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### GREENHOUSE THEORY BEING TESTED ON GLOBAL SCALE, BUT WAITING FOR VERIFICATION COULD PROVE DISASTROUS

the impact of the greenhouse effect 13th in a list of 16 environmental problems, placing it ahead of only x-rays, indoor radon, and radiation from microwave ovens.

On the other hand, organizations including the United Nations Environment Program, the World Meteorological Organization, the International Council of Scientific Unions, the Environmental Defense Fund, and the World Resources Institute insist that an immediate international response aimed at mitigating the greenhouse threat is crucial.

In an effort to arouse public interest in the greenhouse threat, popular magazines such as Time and Newsweek have recently published feature articles attempting to link the summer's temperature extremes to the greenhouse effect. While statistical evidence of global warming is compelling, almost no one in the scientific community will blame the greenhouse effect for the heat and drought of the summer of 1988. Scientists

According to the July 1, 1988, issue of Science magazine, the majority of Americans recently polled rank

are urgently concerned about the greenhouse threat but for other reasons.

### Greenhouse Theory Is More than A Century Old

Within the scientific community, there is widespread acceptance of the greenhouse theory, but most scientists are unwilling to say that the greenhouse effect is upon us and refuse to attribute to it the recent climate extremes. What the scientific community does say, rather emphatically, is that the accumulation of greenhouse gases will, sooner or later, have a dramatic impact on our environment and that we urgently need to better understand the greenhouse effect and the earth's climate and to begin to consider how we can deal with the problem of atmospheric pollution and its consequences.

According to an article by V. Ramanathan in the April 15, 1988, issue of Science, scientists have been theorizing that the greenhouse effect can force climate changes since the early 1800s when J.B. Fourier first described how certain gases, primarily carbon dioxide, absorb infrared radiation and thereby trap energy within the atmosphere. The theoretical climatic effects of changes in atmospheric carbon dioxide were stated formally

before the turn of the century, and subsequent glacial ice studies confirmed that atmospheric carbon dioxide decreased in times of glacial advance and increased in interglacial periods. By 1930 it had been fairly well established that human activity is causing an increase in atmospheric carbon dioxide, and in the late 1960s a model was constructed that provided a way of estimating global warming due to carbon dioxide build-up.

#### **Recent Discovery of Effect of Trace Gases Fuels Concern**

The most recent major discovery related to the greenhouse effect was the recognition in the last decade of the importance of other trace gases. The addition of one molecule of certain chlorofluorocarbons (CFCs) can have the same greenhouse effect as the addition of  $10^4$  molecules of carbon dioxide to the present atmosphere, and concentrations of CFC-11 and CFC-12 in the atmosphere increased more than 100 percent between 1975 and 1985. Other important trace gases, including sulfur and nitrogen oxides and tropospheric ozone, have also been increasing.

It is this evidence of radical changes in the atmospheric gaseous composition that drives the growing concern in the scientific community about the possibility of a forced climate change. Recent temperature extremes have captured the attention of the popular media, but scientists are generally much less impressed by the current heat wave than by the CFC-induced hole in the ozone over the Antarctic.

The great complexity of the climate system inspires scientific caution about questions of specific events--such as this summer's heat and drought--and about short-term predictions. For instance, oceans, with their enormous ability to absorb radiative heating, significantly influence global temperatures and can delay the global warming. However, scientists do seem to be reaching a consensus that the earth may be warming and that an intense research effort is needed to determine if the apparent rate of warming will, indeed, continue or accelerate. Ramanathan states in the Science article, "...the greenhouse theory of climate change has reached the crucial stage of verification...and...if the observed decadal trace gas growth rate continues unabated, the cumulative surface warming (predicted theoretically) would, in the next two decades, become large enough to manifest itself unambiguously in the global temperature records."

However, a report published by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) in June asserts that if decision-makers wait until evidence of global warming is unambiguous, most policy responses will be too late. To provide some measure of preparedness, the scientific community is calling for research to develop the ability to predict not only global but also regional and local effects of various climate scenarios that might result from global warming and to examine the societal impacts of predicted changes.

#### **Support for Research into Impacts of Global Warming and Climate Change Is Building**

Scientific concerns about the impact of global warming have already produced results, and momentum for a significant research effort is building. Through the Climate Protection Act of 1987, Congress directed the Environmental Protection Agency to assess the impact of climate change and to report in late 1988 its findings and its evaluations of policy options that might be used to consider resulting problems. Under this mandate, EPA is sponsoring a number of studies related to the effects of climate change. In addition, the U.S. Geological Survey's research priorities for 1988-89 include the impact of climate change on water resources across the nation. In June the U.S. Senate began a series of committee hearings on the predicted impact of the greenhouse effect, and scientific associations throughout the world are devoting international conferences

to examination of various possible impacts of global warming and climate change.

While a great deal of support is emerging for "what if" research, support for efforts to combat the accumulation of greenhouse gases is much less evident. The UNEP-WMO report calls for immediate international response, including prompt approval and implementation of the Montreal Protocol to reduce the production and use of certain CFCs, re-examination of long-term energy policies aimed at reducing carbon dioxide emissions, and protection of existing rain forests and reforestation. However, it seems unlikely that such policy measures will find a great deal of support in the United States unless there is a dramatic change in the current public perception of the greenhouse threat.

#### **WATER RESOURCES PROFESSIONALS BEGIN TO EXAMINE IMPACT OF CLIMATE CHANGE, CALL FOR ACCELERATED RESEARCH PROGRAM**

According to water resources specialists, predicted climate change caused by the

greenhouse effect will have major impacts on water resources and water management, and water management professionals must prepare for a dramatically altered supply and demand environment.

As excess energy is trapped by greenhouse gases, the earth will warm, but the warming will not be uniform. Because of the interactions between the atmosphere, the cryosphere (ice and snow), the oceans and the land, the predicted warming will vary with latitude, longitude, altitude, and seasons. The resulting temperature and pressure gradients can alter the general circulation of the atmosphere and the oceans. Alteration of global circulation patterns will result in changes in precipitation patterns. In addition, higher temperatures will result in increased evaporative losses from surface water sources.

As the planet warms, thermal expansion of ocean waters along with more rapid melting of alpine and Antarctic and Greenland glaciers will result in an increased rate of sea-level rise. Rising oceans will cause increased salinity in estuaries and increased saltwater intrusion into freshwater aquifers.

Moreover, sea-level rise may also necessitate relocation of industrial production processes and/or population, thereby altering the pattern of water supply demands.

To prepare the profession to deal with possible shifts in water supplies and water demand, water resource specialists are developing the ability to assess impacts of various climate-change scenarios on water resources.

In a paper delivered at the annual meeting of the Universities Council on Water Resources (UCOWR) in July, Dr. David H. Moreau, director of the UNC Water Resources Research Institute and current president of UCOWR, reviewed some studies of the impact of climate change on surface water resources and concluded that while many uncertainties surround the projections, impacts may be profound and warrant an accelerated research program.

According to Moreau, early approaches to the issue may have produced some misleading results: more recent studies indicate that projecting regional and local impacts will be highly complicated.

Early studies of the impact of climate change on water resources were based on scenarios that held constant across the country, said Moreau. Further, many of these studies predicted precipitation runoff to streams and other water bodies by using a temperature-rainfall-runoff relationship which is too sensitive to temperature.

However, he said, models of global circulation patterns are not predicting uniform change. For instance, the Goddard Institute for Space Studies (GISS) global climate model (GCM) predicts that temperature changes across the United States will range from +3.1 degrees C to 5.3 degrees C and that precipitation changes will range from an increase of 20.3% over the Lower Colorado to a decrease of 34.1% over Louisiana, Mississippi, and Alabama. Other GCMs yield other predictions, but all point to nonuniform impacts.

Further, GCMs predict that seasonal climate shifts may be more dramatic than annual shifts in certain areas. Seasonal shifts in certain localities could have more significance for certain water uses than annual shifts.

Recent studies also show that physical characteristics of individual river basins, such as land cover and soil type, can significantly affect the intrabasin impact of climate change. In some basins, just a small increase in precipitation could offset evaporative losses due to increased temperatures. On the other hand, decreases in precipitation will be significant in any location.

Arriving at any reliable predictions of the impact of climate change on local water supplies will involve an enormous degree of complexity, said Moreau, and predicting supply-side impacts is only the beginning. According to Moreau:

Increased temperatures will surely have an effect on demands for energy, reductions in winter and increases in summer. These changes will be translated directly into modifications for demands on hydroelectric facilities. Changes in temperature will have direct effects on demands for irrigation in both agricultural and urban settings, and indirect effects will materialize as the prices for water are adjusted to reflect changes in scarcity.

Moreau pointed out that water resources professionals have begun to identify some of the institutional changes in water management that will be made necessary but that the management issue must receive a much fuller examination. He noted that the time horizons in which the climatic impacts may occur are sufficiently short that the implications for water resource management cannot be wisely set aside as speculation. He asserted that the time has clearly come to assign priority attention to this topic and to increase the funding for it at the national level.

#### **SCIENTISTS EXAMINING EFFECTS OF SEA LEVEL RISE SAY BULKHEADING WILL BLOCK RETREAT OF WETLANDS AND DESTROY ESTUARINE PRODUCTIVITY**

owners in the Albemarle-Pamlico estuarine system who try to protect houses, businesses, and agricultural fields against erosion and sea level rise by installing bulkheads and dikes could eventually destroy the East Coast's most important marine fisheries nursery. The scientists say that, in the long-term, sea-level rise alone will reduce the size of North Carolina's critical estuarine system but that human interference with natural forces could result in drastic, near-term loss of estuarine habitat and fishery resources.

The workshop, titled "Sea Level Rise and Estuarine Resource Management in North Carolina," was sponsored by a number of federal and state agencies, universities, and conservation organizations. It was held to inform the public about the effects of sea level rise on estuarine fishing and wetland resources and to develop a set of technical findings for presentation to policy makers and state agencies responsible for managing estuarine resources.

#### **Rate of Sea Level Rise Expected to Double in Next Two Decades**

In his presentation, Dr. James Titus of the U.S. EPA, said that the sea level on the U.S. East Coast, which has been rising at a rate of about a foot per century for some 10,000 years, is beginning to rise faster because of atmospheric warming. The rate of sea level rise along the North Carolina coast is conservatively expected to double within two decades, resulting in a one- to three-inch rise by 2000. As the sea rises, shoreline along North Carolina's very flat coast will generally recede, coastal water tables will rise, drainage will be slower, existing wetlands will be flooded, and, if nature prevails, low salinity marshes and other wetlands will retreat inland. However, as water rises, erosion along estuarine shoreline property, already significant, will accelerate, and if property owners respond by building bulkheads to protect against erosion, the structures will block the inland migration of marshes which harbor biological communities that provide food for developing fish and shellfish.

#### **Biological Productivity of Wetlands Depends on Marsh Grasses**

Dr. William Kirby-Smith of the Duke University Marine Laboratory in Beaufort, an expert on primary productivity of estuaries, said that the food web upon which fish depend starts with the breakdown of marsh grass and that low salinity marshes at the headwaters of estuarine systems are the most productive of several kinds of estuarine wetlands. His modeling studies of the effects of bulkheading entire shorelines in the Newport River and South River estuaries predict that up to 60 percent of the primary productivity of the systems would be lost. Under a scenario in which the entire estuarine shoreline of the Albemarle and Pamlico Rivers were bulkheaded, he said, the elimination of marsh grass and submerged aquatic vegetation would result in a 95 percent loss of the fisheries dependent upon those estuaries.

According to Dr. Mark Brinson of the East Carolina University Department of Biology, even without interference by man, North Carolina's wetlands probably cannot retreat quickly enough to maintain their current level of productivity. Whether the rate of accretion, or build up, of marsh grasses will equal the rate of loss as marshes migrate inland, Brinson said, is a major question. The problem, he said, is not so much that the sea is rising but that, because of accelerated global warming, it is rising faster than in past periods of sea level rise.

#### **Changing Hydrodynamics of Estuaries and Erosion Threaten Marshes**

The hydrodynamics of a coastal area is a major factor affecting the ability of marshes to maintain area or grow in area, and the accelerated sea level rise is affecting the hydrodynamics of East Coast bays and estuaries, Brinson said. If the force of water erodes a marsh area on one side faster than it can spread on the inland side, the marsh will decrease in area and eventually disappear. According to Brinson, marshes are being lost rapidly in the Chesapeake Bay area. "There are upper limits to how fast a marsh can respond to sea level rise," he said.

#### **Shoreline Clearing Impairs Wetlands' Ability to Adapt**

Dr. Stanley Riggs of the East Carolina University Department of Geology said that accelerated erosion in coastal areas also endangers marshlands by creating steep shoreline slopes which block their migration, and in the Albemarle-Pamlico estuarine system clearing of wetland forests is contributing to the creation of uncharacteristically steep shoreline slopes and bluffs. According to Riggs, North Carolina's northern coast, which comprises the Albemarle and Pamlico sounds, is different

geologically from the state's southern coastline. The northern coast is characterized by a gently sloping shoreline, while the southern coast has a steeper slope, more sharply eroded shoreline, and no major estuaries. Under natural conditions, shoreline erosion would be most threatening to marsh areas along the southern coastal area, which is not a major marine nursery area, he said. But, removal of trees and other vegetation along northern estuarine shorelines is resulting in erosion back to the sediment bank and creation of bluffs in many places, Riggs said.

According to Riggs, eventually migrating marshes will be blocked by a geologic barrier when they reach the Suffolk Scarp, which marks sharply higher ground. At that point, the potential for regeneration of estuarine habitat will drop sharply.

Dr. Orrin Pilkey of the Duke University Geology Department said that another factor that may affect the long-term survival of North Carolina's coastal wetlands is the fate of barrier islands. According to Pilkey, the recent history of the Mississippi River Delta shows that barrier islands may migrate toward the mainland or may be flooded and become sandbars. "If barrier islands disappear," said Pilkey, "then we have an entirely new scenario--one in which erosion and the effects of storms on the shoreline are much worse."

What is immediately evident, said the scientists, is that clearing and development along the estuarine shoreline is already seriously impairing the ability of wetlands to adapt to accelerated hydrological changes and that efforts to stabilize shorelines could spell doom for critical fishery and wildlife habitat.

On the other hand, the scientists acknowledged that without the use of bulkheads and dikes, there will be substantial losses of private property on the estuaries and sounds as erosion worsens and waters rise.

#### **Bulkheading in Estuaries Is Increasing**

According to Preston Pate of the N.C. Division of Coastal Management, as the number of homes and businesses constructed along the estuaries increases, the potential for bulkheading increases because property owners have the legal right to protect their property. Pate said that over the last two years, permits have been issued for bulkheading of 31.5 miles of North Carolina's estuarine shoreline. Laws adopted as part of the Coastal Area Management Act encourage retreat from shoreline erosion on the ocean front, said Pate, but in the estuarine areas, there are no set-back requirements, and state laws governing permitting of bulkheads regulate only the distance bulkheads can be extended from the existing shoreline and what may be used as fill material behind bulkheads. There is a requirement that bulkheads be built shoreward of significant marsh areas, but, Pate said, that will do nothing to protect marshlands in the long-term.

According to Pate, structures other than bulkheads and dikes may also block marsh migration and contribute to loss of wetland productivity. As the ocean rises, saltwater intrusion into low-lying agricultural areas will also worsen, and farmers may increase their use of structures such as tidegates and dikes to protect their fields.

#### **State Could Assert Expanded Public Trust Rights to Protect Estuarine Resources**

Dan McLawhorn, N.C. Assistant Attorney General, and William Raney, a Wilmington attorney, discussed the legal aspects of estuarine resource protection. According to McLawhorn, the state is responsible for maintaining public trust lands, but in estuaries, unlike the oceanfront, there is little public trust land. However, said McLawhorn, while public trust land is defined as that between the mean high

water mark and the mean low water mark, North Carolina has asserted expanded public trust rights in beach areas and could conceivably do so in estuarine areas.

According to Raney, who successfully defended a court challenge to North Carolina's Coastal Area Management Act, in order to assert its right to protect estuarine resources, the state must prove that its exercise of "police powers" is reasonable. Raney said that recent court decisions indicate that the more public support and the more scientific justification that can be shown for regulations, the greater will be the likelihood that courts will consider the regulations as reasonable exercise of police powers.

#### **Findings Call on State and Local Governments to Identify Areas for Resource Protection**

The workshop speakers all agreed that a rational response to sea-level rise on the North Carolina coast should include protecting estuarine resources in areas of high biological productivity and low population density and allowing protection of property in areas that are already densely populated and highly developed.

Workshop findings, agreed upon by the participating scientists and legal experts, (1) call upon the executive and legislative branches of state government to declare it state policy to protect the productivity of coastal wetlands; (2) call upon state officials to work together to revise the CAMA definition of Areas of Environmental Concern to include estuarine shorelines based on a vegetation and topography standard; (3) call upon local governments to decide, in conjunction with state government, which areas should be artificially protected and which areas should be allowed to erode and flood naturally; and (4) suggest that the Albemarle-Pamlico Peninsula provides an excellent location for unprotected shoreline changes.

#### **STUDY INDICATES THAT JUNE DROUGHTS OF 1985 AND 1986 COULD SIGNAL END OF 30-YEAR WET REGIME IN NORTH CAROLINA**

According to scientists in the Department of Geography at the University of Arkansas, North Carolina may be entering a period of relatively dry growing seasons that could last 30 years.

In an article published in the June 10, 1988, issue of *Science*, the scientists describe how they used records of precipitation and temperature variations reflected in annual ring widths of 1700-year-old Bald Cypress Trees growing along North Carolina's Black River to reconstruct a statewide June Palmer Drought Severity Index (PDSI) from A.D. 372 to 1985. The record indicates that the growing season climate of North Carolina has alternated between dry and wet regimes that last approximately 30 years. The reconstruction of the June PDSI also indicates that the period from 1956 to 1984 was one of the five wettest 29-year periods in North Carolina during the past 1614 years and that the June droughts of 1985 and 1986 were the two worst in the state since 1887.

The scientists say that changes between wet and dry regimes in North Carolina could have been associated with differences in atmospheric circulation during the spring and early summer but that a physical explanation has not been documented. They say that any conclusions are, therefore, highly speculative but that the June droughts of 1985 and 1986 could signal the end of the relatively wet regime that began in 1956.

Since the chance for a severe drought is significantly higher during a dry regime, a current change to a new regime could have important effects on agriculture, energy demand, and water supply in North Carolina, the scientists say. They suggest that efforts should be made to confirm

and explain the long-term changes in growing season climate in North Carolina.

**UNC GEOGRAPHERS TO PIONEER METHODS FOR PREDICTING HOW CLIMATE CHANGE MAY AFFECT LOCAL WATER RESOURCES ACROSS THE SOUTHEAST**

If warming of the earth's climate brings about a long-term change in the seasonal position of the sub-tropical high pressure region known as the

Bermuda high, which controls rainfall patterns across the southeastern United States, how will that affect water resources in individual small watersheds in the Southeast--for instance, Raleigh's Falls Lake watershed?

Under grants from the Water Resources Research Institute of the University of North Carolina and the U.S. Geological Survey (USGS), Drs. Peter J. Robinson and Stephen Walsh of the UNC-Chapel Hill Department of Geography will develop methods to help answer such questions.

The grants, awarded recently under the Water Resources Research Institute's Federal Cooperative Program for 1989 and the USGS matching grant program, are among the first in the nation made to support investigations of the effects of global climate change on local water resources, and Robinson and Walsh will be breaking new ground in predictive water resource modeling.

**Research Will Link Predictive Models**

The researchers will develop methods and collect data that will allow them to connect two kinds of predictive computer models. The first kind of model, known as a general circulation model (GCM) simulates atmospheric flow patterns and can be used to predict broadscale, generalized precipitation patterns under various climate scenarios.

The second kind of model simulates the hydrologic, or water, cycle in a local watershed and predicts how much of the water that falls as rain in the watershed will get into streams from overland runoff and groundwater discharge under varying conditions such as temperature. In order to make their predictions, hydrologic models must have information about the variable characteristics of individual rainfall events.

According to Robinson, principal investigator on the project, rainfall events are basically of two kinds: cyclonic, which are widespread, prolonged, and gentle rains resulting from depression tracks; and convective, which are localized, short-lived, and intense storms induced by local instability.

Changes in atmospheric flow patterns brought on by global warming will alter the frequency of both regional and local precipitation events, but general circulation models predict only regional changes in precipitation patterns.

Predicting the occurrence of locally induced storms under various climate scenarios is the missing key to predictive local water resource modeling. Robinson and Walsh will attempt to provide this key by examining historical weather data to determine which atmospheric flow patterns are linked to cyclonic rainfall events and which to convective events. From this information, they will construct a data "layer" which will enable the GCMs to predict local precipitation events as well as regional events under various climate scenarios. Output from GCMs can then serve as input to hydrologic models which water managers can use to estimate seasonal water supplies and to head off local shortages by developing alternative supplies.

The researchers will develop their model link based on historical data for the southeastern United States, where population growth is likely to pose water supply problems.

They say, however, that if the method works, it can easily be applied to other geographical regions.

**IS NOW THE TIME TO MOVE TOWARD REGIONAL WATER MANAGEMENT?**

by David H. Moreau  
reprinted from the August 8, 1988, issue of The Leader

Chapel Hill, Hillsborough, Durham, Apex, Cary, and other municipalities in the Research Triangle either have been or soon will be facing shortfalls in their water supplies. Chapel

Hill, Durham, Cary, Hillsborough, Butner, and several industries are discharging effluents from their sewage treatment plants into streams and lakes used by their neighbors for drinking water or recreation. All urban activities in the area are taking place on a fixed base of land and water resources, and a number of the more rational management options involve more than a single political jurisdiction. Yet, the existing management structure remains fragmented among 15-20 different agencies of local government. Voluntary cooperation among these agencies has been reasonably good, but there are inherent limitations to what can be accomplished through goodwill alone.

Is now the time for a more comprehensive approach to managing this resource? That is a question that has confronted many local and state officials and other interested groups and individuals ever since the concept of the Research Triangle was formulated in the 1950s. It became more serious as the Research Triangle Park became a reality and even more serious with the explosive growth that we have experienced in the 1980s. Serious attention was given to regional wastewater management in the mid-1970s when the Triangle J Council of Governments (TJCOG) conducted a large federally funded planning exercise, but regionalization was seen by local governments as an erosion of home rule, and only marginal changes in regional cooperation have been achieved since that time. At some point in the development of metropolitan areas like the Research Triangle, home rule in the strict sense of municipalities and counties is simply not adequate to the task. As we face ever-increasing pressures on our limited water resource, the question is raised once again: "is now the time for an alternative?"

The Eno River is a clear case where existing arrangements have led to excessive exploitation of the resource. Withdrawals from that stream and wastewater discharges into it have grown to the point that the supply has been over-allocated. In 1986, the stream was practically dewatered. With the encouragement of local governments in Orange County, the North Carolina Department of Natural Resources and Community Development (NRCD) conducted an in-depth study of the area and concluded that demands along the river exceed its supply. In that same area, the City of Durham is seeking to enlarge a wastewater treatment plant which discharges into the Eno River from its present size of 2.5 million gallons per day (MGD) up to 10 MGD to accommodate new development. Treyburn will be the largest single contributor to that plant. Future expansions to 20 and even 30 MGD are being discussed. Yet, NRCD found that discharges of 10 MGD would exceed current estimates of the capacity of the river to assimilate wastes. Unless new studies changes the estimates of that capacity, the state will not allow additional discharges of wastes in that segment of the river.

Local governments have not been able to keep demands and supply in balance along the Eno. It was local governments who requested NRCD to conduct its study, but they have been unwilling to support the recommendation of NRCD to designate the Eno River as a "capacity use area." That step, which would be taken by the N.C. Environmental Management Commission, is an official action that must be

taken before withdrawals from streams and aquifers can be limited, and state action is not likely without local support. Local officials, industries, and large agricultural water users do not like the prospect of state-issued permits that will limit their withdrawals. Yet, local governments are not empowered to set enforceable limits themselves, and without the state permits, the resource pie is being cut into even smaller pieces to serve a larger number of people. If the drought of 1986 is repeated in 1988, each consumer will have less water than he or she had in 1986. Things will continue to get worse until changes are made, either by enlarging the size of the pie, by limiting the number of people who can eat it, or by reducing the size of slices.

In Durham, where water quality is the issue, the city is left with one of several choices: either (1) refuse to accommodate growth (something it has been unwilling to do); (2) find an alternate location for disposing of the waste (something it may not be able to do acting alone); or (3) further degrade the quality of the river.

Regional approaches offer some relief from water supply shortages and from limits on waste disposal. Regional options have costs of their own, but they offer opportunities to reduce conflicts among the various users of the resource, they offer opportunities to reduce costs of service, and they offer opportunities to improve the quality of services and how they are planned and managed. Regional management of the water supply would enhance its reliability, reduce idle capacity and its cost, improve monitoring, operations, maintenance, and enhance planning capabilities. TJCOG has identified a number of regional options, and some of the advantages of regionalization are being achieved through interlocal agreements such as the one between Chatham County and the Orange Water and Sewer Authority that is now under discussion. However, as seen in that case, processes for reaching those agreements are slow and arduous, and the outcomes are highly uncertain.

Regional alternatives for wastewater disposal were identified in the TJCOG study in the 1970s, and the Environmental Impact Statement on the Eno River wastewater treatment plant will update some of those alternatives and examine others. At least one of the options that was formulated in the 1970s would eliminate the discharge of treatment plant effluents upstream of the water supplies in Falls of the Neuse and Jordan lakes.

There is more to the problem of regionalization, however, than simply figuring out the location of treatment plants and pipelines. Serious consideration of any regional alternative cannot proceed very far without looking at a regional management agency to plan, construct, operate, and finance the necessary facilities. Debate on the issue generally ceases at this point because local governments have shown no inclination to give up their prerogatives over the delivery of water and sewer services. A widely held perception is that if you control water and sewer services, you can control the future of a city. Most municipalities in metropolitan areas have come to understand the simplistic nature of such views when they are no longer isolated towns. Until that time arrives, management of water supply and wastewater disposal systems in the Research Triangle will remain highly fragmented. The question remains: Is now the time to take significant steps toward regional management?

#### **USGS ANNOUNCES NEW DEADLINES FOR MATCHING GRANT PROGRAM**

grant proposals under the Section 105 matching grant program under the Water Resources Research Act to early October. A formal announcement of the FY 1988 program was made in August and proposals are due in Washington October 14. Program announcements and application forms are available from:

UNC Water Resources Research Institute  
Box 7912  
North Carolina State University  
Raleigh, NC 27695-7912  
(919) 737-2815

The following areas are of particular interest in FY 1989:  
Groundwater Quality  
Water Quality Management  
Institutional Change in Water Resource Management  
Climate Variability and the Hydrologic Cycle

The Water Resources Research Institute will be happy to assist investigators with the task of satisfying the matching requirement. Only those proposals that are submitted through WRRRI are eligible for Institute funds. To undergo appropriate review, proposals need to be at the Institute office by September 30.

This USGS matching grant program is distinct from the Institute's annual cooperative program which is partially funded by USGS under Section 104 of the Water Resources Research Act. A solicitation for proposals under the latter program will be distributed in the fall of 1988.

In last year's national competition for matching grants, two projects were funded in North Carolina universities. Those projects were "Precipitation Regime Changes Resulting from Climatic Changes" being conducted by Drs. Peter J. Robinson and Stephen J. Walsh of the Department of Geography at the University of North Carolina at Chapel Hill and "Evaluation of Saprofite in the Piedmont and Mountain Regions for On-Site Wastewater Disposal" being conducted by Drs. Aziz Amoozegar, M.T. Hoover, and H. J. Kleiss of the Department of Soil Science at North Carolina State University. The UNC Water Resources Research Institute provides the matching funds for these projects.

#### **EPA TO HAVE NEW POLLUTION PREVENTION OFFICE**

Prevention to promote multimedia waste reduction. The program was established by agency directive within the Office of the Assistant Administrator for Policy Planning and Evaluation. One role of the new office will be to educate business about the existence of cost-effective reduction techniques for a waste or class of wastes. Creation of the new office will enable EPA to coordinate source reduction efforts in all of its regulatory units. It will be concerned with pollutants discharged to water, air, and soil.

The office's primary goal will be to stress source reduction before wastes have to be recycled and treated or disposed of. It will explore alternatives to current regulatory programs which are directed toward waste treatment.

The new office is seen as an attempt by EPA to address support in Congress for implementation of a waste minimization effort that seeks alternative to "end-of-pipe" controls.

According to Roger N. Schecter, Director of the North Carolina Pollution Prevention Program, Congress has appropriated 30 positions for EPA's Pollution Prevention Program, \$2 million to the EPA Office of Research and Development for cooperative agreements and demonstration projects that may involve state agencies, and \$4 million to EPA to operate its Pollution Prevention Program and provide incentive grants to state multimedia technical assistance programs.

The U.S. Geological Survey has changed the deadline for receipt of

For several years, North Carolina has had a strong pollution prevention program which has given emphasis to the positive economic incentives for waste reduction and is non-regulatory. The North Carolina Pollution Prevention Program offers technical assistance to industries, challenge grants, and research and education funds for waste reduction.

#### **EFFORTS UNDERWAY TO ENHANCE AQUACULTURE PRODUCTION IN NORTH CAROLINA**

A Governor's Task Force is analyzing the needs and issues which must be addressed

to speed the growth and development of aquaculture in North Carolina. Aquaculture is seen as one opportunity for a limited number of farmers and other entrepreneurs to diversify and increase their income.

Additional production of mountain trout, crawfish, catfish, clams, striped bass, red fish, and other aquaculture products can have a positive effect on the North Carolina economy. Obtaining the additional production and income will require better systems for financing, improved technical advice, an assessment of impacts on water quality and quantity, expanded production and marketing capabilities, and additional research and biotechnology. It is anticipated that recommendations and actions of the Governor's Task Force on Aquaculture will stimulate aquacultural activity.

The Task Force, formed in March, will make a report to the Governor in December addressing some of the following issues:

- \* analyzing environmental, financial, marketing, processing, educational, and legal issues related to the aquaculture industry;
- \* recommending changes in current North Carolina statutes concerning aquaculture;
- \* recommending agency and university programs which would promote and develop an aquaculture industry in the state;
- \* recommending research programs, demonstration projects, and other transfer activities.

Chief staff person for the Governor's Task Force is Donna Moffitt with the Office of Marine Affairs in the North Carolina Department of Administration.

Currently, the largest and most profitable aquaculture business is trout production in western North Carolina, where five to six million pounds are marketed annually. The state ranks second to Idaho with 60 million pounds. Experts say there is a potential for 30-40 million pounds of annual production in North Carolina.

Catfish, crawfish, and striped bass production are among the newest ventures. Commercial catfish farming is now underway in the Pitt County area with production and processing facilities available for several hundred acres. Mississippi leads the nation in raising catfish with over 100,000 acres devoted to production.

#### **NORTH CAROLINA STUDIES EVALUATE THE USE OF NATURAL WETLAND AND FORESTED AREAS FOR WASTEWATER TREATMENT**

Several studies in North Carolina are exploring the use of wetlands to aid in the removal of nutrients in municipal

wastewater. Several studies are being conducted by Dr. Edward J. Kuenzler, Department of Environmental Sciences and Engineering at UNC-Chapel Hill with support from the Water Resources Research Institute and the Albemarle-Pamlico Estuarine Study, and one study has been conducted by Dr. Curtis Richardson, School of Forestry and

Environmental Studies, Duke University, with WRI support.

#### **Piedmont Study Provides Knowledge about Nutrient Reduction**

A Piedmont study with WRI support examines the mechanism by which swamp and marsh systems reduce nitrogen and phosphorus in wastewater effluent. This research is expected to provide knowledge about the role of swamps in nutrient-reduction controls and rates which will be useful to agencies in efforts to design nutrient-management programs for sensitive streams and lakes. The investigation is part of a three-year study to obtain detailed information on a number of floodplain swamps on the New Hope, Little, and Third Fork Creeks in southwestern Durham and northeastern Chatham counties. This study will provide critical analysis of relationships between nutrient loading rates, swamp retention, and water quality downstream.

#### **Coastal Plain Study Examines Swamp Treatment of Sewage Discharge**

In the North Carolina Coastal Plain, over 250 communities discharge treated wastewater in swamps. A two-year study supported by WRI examined swamp systems currently receiving sewage wastes in relation to water quality, nutrient retention, and vegetative change caused by waste loading. Results from this initial effort are reported in WRI Report #235 authored by Dr. Edward Kuenzler and Report #238 authored by Dr. Curtis Richardson. Additional work with support from the Albemarle-Pamlico Estuarine Study expands the understanding of the efficiency with which Coastal Plain swamp systems remove nitrogen and phosphorus from municipal sewage discharges.

This research by Dr. Kuenzler continues at three study sites with an intensive effort to measure nutrient removal rates below sewage outfalls in riparian forests under existing conditions. At these sites the investigators will integrate the effects of downstream distances and site variability under natural conditions in all seasons and discharge conditions. The research team will also do an extensive study at ten additional sites.

Results of these studies are expected to have important implications for managers who permit discharges from municipal wastewater facilities and package treatment plants.

#### **PROJECT EXPLORES APPLICATION OF MICROCOMPUTERS TO SURFACE-RUNOFF MODELING OF SMALL WATERSHEDS**

In a study supported by the Water Resources Research Institute, Dr. H. Rooney Malcom, Associate Professor of

Civil Engineering at North Carolina State University, and research assistant David A. Nailor evaluated the performance of two microcomputer distributed element models, HEC-1 and Lotus spreadsheet, in modeling two small watersheds in Charlotte.

The models were calibrated with historical storm data from the 380-acre Sudbury Watershed located at Sudbury Road on one of the upper tributaries of Briar Creek and from the 4,470-acre McMullen Creek watershed located on McMullen Creek at Sharon View Road. Both Charlotte watersheds drain primarily residential areas.

The researchers concluded that the HEC-1 model, though developed for river basins, can produce reasonable results in small watersheds. However, they say, the reservoir routing scheme may not be sensitive enough for road culverts. They conclude that the Lotus 1,2,3 spreadsheet model can also produce reasonable results for small watershed. Although tedious to build, the model is an excellent design tool, they report.

A copy of the report on the study, "Watershed Modeling on Microcomputers," is available for examination at the Water Resources Research Institute office, 219 Oberlin Road, NCSU campus, Raleigh.

**GRIGG NAMED COLORADO WATER RESOURCES INSTITUTE DIRECTOR**

Neil Grigg, former director of the Water Resources Research Institute of The

University of North Carolina, has been named director of the Colorado Water Resources Research Institute. The appointment became effective July 1.

A graduate of the U.S. Military Academy, Grigg earned his master's degree at Auburn University in Alabama and a doctorate in civil engineering at Colorado State University. After teaching and conducting research in Colorado State's civil engineering department for five years, he was named director of the UNC-Water Resources Research Institute in 1977. He later served as assistant secretary of the N.C. Department of Natural Resources and Community Development and as director of the Division of Environmental Management. For his management of North Carolina's water and air quality and groundwater regulatory programs, Grigg received the Governor's Conservation Award for Environmental Protection.

He returned to Colorado State in 1982 as professor of civil engineering and director of the International School for Water Resources.

**HEAD OF STATE ENVIRONMENTAL HEALTH SECTION RETIRES**

Jim Stamey retired August 31 from the Division of Health

Services Environmental Health Section. Stamey's section has for years included programs in public water supply, solid and hazardous waste management, sanitation, one-site waste management, engineering planning, and vector control.

Stamey joined the Division of Health Services in 1963 and was appointed Chief of the Environmental Health Section in 1980. In 1987, he was president of the North Carolina Chapters of the American Water Works Association and Water Pollution Control Association.

**FIRST ANNUAL N.C. AQUACULTURE CONFERENCE SLATED**

Aquaculture has the potential to be an additional money-maker

for North Carolina farmers and entrepreneurs. To provide information and encouragement to those interested in this enterprise, the First Annual North Carolina Aquaculture Development Conference has been set for November 1-2, 1988, at the Sheraton Hotel in Greenville.

Sponsored by the N.C. Chapter of the Soil and Water Conservation Society, N.C. Agribusiness Council, N.C. Small Business and Technology Development Center, N.C. State University College of Agriculture and Life Sciences and the N.C. Department of Agriculture, the two-day conference will involve leaders in the aquaculture industry from established aquaculture states such as Louisiana and Mississippi, as well as North Carolina aquaculturists and researchers from N.C. State University.

Among featured speakers for the conference are Richard Lord of New York's Fulton Fish Market, the largest wholesale seafood market in the United States; Larry Delabretonne, a Louisiana State University extension specialist on crawfish production; and Peter Redmayne, editor of Seafood Leader magazine.

The conference will encompass four areas of concentration: (1) an overview of the industry and its economic potential

for the state; (2) culture techniques for species feasible in North Carolina; (3) how the aquaculture industry can be enhanced through genetic research; and (4) a tour of aquaculture sites in the Pitt County area. Species to be discussed during the conference include catfish, crawfish, softshell crawfish, fresh-saltwater shrimp, striped hybrid bass, mountain trout, and tilapia.

For more information on the N.C. Aquaculture Development Conference, contact Rodney Johnson, N.C. Aquaculture Development Conference, 412 W. Queen Street, Edenton, NC 27932 (919) 482-7437.

**WORKSHOP ON WATERSHED PROTECTION TO BE HELD SEPTEMBER 24**

The North Carolina Chapter of the Sierra Club and eight cosponsors will

present a workshop in Raleigh in September directed at strengthening programs for protecting North Carolina's drinking water supplies.

**WATER SUPPLY WATERSHED PROTECTION: WHAT IS THE STATE ROLE?** will be held from 9 am to 1:30 pm on Saturday, September 24, 1988 at the Quality Inn-Mission Valley in Raleigh.

The purpose of the workshop is to examine the effectiveness of the state's current watershed protection program, to consider the state's options in protecting water supply watersheds, and to debate whether the state should increase its financial support and expand its regulatory scope to protect water supply watersheds.

The registration fee is \$12 per person and covers lunch, refreshments, and workshop materials. Preregistration is encouraged.

For additional information and a registration form, write: Workshop Registration  
Sierra Club  
c/o Bill Holman  
112 North Person Street  
Raleigh, NC 27601

**POSITIONS AVAILABLE**

The North Carolina Department of Natural

Resources and Community Development (NRCD) has an opening at its headquarters in Raleigh for a **sedimentation specialist** for statewide coordination of its Sedimentation Control Program. Prefer P.E. with several years experience in erosion and sediment control on construction sites. Requires proficiency in surface water hydrology and hydraulics. Duties include staff training, monitoring local government programs, and overseeing enforcement of N.C. Sedimentation Pollution Control Act. Salary range \$32,328 - \$52,668, starting salary dependent on qualifications. Send resume and three references to Charles H. Gardner, P.G., P.E., Box 27687, Raleigh, NC 27611 by September 30, 1988 (Phone 919/733-4574). Equal Employment Opportunity Employer.

NRCD Water Resources has an opening for an **environmental engineer II** to provide water supply assistance to local governments and conduct engineering studies of water resources and water supply systems. Requires a B.S. degree with a major in civil engineering, environmental engineering, or related engineering curriculum and two years of experience in water resources. Contact Woody Yonts, NRCD Water Resources, P.O. Box 27687, Raleigh, NC 27611 (919/733-4064). Salary range \$29,508 - \$47,976. Closing date October 10, 1988.

The N.C. Division of Health Services is taking applications for the position of **State Environmental Health Director**. This is professional administrative and managerial work in directing the statewide environmental health program within the Division of Health Services.

Considerable expertise will be required in coordinating and managing a diversity of consultative and regulatory environmental health and engineering programs designed to provide the necessary support services to local environmental health programs and to carry out the regulatory programs statutorily vested at the state level. The employee will direct and coordinate the activities of a large technical staff in areas of Public Water Supply, Food, Lodging, Milk & Shellfish Sanitation, On-Site Sewage Disposal, and Vector Control to ensure successful delivery of environmental health services. B.S. degree in environmental engineering, sanitary engineering, civil engineering, or a related engineering curriculum and eight years of experience in environmental health sanitation and engineering including three years in an administrative, supervisory, or managerial capacity; or an equivalent combination of education and experience. Preference will be given to candidates with a graduate degree in the area(s) of environmental engineering or public health administration. For details contact Dr. Samuel Merritt, Chairman; Environmental Health Director Search Committee, N.C. Division of Health Services; P.O. Box 28047, Raleigh, NC 27611.

**WATER RESOURCES  
CONDITIONS FOR JULY**

Streamflow increased  
contraseasonally during  
July in the Piedmont and

Blue Ridge but remained in the below-normal range for the sixth consecutive month. At the Blue Ridge index site on

the French Broad River, the monthly mean flow of 642 cubic feet per second (cfs) was the second lowest mean flow of record for July. Streamflow declined in the Coastal Plain despite scattered thunderstorms and was in the below-normal range following three months of flow in the normal range. Unusually high temperatures resulted in greater than normal evapotranspiration rates, which contributed to the decline.

Four stations recorded record low monthly mean flows for July. Only one station recorded a record minimum daily flow for July. Most mean flows for July 1988 were more than those for July 1986.

Groundwater levels in unconfined (water table) aquifers at monthend declined seasonally in the Blue Ridge and Piedmont but increased in the Coastal Plain. In the Blue Ridge, water levels were below average, while at the index well in the Piedmont, the water level was slightly above average. The water levels in the index well in the Coastal Plain were above average, apparently in response to recent rains in that area.

At monthend, index reservoirs in the western Piedmont had a combined volume of 86 percent of capacity as compared to the long-term average of 81 percent. During July 1986, volume was 72 percent of capacity.

**NEW PUBLICATIONS RECEIVED BY THE INSTITUTE**

(Residents of North Carolina may borrow these from the Institute for a two-week period. Where individual copies are desired, readers are encouraged to request copies from the organization issuing the publication. The addresses are provided by the NEWS for this purpose.)

Water Resources Planning

"National Economic Development Procedures Manual - Urban Flood Damage," (IWR Rpt. 88-R-2), 3/88, ed. by S. David, avail. from U.S. Army Corps of Engineers, Water Resources Support Center, Inst. for Water Resources, Fort Belvoir, VA 22060-5586. (06C)

Water Quality Management

- "Proceedings: Conference on Point-of-Use Treatment of Drinking Water, Cincinnati, OH, Oct. 6-8, 1987," (EPA/600/9-88/012), 6/88, avail. from USEPA, Water Engr. Research Lab., Cincinnati, OH 45268. (05F)
- "Consideration of Dimensional Dependence in Modelling the Structure of Flow Zones Within the Subsurface," (#186), 6/88, by S.E. Silliman, avail. from WRRR, Purdue Univ., W. Lafayette, IN 47907 (04B GW)
- "Groundwater Standards--States Need More Information From EPA," (GAO/PEMD-88-6), 3/88, by The Honorable Max Baucus, Chairman, Subcommittee on Hazardous Wastes and Toxic Substances, avail. from US GAO, Washington, DC 20548. (04B GW Mgt.)
- "Assessment and Compilation of Groundwater Quality Data for Mississippi," 7/87, by D.D. Truax, avail. from WRRR, MS State Univ., PO Drawer AD, Mississippi State, MS 39762, price \$15.00. (04B)
- "The Effects of Heavy Metal Pollution on Epilithic Bacteria," (#184), by 6/88, by D.D. Ross, avail. from WRRR, Purdue Univ., W. Lafayette, IN 47907. (05C)
- "Pretreatment Compliance Monitoring and Enforcement Software," 6/88, by USEPA, Off. of Water Enforcement & Permits, Enforcement Div., (EN-338), PCME Software, 401 M St., SW, Washington, DC 20460. (05D Pretreatment)
- "Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program," 12/87, by USEPA, Office of Water, Office of Water Enforcement and Permits, 401 M St., SW, Washington, DC 20460. (05D Pretreatment)
- "Environmental Regulations and Technology--The National Pretreatment Program," 7/86, by USEPA, Center for Env. Research Infor., Office of Research Program Management, Office of R&D, Cincinnati, OH 45268. (05D Pretreatment)
- "Hydrogeologic Setting, Water Levels, and Quality of Water from Supply Wells at the U.S. Marine Corps Air Station Cherry Point, North Carolina," 1988, by O.B. Lloyd, Jr., et al, for sale from: Books and Open-File Reports Section, USGS, Federal Center, Box 25425, Denver, CO 80225. (USGS)

"Development of Estimation Methods for Tributary Loading Rates of Toxic Chemicals," (#183), 6/88, by V. J. Bierman, Jr., et al, avail. from WRRRC, Purdue Univ., Lilly Hall of Life Sciences, W. Lafayette, IN 47907. (05B)

"Water Quality Progress in North Carolina," (#88-02), 7/88, by Water Quality Section, DEM-NRCD, P.O. Box 27687, Raleigh, NC 27611. (05G)

#### Water Quantity Management

"Techniques of Water-Resources Investigations of the United States Geological Survey - A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model," by M. G. McDonald, et al, for sale by: Books and Open-File Reports Section, USGS, Federal Center, Box 25425, Denver, CO 80225. (04B GW)

"County-Level Projections for Industrial Water Demand in Mississippi," 7/87, by E. Nissan, et al, avail. from MS WRRI, MS State Univ., PO Drawer AD, Mississippi State, MS 39762, price \$7.00. (03D)

"The Situation and Outlook for Water Resource Use in South Carolina 1985-2000," (SC Water Resources Comm.), by Strom Thurmond Inst., Clemson Univ., Clemson, SC 29634. (06D) The following volumes are avail.: First Year Report, 11/85; Second Year Report, 1/87; and Third Year Report, 1/88.

#### Miscellaneous

"AWRA Symposium on Coastal Water Resources, Wilmington, NC (Proceedings)," May 22-25, 1988, ed. by W. L. Lyke, et al, avail. from AWRA, 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814-2192. (02L)

"Water Resources Data North Carolina Water Year 1987," 1987, by B.C. Ragland, et al, avail. from Dist. Chief, USGS, PO Box 2857, Raleigh, NC 27602, (USGS)

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