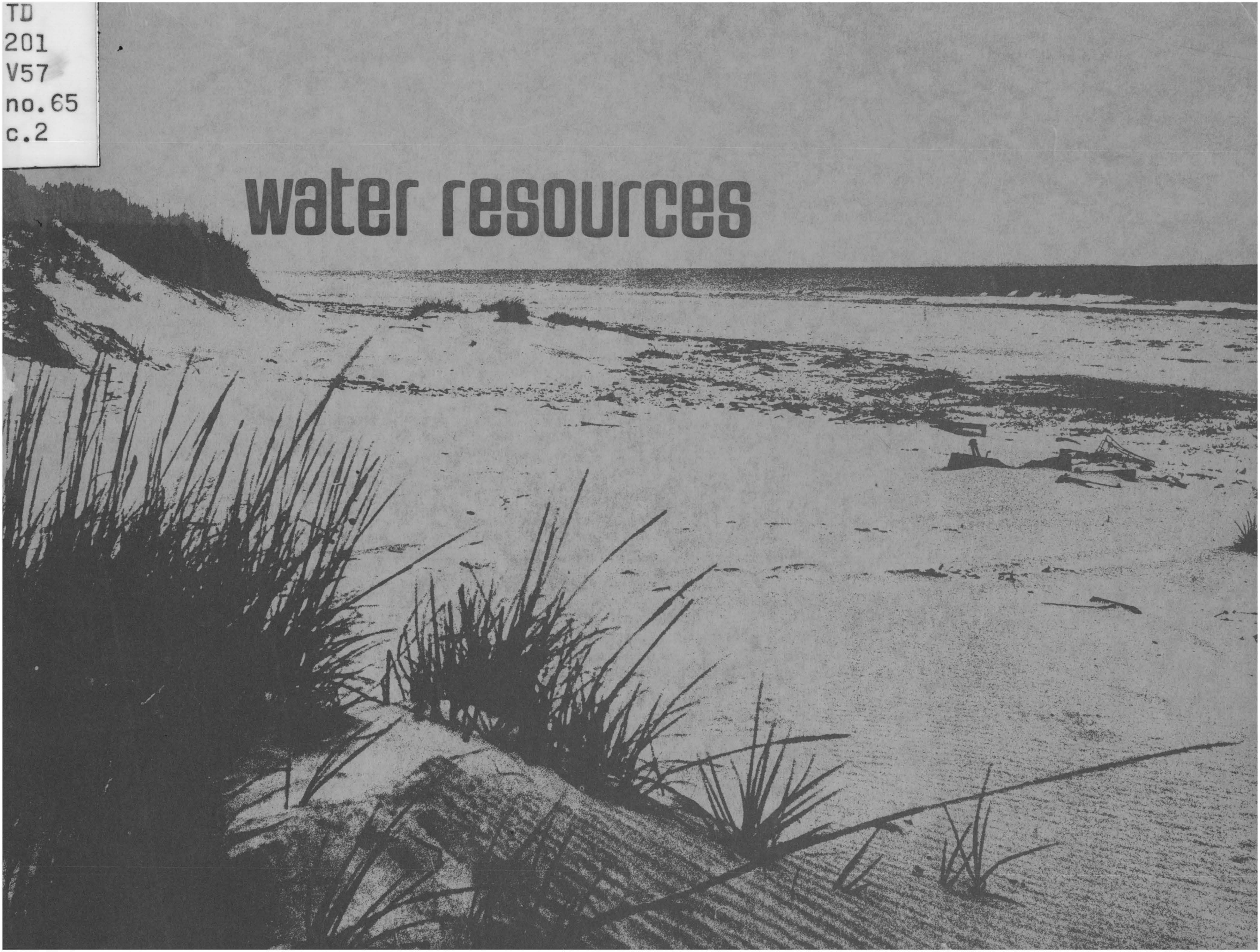
water resources



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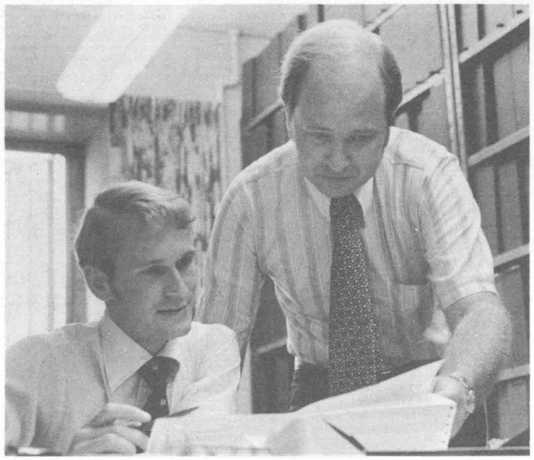

this year's research structure characterizes concern for preserving natural water resources

1 projection

what forecasting techniques can help prevent poor management decisions, p. 6 fish fills, p. 8 plant-clogged lakes, p. 9 fruitless drilling procedures, p. 11 or expensive public utilities? p. 13

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1 projection

The computer has entered water research. Projects funded through the Virginia Water Resources Research Center at Virginia Tech capitalize on the crystal ball ability of the computer. In three studies, programs have been devised to project the outcome of reservoir management decisions, the effects of pollution on the James River, and the density of plant growth at a certain time in a lake.

In managing a multi-purpose reservoir the recreation specialist exceeds his budget by ninety thousand dollars, the fisheries manager decides that this year he will stock twenty thousand striped bass, and the regional planning commissioner investigates a land use plan. All these activities can be analyzed in a matter of minutes using DAM, a computerized game devised this year.

Indeed, in completing DAM, Dr. Robert T. Lackey and Franklin B. Titlow, both in Virginia Tech's Forestry and Wildlife Department, provide economy for the public and training for natural resource management personnel and for individuals involved in engineering, industry, and government. With its quick feed-back, this exciting teaching game supplies realistic management experience which allows the player to evaluate his own decisions, rather than those of other people.

Not intended to totally take the place of actual field practice, DAM, nonetheless, reduces the time and cost of management training programs and can substitute for the sometimes unpopular use of natural resources.

The campus use of DAM can supply more employable persons for resource agencies seeking managers with decision making experience. "These games provide a source of experience in management by developing effective decision makers," Dr. Lackey says. "Teaching natural resource management is difficult in that most experience in decision making is unavailable to the student until he seeks his first job."

Lackey also foresees the inservice training advantages of DAM. In workshops or short courses, persons in the fields of engineering, industry, and government can play the game, either to gain an understanding of the many facets of managing a reservoir or to gain a better understanding of their present job in water resource management.

To construct and qualify DAM with its basic deck of thirteen hundred cards, Lackey collected information about Smith Mountain Lake, a pump-storage facility completed in 1965 by Appalachian Power Company and located near Roanoke, Virginia. Interviews with federal, state, and local agencies, as well as with area citizens,provided data about the lake region.

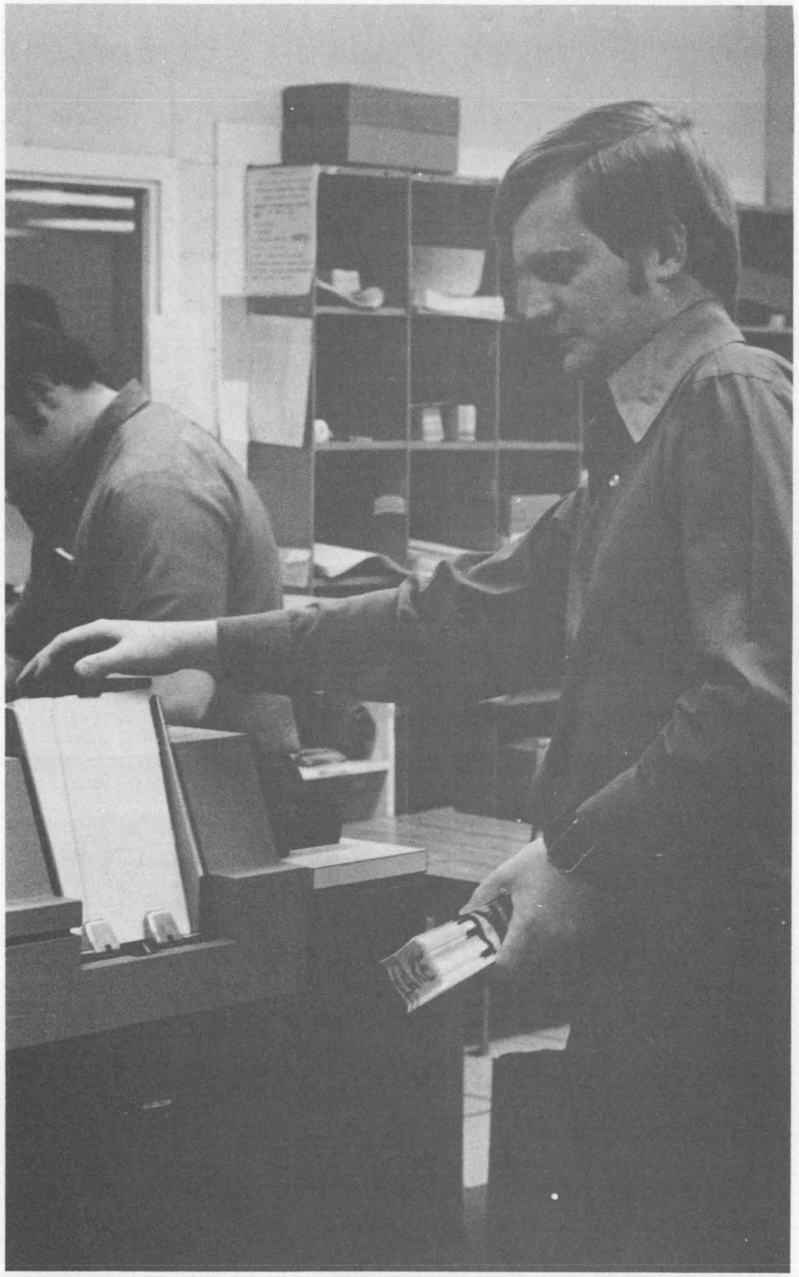
For instance, the Virginia Commission of Game and Inland Fisheries established that a minimum flow of six hundred fifty cubic feet per second is necessary for protecting the fishery in the river below the lake; the Coast Guard Auxiliary stated in an interview that permanent navigation of the river below the dam requires a flow of six thousand cubic feet per second, and real estate agents in the area quoted an average per acre land value of two thousand dollars. Indeed, Lackey emphasizes that the data in the computer game is based on actual experiences and facts.

From the queries, problems and possible solutions for the reservoir management were postulated. Structuring this mass of information into a workable edifice for DAM was the next step for Lackey and his assistant. Five management units were delineated—regional planning commissioner, fisheries manager, power company executive, recreation specialist, and a city mayor. Further, each decision was assigned an area, each area placed in the proper management unit, and each area appropriated several management alternatives.

To play the game, either by computer card manipulation or by the use of the terminal with its almost instant evaluation of decisions, a student assumes the role of all the management units, or a group of students forms a management team with each participant delegated a role. A popular asset to DAM, Lackey points out, is the fact that no prior knowledge of a computer is required; a fifteen to thirty-minute introduction to the learning exercise is adequate.

Reading down the decision alternative sheet, the student makes choices within the alloted range of his authority. For example, the regional planning commissioner may decide to construct four hundred miles of highway near the lake. In the computer the decision will not only be evaluated in terms of his own management area, but also in relation to the responsibilities and decisions of the other managers. In reading the computer responses, the regional planning commissioner finds that his decision would make him subject to being fired, since the costs would exceed his allotted budget, would delay the recreation specialist's plans to construct parks in the area, would prove unpopular with land owners in the Smith Mountain Lake area who want to maintain the natural environment, and would probably be cancelled because a flood in the valley that year would necessitate road repair rather than new road construction.

Having made the "wrong" decision, the regional planning commissioner and other members of his management team then amend their decisions and attempt to find the best policies for that year and perhaps, for the four more years provided in the management scope of DAM. Indeed, Lackey observed in his first test class a competitive atmosphere among the groups seeking to yield the best policies. Realism, economy, efficiency, training, excitement, teamwork—–it's all in the game!



In computer time, one day in the life of the James River can last thirty seconds—–according to Dr. Richard G. Krutchkoff and his graduate assistant Harry Bard of the Statistics Department at Virginia Tech.

This year they have developed a computer program to predict water quality changes brought about by shifts in sources and amounts of organic pollutants. Such projection can be geared to reflect changes by days, months, or years.

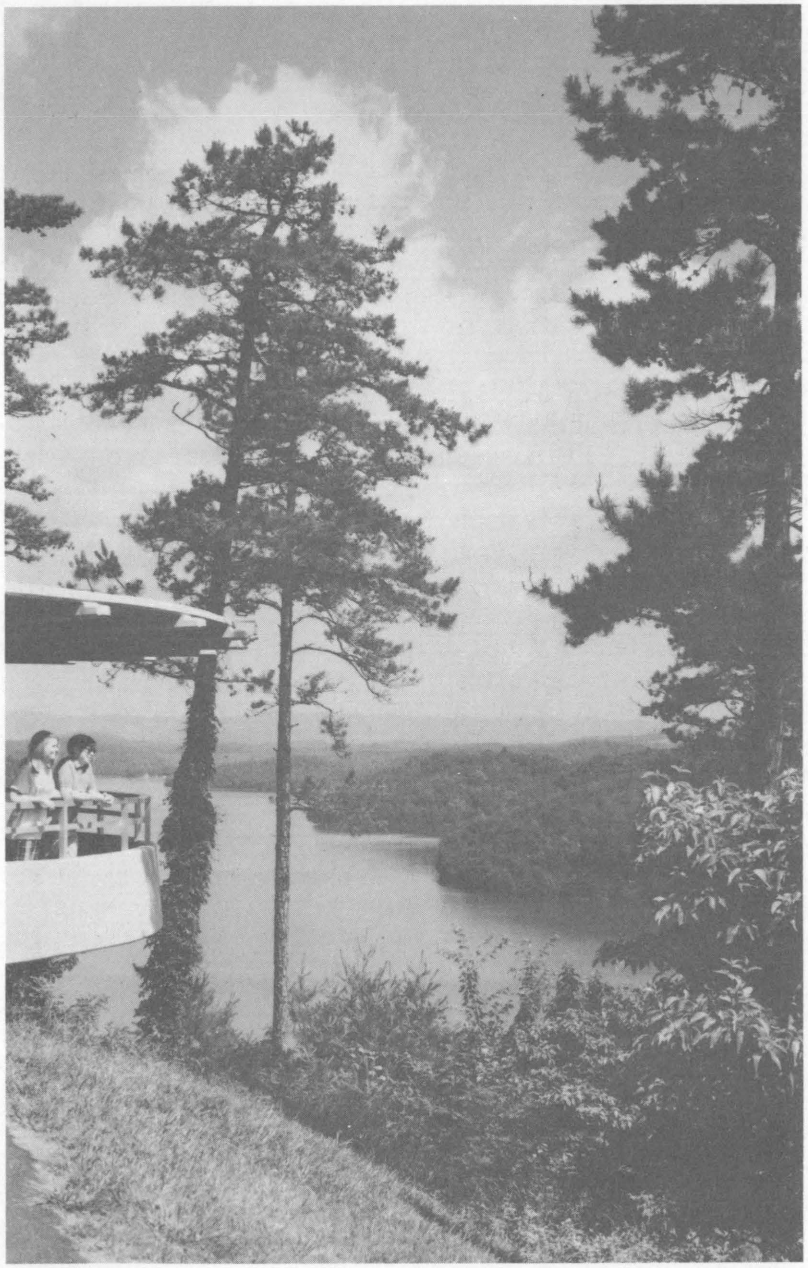
Fish kills and disruptions in other stream recreational functions may no longer need to be investigated; with this forecasting technique they need not happen at all. Data from the computer can predict an imbalance or a deficiency in the water quality that would cause such problems.

In addition, the investigators state that questions about future water quality as it is affected by pollution and population can be answered by such a procedure. They also believe that the model and its analysis can be formalized enough that they may serve as a basis for similar studies of other streams. Data and procedures for future organic life study of streams can be supplied by this James River model.

The study area is a sixty-mile section of the James from Richmond to Hog Island. Fed into the computer are facts about the freshwater flow rate, the region surrounding the stream, and sources and amounts of biodegradable pollution. Since the river is affected by tides, the model includes data concerning tidal velocity and flow.

Introduced into the program are proposed or hypothetical changes. For example, the freshwater flow rate may be speeded up, the water temperature lowered, pollution input at various points increased, and the location of a pollution source moved farther downstream. The model has the ability to predict concentrations of natural nutrients, such as nitrogen, phosphorous, carbon, and oxygen that result from the simulated changes.

The possibilities for using the model to study effects of real-life proposals to change the quantity and quality of water are promising. Perhaps, too, the objective scrutiny of a computer can influence real-life decision makers to choose the alternatives that lead to healthy streams.



Citizens observing a reservoir clogged with unsightly algal masses and smelling of decomposing organisms see faint similarity to the clear lake they had anticipated when debating public costs of its construction.

To help offset such public and management disappointment, Dr. G. M. Hornberger and Dr. M. G. Kelly and their assistants at the Department of Environmental Sciences at the University of Virginia have this year begun constructing a computer model which will be able to predict the growth of floating plants in a reservoir.

When the model is completed next year, it will be able to simulate situations of interest to reservoir managers. For example, the time and depth distribution of spring algal blooms can be projected. The effects on the plant population and variety of artifically mixing the lake can be analyzed. The changes brought about by seasonal shifts can be forecast, and the results of adding specific nutrients to the reservoir may similarly be foreseen.

Using the data after these situations have been examined in the computer, reservoir managers will have an objective foundation on which to make decisions regarding water quality maintenance.

Already in operation is a preliminary version of the descriptive and predictive model. To collect facts to tune the model to fit data collected from field study, testing was begun on an operational reservoir. Being used for study is Sugar Hollow Reservoir which serves as a water supply for Charlottesville, Virginia.

This year the investigators designed experiments to discover when the balance of certain nutrients would favor the increased development of certain plants. This balance is vital because the result of excessive growth of these one-celled plants could be the killing of fish and other animal life. At night, plants consume oxygen, and the increase in algal density could mean a decrease in the supply of dissolved oxygen. Thus, fish and other plant life would be in jeopardy.

Polyethylene bags, the meticulous counting of one-celled plants and animals under a microscope, regular samplings, and combinations of phosphate and nitrates--all these were part of the experiments for the Sugar Hollow field study. Fourteen polyethylene bags were attached to a floating rack and extended about ten feet under the water. Two bags acted as control bags, but the others were treated with high and low concentrations of phosphate and nitrate or combinations of the two nutrients. The growth of the algae was monitored every two days for four weeks by removing samples at three depths in each bag. Also measured was chlorophyll-a, dissolved oxygen, and light and dark bottle productivity.

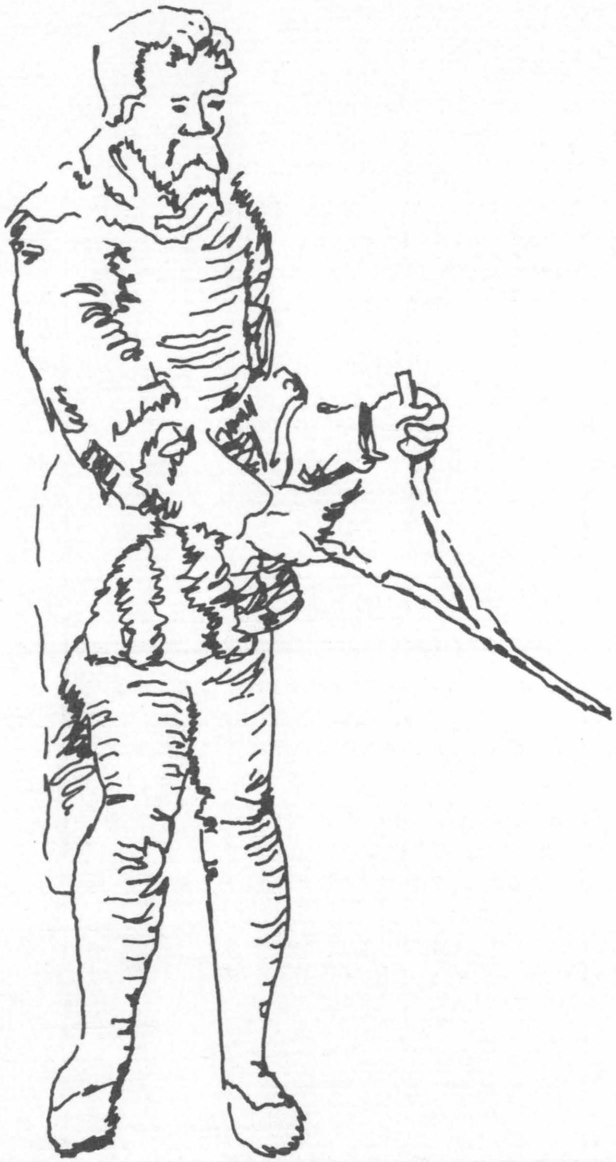
By these samplings, Hornberger and Kelly have this year determined growth rate of the major species in the model. The cell count data will also serve to help resolve controversy as to whether the variety of plant species found in a standing body of water is a satisfactory indicator of suitable water quality.

Next year's plans dictate the expansion of the model. Facts concerning the influence of temperature, depth, and light on plant growth will be included in the completed model. In searching for these answers, new field testing equipment must be designed. For example, some way must be devised to suspend enclosed polyethylene bags to various depths in the lake to collect samples.

Most important in terms of reservoir management, however, are the investigator's plans to simulate in the computer several real-life management techniques and to use the model to evaluate their effects on plant communities in the lake.

Indeed, this realistic approach characterizes many of the methods in this project. Using actual data from a reservoir, the computer model was checked for accuracy. The model will be used to test common management decisions, and the field tests are being devised to avoid what these scientists term the "artificiality imposed by laboratory cultures."

Just this effort to make the data from the model both accurate and practical may provide an additional benefit to Virginians. Hornberger and Kelly foresee that their model could be applied to project conditions on other reservoirs.



The use of the divining rod to find fresh water is well represented in American folklore and superstition. To several farmers on Virginia's coastal plain, Dr. Mohamed Sabet with his electrodes and sensitive volt meter may have seemed a somewhat sophisticated diviner.

Dr. Sabet of Old Dominion University has completed a study this year to help determine at what depth fresh water may be found in various sections of the coastal area tested. Stated another way, the results and interpretation of the testing procedures can indicate how deep not to drill for water. The investigator's system can predict the depth at which the absence of fresh water will probably testify to the absence of fresh water at even deeper levels.

The results of this study are important to towns which must increase their freshwater supply and state agencies which must select sites for observation wells. Obviously, such a well should not be drilled in an area not representative of the geology of the larger area. Sabet explains that his above-the-ground procedures can detect variations beneath the ground and, thus, can help in the selection of appropriate drilling sites.

A further feature of the process is its practical cost and operation. The initial capital investment for equipment is eight thousand dollars. Three persons using the equipment can do one sounding a day. The addition of two thousand dollars worth of equipment and increased manpower could raise the performance level to three or four tests a day. Sabet emphasizes that a person with a high school education could perform the testing using his interpretation scheme perfected this year.

Adopting a method that Sabet terms "well-known" and "successful in other areas," the divining scheme was used in a section of Virginia for the first time. An underlying objective of the study was to determine if the method would work in the coastal plain of Virginia. Sophisticated technology and computers have helped Sabet develop the system to its full potential.

The scientist selected thirty-nine farms for testing. His aim at each site was to identify the layers beneath the surface by their resistance to electricity. A central testing area on each farm was designated. Two electrodes, or steel rods connected to a current source, were strung together and placed over the site. A voltage meter recorded the electrical resistance at various distances from the center. A total of forty-six readings (twenty-three on each side of the meter) were taken at distances of twenty to eight thousand feet. The resistance levels of the layers are subject to the quality of water present. If salt water exists, the resistance is small; whereas, fresh water produces a high resistance. The voltage meter readings plus data already established from such places as observation wells were used to characterize the geological layers and to determine the location of fresh water. The testing depth was virtually unlimited. The testing could continue as far as electricity would penetrate.

Sabet's results are quite specific in indicating possible freshwater depth. For example, fresh water appears to be present at fourteen hundred feet north of Franklin, Virginia, at two hundred fifty feet in a section south of Petersburg, and at seven hundred seventy feet near the South Hampton Prison Farm. Interestingly enough, wide variations of freshwater depth were identified at relatively close sites. For instance, a few miles east of Gloucester fresh water appears to be at a depth of one thousand seven hundred thirty feet. A few miles east, in Mathews county, salt water seems to be found just beyond one hundred fifty feet.

As a modern diviner, Dr. Sabet has provided scientific data that can benefit state agencies and private citizens.

Perhaps the most heated debates within town councils or planning boards center on zoning and patterns for commercial, residential, and industrial growth.

Often officials must base their decisions only on the arguments of citizen groups or other subjective considerations. Dr. John W. Dickey of Virginia Tech's Department of Urban and Regional Planning has developed the means whereby decision makers can be presented alternatives based on objective data.

Using the mathematical projection technique TOPAZ, Technique for the Optimum Placement of Activities in Zones, Dr. Dickey has demonstrated the means of forecasting the most beneficial and economical land use arrangement for water distribution and sewage collection. In other words, the process, which Dickey terms a "pre-step" for zoning, basically describes how homes, apartments, industries, and businesses ought to be placed to bring about the most economical scheme for water and sewage services.

TOPAZ was first used in Australia and only recently in the United States. According to the principal investigator, TOPAZ involves "not new" nor "particularly sophisticated" mathematical procedures. However, TOPAZ has never before been applied to public utilities. According to the director of the Water Resources Research Center, "Little information is available about costs of public service facilities as affected by land use activities." The application of TOPAZ in this area should fill such an information gap.

Blacksburg, Virginia served as the town for Dickey's pilot study. Various types of information about the town were supplied to the basic model. The acreage of vacant land, estimations of future needs for development, water and sewage costs, placement of local roads, and costs of electricity, construction, and pipes were used. Also, the geology of the area, existing waste and sewage systems, and present land uses were described and placed in the model.

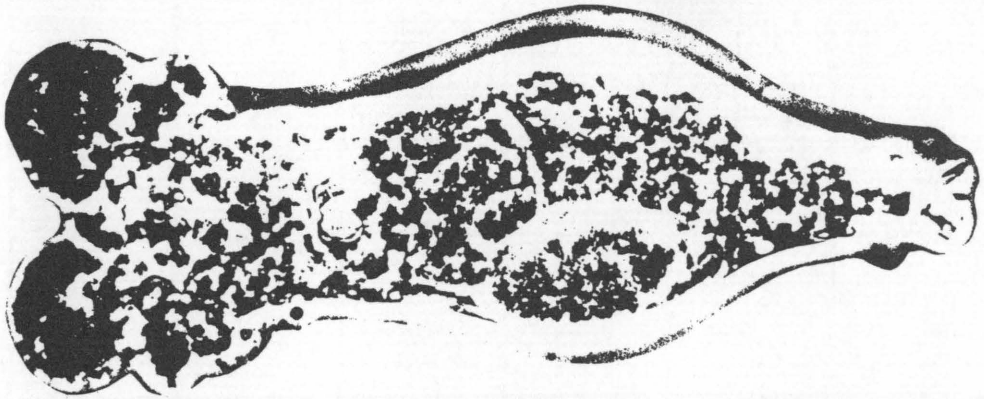
After TOPAZ has been applied to this data, one can use the results, according to Dickey, to act almost like a "dictator" to determine ideal arrangement for land use.

The research for the project extended beyond illustrating the use of TOPAZ for city planning. Answers to several questions were probed. What are the legal tools, such as zoning, necessary to make the results of the study operational? What are the funding sources to finance the use of TOPAZ in other areas? What corporations or organizations could be involved in a TOPAZ study or in the application of the findings?

This projection design can be used on a somewhat smaller scale by hospital designers and campus planners. Richmond, Virginia, is currently using the technique in its urban design processes.

The results of this study should have particular appeal to decision makers in new towns and to the developers of planned communities. For whatever purpose TOPAZ is used, the main advantage is that it can provide objective alternatives for personnel who must chart patterns for building design or land use.

2 monitoring



Can tiny insects and animals in a stream serve as monitors for water quality? Scientists involved in two projects sponsored by the Water Resources Research Center believe that gnats, mosquitoes, and rotifers may be built-in environmental scouts. These studies, completed this year, were designed to test reactions of several small organisms to certain common pollutants. These responses may signal the presence of water contamination.

One of the first organisms observed under the microscope by its seventeenth century inventor, Leeuwenhoek, was the rotifer.

This year using more advanced microscopes, Dr. Arthur L. Buikema, Dr. John Cairns, Jr., and their graduate assistant Gail W Sullivan, all connected with the Biology Department of Virginia Tech, have studied these tiny creatures in a research project which provides information about the effects on the rotifer of several heavy metals such as mercury, lead, and zinc.

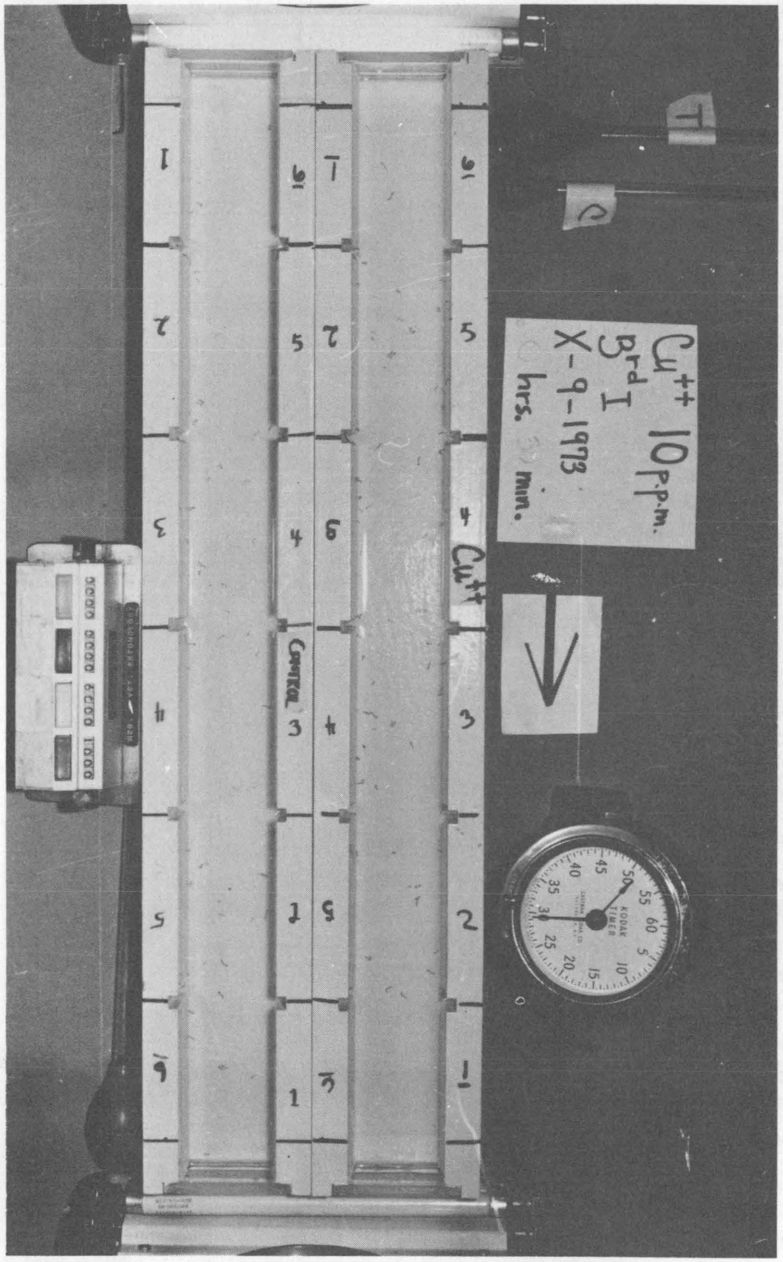
Since the rotifer plays an important role in maintaining a proper decomposition balance in sewage treatment plants by grazing down bacteria and algae, results of this study will serve as a basis for a type of monitoring system for such waste treatment systems. This project has interest, too, for sportsmen. Sometimes called the "wheel animalcule" because of the consistent movement of the tiny ring of hairs in its front section, the rotifer serves as food for newly hatched fish. A decrease in rotifer population would mean fewer mature fish. Further, the investigators predict that the results of this research are expected to be sought by agencies and industries interested in monitoring metal pollution.

Most fascinating perhaps is a final projected outcome of this research. Since the type of rotifer used for testing resembles a type found in Antarctica, procedures devised for the experiment may be adapted to develop methods of monitoring metal pollution as it may drift into the polar region. Already in laboratory refrigerators in the Biology Department are samples of the Antarctica rotifer.

Common from Antarctica to Warm Springs, in clean or polluted water, in fresh or salt water, in sewage plants, and even in mosses and lichens, the rotifer makes a practical test animal and one that can be used for monitoring systems in many areas.

To test the microscopic worm's sensitivity to hard metals, Buikema, Cairns, and Sullivan subjected triplet sets of the animals to various concentration levels of the same metal. The aim of the experiment was basically to determine the period required for a certain metal at a certain strength to kill fifty percent of the organisms. At intervals of twenty-four, forty-eight, and ninety-six hours, the effects of the exposure were examined. The death rate was then calculated by removing the dead rotifers at the bottom of the vessel and counting them under the microscope. The live rotifers were sacrificed and counted. Total population and death percentage could then be determined. By repeating this procedure, the scientists charted the effects on rotifer population of particular metal concentration at definite time intervals.

Put to use in sewage treatment plants, this information about metals harmful to the rotifer could suggest procedures that would preserve the rotifer population in the trickling systems of these treatment plants. Waters entering the system could be monitored for the metals proven harmful to rotifers and these poisons could be filtered out. A check system can also be vital in detecting harmful metals in popular fishing streams. Regulatory agencies and industries can clear streams of those metals which would decrease rotifer population and fish numbers. These investigators have data which can help erase the chance of a break in the food chain of a stream and which can further the goals of conservationists in keeping natural stream organisms.



Mosquitoes and gnats, usually considered man's enemies, will serve as man's allies.

So say Dr. E. C. Turner and his assistant Walter I. Knausenberger of Virginia Tech's Entomology Department. Soon they will complete field and laboratory testing which will produce two separate systems for monitoring water pollution. One is a scheme which will require the user to actually count gnats or flies to determine the presence of water pollution. Another system features an early warning test kit and uniquely enough, dried mosquito eggs. While the first plan requires technical personnel and equipment, Turner emphasizes that the projected test kit will be one which a laboratory technician or a very careful non-technical person could operate. Thus, citizens and governmental agencies interested in the quality of their natural streams, and large or small industries concerned about controlling their own waste discharge will shortly have a practical method of detecting water pollution in time to take corrective measures.

Phase one, the field testing using gnats and midges, was instituted to select the insect for laboratory testing to perfect the sample test kit. However, this testing has, itself, produced a monitoring solution. At selected industrial plants along streams in southwestern Virginia, such as the New River and Cedar Run, Turner and Knausenberger have established collection sites for the insects. As many as twenty places were chosen above and below each plant.

Using grab sampling, or a scooping technique, to get the immature insects from their muddy breeding home at the bottom of the stream, the investigators chart the number of insects at each point. The "normal" number is considered that of the count above the plant. Thus, if at the first collection point below the plant the insects demonstrate a reduced population, metal pollution is thought to be present. If the number of insects becomes more "normal" the farther the collection site is away from the industry, the plant is then thought to be discharging poisons.

Gnats and midges are particularly suitable test insects. These insects have a short life span and can recover quickly from pollution destruction. This makes it possible for testing to be done more frequently. Also, these insects appear in streams that are already polluted, unlike other popular test insects. This makes detection of increased pollution feasible. Finally, because gnats and midges feed on organic wastes, they can serve as reverse indicators. That is, if the population below the industrial site increases, this would indicate organic pollution rather than metal pollution.

The second stage of this research project, the laboratory testing, focuses on the easily reared mosquito. Placed in the front section of a laboratory trough, mosquito larvae are prodded by means of a bright light farther down the stream of water. For each experiment the water is treated with measured doses of a metal such as zinc. Using a stop watch, the investigators chart the insect's time and note their behavior as they reach certain points in the trough. By increasing dosages of the metal and charting changes in behavior in comparison with the preceding test, Turner and Knausenberger set standards for determining toxicant presence and strength. These criteria will then serve to construct the sample for the reusable test kit. The operator will put into a modified trough the water he is testing, introduce the mosquito larvae that have come to him as dried mosquito eggs, and determine from the kit's data sheets the presence and degree of pollution.

No longer will Virginia industries and regulatory agencies have to rely only on time consuming and expensive chemical techniques to discover water contamination. Early warning by studying insect population and behavior will mean early correction of pollution problems.

Which end is the head? Which is the tail? These are predictable questions of the inexperienced observer of the bacterium studied this year in the biology laboratories at Virginia Tech.

To Dr. Noel Krieg and his assistant Jean Bowdre, however, these questions become critical ones. They have experimented with a type of barterium, spirillum voluntans, that appears under a microscope like a worm with a flexible hair attached to each end. The scientists have concluded that the inability of this worm-like organism to swim about may signal that the water has too high a pollution content to be returned to the natural stream.

The monitoring technique that they have established is of particular interest to industries which must check their waste stream to see if it is acceptable for release into the discharge stream. This "fast and simple" technique can tell industry when it is necessary to put too heavily polluted discharges into holding ponds for retreatment or investigation before releasing them into the run-off stream. Needless damage to rivers and creeks can then be prevented.

The normal action of this bacterium--called the fastest swimmer among bacteria--is coordinated propeller-type movements of the hair found at each end of the body. The investigators have found that when the water contains such toxicants as zinc, mercury, nickel, or alcohol, the micro-organisms are unable to swim because their flagella (tails) will not work together properly. In a manner of speaking, both ends become heads or both become tails.

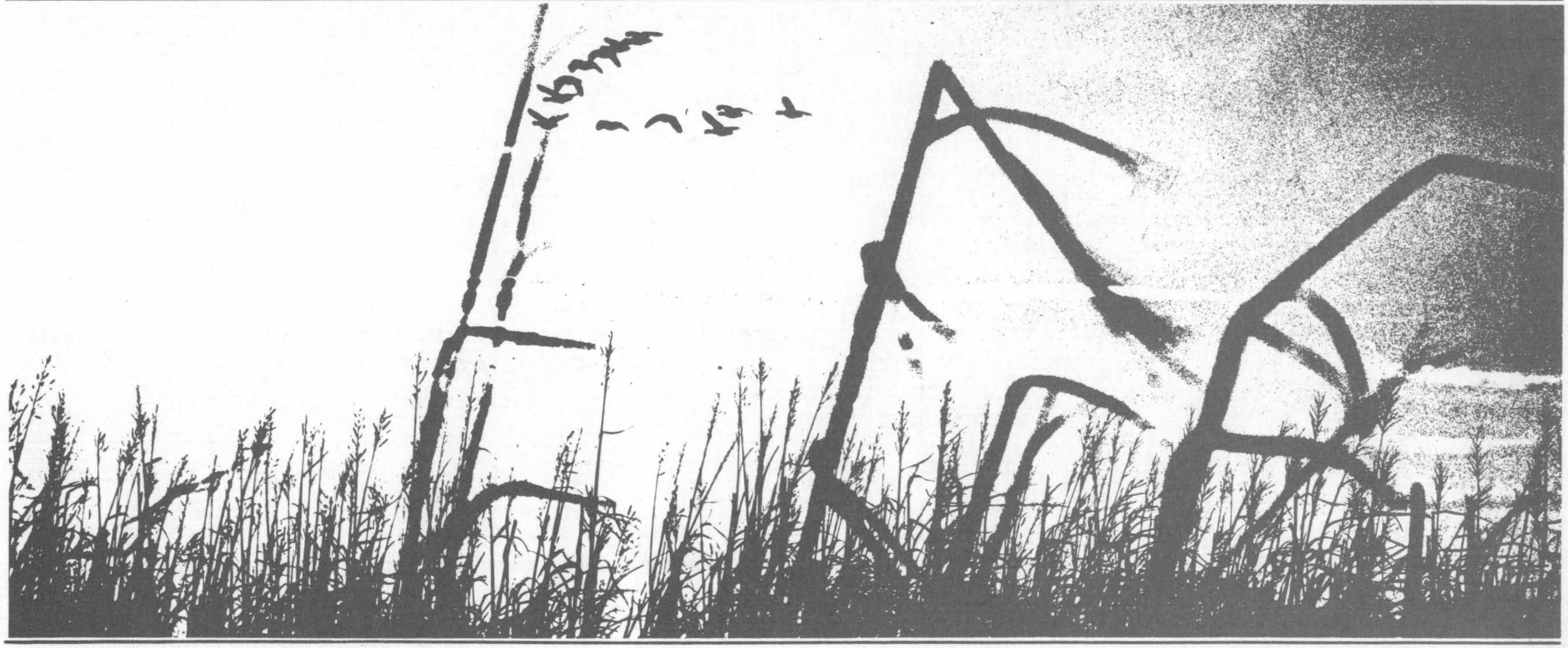
Simply stated, this research program involved exposing the organism to various levels of concentrations and several combinations of metals, detergents, alcohols, and other substances listed as possibly harmful by the Environmental Protection Agency. The swimming reactions of the bacterium to the poisons were charted and classified. Approximately fifteen combinations of the test substances were used, but the investigators recognize the possibility of "endless" combinations and concentrations.

The monitoring system appears a practical one. First, the bacterium is one of the largest and can be easily observed under the microscope. Second, the organism is conveniently found just below the surface of a freshwater pond. Also, the method makes possible a short lag time between testing and the results. Since the analysis is done by sight, there is only a wait between testings. The uncoordination occurs immediately after the water is contaminated. Finally, a non-technical person could be quickly trained in the technique.

To establish an in-plant monitoring system, the technician would determine the dilution of the acceptable discharge that permits the normal swimming movement of the test bacteria. Then, a rise in the concentration of pollutants caused by a spill or failure in the plant's waste treatment process would be detected by the uncoordination of the tiny swimmers.

Krieg and Bowdre are quick to point out that the reaction of this bacterium cannot be considered representative of other species or of the entire water community. Nonetheless, the significant interest of industries--that of insuring properly treated wastes--can be served by a seemingly insignificant type of bacterium.

3 water quality



Wide-ranging are the possibilities for pollution sources, and appropriately enough varied in aim are this year's projects directed toward preserving water quality. Can weed killers destroy non-target plants? Do marshes keep the main stream of water from becoming clogged with algae? How fast can a stream of water recover from seepage of mine acids? Three projects sponsored by the Water Resources Research Center zero in on removing nuisance elements from water.

In the Appalachian area at least eleven thousand miles of streams are affected by acid drainage from coal mines that are no longer in use.

As citizens and government agencies seek to increase tourism and industry in the region, more emphasis will be placed on clearing streams of acids in order to recapture their natural biological communities.

Biologists Dr. John Cairns, Jr. and Dr. Edwin E. Herricks of Virginia Tech have completed studies of organisms that live in the bottom of such streams. The results of these tests can lead to more knowledgeable selection of rehabilitation processes. Further, the data established from the project can be used by mining personnel to select operational sites that will least affect the watershed of the area. Proper choices of mining locations can reduce public and industrial water reclamation costs.

To study the effects of acid mine drainage on the numbers and varieties of animals that live near the bottom of streams, the investigators divided their efforts into two sections. The first aim was to determine the time needed for recovery when a stream is subjected to acid pollution. The second effort was to investigate the recovery process as it occurred through distance.

The time study took place in Mill Creek, a tributary of the Roanoke River. A one hundred-foot section of the creek was divided down the middle by plastic material. Thus, the scientists created experimental and reference sides that were subject to the same natural environmental changes. Samples of animal communities were taken on both sides of the divider. Then sulfuric acid was added to the experimental half. Beginning immediately after the addition of acid and continuing at two-hour intervals for sixty-six hours, samples were taken on both sides of the divider. For about a month following this initial series of samples, periodic samples were taken.

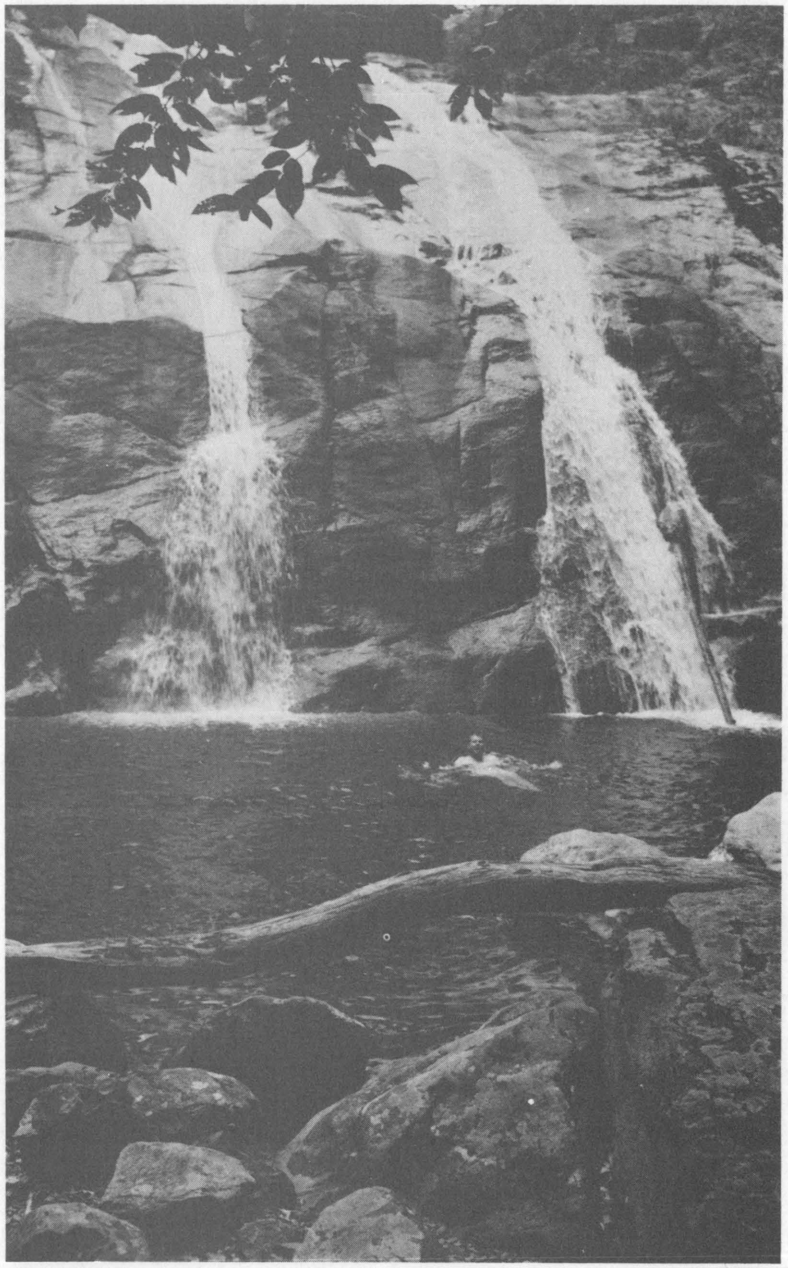
Cairns and Herricks determined the variety and density of the organisms after each sampling and charted the time it took the experimental side to be suitably repopulated by means of drift. Generally, conclusions from this phase of the research project indicate that the recovery of a stream after short term exposure to acid takes approximately nineteen to twenty-eight days. Also the results show proof that recovery is related to the downstream drift of healthy organisms.

For the second goal, that of determining the role of distance in stream recovery, two ten-mile creeks in Pennsylvania that receive acid drainage were selected for testing. One, Indian Creek in Fayette County, has a combination of good water quality and a healthy animal population in its tributaries that contributes to the natural restoration. The second test creek, Little Scrubgrass in Venango County, depends upon an artificial lime neutralization plant for reacquiring its natural animal population. This prong of the research had the possibility of comparing the role of distance under natural and artificial treatment.

A total of twenty-three sampling stations on the creeks were visited over a period of two years for collection of organisms. After each station's sample was identified and placed in a separate container, it was returned to the laboratory at Virginia Tech for analysis. Here, the investigators could establish changes in types and numbers of organisms for each station. In making final conclusions, other factors besides the animals themselves had to be considered. For example, changes in seasons, distances from the acid pollution source, and water quality of each stream's tributaries had to be appraised.

Important conclusions are drawn from this mass of data. First, rehabilitation through distance is successful when environmental conditions are stable enough to allow repopulation of the bottom-stream communities. Second, recovery from mine seepage is closely related to the volume of the stream and of the acid drainage.

Already the Virginia Division of Mined Land Reclamation and the Virginia Surface Mining and Reclamation Association have expressed interest in the project's results. The investigators state, "Knowledge of recovery rates and processes will allow reclamation officials to extend their interest to the effects of mine drainage and to mine drainage prevention in streams."



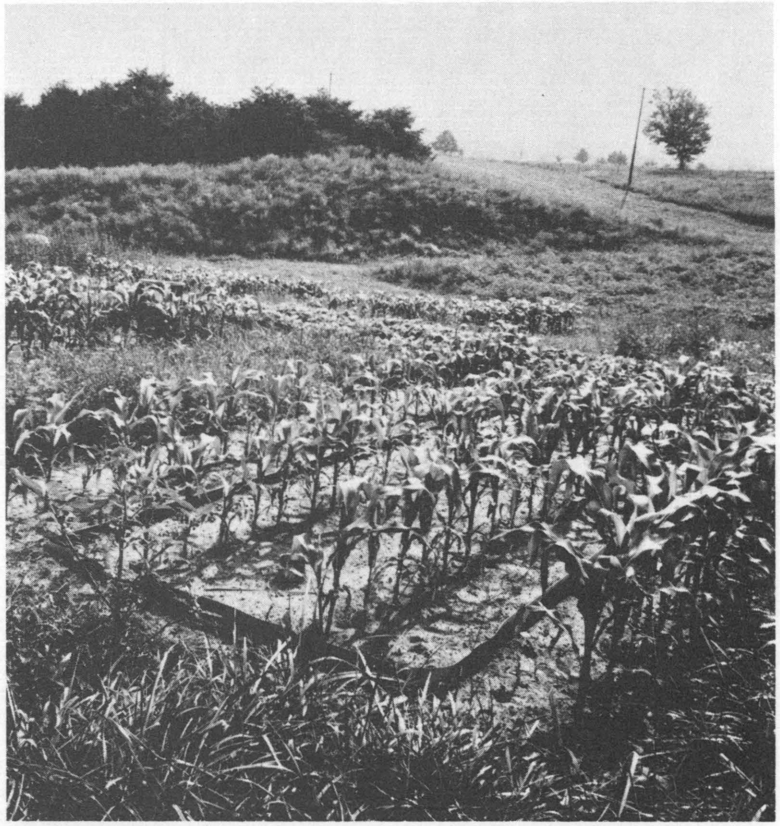
Over one million pounds of the herbicide atrazine are used each year in Virginia. One hundred fifty compounds are registered nationally as herbicides. Up to one hundred of these weed killers are recommended for use in Virginia.

Facts such as these help explain the controversy among environmentalists concerning the increasing use of these compounds. Public reasoning often concludes that if the chemicals kill weeds, then they may kill other, non-target, plants.

Dr. Chester A. Foy of the Plant Pathology and Physiology Department at Virginia Tech and several assistants have begun a project to provide facts that can prevent unjustified, emotional generalizations about all herbicides. Even though the study is incomplete, at the end of the first year, Foy reports that his results indicate "little likelihood" that herbicides used according to recommended practice hamper the growth of non-target plants for more than a relatively brief period of time.

For phase one of his study Foy subjected four species of freshwater algae to various concentration levels of widely used herbicides. His aim here was to verify the short and long term effect of these chemicals on the growth and life processes of the one-celled plants. Foy's tentative analysis indicates that algae tend to become tolerant of the herbicides as they are repeatedly exposed to the different test solutions.

The second stage, that of field research, is already underway. Field plots will serve as sites to investigate the route and disappearance of atrazine. This will be accomplished by sampling the run-off water after a rain or after an irrigation system has created conditions simulating real waterfall. In general, the investigators will determine how much of the weed killer runs off the application area and,in turn, discover the resulting effect on algae in the water.



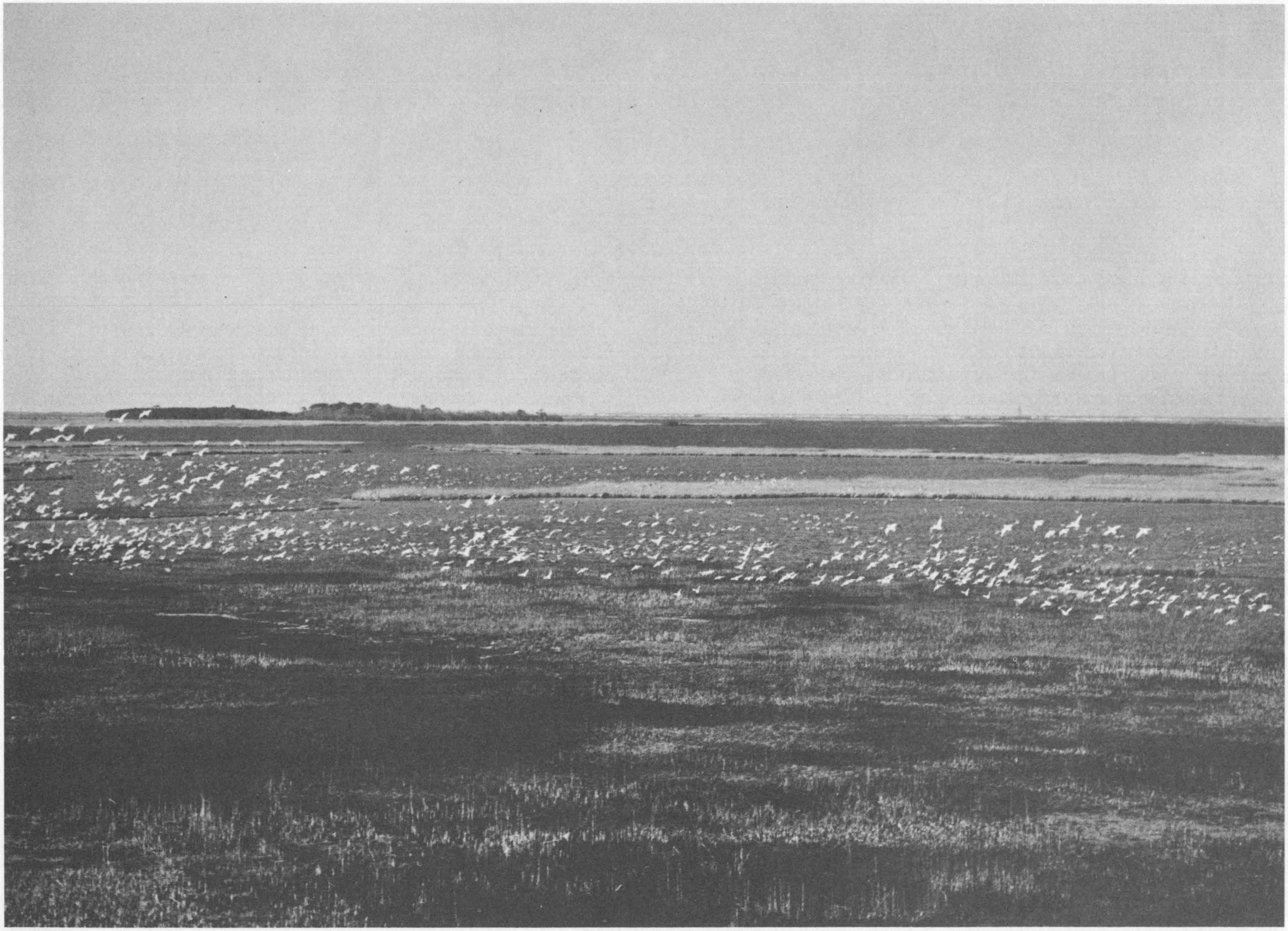
Atrazine will be sprayed on four twelve by twenty-foot plots at the rate of four pounds per acre. Conventionally tilled corn and non-tilled corn will act as comparison points in the study. To collect the run-off water from each plot a thirty-gallon drum and several plastic quart cups will be buried. A part of this water will be frozen until ready for analysis, and the remaining samples of water will be used in tests on algae to determine the effect of the naturally diluted atrazine on their growth and photosynthesis.

The scientists believe that the herbicides under study in their project are not "pollutants in the undesirable sense when cost (risk) versus benefits are considered." Indeed, the investigators through this research are providing the foundation for judging when the risk to the environment through the use of herbicides will outweigh the benefits.

Marshes are perhaps the least understood of all water resources. Local residents consider them merely breeding grounds for flies and mosquitoes. Land developers look to them as potential sites for housing or industries. Federal agencies often view marshes as suitable disposal areas for dredging operations. Managers of waste treatment plants have suggested using them as a secondary run-off ground for purification.

Faced with such pressures to disturb the natural state of marshes, resource managers responsible for them lack scientific facts to counter demands made for their destruction. Persons interested in preserving marshes may point to their role as buffers for erosion and as home for many species of wildlife. But defenders of these natural resources must often rely on theory to sustain their arguments.

Three scientists at Virginia Institute of Marine Science, Gloucester Point, Virginia have this year completed a project that defines more clearly the function of marshes. The results of this study provide supporting data for legislation designed to prevent the needless destruction of marshes. Further, the information derived from this study is important to the entire field of wetland ecology.

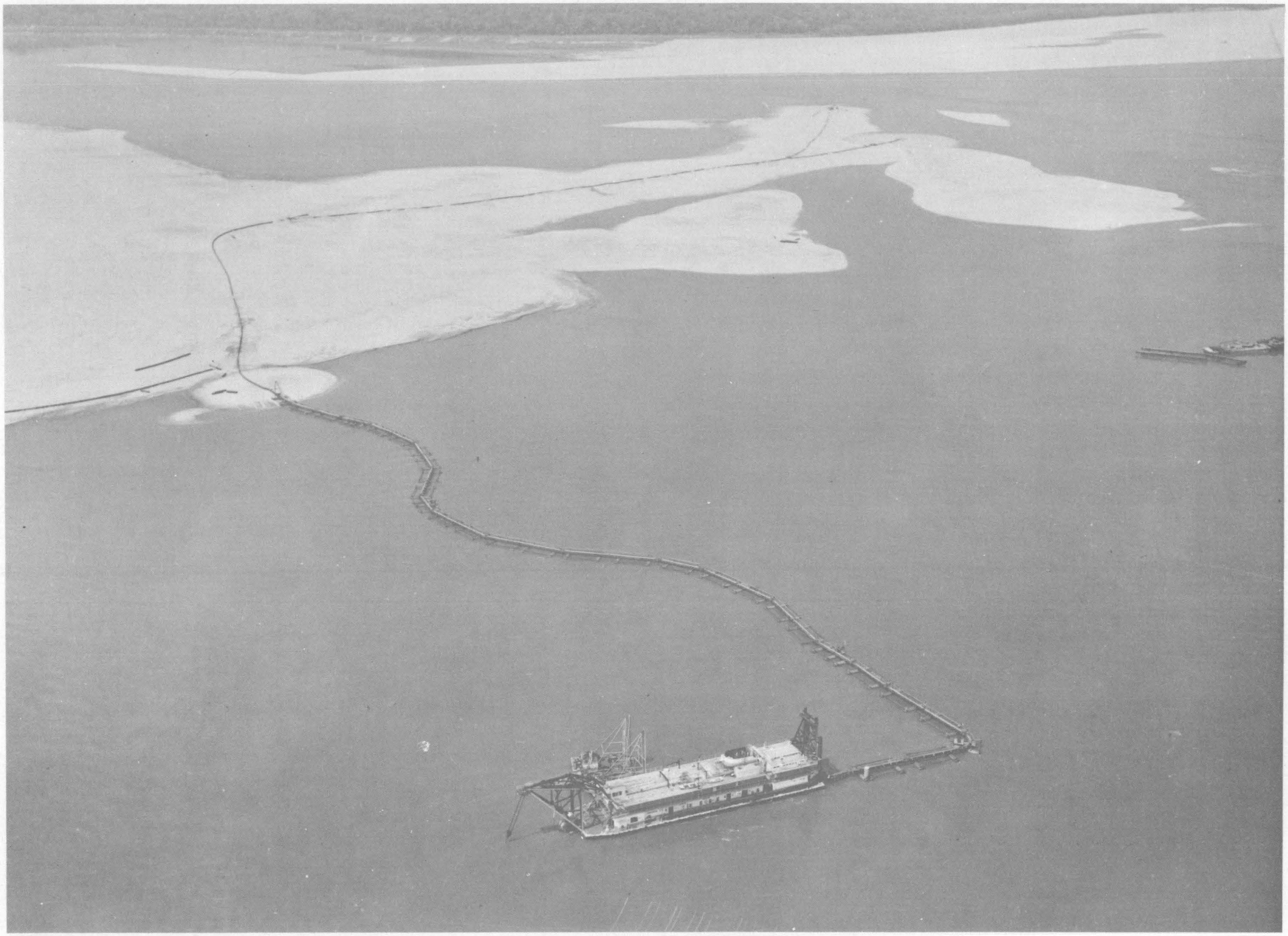


Dr. Michael E. Bender, Dr. Kenneth L. Marcellus, and Mr. H. D. Slone have studied two tidal marshes to determine what nutrients the marshes add or take out of adjacent estuaries. This information provides a basis for defining the role of marshes in controlling the plant growth in the main stream of water. Does the marsh reduce such growth? Does the marsh keep the nutrient levels too low? How does the marsh control the diet of the estuary? Does a marsh help maintain the nutrient balance in the adjacent stream so that plant life will be sufficient for the fish population?

Two tidal marshes in the York River system were selected for the field study. Ware Creek, thirty-eight acres, and Carter Creek, eighteen acres, were tested first for their annual production of marsh grass. Twenty-five areas in each marsh were harvested every four to six weeks throughout the growth season, and the changes in the standing crop of grass were noted. After the grass had been removed, the soil in the test site was analyzed for presence of nutrients such as nitrogen and phosphorus. This process related the growth of the grass to the amounts of the nutrients in the soil.

In another phase of the research, the investigators measured the flow of organic matter, carbon, living material and the water itself in and out of the marshes. To analyze the flow of organic material throughout a tidal cycle, hourly samples and current measurement served to plot amounts of material entering and leaving the marsh. The data from this part of the study became parts of a computer program adapted to relate time to the flow of materials during the tidal cycle.

Next, monthly tidal cycles were sampled and the water measured for the ebb and flood. This procedure established that the two were not, as had been assumed in previous studies, equal. Differences in the level in the ebb and flood range between five to twenty percent.



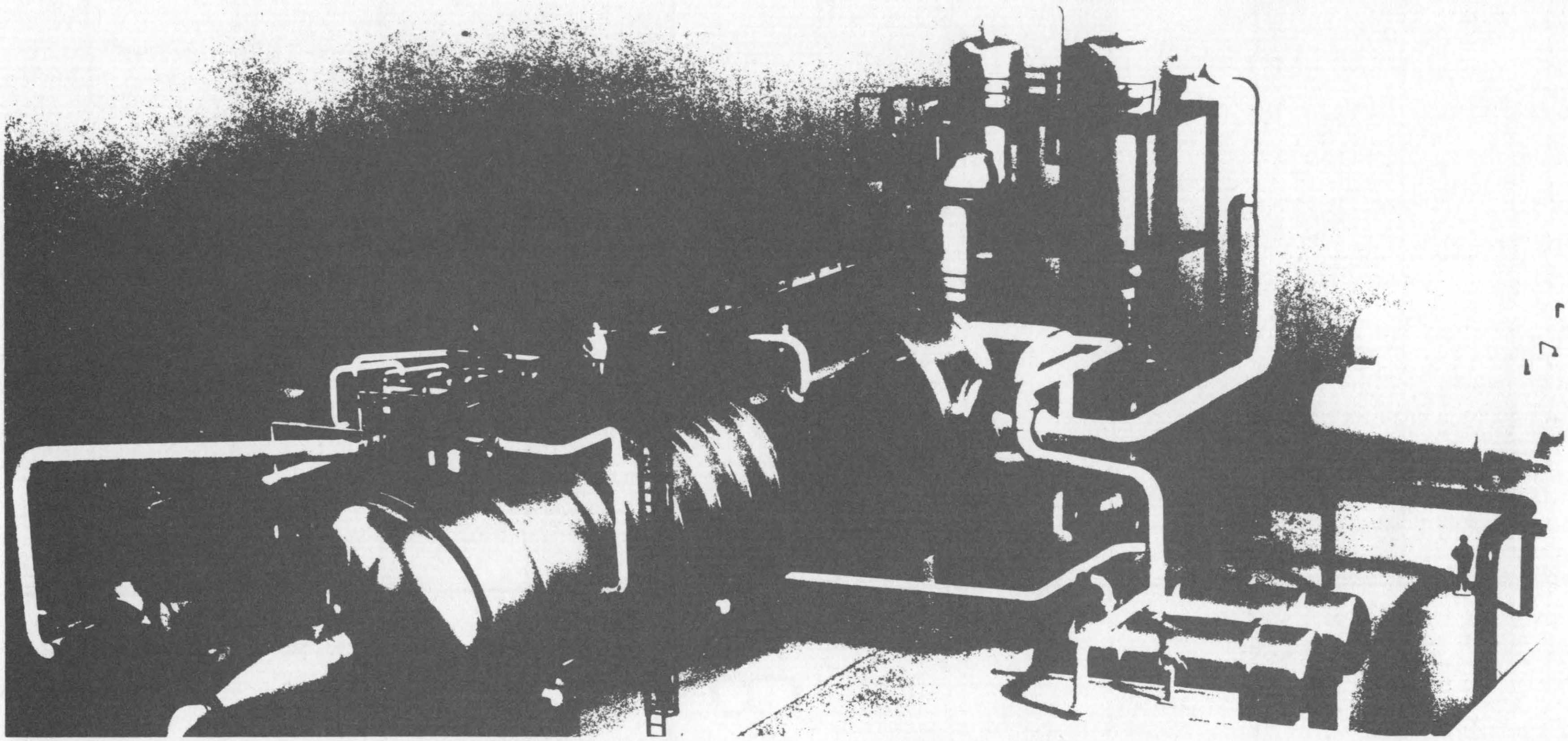
Using an organic carbon analyzer, the transport of carbon was measured. Preliminary sample analysis indicates that there is an apparent loss of carbon from both marshes during most of the year.

Further investigations measured the concentration of living material in the ebb and flood waters of the marshes. Conclusions from this testing indicate a loss of living material from the marshes. Since such matter serves as fish food, the investigators state that if such living material "is a more nutritious food source for organisms than non-organic material, then the marshes appear to be contributing in this manner to the productivity of the estuary."

Finally the nutrient flux was determined and, basically, the results show that the marshes function to help maintain high phosphate concentrations in the estuary, and to decrease the amount of nitrogen in the estuary. In essence, marshes prevent the overgrowth of plants in the estuary.

Marshes seem to enforce the diet of an estuary to help it maintain proper biological balance.

4 control



The Water Resources Research Center extends its interest to finding effective and economic ways to treat wastes so that water resources may be preserved. The recovering of treatment chemicals for reuse, using tannery hair, drilling deep wells, improving lagoon treatment systems, and even freezing sludge--all these enter into the investigations by scientists funded through the Research Center.

Six artificial streams housed in a Virginia Tech laboratory may help towns determine the design for their waste treatment plant and may save them money.

Wastes, processed as they would be in an average sewage treatment plant, are circulated into these four-foot streams, and the effect of the treated water on the organisms living in the stream is monitored.

In a unique interdisciplinary effort of sanitary engineers and ecologists, this study proposes to determine what effect sewage plant treatment for carbon, nitrogen, and phosphorus has on the stream that receives the discharge from the plant. Does one process cause a fish kill? Does the algae grow too heavily in a stream after a particular procedure? Is there a stench that follows certain treatments?

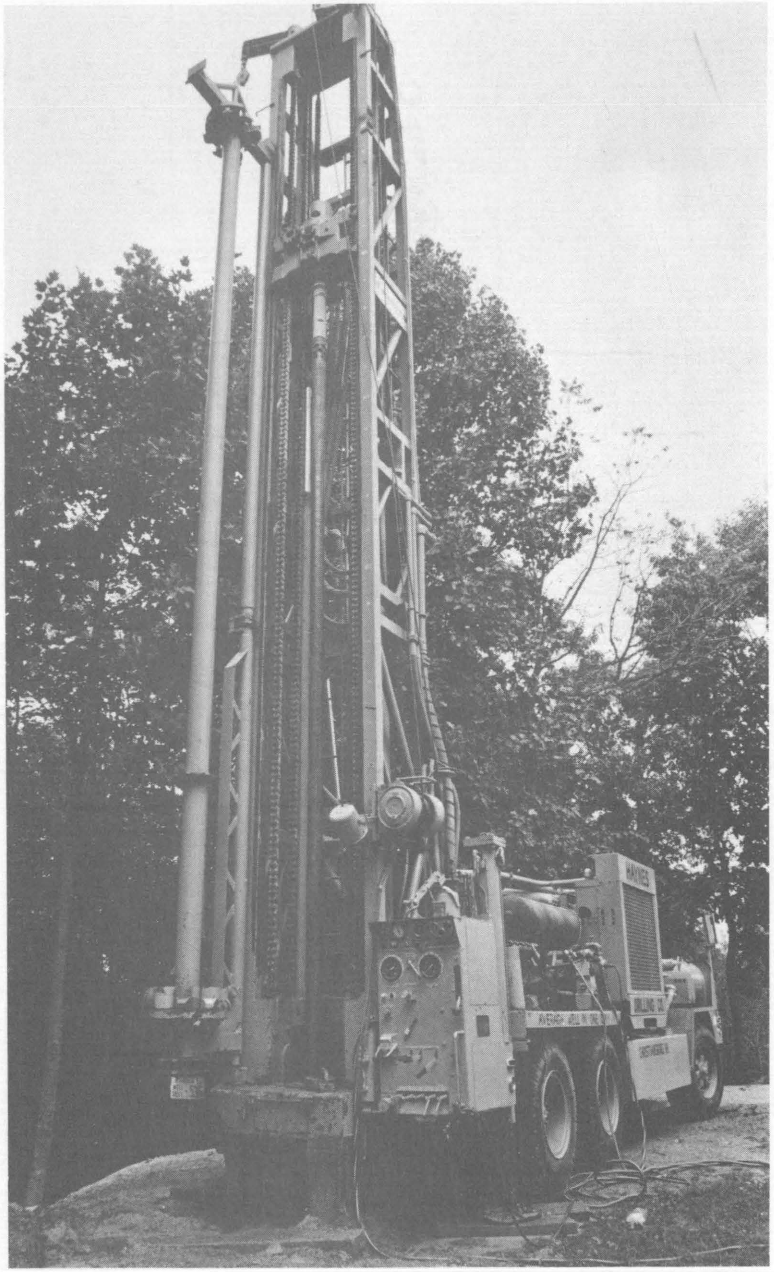
Dr. John Cairns, Jr. and Dr. Kenneth L. Dickson of the Center for Environmental Studies, and Dr. Paul King and Dr. Clifford Randall of the Sanitary Engineering Department and their assistants emphasize the application of their finding to management decisions at waste treatment plants. The federal government encourages the advance removal of the three test nutrients, carbon, nitrogen, and phosphorus, from the wastes in an effort to improve the quality of streams receiving flow from treatment plants. This third step, or chemical treatment, is not present in all treatment operations, and implementation of such procedures would bring about additional public expenditures.

The investigators are trying to help plant managers decide when money invested for the costly removal of their nutrients would result in an improved situation for the stream used for run-off. Perhaps some streams because of their chemical make-up would not benefit from such treatment. Some streams may need treatment for only one nutrient. Therefore, the scientists have provided facts for assessment of treatment alternatives by showing the effects on plant growth of the various procedures used to remove one nutrient or several nutrients at the same time.

The research scheme followed four steps. First, sewage samples were procured and tested. This sewage was treated by practical removal processes used in many cities to remove carbon, nitrogen, and phosphorus. The water was then introduced into the model streams. Finally, the productivity of microscopic animals and plants was charted weekly and compared with that of the streams used as controls.

Results from the project completed this year indicate that reaction to certain processes depends, first of all, upon the state of the stream that receives the run-off. Further, the investigators report that the relationship between carbon, nitrogen, and phosphorus treatments is "critical" in diagnosing the reaction of a stream to processing. In other words, knowledge of the combination and concentration of nutrients and information about the nature of the stream itself is required to predict the outcome of removal processes on a particular stream.

Answers from these scientific tests may provide economic answers for plant managers. Indeed, the ultimate goal of this project is to assist water treatment officials in justifying plant expansion expenditures or to help them save the cost of needless plant expansion for new removal techniques.



For several years the petroleum industry has been pumping back into non-operational oil wells, the salt water that results from processing.

Realizing the seeming success of this method, industries have recently begun to use two hundred fifty deep wells as solutions for disposal of their chemical and acid wastes.

The economic advantages for this deep well injection system may have spurred the interest in this method of waste control. Wastes require little pretreatment and small surface area is necessary for such disposal. The method requires less energy than ordinary treatment plants--an important consideration in the face of an energy crisis. Finally, most wells are present on the site of the industry.

Because of the relatively recent development of this disposal method, little is known, however, about all aspects of the deep well system. State legislatures and regulatory agencies such as the State Water Control Board need more pro and con data to evaluate the procedure.

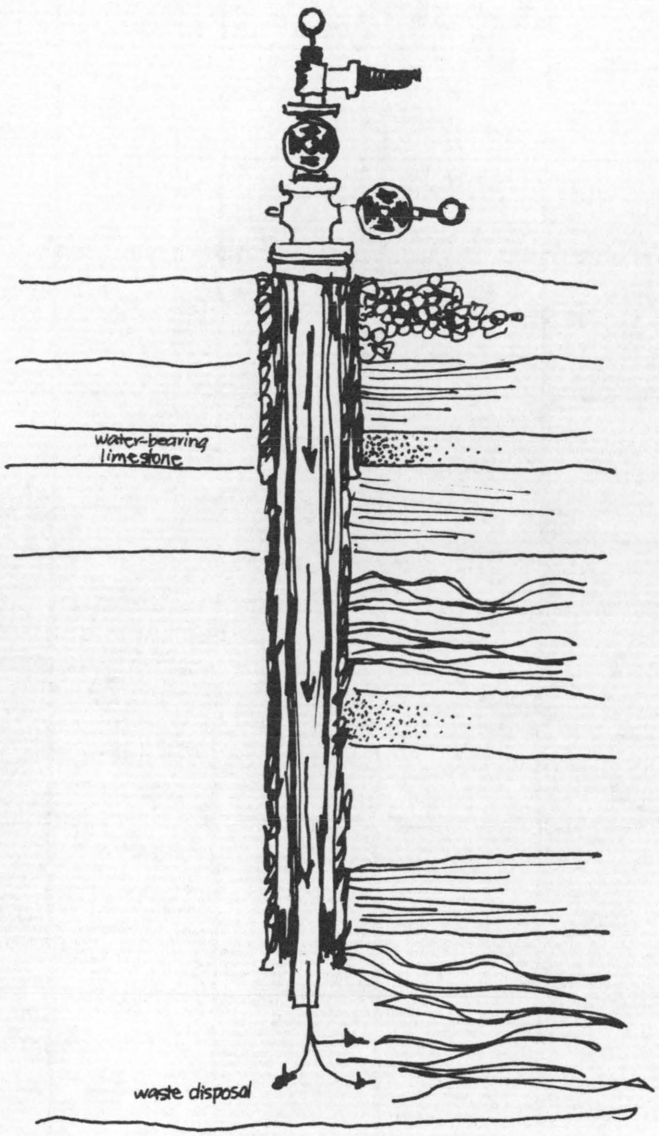
To fill this information gap, a team of investigators has this year begun to consider the legal, physical, and economic aspects of the method. Dr. William R. Walker; director of the Water Resources Research Center; Dr. Burl Long, agricultural economist; Dr. James Hackett, geologist; and William E. Cox, civil engineer form the team for the project. They are looking at the advantages and disadvantages of the deep well system and are evaluating the possible total benefit to society.

Exploration of the physical problems centers mainly around factors that enter into the selection of the disposal zone. Is there anything of value on the site? Is the rock at the bottom of the well the type that will absorb the wastes? Is the rock over the deep disposal zone such that will not allow the liquid to rise? Are there any faults that will break this horizontal lid? Is the disposal zone in an earthquake zone or in one that has a tendency toward earthquakes?

The economic phase of the study explores costs for drilling the well, pretreatment, pumps, pipes, operators, and equipment. Many variables determine the economy of the wells. For example, one plant might need more expensive pipes since the chemical being removed would eat through less expensive pipes.

Finally, the legal ramifications of deep well injection are being outlined. Legislative and statutory restrictions on the methods are being surveyed. Property rights, states rights, and federal laws are being studied for their application to deep well injection. And because few court cases dealing directly with the deep well problem have occurred, review of court decisions in related cases form an important part of the legal study.

This study neither endorses or rejects the deep well system. The primary function of the effort is to provide more information about a waste control system that has already been proven technically and economically feasible. The results should be valuable to citizens and public officials concerned with protecting the environment.



Often small rural communities are financially strained to meet water quality standards in their waste treatment operations.

Funds to operate elaborate treatment plants are not available, and these areas find it difficult to match federal funds to construct sophisticated plants.

Recognizing this problem, Dr. Clinton E. Parker, a civil engineer at the University of Virginia, Charlottesville, Virginia, has focused a study on the economic and design aspects of using a lagoon system followed by chemical and physical processes for treating wastes. Such oxidation ponds have always been popular in rural areas where land costs are less and money is not available for construction of new treatment facilities. But in recent years the lagoon system has not received much attention among researchers.

Dr. Parker maintains that "with proper design and operational supervision the stabilization lagoon is capable of producing a highly stable effluent." Thus, his investigation has established a design for a lagoon system that will economically and adequately serve small rural communities. The scheme provides a flexible method whereby water level can be fluctuated so that physical and chemical treatment of the run off could take place on the basis of an eight-hour day, five days a week.

Parker's aim, first of all, was to devise a method for separating the algal cells from the liquid discharge of the lagoon. Since alum coagulated cells float naturally and since these floating layers can be removed easily by mechanical means, the investigator designed his system for flotation of the algae. Next, the conditions bringing about the flotation and settling of the algal cells were investigated. Laboratory algal growth units were used to establish these criteria. From these laboratory test results come the conclusion that dissolved oxygen saturation can be used to predict whether or not the algae will float or sink.

Also different types of treatment to separate algae from the water were tested. Finally, on the basis of the knowledge of the conditions needed to make the alum treated algae float, Parker established a chemical and physical purifying treatment for lagoon run off.

Keen interest in the project's results has come from town managers and regulatory agencies. These people can use the research to plan treatment plants or to apply the finding to their present lagoon systems.

Freezing can make more economical the disposal of sludge——one of the most expensive operations in a waste treatment plant.

The freezing process has been developed and evaluated this year by Dr. Clifford W. Randall and Dr. N. Thomas Stephens of the Sanitary Engineering Department at Virginia Tech.

Currently, the disposal of sludge in waste treatment plants is accomplished in a variety of ways. A sand filter bed, or gravity process, serves as a means for settling the wastes.

Some plants use a vacuuming process to suck off the sludge. Whatever the method, the central problem is separating the water from the wastes, for they will not settle naturally.

The investigators have found that the freezing of sludge with butane gas before attempting to filter it makes the eventual separation of the solid waste from the water--by whatever means--easier. In other words, freezing changes the chemical nature of sludge so that it drains more easily. In addition, the economy of the process is recognized in the phase of the research that has developed means for recovering the refrigerant for reuse in the system.

One of the most interesting facets of the research plan is the transfer of the technology used for desalting seawater to the process used for dewatering sludge. Before coming to Virginia Tech, Dr. Stephens served as manager of a seawater conversion plant. Using this firsthand experience, the researchers adapted the method, which they term "surprisingly simple" to waste treatment. This is the first application of the desalination procedure to a waste treatment plant.

In their laboratory Randall and Stephens developed a direct freezing process, as opposed to the indirect method used in refrigerators. Liquid butane gas, similar to the type used in camp stoves and lanterns, was vaporized into the sludge. The heat of the vaporization was taken from the sludge, and freezing, in the form of an ice slurry, was accomplished. The frozen sludge was then melted and disposed of by the gravity or vacuum method. The butane was recovered by compressing the freezer vapors and passing them through a heat exchanger into a condenser.

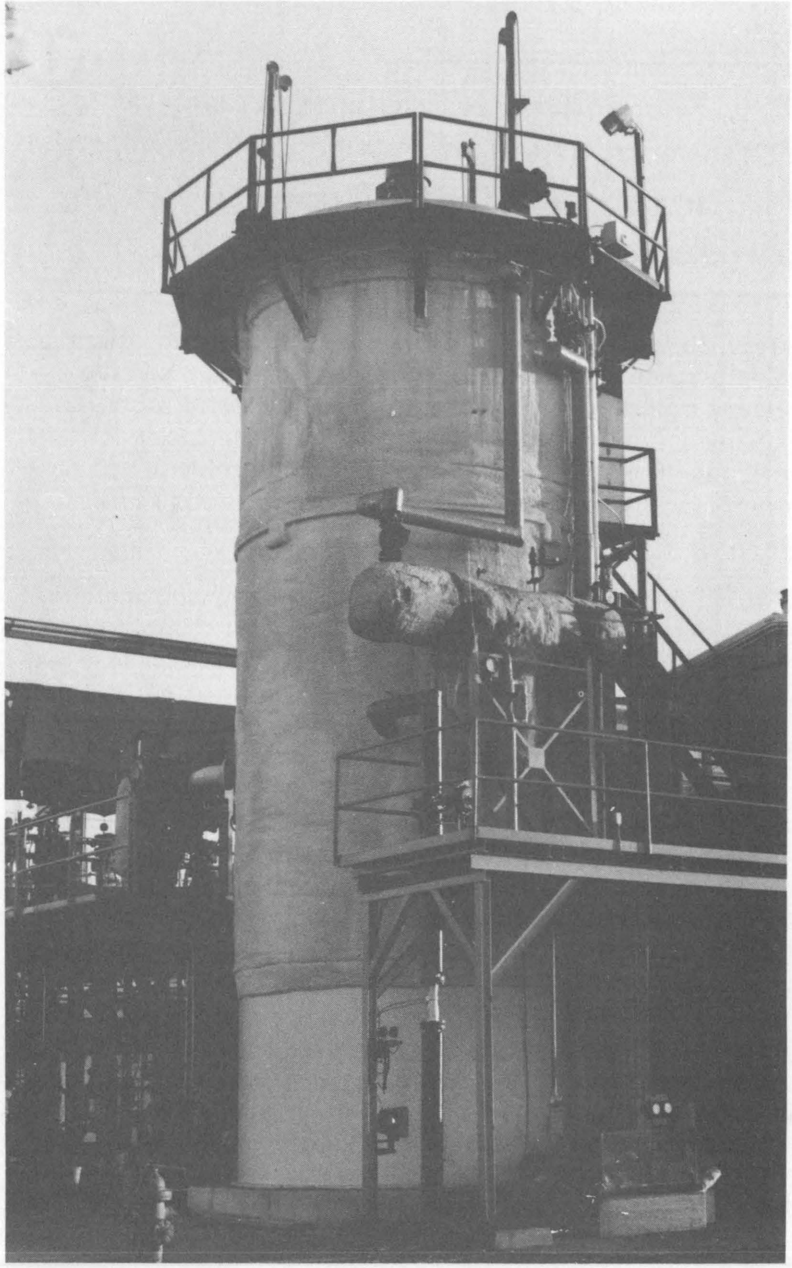
To accomplish their testing, the scientists obtained sludge samples from the Roanoke plant and tested them to determine types of material and the resistance of the sludge to gravity or vacuum filtration. These tests were repeated for comparison after filtration following the freezing process. Then the laboratory apparatus for freezing was designed and pressures, temperatures, and flow rates established for the procedure. Also constructed in the laboratory were mock-ups of gravity and vacuum drainage systems.

Results of their experiments show, first, that the sludge had practically no smell after freezing. It settled almost twice as fast as before freezing. The moisture holding power of the sludge particles was "drastically reduced." Thus, handling the sludge was easier. Finally, the investigators term as "most surprising" the reduction of organic matter in the sludge. This means less sludge volume to be burned or put into a landfill.

The results signal economic advantages for the use of butane freezing. For example, if burned, the frozen sludge would sustain combustion by itself because of the low moisture. The burning could generate excess energy that might be used for refrigeration purposes. Then too, the reuse of butane forwards economy. Although the economics of butane freezing will be more closely analyzed for different size plants, preliminary considerations show that the cost of the process would range from six to twenty dollars per ton of dry sludge handled. Cost would vary according to solid concentration, size of plant, type of labor available, and price of power and liquid butane. This year's theoretical calculations indicate, however, that the cost of the butane freezing process would be less than that of most of the processes in present use.

In the second year of the study, Randall and Stephens will develop methods for practical utilization. They plan to define more thoroughly the butane recovery process. Sludges from a variety of sources will be examined. These studies will permit more accurate economical comparison with other sludge handling methods.

Inquiries for results of the study have come from such places as Japan. These requests express hope of using the new process for commercial, municipal, and military waste disposal plants.



In 1969 a considerable mercury scare erupted in the United States, and the significant problem of mercury pollution came to light.

Indeed, a survey of one thousand industries in Virginia indicates that one hundred eighty are potential sources of mercury pollution. Last year the Olin Matheson Corporation in Saltville, Virginia closed because of the lack of an economic answer for its mercury pollution problem. Seepage from the sludge of even such closed operations remains a source of mercury pollution.

A promising and economic solution to removing mercury from waste water is the use of tannery hair. This opinion results from a study by Dr. Donald L. Michelsen and his assistants in the Chemical Engineering Department at Virginia Tech.

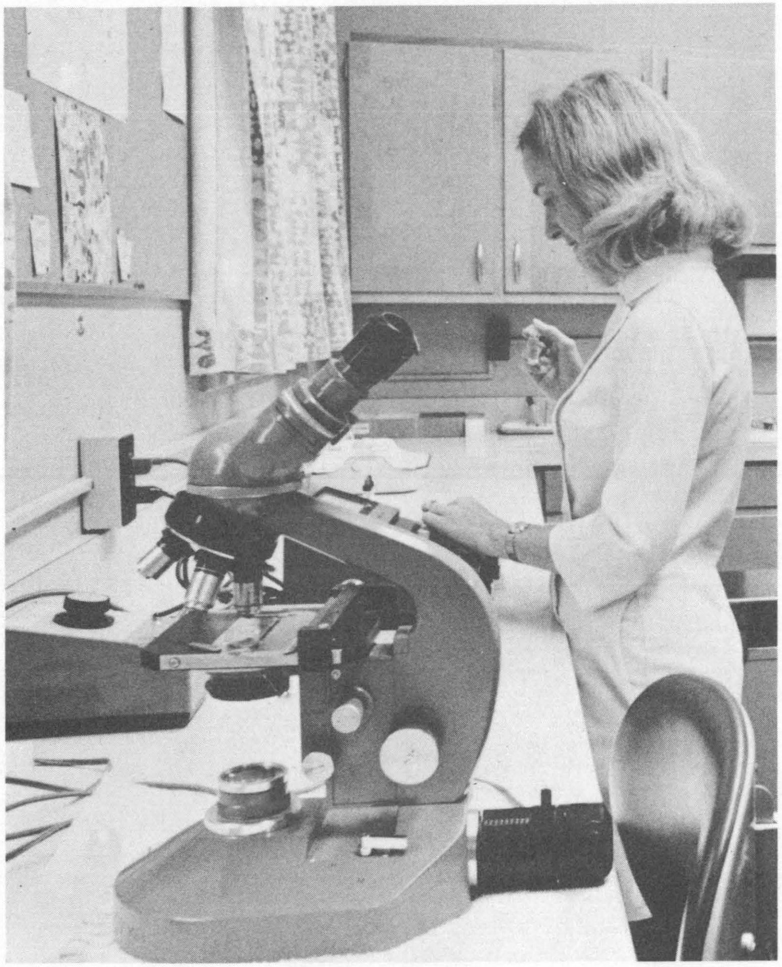
Although mercury pollution would not perhaps be considered an urgent problem area today because of governmental action to phase out plants with mercury cells, many industries, hospitals, and chemical laboratories use mercury in their processing and preservation techniques. The removal of mercury, for the most part, is left up to the domestic waste disposal plant, where most of it is simply diluted to acceptable drinking levels. This scheme, Michelsen states, is "the solution to pollution by dilution."

Recent government action, however, transfers some of the burden of recovering mercury from waste water to the points of discharge. Michelsen affirms that his process can be used on-the-site in large or small scale remedial operations to bring the mercury concentration down to drinking water standards.

The project at Virginia Tech has concentrated on the use of tannery hair, although other hair may be processed to perform the same function. In the process of removing hair from the animal skin to make leather, the structure of the hair is modified so that it absorbs mercury.

Tests were conducted to compare the effectiveness of animal hair for the removal of mercury with that of the more expensive resins presently being used. Tannery hair is ten to fifteen cents per pound, while the resins are one to two dollars per pound. Various concentrations of mercury were correlated with amounts of hair required for suitable removal. Techniques for mixing the mercury polluted water with the tannery hair have been devised and evaluated. Further, the investigators explored methods for recovering the mercury from the tannery hair with the idea that the pure mercury, when recovered, could be sold and the restored tannery hair recycled through a waste treatment plant. Another stage of the research involved scaling up laboratory results to produce design examples and economic evaluations to illustrate mercury removal processed in typical waste streams.

The next phase of the investigation will be the pilot plant testing of the process. And the investigators are now considering other materials, such as waste tire tread rubber, for the removal of mercury. From the standpoint of economy and conservation, the project results should be of interest to industries and government agencies alike.



The prospect of reusing the chemicals in water treatment plants is an attractive one in terms of economy and conservation.

In response to such motivation, Dr. Paul H. King and his assistant in Virginia Tech's Sanitary Egnineering Department have devised a practical method whereby alum, the metal added to remove phosphorus and clear the water, may be recovered for reuse in a treatment plant. Facts from laboratory testing establish that a plant can economically recover eighty percent of the aluminium present in the wastes that remain after treatment. Plants in Sweden, Japan, and Scotland have demonstrated alum recovery; however, this project brings to Virginia exploration in reusing this recovered chemical in the plant.

The source for reclaiming the alum is the sludge that results when chemical clotters, such as alum, trap inorganic and organic impurities and settle them. The problem is to separate the alum from the other matter.

To develop his recovery technique, King obtained samples of sludge from four representative water treatment plants in Virginia--Radford, Timberville, Harrisonburg, and Blacksburg. In the laboratory sulfuric acid was mixed with the sludge and relationships between acid concentrations and quantity of alum recovered established. The remaining sludge, it was found, could now be filtered and disposed of more easily.

A high percentage of alum was extracted from the sludge. When testing for the effectiveness in reuse, the performance of the recovered alum was termed "marginally superior" to fresh alum in some instances.

King then explored the economic advantages of using his recovery system in a conventional treatment plant. Content and volume of sludge, filter run times, and aluminum content of sludge were assumed. Other budget items, such as interest rates, equipment, land cost, and extra operators were estimated. A computer program was developed to solve problems using laboratory data and sludge from the Harrisonburg Plant. Savings were subsequently projected for plants of various volumes of output. King characterizes as "encouraging . . . the possibilities for employing aluminum recovery in conventional water treatment plants, especially those which serve large populations and can consequently expect to encounter increasingly serious sludge disposal problems."

Inquiries for the results of the study have come from consulting engineers and operating personnel. These people recognize the work's direct application to conventional water treatment plants as well as to water reclamation facilities. The basic data from the project can be an important input in decision making processes.

5 administration

Not all the concerns of the Water Resources Research Center are liquid ones! This year the Center sponsored studies into the legal, institutional, and economic structures of flood insurance programs, agencies responsible for the control of Virginia's water resources, and water laws.

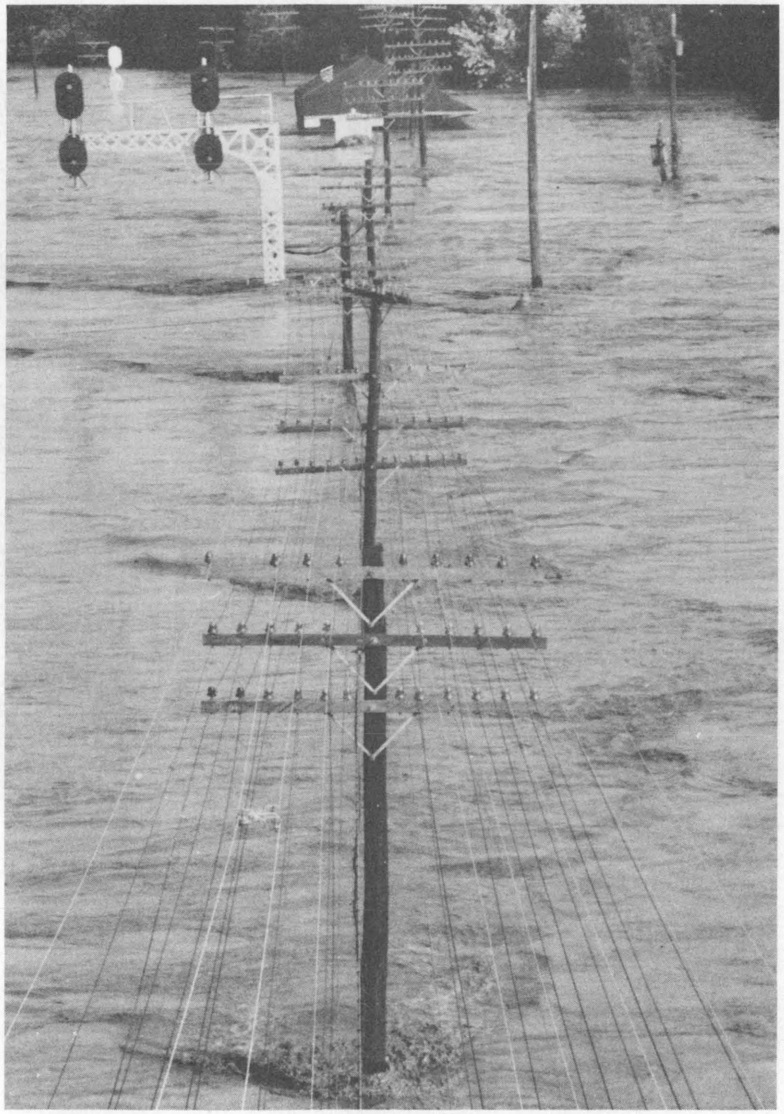
In the long run, would flood insurance be cheaper for the taxpayer than the cost of federal and private recovery and relief funds?

Should the federal government continue to subsidize flood insurance or should the support be eliminated?

Is it reasonable for the Red Cross, churches, and other charity organizations to assume full responsibility for recovery after major floods?

Should flood insurance be required of people living in a flood plain?

Is it worthwhile for communities to adopt land control measures necessary to meet government guidelines to qualify for a flood insurance program?



Dr. William R. Walker, Director of the Water Resources Research Center, serves as principal investigator of a project that is providing answers to these questions.

Using data collected at Buena Vista, Virginia, a town heavily damaged by Hurricane Camille in August, 1969, Walker is basically comparing the cost and rate of recovery if the community had flood insurance with the cost and rate of recovery using conventional relief.

In this "examination of the problem in reverse," the investigators of the project are equipped with facts derived from an actual community after a real disaster. This technique reduces the time required to gain insight into the impact of a flood insurance program. Another investigation scheme could require the waiting of several years to evaluate the program after a flood. By this time, much money might have been spent to implement flood insurance.

A phase of this legal and economic study utilizes a computer program designed to show the amount of premium paid for the flood insurance and the amount of damage that could be expected for floods of various depths.

Obtaining past data from a gauging station on the Maury River near Buena Vista, the investigators are seeking to predict the elevation of flood waters likely to occur within certain time spans. For example, predictions are being made for depths of floods possible every ten years, twenty-five years, and up to one hundred forty years.

From this basic analysis it will be possible to suggest answers to several questions:

Could the federal subsidy be eliminated if all the people on the flood plain were required to carry insurance?

Are the present levels of coverage by insurance ($17,500 for a dwelling and $5000 for contents) realistic?

Is the federal subsidy still cheaper for the general taxpayer than the amount provided for in general relief and forgiveable and low interest loans?

Would the rate of recovery be faster than with conventional relief if insurance were available?

The computer program used in this study can be used in other parts of Virginia and the nation. It will provide guidance in determining the emphasis to be placed on the flood insurance program in Virginia and will assist the Department of Housing in evaluating the insurance program nationally.

Department of Conservation and Economic Development
State Water Control Board
Department of Health
Bureau of Sanitary Engineering
Outdoor Recreation Commission
Commission of Fisheries
Commission of Game and Inland Fisheries
State Coporation Commission
Virginia State Ports Authority
Virgi nia Airports Authority
Soil and Water Conservation Commission
Virginia Institute of Marine Science
State Soil Conservation Commission
Virginia Beach Erosion Commission
Virginia Fisheries Laboratory
Potomac River Oyster Commission
Atlantic Marine Fisheries Commission
Ohio River Valley Water Sanitation Commission
Potomac River Basin Commission of Virginia

The symptoms:

Virginia water resources management responsibilities fractured among several state and federal agencies,

a red-tape syndrome that demanded a citizen process through several regulatory agencies to gain a permit for a single project,

weak coordination among state and interstate agencies concerned in some aspect with Virginia's water resource management, and

lack of clear delineation of authority in specific areas.

Such observations as these prompted a study to analyze and evaluate the many boards and commissions controlling the use and management of Virginia's waters.

Dr. William R. Walker and William E. Cox of the Water Resources Research Center have for the past several years examined the fifteen state boards and three interstate agencies that are active in some aspects of water resource management. The aim of this project has been to get a clear view of each agency's responsibilities and of the manner in which each agency operates.

The result of the task has been a series of recommendations for alternate arrangements of responsibilities within the agencies. These suggestions should better serve the objective of the state to preserve water resources while providing for their maximum use. If implemented, such alterations can provide convenience and economy for the Virginia citizen.

The findings of this investigation are already in use. The state is undergoing a study to reorganize and provide for coordination among agencies. The state's study team has asked for the results of this Walker-Cox study.

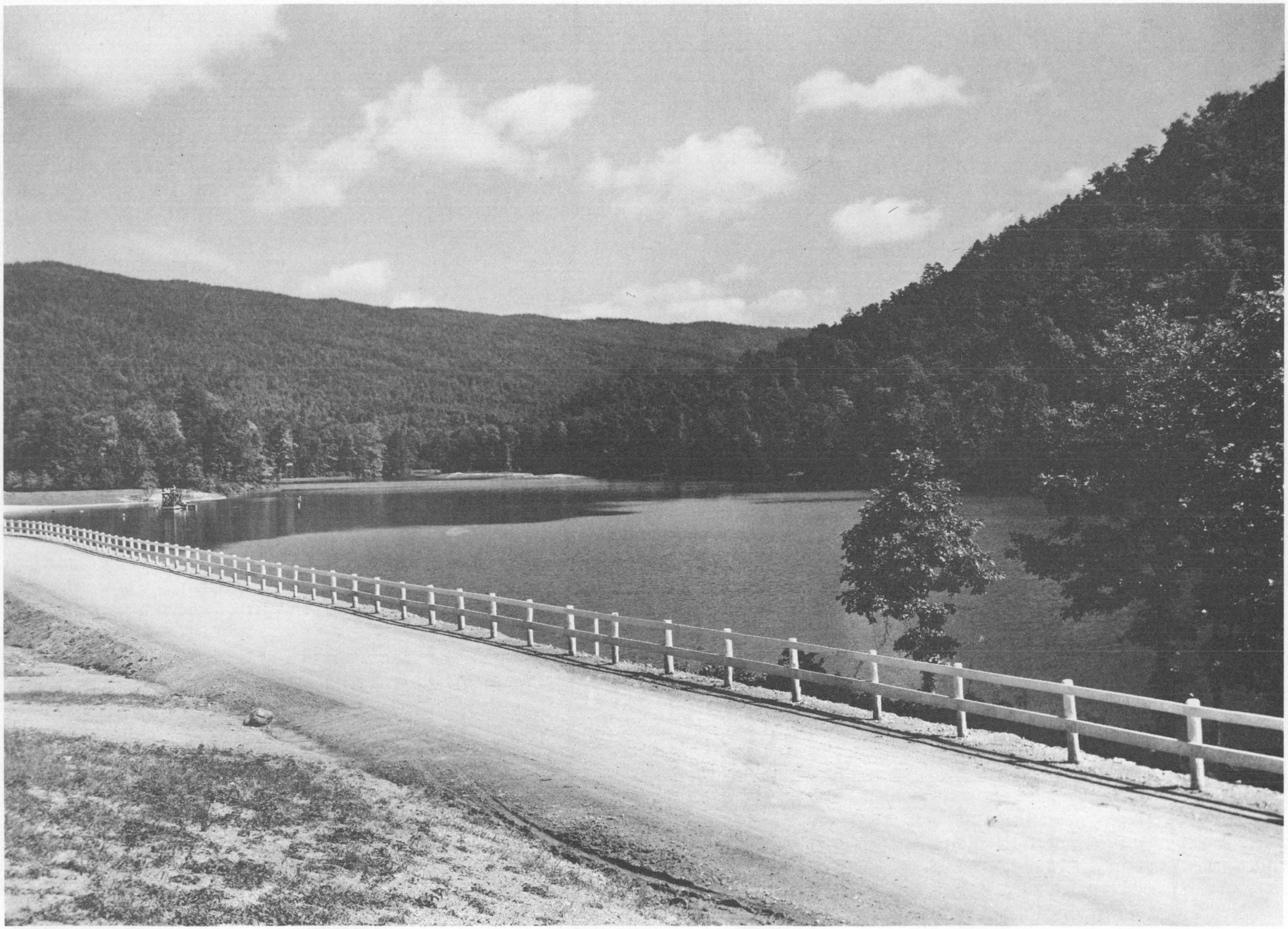
One phase of the study concentrated on determining how the boards came into existence. Discoveries show that often a specific agency was created in response to a specific need. For example, when water quality became an important issue in 1946, the State Water Control Board was legislated. This means of appointing boards for specific needs without consideration of the roles of existing agencies has contributed somewhat to dual responsibilities and cross-purposes among agencies. One agency might have to make decisions that affect a responsibility also designated to another agency.

Further investigations probed the underlying laws creating each agency and obtained from each agency their interpretation of these laws. Each board was asked to summarize their views of their responsibilities.

An examination of the legal framework of the agencies revealed, first, that in many cases there is no binding requirement to cooperate with other agencies. This lack of a legislative foundation for coordination has discouraged compressing related activities or responsibilities into one appropriate agency. A second discovery of this legal search was that the state had no comprehensive statement of water policy for Virginia. Since this study has begun, however, a tentative policy has been drafted.

Another part of the research examined what Walker and Cox term "Virginia's administrative format." In turn, they analyzed the "distinctly different" formats found in other states. This process served to help formulate proposed changes in the administrative structure of Virginia's water control agencies.

Concern for the most extensive, efficient, and economic scheme for preserving and using Virginia's water is on-going. Adjustments have to be made frequently. So is the case with this project. Mr. Cox reports that a particular task in the progress of the investigation has been to keep the analysis up to date. Yearly changes in the agencies and their duties have been legislated. Thus, the recommendations of this study have been amended or adjusted to fit the alterations.



In June of 1973, the report of the National Water Commission highlighted the need for research into the maze of water laws and water rights.

Dr. William R. Walker of the Water Resources Research Center at Virginia Tech recognized this need several years ago when he proposed an investigation into institutions and laws which control the surface and ground waters of the United States.

Currently underway is a research program that will identify institutional arrangements and legal constraints which prevent effective management, use, and enjoyment of water resources. Such an investigation is important, for as one writer stated, why should economists develop elaborate models to program water allocation and "fuss over finer points of theory, when water law may not let one move water across the street from a swamp to a desert?" Walker's research will identify areas where change is necessary and will demonstrate the need to explore the consequences resulting from modifications in water laws.

In general, water laws have been passed to reflect the needs of a people at a certain time in a certain region of the country. When America was first settled, navigation by water was essential. Consequently, laws regulating the water resources supported the use of natural streams as a means of travel. As the West was settled, water was necessary for the development of agriculture and mining. Therefore, water laws tended to favor these industries. From a historical point of view, the systems of controlling water have often neglected one use of water in favor of another more obvious purpose.

Laws change slowly. As uses for water have varied, laws have not kept pace with shifting populations, urban development, and altered life styles. Indeed, laws which at one time reflected popular demands and goals now frustrate and hinder the conservation and orderly use of water.

Many examples of ineffective or inefficient water laws have been noted by the researchers. To illustrate, the laws dealing with the water on the surface are different from those which center on the water beneath the ground. Such a situation exists because early in our history the physical relationship between the two waters was little understood. It is now realized, of course, that ground water contributes to surface flow under certain conditions; while in other situations, surface waters replenish ground water reservoirs. Thus, present laws may permit the uncontrolled pumping of ground water although the process might substantially influence the water in the surface stream. In this way, any law regulating surface water would be rendered somewhat useless.

Another example of concern frustrated by out-dated or poorly conceived laws is found in the West. There, a person would give notice that he was establishing a claim to an amount of water by diverting the water from a surface stream. Naturally, this method denied efforts to preserve the water for instream uses, for wildlife, or for recreation. These uses for water are receiving increased attention, but under the laws in some states, it is difficult to meet these concerns.

The results of Walker's investigations will prescribe alterations that take into account the impact on property rights and provide management flexibility for future needs. The research project, most of all, will pinpoint laws and arrangements that thwart popular interests and erase the benefits to the majority.

ILLUSTRATIONS

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cover the virginia coast

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Peter M. Ashton, Extension Specialist

William E. Cox, Research Associate

T. W. Johnson, Assistant to the Director

Eileen Garner, Editorial Assistant

Jean Hagerbaumer, Typist

Norene Essary, Department Secretary

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46 a recreation area

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