1992-93 Program

Water Resources Research Institute
of The University of North Carolina

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The University of North Carolina Water Resources Research Institute was established in 1964 to meet the North Carolina’s water research needs. A unit of the University system, the Institute is located in Jordan Hall at North Carolina State University. The mission of the Institute is threefold: to identify the state’s ever-changing research needs, to motivate and support research by qualified scientists, and to provide for technology transfer. Findings from research funded by the Institute help local, state, and federal agencies make better decisions in managing water resources. To formulate a research program responsive to state water resources problems, the Institute works closely with the North Carolina Department of Environment, Health, and Natural Resources and other agencies. An Advisory Committee provides guidance and review. A Technical Committee of university faculty representing many disciplines also lends professional expertise to Institute programs and activities, particularly in research.

Water Issues and Institute Research Priorities

The Advisory Committee of the Water Resources Research Institute—made up of representatives from state and federal programs, local governments, industry, environmental organizations, private consultants, water and wastewater treatment plants, the university research community and others—advises on the need for water-related research in North Carolina, the region and the nation. Water resources and water quality issues recently identified by the committee for priority attention are discussed below.

Surface Waters

Three problems relating to surface waters need special attention from the research community:

Toxic Substances. Information about the fate of toxic substances in surface waters is essential for determining the degree of risk posed to aquatic species and to human health. It is also essential for developing effective monitoring programs.

Low Flows. The effects of minimum flows on fish in small streams affected by intensive urban and agricultural activities need to be better understood to aid in setting mandatory releases from water supply impoundments. The effects of stormwater and agricultural detention ponds on low flows are also worthy of attention.

Assimilative Capacity. As growth continues in the state, there is an increasing need to improve methods for allocating assimilative capacities of streams. In some areas, such as the lower Cape Fear River and in the Research Triangle, 100% of the assimilative capacity of streams has been allocated to existing dischargers, and no reallocation policy has been
developed for accommodating new dischargers. A critical question, from both a technical and public policy standpoint, is what kind of allocation process will best serve the public interest.

Nonpoint Source Pollution. Nonpoint source pollution from both agricultural and urban areas is a primary cause of surface water degradation in the state. There continues to be a need for research on best management practices (BMPs) to control agricultural and urban runoff.

Climate Change. There appears to be an emerging consensus that the earth is warming and that we will experience continued sea level rise. The consequences for North Carolina and how the state can adapt to the change are poorly understood topics. Preliminary findings, based on scenarios generated by global climate models, suggest that neither the magnitude nor the direction of changes to inland waters can be determined at this time. Nonetheless, the range of possible changes in either direction is sufficiently large that the topic must be taken seriously.

Because of the physical interactions between surface water and groundwater, many of the research priorities related to surface waters also relate to groundwater. The preceding discussion of climate change is a good example. Some scenarios show increased precipitation during the growing season; others show reductions. One method for estimating impacts of climate change on streamflow and soil moisture shows strong dependencies on temperature; others show very little of that dependence. Improvements are needed in the ability to predict soil moisture and streamflow in response to climate variables in order to reduce uncertainty about how long-term shifts will affect water resources and to improve hydrologists' ability to identify the onset of droughts and to make short-run forecasts during droughts.

Other groundwater issues needing attention are as follows:

Pesticides. There is a very limited data base on the use of pesticides in North Carolina and even less on their occurrence in groundwater. Furthermore, monitoring alone is not sufficient to detect potential hazards. There needs to be better information about the movement of the most commonly used pesticides in the soil types and aquifer conditions in North Carolina and where the highest potential for contamination exists.

Hydrocarbon Contamination. The most widespread source of groundwater contamination in North Carolina continues to be the storage and handling of gasoline and other hydrocarbons. Research is needed to enhance the understanding of the fates of these substances in the
underground environment and to develop more cost-effective methods for cleaning up contamination after it occurs.

**Landfills.** The impact of sanitary landfills on the quality of groundwater and nearby streams has received much attention in North Carolina. Further study is necessary to assist the state in formulating siting criteria and cost-effective contaminant containment methods that are appropriate in the state. Improved understanding of the hydraulics of leachate from landfills is also necessary.

**Sludge Disposal.** Finally, the expanded use of land disposal of sludge from wastewater treatment plants has attracted increased public interest in the fate of substances from those sites. Research on this topic under conditions that prevail in North Carolina would help to inform the public and identify any need for changes in present policy.

Although many of the priorities under the category of urban water management are related to surface waters, there are more specific concerns such as: watershed protection, treatment of drinking water and wastewater, management of urban stormwater, and regional management of supplies.

**Watershed Protection.** Several studies related to watershed protection have been completed through the Institute's research program, and several have been done by consulting firms under contract to local governments. While much has been and will be learned from these studies, there is not yet a general consensus about what levels and types of controls are appropriate for these watersheds. A particularly difficult and unresolved problem is that of protecting water supplies that are located downstream of existing municipal and industrial waste dischargers. There is a need to formulate and evaluate alternative institutional arrangements, minimum standards, and possible financing mechanisms for these types of protection programs. Research is also needed to identify the cumulative effects of many upstream developments on the quality of water in large impoundments.

**Water and Wastewater Treatment.** The treatment of supplies that are affected by upstream discharges from municipal, industrial, and agricultural sources continues to be a high priority. A variety of substances and treatment processes could have significant effects on the ability of new and existing water treatment plants to produce a product that satisfies the new drinking water standards and protects public health.

The identification and elimination of toxic materials in municipal and industrial wastewaters remains high on the list of priorities. Over half of
the waste streams tested in North Carolina have failed to pass one of the toxicity tests now used by the Division of Environmental Management. Additional study is needed to understand what substances are causing these failures and how they can be eliminated. Further study is also needed to evaluate the test procedures themselves to determine the existence of false positives and false negatives.

There is also a need to examine incentives and barriers to the non-potable reuse of wastewater effluents, especially during droughts.

**Urban Stormwater Management.** Urban stormwater management is not a new topic, but a number of cities in North Carolina are currently seeking new ways to cope with the increased magnitude of the problem as urbanization spreads. There is a need to evaluate the cost-effectiveness of management alternatives, to explore financing mechanisms for expanding services, and to develop new methods for operating and maintaining stormwater facilities. There is a special problem of integrating techniques and regulatory programs that address both the quantity and quality aspects of stormwater management.

**Management of Small Systems.** The management of small water and wastewater systems continues to be a problem for North Carolina as well as for the nation as a whole. The National Council for Public Works Improvement, established by Congress to evaluate the nation’s infrastructure, identified this as a major problem. Research is needed to identify and evaluate alternative management strategies for coping with this problem in North Carolina.

**Program Support**

In 1990-92 support for the Institute came from the U.S. Geological Survey through the Water Resources Institute Program (WRIP) and individual matching grants and support from the State of North Carolina through The University of North Carolina system. This was supplemented by the Urban Water Consortium, the City of Charlotte, the Orange Water and Sewer Authority, the City of Raleigh, and contracts with the Division of Land Resources, the Albemarle-Pamlico Estuarine Study, and the Office of Waste Reduction of the N.C. Department of Environment, Health, and Natural Resources; the U.S. Department of Agriculture’s Soil Conservation Service and the U.S. Environmental Protection Agency.
1992-93 Projects
New Research

Innovative Methods for Treatment of Municipal Landfill Leachate (70125)

PRINCIPAL INVESTIGATOR:
Sarah K. Liehr, Department of Civil Engineering, North Carolina State University

Starting Date: July 1, 1992
Completion Date: June 30, 1993

Predicting Contaminant Transport along Veins and Fractures above the Water Table (70121)

PRINCIPAL INVESTIGATOR:
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Starting Date: April 1, 1992
Completion Date: June 30, 1993

Regulations require collection and treatment of all leachate from active landfills. Currently, most landfill leachate is transported to municipal sewage plants for treatment, but this option may not be efficient or cost effective for many landfill operations. Other possible treatment methods include leachate recirculation, subsurface disposal, land application and various on-site methods utilizing engineered reactors or constructed natural systems. The effectiveness of any method will depend to a large degree on the composition of the leachate; however, the composition of municipal landfill leachate is highly variable. Generally, leachate contains high concentrations of degradable organics (TOC, COD, BOD), high solids (TDS, TSS), metals (Fe, Mn, Cd, Cu, Cr, Ni, Pb, Zn), nutrients (N, P) and potentially some toxic compounds. The goal of this study is to determine low cost treatment alternatives for landfill leachate. For the study, the investigator will review the literature on landfill leachate characteristics and implications for treatment by various methods. Since one possible option is using natural or constructed natural systems, the investigator will undertake a survey to determine the fate of leachate contaminants that leak to the surface and enter natural environments; and, finally, the investigator will design a research project utilizing one of the treatment alternatives identified.

There is strong demand for use of septic systems for on-site disposal of household wastes in North Carolina, but up to 30 percent of the land in some Piedmont and mountain counties is not considered suitable for septic systems because soils are shallow and wastes would have to be placed in weathered rock called saprolite. State regulations prohibit the use of saprolite for waste disposal if the saprolite contains mineral veins and fractures within 60 cm of the bottom of the drainfield. This is because the veins and fractures appear to be open pipelines through which wastewater can flow to groundwater. (Fractures and veins may also facilitate movement to groundwater of other contaminants since gasoline storage tanks, sanitary landfills and nuclear waste disposal facilities in Piedmont and mountain areas can be placed in saprolite.) Most saprolites examined to date contain such veins and fractures. It is known that many septic systems in Piedmont and mountain areas are failing. Recent research suggests that the number of systems that cause a surface discharge could be reduced if drainfields were placed deeper in the ground, specifically, in the saprolite. This is now being done in Virginia and Maryland in saprolites derived from felsic crystalline rock. A deep system in saprolite will lower the risk of effluent surfacing but may increase the risk of effluent reaching groundwater if veins and fractures are preferential flow paths. If it can be shown that fractures and veins do not function as pipelines for wastewater, then it should be possible to modify the N.C. septic system regulations to permit more use of saprolite for on-site waste disposal. The goals of this study are to determine how fast soluble contaminants will move along veins and fractures in saprolite as compared to the saprolite matrix and to assess whether the measured rates of movement pose a threat to groundwater. The investigator will also evaluate the usefulness of time-of-travel calculations for predicting solute movement through materials containing macropores or veins and will determine simple visual criteria that county environmental health specialists can use to determine where veins and fractures may facilitate movement of water and water-borne contaminants to groundwater.
Statistical and Time Series Analyses of Long-Term Suspended Sediment Concentrations and Yields in the Yadkin River Basin, NC (70123)

PRINCIPAL INVESTIGATORS:
Daniel D. Richter, School of the Environment, and Robert Nau, Fuqua School of Business, Duke University

Starting Date: June 1, 1992
Completion Date: June 30, 1993

Due to improving agricultural practices and conversion of cultivated land to pasture and forest, sedimentation is presumed to have decreased in many rivers in North Carolina and the region over the last few decades. The evidence to support such improvements in water quality is not, however, well quantified. This study's objective is to statistically analyze sedimentation patterns of the Yadkin River to evaluate changes in sediment dynamics between 1950 and the present. The analyses are significant for several reasons: (1) the basin has high sediment yields per unit area, the highest rates of North Carolina's major river basins; and (2) the suspended sediment record for this river is not only the best in North Carolina and the region, it may be the best in the nation (a daily U.S. Geological Survey record of suspended sediment and discharge from 1951 to present). Descriptive, frequency, regression, and time-trend analyses will evaluate sedimentation dynamics over the four-decade period. Changes in sedimentation can thus be examined with a resolution and over a duration that is far greater than any other river in the region, and probably the nation and the world. Since water resource planning depends directly on understanding long-term trends in water quality, these analyses based on such unusual data will be useful and interesting not just within the basin and region, but throughout the world.

Effects of Urbanization and Land Use Changes on Low Streamflows (70122)

PRINCIPAL INVESTIGATOR:
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Starting Date: June 1, 1992
Completion Date: June 30, 1993

Extremely low streamflows affect the ability of a stream to supply water for municipal, industrial and agricultural use, to dilute and disperse wastes, and to sustain aquatic life. While considerable work has been done to quantify historical low flows, little has been done to identify and document specific causes of low-flow variations over time or to develop the ability to predict low flows. This study is aimed at identifying and documenting the effects of urbanization and land-use changes on low streamflows. Detailed historical streamflow records will be obtained from the U.S. Geological Survey for a number of strategic streamgaging stations. For a given urban area or area where significant changes in land use have occurred, one upstream and one downstream station will be selected and the monthly flow records will be examined. Additionally, two stations nearby but not in the area affected by land-use changes will be selected and monthly flow records will be examined. Various comparisons of the low-flow records for these stations will be made to attempt to identify and document changes in low-flow history for the affected area. Results of this study could be used to predict changes in low flows in areas subject to urbanization and land-use changes. Using information derived from the study, regulators could plan future modification of regulations for affected areas, such as altering 7Q10 requirements.
Coastal Eutrophication and Disappearing Submersed Vegetation: Lethal Effects of Nitrate Enrichment on Eelgrass and Other Beneficial Aquatic Plants (50178)

PRINCIPAL INVESTIGATOR: JoAnn M. Burkholder, Department of Botany, North Carolina State University

Starting Date: Jan 1, 1992
Completion Date: Dec 31, 1992

This study is being funded by the Albemarle-Pamlico Estuarine Study.

Over the past few decades there has been a catastrophic decline of valuable eelgrass and other beneficial submersed aquatic plants along the Atlantic Coast. This decline has been strongly correlated with cultural eutrophication, a condition which increasingly characterizes North Carolina's Albemarle-Pamlico estuaries. Recent research demonstrates that during the warm spring growing season, water-column nitrate enrichment can cause death to eelgrass as a direct physiological effect. Pulsed daily additions of even fairly low levels of nitrate enrichment can be toxic. This indicates that before effective management practices can be developed to protect aquatic plants, the physiological mechanisms which control plant response and, hence, determine the fate of the total community must be understood. Also needed is an understanding of the threshold level of nitrate loading that begins to inhibit growth of desirable vegetation. The objectives of this project are to (1) work toward determination of the threshold level of nitrate loading which promotes destruction of eelgrass and (2) examine whether nitrate enrichment is also toxic to other valuable aquatic plants such as *Halodule wrightii* and *Ruppia maritima*. Hypotheses to be tested include (1) the toxic effects of nitrate act through self-imposed carbon limitation resulting from sustained high uptake of nitrate; and/or nitrate inhibition acts through phosphate limitation during sustained high nitrate uptake; and (2) growth of nuisance floating mats of "weedy" macroalgae such as *Enteromorpha* and *Ectocarpus* is stimulated at low levels of nitrate enrichment which begin to inhibit *Zostera*, resulting in reduction of available light and exacerbation of the effects of nitrate on eelgrass survival. Since continuously changing field conditions limit interpretation of interactive controls on seagrass survival, this project will utilize the mesocosm system. This system will make possible a realistic seasonal experiment under carefully controlled conditions of available nutrients, light and other factors.

The Role of a New Toxic Dinoflagellate in Estuarine Finfish and Shellfish Kills in the Neuse and Pamlico Estuaries (50179)

PRINCIPAL INVESTIGATORS: JoAnn M. Burkholder, Department of Botany, and Edward J. Noga, Department of Companion Animal and Special Species Medicine, North Carolina State University

Starting Date: Jan 1, 1992
Completion Date: Dec 31, 1992

This study is being funded by the Albemarle-Pamlico Estuarine Study.

In 1991 the principal investigators discovered a phantom dinoflagellate (a new species of the genus *Gymnodinium*) that is extremely toxic to a wide array of commercially important finfish and shellfish. The presence of live fish stimulates excystment and dinoflagellate activity. Without live fish, the *Gymnodinium* completes its sexual cycle and re-encysts. Such behavior makes the organism exceedingly difficult to detect and it was not until last year that its role as the causative agent of several major kills of finfish in the Pamlico and Neuse River Estuaries was documented. This project is aimed at providing information about the seasonal dynamics of this dinoflagellate, its overall role in finfish/shellfish skills, and its stimulation by nutrient enrichment from cultural eutrophication. The investigators will establish a network with State biologists for detecting the presence and economic impact of the dinoflagellate. Using isolates of this *Gymnodinium* they will conduct experiments to learn about optimal conditions for lethal activity, effects of nutrient enrichment, and effects on a range of finfish and shellfish. Finally they will work toward determining the potential for the protozoan *Styloynchia* to be used to control the dinoflagellate.
Biomarkers for Bleached Kraft Mill Effluent Exposures and Effects in Aquatic Animals (70124)

PRINCIPAL INVESTIGATOR:
Richard T. Di Giulio, School of the Environment, Duke University

Starting Date: Sept 1, 1992
Completion Date: Aug 31, 1993

Bleached kraft mill effluents (BKMEs) discharged into surface waters by pulp and paper mills constitute a significant source of contamination in many aquatic ecosystems in North Carolina. Present in these effluents are chlorinated phenolics, dioxins, furans, and resin acids. These compounds have been shown to produce a number of significant toxic effects in various organisms, and recent large-scale field studies in northern Europe have revealed ecological impacts in receiving systems. However, they do not typically exhibit acute toxicity, and routine bioassay approaches do not appear to adequately address the hazards associated with them. State-of-the-art biochemical monitoring techniques can be useful for elucidating the extent and effects of bioavailable contaminants in N.C. surface waters receiving BKME. This study will employ selected "biomarkers" (biochemical or physiological responses measured in organisms that provide sensitive, dose-dependent indices of exposure and/or sublethal stress in exposed organisms) in caged fish to track and quantify exposures and biochemical effects of BKME in the Roanoke River in eastern North Carolina and the Pigeon River in western North Carolina. The results will provide important information concerning the environmental impacts of paper mills on water quality in North Carolina. Additionally, the study will greatly enhance the development of sophisticated biomonitoring techniques applicable to BKME and other potential sources of aquatic pollution in the state.

Continuing Research

Management of Forested Filter Zones for Dispersion and Treatment of Agricultural Runoff (20161)

PRINCIPAL INVESTIGATORS:
E. Carlyle Franklin and James D. Gregory, Department of Forestry, and John E. Parsons, Biological and Agricultural Engineering, North Carolina State University

Starting Date: Aug 1, 1991
Completion Date: July 31, 1994

This project is being funded by a three-year matching grant to the Water Resources Research Institute from the U.S. Geological Survey.

The 1989 N.C. Nonpoint Source Assessment showed that agricultural pollution is responsible for 67 percent of the nonpoint source degradation of N.C. streams. Forested filter zones provide an especially good opportunity to reduce agricultural nonpoint source pollution. Farmers own about 30 percent of nonindustrial private forest lands in the N.C. Piedmont and Coastal Plain, and much of this is riparian forest also bordering agricultural fields. However, on most farms, runoff from fields flows through natural drainageways in the forested zone so that little filtering of nutrients and sediment takes place. In an earlier study, the investigators demonstrated that it is possible to enhance the filtering effectiveness of forested zones by distributing surface runoff uniformly across the upper portion of the forested zone with a level spreader. In this project, two small adjacent watersheds in Granville County have been equipped with (1) an H-flume to collect and measure stormflow at the inlet to the forested filter zones, (2) a level spreader to disperse stormflow across the slope, and (3) a second H-flume with wingwalls to intercept interflow and overland flows at the outlet from the forested area. The investigators have collected data on both natural and artificial precipitation events, and the data confirm reductions in peak discharge and peak flow between upper and lower flumes, resulting in increased infiltration and corresponding reductions in nutrients leaving the watersheds. Data collection continues in order to allow determination of the relationship between filter zone performance and factors such as slope, filter zone distance, microtopography, and vegetation characteristics. The resulting data can be incorporated into recommended best management practices and will be used to develop a model to assist in designing filter zones for water quality protection.
A promising technology for cleaning up oil-contaminated soil is in-situ degradation by bacteria. However, the potential for biodegradation may be limited if sorption of contaminants to soil components makes them inaccessible to bacteria. It has been found that some bacteria have the ability to produce extracellular surfactants with the ability to reduce surface and interfacial tension between soil solids and pollutants and thereby enhance the bioavailability of pollutants. The goal of this project is to study biodegradation by an organism found to produce surfactants of a hydrophobic pollutant that can be expected to sorb onto soil solids. Polycyclic aromatic hydrocarbons (PAH) will be studied since they are common contaminants. In the first year, the investigator has isolated and identified 5 degraders of the PAH phenanthrene from soil contaminated with wood treatment chemicals. Measurement of cultures of the five degraders revealed two that exhibited surface tension reduction. These two are now being investigated for surfactant production. Effects of biosurfactants on biodegradation will be evaluated, and stimulation of surfactant production and its effects on biodegradation will be studied. The research has direct implications for bioremediation in the field. If the role of surfactants is as significant as expected, the research can lead to an understanding of how to design remediation programs to stimulate surfactant production.

In 1989-90 nitrate-nitrogen concentrations exceeding the U.S. EPA health advisory level of 10 milligrams per liter (mg/l) were found in 5 percent of the private wells tested in N.C. Coastal Plain counties. Nitrate contamination of groundwater has been linked to application of fertilizers, and research in North Carolina has shown high levels of nitrates in very shallow groundwater beneath agricultural fields in the Coastal Plain. However, research in the N.C. Coastal Plain has never found nitrate concentrations greater than 1 mg/l in groundwater below about 25 feet from the surface. In some agricultural areas a clay layer (aquitard) about 25 feet below the surface soils prevents movement of chemicals to deeper aquifers, and in other areas the process of denitrification in the surface soil eliminates nitrates before they can move into deeper groundwater. The discovery of high nitrate concentrations in private wells therefore presents a mystery. It is not known if deeper aquifers are actually being contaminated or if contaminated shallow groundwater is being drawn into poorly constructed wells. The purpose of this project is to determine if nitrates in shallow groundwater under agricultural fields may move into deeper aquifers in the N.C. Coastal Plain and where high nitrate concentrations in the surficial aquifer may pose a threat to private drinking water wells. Since there is a positive correlation between movement of nitrates and movement of pesticides in groundwater, the project will also indirectly determine the potential for movement of pesticides into deeper aquifers. In the first year of the study, sites in northeastern Duplin County and at Kinston in Lenoir County were selected. Both were chosen because they are intensively cultivated and considered hydrogeologically sensitive. Transect selection, sediment sampling and fields analyses and descriptions have been completed for the Duplin County site and have been initiated at the Lenoir County site. In the second year, field studies at Kinston will be completed, and laboratory analyses and sampling for flow direction determination for both sites will be completed. Finally, modelling will be done to integrate data and determine the potential for groundwater contamination.
As population growth has increased the demand for home building sites in North Carolina, alternative low-pressure pipe septic systems have been approved for use in soils that will not support conventional systems, and some have been used extensively in some counties. However, compared to conventional systems, they are quite expensive and, like conventional systems, can fail. Responding to the demand for other on-site disposal options in soils unsuitable for conventional septic systems, the N.C. General Assembly approved the use of an on-site household wastewater treatment system that incorporates aerobic pretreatment of waste, disinfection of wastewater, and on-site disposal of wastewater by spray irrigation or trickle irrigation. The N.C. Division of Environmental Health is presently working to develop rules for design, installation, and operation of these on-site aerobic sewage treatment systems, but there is little information available to regulators to assist them in this task. The purpose of this research is to assess the performance of aerobic pretreatment with surface irrigation or subsurface disposal for individual on-site wastewater treatment systems in North Carolina. In addition, the study will address whether or not the proposed ground absorption loading rates for pretreated effluent could be increased for suitable and provisionally suitable soils. A design manual, based on the research, for individual spray irrigation and trickle irrigation systems will be developed. In the first year of the research, the investigator has negotiated agreements with a homeowner in Chatham County for evaluation of his spray irrigation/septic system and with a utilities company for installation of a low-pressure pipe disposal system and a trickle irrigation system at the community septic system of a subdivision in North Wake County. The investigator has also arranged for purchase or loan and installation of aerobic treatment units and two different types of trickle irrigation equipment, and has designed a dual low-pressure pipe system and a dual trickle irrigation system for the disposal of treated and untreated septic tank effluent at the Wake County subdivision. Installation of systems and instrumentation is expected to be complete in September, and monitoring will begin.

Most sanitary landfills in North Carolina were built in the early 1970s and are unlined. Leachate, which frequently contains toxic contaminants, can be expected to move through soil underlying landfills and into groundwater. Existing regulations require that if groundwater contamination moves beyond landfill boundaries, it must be cleaned up. The most commonly used cleanup technology—pump and treat—is very expensive. Current research suggests that natural biodegradation may reduce or eliminate many hazardous organic contaminants as leachate moves through soil and that there may be ways to enhance this natural biodegradation to help contain contaminants within landfill boundaries. This project will build on research completed by Robert C. Borden and J. L. Douglas which indicated that contaminants in leachate from a Raleigh landfill are being biodegraded as the liquid moves through soil. This project will confirm that apparent biodegradation of contaminants and will measure the rate of degradation of certain contaminants under both field and laboratory conditions. Knowing the rate of biodegradation will make it possible to project the distance between the edge of a landfill and a regional aquifer or stream required to fully degrade a contaminant. This knowledge will assist state regulators in the development of priorities and strategies for the management of landfills in North
Improvement of the Nanofiltration Membrane Process by Addition of Powdered Activated Carbon for Enhanced Removal of Precursors to Disinfection By-products in Small Water Utilities (70113)

PRINCIPAL INVESTIGATOR: Francis A. DiGiano, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill

Starting Date: July 1, 1991
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Carolina which are releasing leachate to groundwater. The field component of the work involves monitoring concentrations of target compounds in groundwater wells adjacent to and downgradient of a Raleigh landfill. In the first year of work, weekly monitoring has shown that a tracer is moving downgradient along the expected direction and at roughly the expected speed and that toluene appears to be degrading in the subsurface. The capability of microorganisms to biodegrade target contaminants is being measured in closely controlled microcosm experiments. Microcosms using aquifer soil and groundwater from three boreholes near monitoring wells have been constructed and are being sampled for detection of biodegradation. An additional set of microcosms has been set up to test the effects of buffer addition, addition of buffer and butyrate as a supplemental carbon source, and addition of buffer, butyrate and nutrients. In the second year, monitoring, sampling and data analysis will continue.

Chlorination of raw water containing high concentrations of natural organic matter and color often produces high concentrations of trihalomethanes (THMs), which are suspected carcinogens regulated by the EPA. Although small water systems are not yet required to monitor routinely for THMs, there is a great deal of concern about possible high levels of these substances in the drinking water of small towns, particularly in parts of the Southeast. Most of the alternatives to chlorination for treating drinking water are very expensive and may have other disadvantages. Small systems need a cost-effective method to further treat chlorinated water to remove precursors to chlorination by-products. Treatment by membrane systems may be attractive for small utilities since operating costs for such processes can be competitive. However, membrane separation systems can accumulate organic matter and become fouled. In this project, the investigator is examining a treatment system that combines powdered activated carbon (PAC) with membrane separation. The hypothesis is that membrane fouling can be reduced by the scouring effect of recirculating PAC particles as a slurry flowing across the membrane surface. The purpose is to demonstrate that a PAC-membrane treatment system can be cost-effective for small water systems and can produce drinking water of outstanding quality. In the first year of work, efforts have focused (1) on characterizing the molecular weight distribution of raw water from the Tar River and this same water after treatment with different PAC dosages; (2) determining rates of natural organic matter (NOM) adsorption by PAC and patterns of NOM removal at equilibrium; and (3) studies of the fouling of hollow fiber nanofiltration membranes with circulation of raw water and a PAC-raw water slurry. During the second year, the investigator will focus on reduction of membrane fouling and removal of NOM by addition of PAC. Bench-scale studies will be designed to optimize the PAC dosage/NOM removal relationship, as well as provide high rates of fluid shear across the membrane surface in order to reduce NOM solute fouling of the membrane.
Disinfection By-products in North Carolina Drinking Water (50168)

PRINCIPAL INVESTIGATOR:
Philip C. Singer, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill

Starting Date: Jan 1, 1991
Completion Date: July 31, 1992

This project is funded by the N.C. Urban Water Consortium

Trihalomethanes, suspected carcinogens created as by-products of chlorine disinfection of raw water containing humic substances, are regulated in drinking water by EPA, and it is expected that the current maximum contaminant level (MCL) for total THMs will soon be revised from 100 micrograms per liter (µg/l) to 50 or 25 µg/l. It has been shown that because waters in North Carolina have high concentrations of total organic carbon (TOC), high concentrations of trihalomethanes (THMs) result from chlorination, and an examination of State compliance records has shown that many larger public water systems have THM levels above 50 µg/l. In addition, a variety of other disinfection by-products (DBPs) are formed during drinking water treatment, and a number of these may also be regulated. This project is aimed at ascertaining the extent of DBP formation in finished drinking waters of the members of the N.C. Urban Water Consortium so that these utilities can be in a position to take remedial action to control formation when MCLs are revised and/or established. During the past year, three sets of samples of finished drinking water have been collected from each of six utilities. Samples were collected at the entrance to the distribution system and from several locations within the distribution system. Samples of settled water prior to chlorination were also collected. To obtain a prechlorination baseline, settled water samples were analyzed for TOC, pH, temperature and DBPs. Samples from the distribution systems were analyzed for residual chlorine, pH and DBPs. Chlorine dose was also determined to allow for calculation of chlorine consumption associated with DBP formation. The investigator is now analyzing the data to explore correlations among the different parameters analyzed. He is also testing a model developed for EPA to predict DBP concentrations as a function of water quality and operations parameters such as pH, temperature, chlorine dose, TOC concentration and residence time. Finally, he will use the results to assess the effectiveness of adding chloramine to treated water at the entrance to the distribution system to inhibit DBP production in the distribution system and will make recommendations for DBP control.

An Evaluation of Enhanced Aquifer Remediation Strategies for Subsurface Restoration (70117)

PRINCIPAL INVESTIGATOR:
Cass T. Miller, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill

Starting Date: June 1, 1991
Completion Date: Dec 31, 1992

The most common method of cleaning up groundwater contamination from underground storage tanks is to pump groundwater out of the aquifer, treat it, and return it to the aquifer. A 1990 national survey concluded that this method has not succeeded in reaching mandated clean-up levels at even one site in the United States. Some researchers insist that this method will never be effective for substances such as petroleum products that do not blend with water. This project is aimed at evaluating other aquifer remediation strategies, specifically (1) organic solvent extraction and (2) thermal extraction. In addition to evaluating the remediation strategy, the investigator is developing a two-dimensional multiphase flow and transport model capable of evaluating experimental data collected and predicting the response of porous media systems to combinations of single processes. The results from experiments and model analysis will be used in an economic analysis to determine the lowest contaminant levels achievable at a given cost and the cost and time required to achieve a typical cleanup standard. A structured approach is being used to investigate the effects of thermal variations and cosolvent properties on solute solubility, interfacial tension, fluid viscosity, pressure-saturation-conductivity relations, and mass transfer characteristics in multiphase, porous-media systems. Perchloroethylene (PCE) is the solute being studied, methanol the cosolvent, and both glass beads and a natural sand are the
Sediment and Phosphorous Loading: Predicting Water Quality in Urban and Agricultural Piedmont Reservoirs (70112)

PRINCIPAL INVESTIGATORS: JoAnn M. Burkholder, Department of Botany, and John E. Parsons, Department of Biological and Agricultural Engineering, North Carolina State University

Beginning Date: July 1, 1991
Completion Date: Dec 31, 1992

Runoff Potential and Chemical Transport in Agricultural Soils (70110)

PRINCIPAL INVESTIGATORS: Michael G. Wagger, Department of Soil Science and Ross B. Leidy and T. Jackson Sheets, Department of Toxicology; North Carolina State University

Starting Date: Nov 1, 1990
Completion Date: June 30, 1992

solid media being used. Most of the efforts to date have involved developing methods for the large number of measurements needed for the project, including an X-ray method of measuring fluid saturations as a function of position and time during mass transfer experiments and a method for measuring viscosity as a function of solvent properties and temperature. Methods have been worked out for every measurement needed, and routine applications of developed methods is under way. Modeling efforts are currently focused on the use of network models to describe residual saturation as a function of wetting-phase properties and temperature. This is a new application of such methods, and one that shows promise.

The purpose of the project is to enhance the ability of reservoir managers and water quality regulatory agencies to predict water quality in Piedmont freshwater reservoirs by (1) identifying and modeling biological responses to gradients of sediment and phosphorous loading and (2) characterizing nutrient and sediment loadings to Piedmont urban and agricultural reservoirs. During an earlier study, the investigators experimentally determined the response of aquatic communities to gradients of suspended sediment and high phosphate enrichment in Lake Durant, an urban reservoir, and used the data to develop a model for predicting water quality in Piedmont urban reservoirs. In this study, they have used an experimental field enclosure system (mesocosms) to test the effects of addition of 20 different phosphorus/suspended sediment cross gradient loadings in an effort to determine the threshold conditions that promote blooms of noxious algae. In the second year of the study, they are completing data analysis from the mesocosm experiment and monitoring nutrient and suspended sediment loading and water quality during precipitation events at Lake Durant and at Lake Devin, a representative agricultural reservoir. At Lake Devin this research team is cooperating with Dr. Carlyle Franklin's research team (see project 20161) to characterize runoff from various crop types on land adjacent to the reservoir. The data gathered through experiments and monitoring will be used to modify the predictive model for application to both urban and agricultural Piedmont reservoirs.

Conservation tillage (no tilling) has been hailed as a method of protecting water quality by reducing erosion from agricultural fields and therefore sedimentation in nearby streams. No-till, which leaves crop residues covering the soil surface, has also been promoted as a way of conserving soil moisture and increasing water available to plants by retarding evaporation. However, there are concerns that conservation tillage may require farmers to use more herbicides to control weeds in crops, and there is evidence that soluble nutrient concentrations in runoff increase with increased residue cover. This project is aimed at identifying specific agrichemical problems that arise from soil management methods and improving the ability to predict which management methods are most effective with various N.C. soils for enhancing water quality. Using data from long-term till and no-till studies at Agricultural Research Service stations in Reidsville and Rocky Mount and newly established experimental till and no-till plots at stations at Reidsville and Kinston, the investigators are quantifying pesticide and nitrate leaching under different tillage system/soil type combinations. In addition, they are conducting
Biomarkers for Redox-Active Genotoxins in Contaminated Sediments: A Mechanistic Approach (20158)

PRINCIPAL INVESTIGATOR: Richard T. Di Giulio, School of the Environment, Duke University
Starting Date: July 15, 1990
Completion Date: Jan 14, 1993

This project is being funded by a two-year matching grant to the Water Resources Research Institute by the U.S. Geological Survey.

rainfall simulation studies to provide information on the potential for chemical transport of some commonly used pesticides under a wide range of soil conditions. Soil sampling, rainfall simulation, and other field studies were completed during the first year of the study. Analysis of runoff and soil samples is being completed, and data analysis will follow. Cursory examination of early results seems to indicate that in the Piedmont, residual soil NO₃ concentrations are strongly influenced by tillage and only marginally affected by crop rotation.

It has been shown that persistent contaminants in rivers, lakes, and estuaries frequently collect in bottom soils or sediments, and recent studies have revealed elevated rates of tumors in bottom-dwelling fish taken from contaminated environments. There is, therefore, a need for methods for assessing the hazards posed by contaminated sediments to aquatic systems and people who use them. This project focuses on genotoxins that have been associated with tumors in fish and on the role played by free radicals in genotoxic sequelae and their implications for biomonitoring. The goal is to develop a sensitive, mechanistically based approach for monitoring DNA damage and associated indices of oxidative stress and contaminant metabolism in benthic fish exposed to contaminated sediments. Sediments from three locations in the Niagara River system with contamination (PAHs, PCBs, chlorinated pesticides) concentrations ranging from low to very high were obtained for use in sediment exposure experiments using channel and brown bullhead catfish. Exposure experiments have been completed and biochemical and genotoxicity analyses are in progress. These experiments will serve to quantify relationships between exposures to sediments and responses indicative of genotoxicity, oxidative stress, and hydrocarbon metabolism. Brown bullhead catfish were collected twice from the same Niagara sites that furnished sediments for measurement and histopathological analysis. DNA unwinding as well as a more novel biomarker (8-hydroxydeoxyguanine—assay standards for which were developed in this project) reflected the contamination gradient. When integrated, these laboratory and field studies will provide for creation of a sensitive and practical methodology for assessing the bioavailability and genotoxic impacts of compounds widely occurring in sediments of contaminated aquatic ecosystems. The methodology will have very practical uses for evaluating contaminated systems, prioritizing areas for clean-up efforts, and determining the success of clean-up efforts.
Determining the Role of Nitrogen-Enriched Acid Rain in Estuarine Eutrophication: The Neuse River Estuary, NC

PRINCIPAL INVESTIGATOR:
Hans W. Paerl, Institute of Marine Sciences, University of North Carolina at Chapel Hill
STARTING DATE: July 15, 1990
COMPLETION DATE: June 14, 1993

This project is being funded by a three-year matching grant to the Water Resources Research Institute by the U.S. Geological Survey.

Acid rain and associated dry deposition constitute a significant, yet frequently overlooked and unassessed source of biologically available nitrogen in shallow East Coast estuaries. The increasing frequency of nuisance algae blooms and the resulting water quality degradation in these waters suggest that the role of atmospheric nitrogen loading in estuarine eutrophication should be quantified. This project is examining productive and trophic impacts of atmospheric nitrogen deposition on the Neuse River Estuary. During the first two years of the study, the research team has used several techniques in parallel to investigate inputs of nitrogen in atmospheric deposition on in situ primary production. In addition to measuring responses by $^{14}$C assimilation and chlorophyll a assays, the researchers have used nitrogen isotope tracers at the natural abundance level to test whether the nitrogen in atmospheric deposition is responsible for increased primary productivity. First, they determined that the isotope of nitrogen from rainfall had low values relative to possible terrigenous or regenerated nitrogen sources. Then, in bioassay experiments with added rainwater, enhanced primary production and phytoplankton biomass responses were coupled to depletions in the isotope tracer of the natural phytoplankton community, indicating that it is indeed nitrogen from atmospheric deposition that is supporting new production in coastal ecosystems. Data from ongoing sampling at stations throughout the Neuse River estuary and from analysis of rainfall collections will help determine if acid rain events can be linked spatially and temporally to phytoplankton production or community composition and if acid rain plays a specific role in estuarine eutrophication and nuisance bloom dynamics.

Economic Impacts of Pesticide Regulations to Protect Groundwater

PRINCIPAL INVESTIGATORS:
Leon E. Danielson and Gerald A. Carlson, Department of Economics and Business, and Jerome B. Weber, Department of Crop Science, North Carolina State University

Starting Date: July 15, 1990
Completion Date: Jan 14, 1993

This project is being funded by a two-year matching grant to the Water Resources Research Institute by the U.S. Geological Survey.

Assessments of the potential for pesticide contamination of groundwater traditionally have been done without relevant local or regional input and without consideration of several critical hydrogeologic factors, including the characteristics of pesticides and site-specific soil characteristics. Moreover, local officials responsible for selecting policies to protect groundwater from pesticide contamination rarely have information about how well various policies protect groundwater or how the policies affect consumers and agricultural producers economically. This research will provide missing information that policy makers need to assess pesticide contamination threat and select the most efficient policies to protect groundwater resources. Work has largely been completed on compiling a comprehensive, up-to-date pesticide use database for the Southeast that reflects regional differences within each of the six states and on development of a system for rating the contamination potential of pesticides in 123 soil series. Field verification of the contamination potential rating system is underway as are county and subcounty comparisons of this system with the DRASTIC system. Several components for a model of pesticide efficacy-pesticide contamination tradeoffs have been developed or refined, including one to better estimate supply shifts from pesticide cancellations.
Movement and Dissipation of Pesticides and Water in Soils (21055-56)

PRINCIPAL INVESTIGATORS: Jerome B. Weber, Department of Crop Science, North Carolina State University, and Cass T. Miller, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill

Starting Date: June 1, 1989
Completion Date: Nov 30, 1992

This three-year project is funded by a matching grant to the UNC Water Resources Research Institute from the U.S. Geological Survey.

The major limitation in predicting groundwater contamination is the lack of understanding of the interactions among the processes involved in the dissipation of organic solutes, such as pesticides, in soil under natural conditions. Pesticide behavior in soil is affected typically by the processes of advection, hydrodynamic dispersion, evapotranspiration, volatilization, sorption/desorption, and degradation. While much work has been done in the area of pesticide process reactions, few studies have examined all of the operative processes for a given system. This project will add new information about the interaction of processes that affect the fate and transport of common organic solutes in the unsaturated soil zone. The overall goal is to gain a better understanding of the interactions among the processes mentioned above for a range of typical pesticides-soil systems. The expected results will also include new information about the feasibility of using polymers to limit the mobility of potential groundwater contaminants.

Controlled field studies utilizing 58 minilysimeters to evaluate the movement of water and three pesticides (metolachlor, alachlor, and primisulfuron) as a function of time, compound type, fertilizer content (nitrate), crop conditions and polymer additive have been completed. Parallel laboratory studies are determining a comprehensive range of physical and chemical characteristics of the field site materials as a function of position. Process studies are also determining the rate and products of biodegradation of each of the pesticides and the sorption-desorption equilibrium and rate characteristics of each pesticide as a function of position. Experimental results are being interpreted using developed models, while a common model (PRZM) is being used to compare predicted conditions with observed conditions in the field.

Effects of Drainage and Water Table Control on Groundwater and Surface Water Quality (20160)

PRINCIPAL INVESTIGATORS: R. Wayne Skaggs, Robert O. Evans, and John E. Parsons, Department of Biological and Agricultural Engineering; J. Wendell Gilliam, Department of Soil Science; and T. Jackson Sheets, Departments of Entomology, Crop Science, and Horticultural Science; North Carolina State University

Starting Date: Aug 1, 1990
Completion Date: July 31, 1993

This project is being funded by a three-year matching grant to the Water Resources Research Institute by the U.S. Geological Survey.

Poorly drained agricultural soils account for 40 percent of North Carolina’s total cropland. Because poorly drained areas lie near creeks, rivers, and estuaries, nonpoint source pollution from such areas used for agriculture pose a significant potential threat to surface waters and to groundwater. Controlled drainage methods are now being used as best management practices (BMPs) on thousands of acres of poorly drained agricultural soils in North Carolina and other Atlantic coast states. However the use of controlled drainage and subirrigation can reduce subsurface drainage and storage in the soil profile for subsequent rainfall events, thus potentially increasing surface runoff. Little research has been done on the effects of water table management on nutrient and pesticide movement and fate in the groundwater and surface water of poorly drained soils. This study is aimed at determining the effects of drainage and related water table control practices on groundwater and surface water quality, with particular focus on the movement and fate of pesticides and nutrients. Instrumentation to provide data on drain flow rates, water tables, and surface runoff water quality parameters has been installed on 8 plots. In addition, groundwater samples are being collected and analyzed at regular intervals. Two replications each of conventional, controlled, and subirrigation water management are being studied with two soybean-corn-wheat rotations using standard, recommended applications of pesticide and fertilizer. The second crop rotation began in June of this year. Data being collected will be analyzed to determine effects of water management, and fertility and pesticide practices on the quality of groundwater, drainage water and surface runoff. The data are also being used to test the reliability of simulation models for predicting the fate of pollutants in ground and surface waters. The most promising of these...
models will be further developed to improve their reliability for shallow water table conditions. The results will be useful to state and federal agencies, consultants, and farmers who are developing, evaluating, and applying methods for reducing nonpoint source pollution.

A previous study at the Neuse River Wastewater Treatment Plant sludge application site has shown nitrate contamination of groundwater at some fields, suggesting the need for more detailed studies to determine possible various routes of nitrate movement into groundwater and to surface water. This research is utilizing three test sites at the Neuse River Wastewater Treatment Plant facility. At Site 1, a field which borders a stream and which had not been used for sludge application before the project began, background information has been gathered about groundwater and surface water quality. As sludge application began, data were collected to determine the effects of application on the groundwater and surface water system. At Site 2, a field where sludge has been applied for several years, sampling of a number of monitoring wells is being conducted weekly for specific conductance, pH, and water level; monthly for chloride, nitrate, sodium, potassium and calcium; and quarterly for more complete analyses. These data will provide insight into the actual movement of nitrate through the vadose zone into the saturated zone and then toward stream discharge areas as well as an understanding of the potential for contamination of a bedrock well by nitrate originating in sludge. At Site 3, located on NCSU’s Randleigh Dairy Farm, four wells are providing information on nitrate movement to the shallow groundwater for three different potential sources of nitrate: commercial fertilizer applications to a grain field, dairy barns and feedlots, and a wastewater holding pond. Data from this site will allow the investigator to compare the potential for groundwater nitrate contamination at a sludge application site to the contamination potential at a dairy farm. Data obtained to date confirm the complexity of nitrate movement from sludge application areas into shallow ground water. Water level data from vertical monitoring stations show that at times there are places where the hydraulic gradient may be in an upward direction.

Alkaline stabilization of wastewater solids through the addition of lime has been commonly practiced for some time and has advanced from the use of lime principally for odor and vector control to more advanced processes that produce a stable, pathogen-free "biosolids" product. The stabilized end-product from these processes has soil-like characteristics, and thus is called "artificial soil." Artificial soil can be used as a soil amendment, as an agricultural liming agent, or in final cover material in landfill operations. This research project focuses on determining whether it can be used as an amendment to soil used to cover each day’s deposit of solid waste in landfills. Currently, disposal of sludge in solid waste landfills is restricted to incorporation into the final two feet of cover. If sludge could be incorporated into daily cover, solid waste landfills could again become a significant disposal option. In this project the Charlotte-Mecklenburg Utility Department transports artificial soil produced at its McAlpine Creek Wastewater Management Facility to the Mecklenburg County Harrisburg Landfill, which is undergoing final closure. The artificial soil is blended with soil cover material at the landfill. Landfill operations using the substitute soil are closely monitored, and
Evaluation of Technologies for Locating Utility Customers (50173)

PRINCIPAL INVESTIGATOR:
David H. Moreau, Water Resources Research Institute

Starting Date: Dec 1, 1991
Completion Date: June 30, 1992

This study is being funded by the Urban Water Consortium.

In a study for the Urban Water Consortium, WRRI is assessing technologies for geographically locating water and sewer customers. Assigning geographic coordinates to each customer allows a utility to group and analyze customer data for various system management purposes. WRRI will evaluate four methods of locating customers. Two of the four methods involve using the Pathfinder Basic Global Positioning System (GPS) to provide latitude and longitude for customer locations. GPS is a satellite-based, radio-navigation system operated by the U.S. Department of Defense. To obtain 3-dimensional readings, GPS tracks four satellites at a time and triangulates its position based on the locations of the satellites. This data is used in conjunction with a stationary base station, located at N.C. State University, which saves continuous records of satellite locations that can be used to correct the data recorded by the hand-held receiver. Another customer location method involves computer matching of customer addresses with the street addresses on the TIGER files from the U.S. Bureau of the Census. WRRI will use a geographic information system, Atlas GIS, to match customers to latitude and longitude coordinates. Street files from the 1990 U.S. Bureau of the Census TIGER files will be used as a base by which to address-match customers in a system. A fourth method to be evaluated will use meter books as a guide to digitizing customer location points.

Evaluation of Land-Use Changes within the APES Area Utilizing the GIS (50172)

PRINCIPAL INVESTIGATOR:
Robert E. Holman, Water Resources Research Institute

Starting Date: May 1, 1991
Completion Date: Sept 30, 1992

This study is being funded by the Albemarle-Pamlico Estuarine Study.

Critical to the successful development of a Comprehensive Conservation Management Plan for the Albemarle-Pamlico Estuarine system is the evaluation of human development trends throughout the entire area. The existing Geographic Information System (GIS) can be a powerful tool in evaluating many important data layers. Investigating land use and population census data layers currently available to the Albemarle-Pamlico Estuarine Study (APES) will produce a better understanding of where human impacts have and are taking place. Preliminary evaluation of the 1987-88 LANDSAT land-use classifications indicates an underestimation of residential development and forested wetlands. This can lead to large errors if the data are utilized below a basin level, especially on a sub-county and sub-basin level analysis. Much of the urban classification is composed of rural residential development, and the wetland classification is composed of forested wetlands. This study is utilizing county officials to determine the extent of development within each county based on earlier Land Use Data Analysis (LUDA) data and combining National Wetland Inventory data with LANDSAT wetland data to correct these classification errors. Current population densities and land use/land cover maps for each county will be developed for the entire APES study area.
Urban Water Consortium

The 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. The Consortium program is administered by the Institute. Participating cities support and guide the program through annual dues, which are matched by state funds, and representation on an advisory board. Membership in the Consortium is open to all cities and special districts in North Carolina. The program initially received support from the N.C. Department of Environment, Health and Natural Resources and appropriations from the N.C. General Assembly. Support for Consortium projects during this year included the Orange Water and Sewer Authority, Raleigh, Durham, High Point, Burlington, Winston-Salem, Charlotte, and Greenville. Urban water research needs cover a broad range of topics. Problems addressed with Consortium support included:

- Nitrate Movement to Groundwater at a Wastewater Treatment Facility
- Disinfection By-Products in North Carolina Drinking Water
- Treated Wastewater Sludge for Landfill Cover
- Mapping Customer Records with a Geographic Information System

Information & Technology Transfer Activities

Publications

The Institute disseminates information and promotes the adoption of new technology through publication of newsletters and of technical completion reports on its projects and through conferences, workshops, and seminars.

Newsletters. The WRRI NEWS, a 16-page newsletter, was distributed bimonthly to more than 2,900 federal and state agencies, university personnel, multi-county planning regions, city and local officials, consultants, and interested individuals. The NEWS regularly covers a wide range of water-related topics from current federal and state activities and new research findings to special announcements and listings of new publications.

The Urban Water Consortium News is published periodically and distributed to members of the Urban Water Consortium, who use the newsletter to keep their constituencies (city councils, county commissioners, etc.) informed about the activities of the consortium and about water-related issues affecting municipalities. The newsletter carries descriptions of research funded through the consortium as well as news about water-related projects undertaken independently by members and state and federal programs and legislation.
**Research Reports**

A strong demand for Institute reports continues. During the year, the Institute published the following reports for distribution to users throughout the state and nation:

- **WRRI-260** Use of Activated Carbon to Remove Radon from Drinking Water
- **WRRI-261** Application of the Toxicity Reduction Evaluation Protocol for Municipal Wastewater Treatment Plants: Case Histories at High Point and Fayetteville, NC
- **WRRI-262** Effect of Vapor-Phase Mass Transfer on Aquifer Restoration
- **WRRI-263** Investigation of Multicomponent Sorption and Desorption Rates in Saturated Groundwater Systems
- **WRRI-264** A Study of Water Quality in Lake Raleigh
- **WRRI-265** Development of Analytical Methods for the Identification of Organic Nitrogen Chlorination By-Products in North Carolina Surface Waters
- **WRRI-266** The Impact of a Piedmont Sanitary Landfill on Surface and Groundwater Quality
- **WRRI-267** Evaluation of Urban Stormwater Maintenance in North Carolina
- **WRRI-268** Application of Passive Dosimetry for Detection of Leaking Underground Storage Tanks
- **WRRI-269** Cloud Point Extraction and Preconcentration Procedures for Organic and Related Pollutants of State Concern
- **SRS-8** Water Reuse in Selected States

**Water Fact Sheets**

Fact sheets dealing with various aspects of North Carolina's water resources have been published by the Institute. Six different fact sheets include

- *facts about major river basins,
- *facts about principal aquifers,
- *a water resources quiz,
- *a water use quiz,
- *water conservation with low-flush toilets, and
- *home water treatment devices.

**Conferences, Workshops, and Seminars**

During the past year the Institute sponsored and helped plan four conferences, six seminars, and three workshops on key water issues. Following is a brief description of them.

**Watershed Protection and Stormwater Permitting Conference.** In May, WRRI, UNC-Charlotte, Catawba Valley Community College-Environmental Policy & Studies Center and others sponsored a conference to review the current status of watershed protection in North Carolina and stormwater permitting. Perspectives were gained from a federal, state, county, city, industry, legal and consultant viewpoint during this one-day meeting. Two hundred and fifty people attended.

**Southeast Roundtable Conference of State Pollution Prevention Programs.** In April, WRRI and the North Carolina Pollution Prevention Program sponsored a conference to bring together all eight state pollution prevention programs in the southeastern United States. The purpose of this conference was to discuss
activities that are taking place at both a state and regional level over a two-day period. Forty people attended.

National Roundtable Conference of State Pollution Prevention Programs. In April, WRRI, N.C. Pollution Prevention Program, Duke Power, Tennessee Valley Authority, and Waste Reduction Institute for Training and Application Research sponsored a conference to bring together state pollution prevention programs from around the United States. This conference's purpose was to discuss activities that are taking place at the state, regional, and national levels over a three-day period. One hundred and forty-one people attended.

Groundwater and Associated Environmental Concerns: State and Local Responses Conference. In March, WRRI, N.C. Cooperative Extension Service, N.C. Association of County Commissioners, N.C. League of Municipalities, and others co-sponsored a conference that focused on state and local responses to a host of environmental issues. The conference covered such topics as groundwater protection, watershed management, on-site waste disposal, and wetlands over a two-day period. One hundred and sixty-five people attended.

Erosion and Sediment Control Workshop for Local Programs. In February, WRRI, the N.C. Sedimentation Control Commission, and the N.C. Land Quality Section presented a two-day workshop to allow local programs to get together and exchange ideas and practices utilized at the local level. Topics included sediment control law, inspection, installation practices, plan, and administration and organization. Sixty-one people attended.

Expert Panel Workshops. In January and February, WRRI brought together two groups of experts in the fields of stormwater and wetlands to discuss issues, research needs, and potential conference agendas. These workshops have proven to be very valuable to the Institute in staying abreast of the current and future thinking on these subjects and what type of research is needed to address critical issues. Seventeen people attended.

Water Resources Research Seminar Series. In October, WRRI started a monthly seminar series of ongoing research projects being funded by the Institute. Project reviews included municipal sludge, constructed wetland systems, stormwater management systems, vegetative filter strips enhancement, vegetative filter strip nutrient removal, and sediment and phosphorus loadings.
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