Advisory Committee prior to its final meeting on Thursday, November 5, 1998, at the Parker-Lincoln Building on Capital Boulevard in Raleigh.

Following any final changes or refinements to the draft by the advisory committee, the draft plan will be presented to the public at three public meetings (in the mountains, Piedmont and Coastal Plain) to be held in December.

Following internal review by the Department of Environment and Natural Resources—which will include responding to comments received at public meetings—the plan will be submitted to EPA for approval.

According to Public Water Supply Chief, Jessica Miles, North Carolina will submit a plan that uses the maximum time available—three and one-half years from the time the plan is approved—to complete its source water assessments.

Phased susceptibility assessments and opportunity for system operator comments

At this point, the draft plan calls for assessments of the susceptibility of public water supply sources to contamination to be done in two phases.

A phase one assessment will be completed for all system intakes (or wells). Phase one assessment will include an evaluation of the inherent vulnerability of a water source coupled with an evaluation of potential sources of contamination within the delineated assessment area.

After the phase one assessment, systems could be assigned a letter rating (A,B,C,D,E based on degree of susceptibility) or their susceptibility matrix could simply be published without a comparative rating. This is a point of disagreement among the advisory committee and an issue that may be settled by EPA.

When phase one assessments have been done, they will be made available to water systems for comment. System operators will be able to provide additional information about contaminant sources that might affect their susceptibility evaluation. Following a comment period for systems operators, results of the phase one assessments will be released to the public.

At the same time, the most susceptible 40 percent of surface water intakes and the most susceptible 20 percent of groundwater intakes will be receiving a phase two assessment. The phase two assessment will involve a more detailed evaluation of contaminant sources and the risk they pose.

At this time, there is disagreement whether the phase two assessment should result in a relative risk level assignment—such as higher, moderate, or lower—or simply be presented as a table of evaluation information. Again, EPA will make the final decision, and,

according to Jessica Miles, will probably insist on the relative risk ranking.

Miles also said that systems may be provided opportunity for a quick review of phase 2 assessments before their release to the public. This is another issue to be worked out before the draft plan is complete.

Early in the SWAP implementation process, the Public Water Supply Section plans to conduct pilot studies to evaluate the susceptibility determination procedure. Several pilot studies will be conducted in systems selected to represent different physiographic regions of the state and different types of water systems.

Now is the time for public water system operators to learn the details of the state's draft plan for its Source Water Assessment Program and provide input for the final plan. For a draft plan and information on the November 5 meeting of the SWAP Citizens and Technical Advisory Committee, contact Elizabeth Morey at (919) 715-0674 or email Elizabeth_Morey@mail.enr.state.nc.us.

UNC-CHAPEL HILL ENVIRONMENTAL FINANCE CENTER

The U.S. Environmental Protection Agency has awarded a \$65,000 grant to establish an Environmental Finance Center at the University of North Carolina at Chapel Hill.

Environmental Finance Centers provide finance training as well as educational and analytical services designed around the "how to pay" issues of environmental compliance. The new UNC-CH center is one of a network strategically located at major universities throughout the country. It will be jointly administered by the Department of City and Regional Planning and the Institute of Government. Co-directors are Michael Luger of DCRP and Richard Whisnant of IOG.

The UNC-CH Environmental Finance Center will focus on regionalization issues. For additional information, contact Richard Whisnant at (919) 962-9320.

Potential effects discussed

General Assembly amends water supply and interbasin transfer laws

In September, the General Assembly approved changes to state statutes governing withdrawal of surface and ground waters, submission by local governments of water supply plans, development and updating of a state water supply plan, and transfers of water from one river basin to another.

Senate Bill 1299, An act to amend the laws regarding the withdrawal and transfer of surface waters and the state water supply plan, provides the following:

N Adds to the statement of state's public policy that cumulative impact of transfers from source river basin must not result in violation of antidegradation policy set out in 40 CFR Sec. 131.12 and the state antidegradation policy.

N Amends GS 143-215 (a) to require the Environmental Management Commission (EMC), in developing water quality management plans for major river basins in the state, to consider impacts of all transfers into and from a river basin that must be registered under GS 143-215.22H

N Amends GS 143-215.22H to reduce from 1,000,000 to 100,000 gallons per day the amount of water for which ground or surface water withdrawals or transfers (withdrawal/discharge) must be registered. This requirement becomes effective March 1, 2000, and the amount registered is to be based on water withdrawn or transferred during the 1999 calendar year.

N Exempts agricultural activities from registration requirements for less than 1,000,000 gallons per day.

N Adds GS 143-215.22I9f)(2a) to

require that in deciding whether to issue a certificate for a water transfer, the EMC must consider the cumulative effect on the river basin of any water transfer or consumptive water use that is already occurring, is authorized under GS 143-215.11I, or is projected in any local water supply plan.

N Clarifies that an environmental assessment must be prepared for any petition for an interbasin transfer certificate and that anyone who petitions the EMC for a water transfer certificate must pay the cost of the special studies needed to comply with State Environmental Policy Act provisions concerning environmental assessments or environmental impact statements, if determined necessary.

N Provides that any certificate granted for interbasin transfer must include a drought management plan that specifies how the transfer shall be managed to protect the source river basin during drought conditions.

N Provides that when any transfer for which a certificate has been granted reaches 80% of the maximum amount authorized, the applicant must submit to the Department of Environment and Natural Resources (DENR) a plan showing how the applicant's future foreseeable water needs will be met. This plan is to be an amendment to the applicant's local water supply plan. Provides that when the transfer equals 90% of the maximum amount authorized, the applicant shall begin implementing the plan.

N Removes the provision that prepara-

continued next page

tion of local water supply plans are required only to the extent that technical assistance is available from DENR and requires that all local governments that provide or plan to provide water service submit a local water supply plan by January 1, 1999.

N Provides that updated local water supply plans include a statement of the current and anticipated reliance by the local government unit on surface water transfers as defined by G.S. 143-215.22G.

N Provides that by Jan 1, 2000, DENR must develop a state water supply plan that identifies any area in the State that appears to face existing or future water shortages, conflicts among water users, or depletion of water resources. Requires plan be updated very five years.

Except for the change in amount of water required to be registered, provisions of the act became effective October 1, 1998.

Effects of the new provisions

According to Tom Fransen with the N.C. Division of Water Resources (DWR), many of the new provisions of the interbasin transfer law were included to clarify issues about which there had been disagreement.

For one thing, Fransen said, some transfer certification petitioners had maintained that the law did not require a SEPA (State Environmental Policy Act) environmental assessment (EA), while DWR had maintained that it did. The new amendments settle that issue by specifying that an EA (or perhaps an Environmental Impact Statement) is required and that the petitioner must pay for it.

Another point of disagreement between DWR and petitioners or other interested parties had been the inclusion of consumptive uses in calculating the quantity of an interbasin transfer. When administrative rules were adopted by the EMC for implementing the interbasin

transfer law (15A NCAC 2E .0401), a definition was adopted for “transfer” that reads: “withdrawal, diversion, or pumping of surface water from one river basin and the discharge or all or any part of the water in a river basin different from the origin,” which is essentially the same definition contained in the law. However, the rule specifies that a discharge associated with a transfer “shall include any release, disposal, or use of water that is not returned to the source basin.”

Some (including the City of Durham’s Environmental Resources Director Terry Rolan) had argued that this additional provision in the rule was at odds with the intent of the law because it regulates consumptive uses only for systems that need interbasin transfer certificates.

While the new amendments do not directly address whether “transfers” include consumptive uses, a new provision requires the EMC to consider cumulative effects of transfers and consumptive water uses when determining whether or not to grant transfer certificates. This provision, said Tom Fransen, lends support to DWR’s interpretation of legislative intent.

Fransen said that amendments lowering the threshold for required registration of water withdrawals and transfers will allow DWR to more accurately estimate quantities of withdrawals and transfers. More accurate estimates will be needed to assess cumulative impacts. Terry Rolan, however, questions whether current water quality models can adequately represent the effects of such small volumes on the assimilative capacity of source basins.

Rolan also points out that exempting agriculture from registering withdrawals less than 1 MGD creates a double standard for agriculture and small rural water systems.

Moreover, he said, the ultimate effects of the law won’t be known until data have been collected at the 100,000 gallons-per-day level and regulation based on cumulative withdrawals begins.

“At my last count, there are about 80 plus counties in North Carolina that have major river basins as defined in the law running through them. For small countywide water systems, the new law may have major impacts in the future that are not even recognized today. There is also the issue of non-discharging systems like septic tanks that serve most county systems where little or no water returns to the basin of origin, at least not directly. There is no way that they [General Assembly] could adequately address the potential [economic] impact that this bill could have on local governments, especially the smaller ones.”

Toward statewide water withdrawal permitting?

While Terry Rolan questions the fairness of regulating consumptive uses for some water systems and not for others, Dr. David Moreau, now chairman of the N.C. Environmental Management Commission, has questioned the logic of regulating interbasin transfers and not consumptive uses in general.

In a 1993 North Carolina Water Resources Association forum on interbasin transfer Moreau asked, “What’s the difference between interbasin transfers and large consumptive uses? What’s the difference to fish? What’s the difference to industry on a river? Why should these two kinds of uses be considered separately?”

The answer, Moreau said, lies in claims to water rights. Because the Doctrine of Riparian Rights, which the eastern United States has traditionally relied upon, no longer provides an adequate basis for water allocation, eastern states are now involved in replacing riparian rights with administrative processes.

The fact that some states have already adopted statewide permitting of water withdrawals suggests that North Carolina is just beginning a process of defining water rights and that interbasin transfer is only the first of many water rights issues that will eventually have to be addressed and readdressed by legislation.

General Assembly revises annexation laws

On September 14, the N.C. General Assembly ratified House Bill 1361, An Act to revise the municipal annexation laws and to change the criteria to be considered by the joint legislative commission on municipal incorporations. Governor Hunt signed the bill on September 23 (Session Law 98-0150). Following is a summary of the primary provisions of the law:

N Enacts new GS 120-169.1 (regarding criteria to be considered by the Joint Legislative Comm'n on Municipal Incorporations) to prohibit Comm'n from making a positive recommendation for incorporation unless

- (1) the entire area meets the criteria for development under GS 160A-36(c) or 160A-48(c) (regarding area's urban development character), and
- (2) the plan for incorporation proposes to provide at least two of the following services: police protection; fire protection; garbage collection or disposal; water distribution; sewer collection or disposal; street maintenance or construction; street lighting; citywide planning and zoning.

N Makes following changes to procedures for annexations by cities:

M Amends GS 160A-35 and 160A-47 to provide that in areas where the installation of sewer is not feasible, the municipality may agree to provide septic system maintenance and repair.

M Amends GS 160A-36 and 160A-48 to provide that in considering whether a proposed area for annexation meets the urban development requirements, a tract may not be considered in use for a commercial, industrial, or institutional purpose if the tract is used only temporarily or incidentally for that purpose, and to provide that areas of streets and rights-of-way may not be used to determine total acreage under these statutes. Further provides that an area may be considered developed for urban purposes if all tracts in the area are used for commercial, industrial, governmental, or institutional purposes, and that in fixing the new municipal boundaries recorded property lines and streets must (now, may) be used.

M Amends GS 160A-37 and 160A-49 to provide that not less than 45 days and not more than 55 days after adopting a resolution of intent to annex, the municipal governing board must hold an informational hearing at which the report on the area to be annexed is explained and interested parties are given an opportunity to ask questions. Requires that not less than 60 days nor more than 90 days following passage of the resolution, a public hearing on the proposed annexation must be held. Requires that notice of public hearing include an explanation of property owners' rights under present-use exemptions. Requires that annexation report include statement showing how the proposed annexation will affect the city's finances and services and that the statement be delivered to county clerk at least 30 days before the information hearing.

M Amends GS 160A-37(I) to require that resolution identifying area under consideration for annexation also include statement notifying persons subject to annexation of their rights under present-use appraisal statutes.

M Further provides that if there is land in the area to be annexed that qualifies for use-value taxation as farmland, forest land, or horticultural land, and is in actual production but that is not being taxed at use-value, the annexation becomes effective as to that land as follows:

- (1) upon the effective date of the annexation ordinance, the property is considered part of the city only (a) for the purpose of establishing city boundaries for additional annexations, and (b) for the exercise of city planning and zoning authority;
- (2) for all other purposes, the annexation becomes effective as to each tract of such property or part thereof on the last day of the month in which the tract or part thereof becomes ineligible for use-value taxation and until annexation of a tract or part of a tract becomes effective pursuant to this provision, the tract or part is not subject to property taxation by the city, nor entitled to city services.

M Further provides that if, within 60 days after the effective date of annexation, a city fails to deliver police, fire protection, solid waste, or street maintenance services to a newly annexed area on substantially the same basis as they are provided to the rest of the city, an owner of property in the area may petition the Local Government Comm'n for abatement of the city taxes levied. If the Comm'n finds that services were not extended, it must order the city not to levy any further taxes on the property until the fiscal year commencing after extension of the municipal services.

N Amends GS 160A-37.3 and 160A-49.3 (regarding contracts with private solid waste collection firms) to provide that a firm forfeits its rights under the statute if it fails to make a good faith response within 10 business days following receipt of the written request for information from the city. Amends 160A-49.3 (h) to require firms providing notice to the city under that subsection to do so by certified mail, return receipt requested.

N Amends GS 160A-38 and 160A-50 to extend the period for filing an appeal of an annexation from 30 days to 60 days after enactment of the annexation ordinance.

N Amends GS 160A-42 and 160A-54 to provide that, in reviewing an annexation, a court must accept the estimates of the municipality unless the land area or degree of subdivision falls below the standards of GS 160A-36 or 160A-48 (degree of urban development).

N Amends GS 105-277.4(b) to require tax assessor to make determination of eligibility for present-use value designation within 30 days of request.

Makes additional technical and conforming changes. Effective Nov. 1, 1998; applies to annexations for which the resolution of intent is adopted on or after that date.

This report was compiled from the Institute of Government's *Weekly Bulletin* reports. It is not meant to be a complete description of all the law's provisions and should not be relied upon for compliance purposes.

La Niña said to increase risk of drought in North Carolina

Every two to seven years, when the steady westward blowing trade winds weaken, or even reverse direction, a large mass of warm water normally located near Australia moves eastward along the equator until it reaches the coast of South America. The displacement of so much warm water affects evaporation, causing the formation of rain clouds and altering the typical atmospheric jet stream patterns around the world. During such an “El Niño” event, the jet stream over the United States is oriented from west to east over the northern Gulf of Mexico and northern Florida. Displacement of the jet stream brings abnormally large amounts of rain and flooding to the West Coast and severe weather to the region around the Gulf of Mexico and northern Florida (although hurricane activity is usually minimal in the Atlantic). The impacts of El Niño are most dramatic in winter. El Niño produces winters that are generally mild in the northeast and central United States and wet over the south from Florida to Texas.

The 1997-98 El Niño

In early 1997 an array of buoys in the Central Pacific—called the El Niño tripwire system—detected a very large volume (enough to cover the lower 48 states to a depth of about 3300 feet) of hot water (85-90 degrees Fahrenheit) travelling eastward from Indonesia. The media, alerted by reports from NOAA and other agencies, made a beeline for California, where they spent nearly six months waiting for the El Niño-related weather disasters.

The 1997-98 El Niño was predicted to be the strongest of the century, outdoing the 1982-84 El Niño that triggered fierce winds, heavy rains and mammoth waves along the California coast, eroding beaches, damaging the Santa Monica Pier, wrecking homes, and causing mudslides. California was

battered during the winter of 1997-98 but just how badly is not clear.

Also attributed to the 1997-98 El Niño are record-breaking warm temperatures during December 1997 to February 1998 in the U.S. Midwest, with more snow falling in Mississippi than in Minnesota during December. In addition, much of the Southwest had cooler and wetter than normal weather, and in Southern Arizona, the desert bloomed spectacularly during mid November 1997 to March 1998.

Generally, temperature and precipitation records and anecdotal evidence indicate that the 1997-98 El Niño was very strong, although a complete analysis of the climatological and economic effects of the year-and-a-half long event is not available.

However, even before the 1997-98 El Niño epitaph is written, oceanographers and climatologists are warning of a developing La Niña, or cold phase, which tends to bring nearly opposite effects of El Niño to the United States.

La Niña

El Niño and La Niña are extreme phases of a naturally occurring climate cycle referred to as El Niño/Southern Oscillation (ENSO). Both terms refer to large-scale changes in sea-surface temperature across the eastern tropical Pacific. During La Niña the easterly trade winds strengthen, and cold upwelling along the equator and the west coast of South America intensifies. Sea-surface temperatures along the equator can fall as much as 7 degrees Fahrenheit below normal.

During La Niña, the jet stream over the United States extends from the central Rockies east-northeastward to the eastern Great Lakes, making severe weather more likely further north and west than during an El Niño. In many locations, La Niña produces the opposite

climate variations from El Niño. Like El Niño, La Niña’s effects are seen most clearly in the winter in the United States. During a La Niña year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest. La Niña often features drier than normal conditions in the Southwest in late summer through the subsequent winter. Drier than normal conditions also typically occur in the Central Plains in the fall and in the Southeast in the winter. The Pacific Northwest, in contrast, is more likely to see wetter than normal weather in the late fall and early winter.

The current La Niña

Sea Surface Temperatures (SSTs) in the Pacific began to cool significantly in June. Early forecasts were that the cooling would continue and that moderate to strong La Niña conditions would be in place this fall and winter. However, by late September, cooling had slowed and the area of cold water had slightly decreased in size and strength. Based on early monitoring of sea surface temperatures, the National Weather Service Climate Prediction Center (CPC) assumed cold ENSO conditions in formulating its October 1998 through June 1999 U.S. temperature and precipitation forecasts. The CPC reported a 90 percent confidence level for its predictions, based on historical distributions of seasonal mean temperatures and precipitation associated with previous La Niñas. The prediction is for below-median precipitation in the Southwest extending across Texas to the Gulf Coast and the southeastern United States. All the CPC’s models forecast dry and warm weather in the South during October-April.

La Niña and North Carolina water resources

There seems to be a stronger influence by El Niño/La Niña events on regions in

the lower latitudes, especially in the equatorial Pacific and bordering tropical areas. At higher latitudes, El Niño and La Niña are among a number of factors that influence climate, and relationships are not as consistent in the way wet or dry patterns develop or in the intensity of the anomalies.

An examination of rainfall patterns in North Carolina during all La Niña years reveals the following:

N During winter months (December – March), precipitation has ranged from 65 percent of average to 120.25 percent of average with an average for all La Niñas of 97.25 percent of average.

N During Spring-Summer months (April – August), precipitation has ranged from 83.2 percent of average to 122.6 percent of average, with an average for all La Niñas of 105.76 percent of average.

During the eight strongest La Niñas, October through December precipitation was below average four times and above average four times, and January-March precipitation was below average six times and above average twice.

This evidence does not seem to suggest a strong relationship between La Niña conditions and precipitation in North Carolina. However, some sophisticated probability analyses do place North Carolina in La Niña risk areas for dry weather. The risk map accompanying discussion of the ong-going 1998 Texas drought at NOAA’s Climate Diagnostic Center is reproduced below, but is more useful in color. To view the color version go to website <http://www.cdc.noaa.gov/TXdrought/#enso.>

If North Carolina did experience below-median precipitation during the winter and spring, the lack of rain would exacerbate deficits already felt in many parts of the state, which are suffering

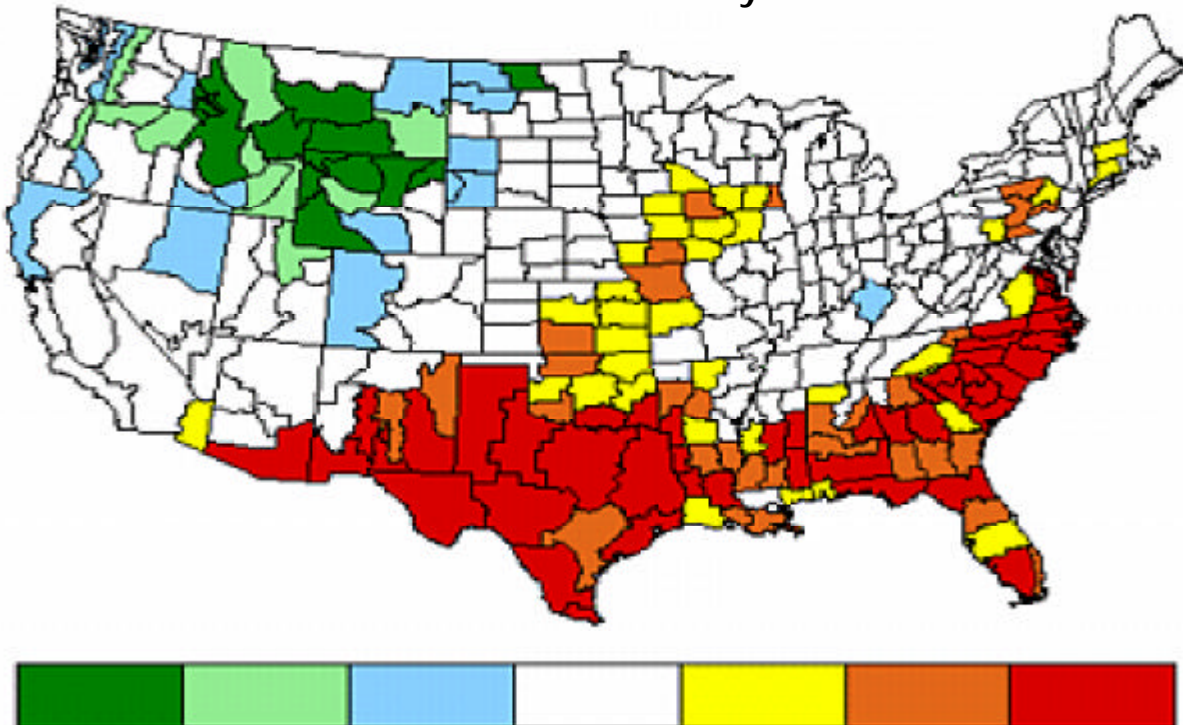
moderate to severe drought conditions as determined by the Palmer Drought Index (See box on the next page).

Monitoring drought conditions

Monitoring emerging drought conditions in North Carolina is the responsibility of the North Carolina Drought Monitoring Council (DMC), a group of federal and state agencies. Chaired by the N.C. Division of Water Resources, the DMC held its annual meeting on August 13, 1998. The National Weather Service reported moderate drought in Climatic Divisions 2,3,4,5, and 6 but total rainfall in the Raleigh-Durham area near normal for the time of year. The Army Corps of Engineers reported Corps reservoirs with water supply storage at near normal levels for the time of year. The Division of Water Resources reported public water supply reservoirs at near normal levels. The U.S. Geological Survey reported some streams in the state flowing at two-

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**Nov/Dec/Jan Precipitation Extremes during La Niña
Risk of Extreme Wet or Dry Years**



WetExtreme

Risk Relative to Climatological Average Risk (20%)

DryExtreme

to-five year lows, with most streams at normal for the time of year. Streams in the Pigeon River basin in western North Carolina were reported to be at five-to-ten-year lows. Groundwater levels were reported normal.

Various agencies in North Carolina regularly monitor drought conditions. If reports and trends indicate increasing drought severity, the Division of Water Resources will reconvene the Drought Monitoring Council. If the Council should decide conditions warrant, a drought response plan would be activated in accordance with a sequence of actions specified in the *North Carolina Emergency Operations Procedures for Drought Emergencies*.

As of late September, western North Carolina was the only part of the state where officials saw reason for concern. The N.C. Division of Water Resources held a Drought Response Workshop in Asheville on September 28. According to John Morris, Division Director, the purpose of the workshop was to advise local governments in

western North Carolina about drought and water resources conditions and to review what they can do to conserve water.

To keep up with drought monitoring in the state, check the N.C. Division of Water Resources Drought Monitoring Council web site at <http://www.dwr.ehnr.state.nc.us/drought/index.htm> or the National Drought Mitigation Center Drought Watch at <http://enso.unl.edu/ndmc/watch/watch.htm>.

For a copy of the *N.C. Emergency Operations Procedures for Drought Emergencies* (April 1994) go to the National Drought Mitigation Center's Drought Mitigation site at <http://enso.unl.edu/ndmc/mitigate/mitigate.htm> and click on State Drought Plans and Related Documents. You can download North Carolina's plan in pdf format using Adobe Acrobat Reader.

There is a world of information about El Niño and La Niña on the Internet. Sources used for this article include the following:

N NASA Jet Propulsion Laboratory at <http://www.jpl.nasa.gov/>

N The Southeast Regional Climate Center at <http://water.dnr.state.sc.us/climate/sercc/>

N The NOAA/National Weather Service Climate Prediction Center at <http://nic.fb4.noaa.gov/index.html>

N The State Climate Office of North Carolina at <http://www.nc-climate.ncsu.edu/>

N The National Drought Mitigation Center at <http://enso.unl.edu/ndmc>

N The Texas Water Resources Research Institute on-line newsletter Texas Water Resources Vol 22 No 2 at <http://twri.tamu.edu/twripubs/WtrResrc/v22n2/>

For week 29 of the 1998 growing season ending September 19, the following conditions were reported in the state's 8 climatic divisions:

Climatic Division	Month's moisture anomaly index	Preliminary/final Palmer Drought index	Precipitation needed to end drought (inches)
Southern Mountains	-7.35	-2.09 (F)	8.37
Northern Mountains	-6.98	-3.18 (F)	10.74
Northern Piedmont	-9.16	-2.61 (P)	6.25
Central Piedmont	-10.06	-2.88 (F)	7.15
Southern Piedmont	-8.78	-2.18 (P)	4.73
Southern Coastal Plain	-4.55	-0.52 (P)	0.99
Central Coastal Plain	-4.38	-0.42 (P)	
Northern Coastal Plain	-5.62	-0.46 (P)	

Palmer Drought Index:

- | | | | |
|--------------------------|-------------------------------------|-----------------------------|-----------------------------|
| Less than or equal to -3 | Extreme or Severe Drought | Greater than or equal to +1 | Moist Spell |
| Less than or equal to -2 | Moderate Drought | Greater than or equal to +2 | Unusual Moist Spell |
| Less than or equal to -1 | Near Normal or Incipient Conditions | Greater than or equal to +3 | Very or Extreme Moist Spell |