

July 1972

Water Research at the University of Connecticut

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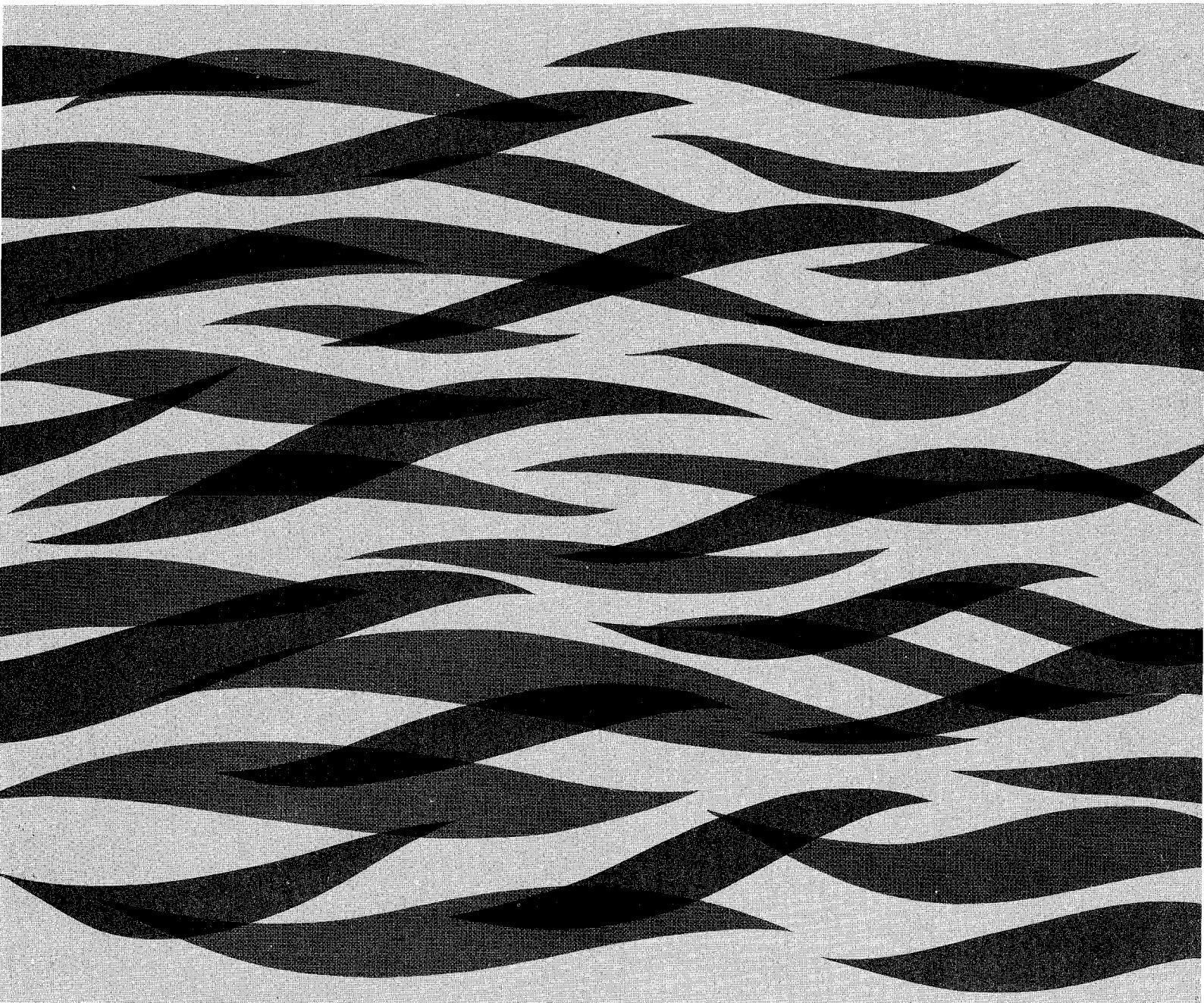
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WATER RESEARCH AT THE UNIVERSITY OF CONNECTICUT

REPORT NO.16

JULY 1972



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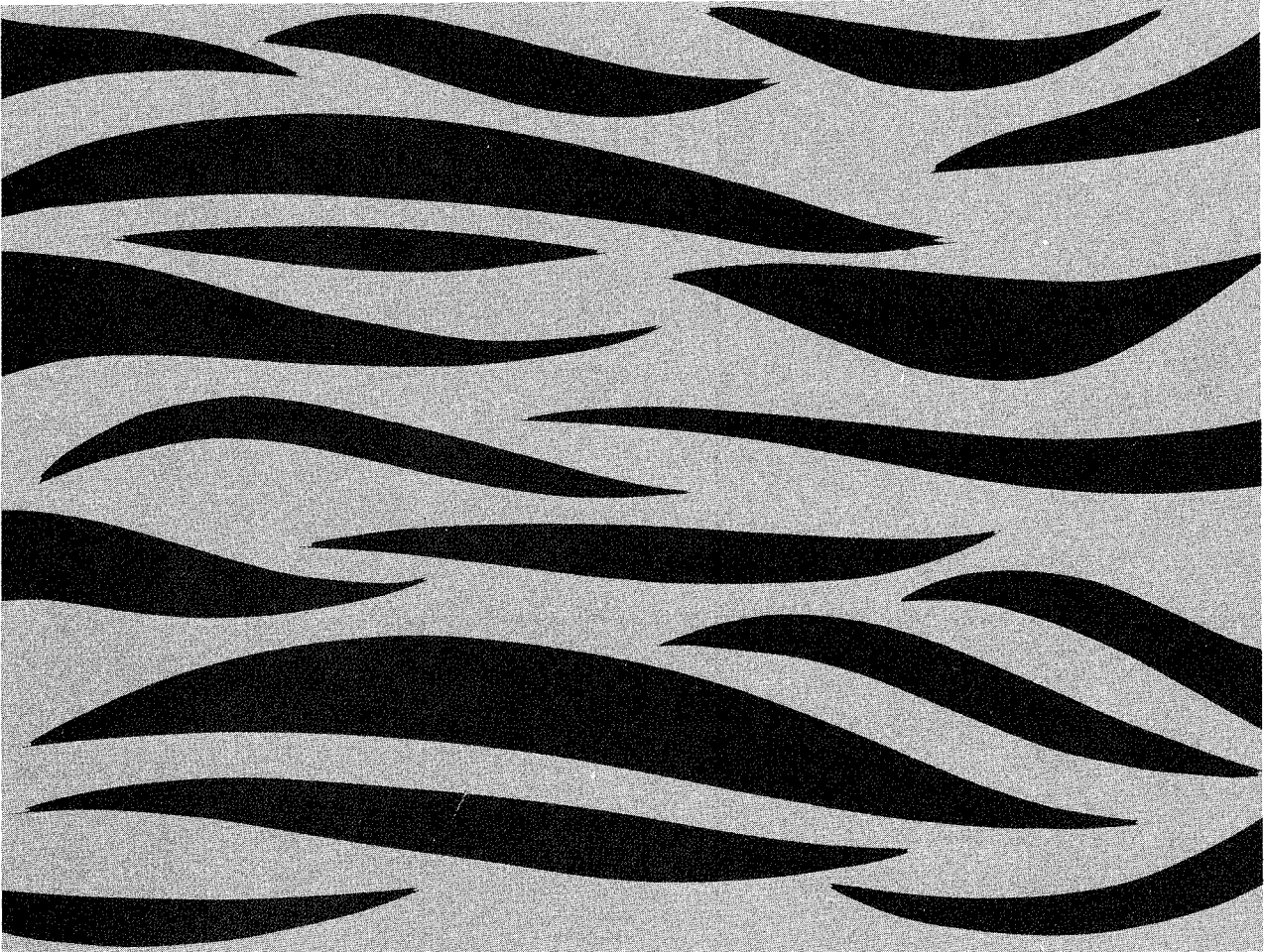
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WATER RESEARCH AT THE UNIVERSITY OF CONNECTICUT

REPORT NO. 16

JULY 1972



William C. Kennard, Director
and
M. S. Williams, Research Assistant

INSTITUTE OF WATER RESOURCES
THE UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT

TABLE OF CONTENTS

4 INTRODUCTION

CURRENT RESEARCH

- 5 Water Quality and Management
- 5 Thermal Regeneration of Activated Carbon
- 5 Air Oxidation of Organic Compounds in Water
- 7 Chemical Analysis of Constituents of Wastewaters
- 7 Effects of Metal Ions on Flocculation of Micro-organisms
- 7 Shellfish Culture in the Heated Wastewaters of Power Plants
- 8 Analysis of Tritium Oxide in the Connecticut River
- 9 Drinking Water Additives, Fluorine and Chlorine
- 9 Diatom Variation in Relation to Water Pollution
- 10 Diatoms as Indicator Species in Water Pollution
- 10 Biotic Changes Associated with Improved Sewage Treatment
- 11 Ecological Evaluation of Primary Treatment Wastewaters
- 12 A Covered Domestic Lagoon System for Groundwater Recharge
- 13 Analysis of Earthy-musty Odor in Water
- 13 Water Resources Planning and Engineering
- 13 The Politics of Water Pollution
- 13 Use of Interactive Computer Graphics in Planning
- 14 Legal and Administrative Practices Concerning Lake Pollution
- 15 Efficient Pricing for Urban Wastewater Renovation
- 15 Pollution Strengths for Undiluted Household Wastes
- 16 Planning for Proper Discharge of Heated Water Jets
- 16 Stability Criteria for Bound-rock Erosion Proofing
- 17 Effect of Environmental Factors on White Catfish
- 17 Water Characteristics and Water Cycle
- 17 Ability of Water to Hold Pesticides in Solution
- 18 The Interaction of Water Molecules with Alkali Atoms
- 18 Nitrate Quantity and Movement in Soil Water
- 19 Hydrological Analysis Using Atmospheric Vapor Data

- 19 Hydrogeologic Investigation of a Sanitary Landfill
- 20 Analysis of Surface Roughnesses Affecting Water Flow
- 20 Movement of Water Within a Plant
- 21 Investigation of Turbidity in Estuarine Waters

COMPLETED RESEARCH

- 22 Water Quality and Management
- 22 Thermo-physical Properties of Dissolved Solids
- 22 Development of Techniques for Analyzing Trace Organics in Water
- 22 Response of Fish to Environmental Factors
- 22 Algal Communities in Natural and Artificial Substrates
- 23 Water Quality Control by Flocculation
- 23 Study of Phosphates in Eutrophic Lakes
- 23 Water Resources Planning and Engineering
- 23 Role of Regional Planning—Farmington River Valley
- 24 Integration of Connecticut Water Rights and Laws
- 25 Reduction of River Heat Pollution
- 25 Air-water Interfacial Interactions
- 25 Individual Waste Disposal Systems
- 25 Reverse Filter Erosion Protection
- 26 Water Cycle and Water Characteristics
- 26 Diffusion Through Multiperforate Septa of Plants
- 26 Flow of Water Through a Soil-plant System
- 26 Oxygen Status of Soil-air and Soil-water
- 27 Relationship of Bedrock Fractures to Underground Water Supplies
- 27 Trace Elements in Groundwater Supplies
- 27 Rate and Direction of Groundwater Circulation
- 27 Analysis of Quasi-periodic Weather Data
- 27 Ion-ion, Ion-molecule Interactions in Aqueous Solutions
- 28 Structure of Amide-water Systems
- 28 SUMMARY
- BC PUBLICATIONS OF THE INSTITUTE

INTRODUCTION

The Institute of Water Resources at The University of Connecticut has as its prime objective the encouragement, conduct, and coordination of research into the many aspects of water, its use, and management. Since its establishment in 1964, the institute has been a focal point for research activities oriented to the myriad water resources problems of Connecticut. At the same time, investigations have been sponsored which have contributed significantly to basic knowledge in water science.

The charter of the institute gives it responsibility for:

Research on water in any part of the hydrologic cycle which can be used directly or indirectly by man...any study which adds to the knowledge of the quantity, quality, nature or uses of water, including those designed to provide information on the nature, sources, production, behavior, transport and conservation of water, including socio-economic aspects, for agricultural, domestic, industrial, municipal, and recreational uses by the citizens of the state....

The institute has administered 50 projects in the past eight years, of which 29 currently are active. The broad scope of these projects has come about because investigators have been actively sought from many diverse fields and disciplines in the schools and colleges of the University. To date, scientists and students from the following disciplines or academic departments have been involved in the research:

<i>Administration</i>	<i>Fresh Water</i>
<i>Aerospace</i>	<i>Fisheries</i>
<i>Engineering</i>	<i>Geography</i>
<i>Agricultural</i>	<i>Geology</i>
<i>Economics</i>	<i>History</i>
<i>Agricultural</i>	<i>Hydrology</i>
<i>Engineering</i>	<i>Laboratory</i>
<i>Agronomy</i>	<i>Medicine</i>
<i>Bacteriology</i>	<i>Law</i>
<i>Biology</i>	<i>Marine Biology</i>
<i>Chemical</i>	<i>Mechanical</i>
<i>Engineering</i>	<i>Engineering</i>
<i>Chemistry</i>	<i>Microbiology</i>
<i>Civil</i>	<i>Pharmacy</i>
<i>Engineering</i>	<i>Physics</i>
<i>Economics</i>	<i>Plant Physiology</i>
<i>Electrical</i>	<i>Political Science</i>
<i>Engineering</i>	<i>Psychology</i>
<i>Forestry</i>	<i>Sociology</i>

Tied very closely to the research mission of the institute is its training responsibility, with both graduate and undergraduate students working actively on the projects. Presently there are 23 graduate assistants who are using water-related problems as master's or doctoral theses. In addition, the institute has aided the development of formal courses at the University on both graduate and undergraduate levels.

The institute is a joint federal-State undertaking, with funding coming from both sources to support research, training, and related activities. Federal funds come to the institute through the Office of Water Resources, Research, U.S. Department of the Interior, Washington, D.C., based on appropriations authorized under PL 88-379 and amendments. As an administrative unit of The University of Connecticut the institute receives State funds to support its several functions. Additionally, many of the staff have research funded by grants from federal agencies, private foundations, and industries.

In an effort to form a bridge of communication from the institute to the University community and citizens at large who are interested in water resources, a monthly seminar series has been sponsored throughout each academic year. These seminars have covered a wide range of subjects and have been attended by representatives of the academic, scientific, business, industrial, and governmental communities, as well as by private citizens. Various themes have been followed each year, with the 1971-72 series being concerned with "Water Policy: Administrative Interpretation and Implementation." In addition to the monthly seminars, the institute has joined with other units of the University in presenting speakers whose lectures relate to the broad field of water resources.

In still another activity, the institute has co-sponsored with various agencies one-day conferences at which a particular topic is discussed in depth. The most recent such meeting was concerned with treating and conditioning home water supplies, an important topic in Connecticut, where many homes have private water systems.

Although the institute is concerned primarily with research and training at the University level, it has developed a secondary but vital role: that of interactor with the many agencies, organizations, businesses, industries, and communities which have a common concern for the condition of Connecticut's waters. Institute personnel have conducted surveys of water problems in several parts of the State and have served on the Governor's Committee on Environmental Policy, the Clean Water Task Force, and on the Legislature's Special

Committee to Study Water Resources. The work of this latter committee resulted in the Connecticut Wetlands Law (PA 46-1971). Staff members also serve on international and national organizations, as well as on local committees. There has been a staff member on The International Hydrological Decade, UNESCO, International Union of Geodesy and Biophysics, National Academy of Sciences committees advisory to the Department of the Interior and NASA, the Capital Region Planning Agency (Hartford), and the Capital Region Council of Governments. One member of the institute served as instructor for the local American Society of Civil Engineers course in urban drainage. Institute personnel also participate in a number of town committees related to water and its management.

In a move to give concerted attention to a watershed area, the institute in 1969 "adopted" the Willimantic-Shetucket River. Several different investigations have been carried out on the river, and recently there has been activated a long-term, multidisciplinary effort directed toward understanding the effect of sewage treatment on water quality and the entire ecology of the river. The results of these studies will be of great value in planning and managing river and stream systems throughout the State and the region.

Recognizing that Connecticut's water resources problems are also regional in nature, the institute joined with the five other New England states in 1966 to form the New England Council of Water Center Directors. Since that time the institute has taken a very active part in all the actions of the council to identify and resolve all the common issues concerning water resources of the six states so closely bound together by tradition and topography. The council has sponsored many highly successful regional conferences, and from one of these in 1966, one fact emerged clearly: that there was a need for coordination of research in water resources among the states. In 1970, the council initiated a project to survey the coordination and advancement of cooperative regional research. A special effort will be directed also toward using research results in solving important water resources problems in New England.

CURRENT RESEARCH

In the following section the objectives, on-going activities, and early findings are given for the 29 projects currently active in the institute. The projects cover a broad spectrum of scientific disciplines but, for convenience, have been grouped under three main headings: "Water Quality and Management," "Water Resources Planning and Engineering," and "Water Characteristics and Water Cycle." The synopsis given for each project is

intended only to provide a brief overview; details can be obtained from publications listed or by contacting the institute office.

WATER QUALITY AND MANAGEMENT

Project Title: *Rate of Thermal Regeneration of Activated Carbon*

Relevance to Water Resources Problems: Activated carbon has found increasing use in wastewater treatment processes because it effectively removes many impurities from water. Since the carbon must be regenerated in order to make its use economically sound, the mechanism and kinetics of the regeneration reaction need to be understood. This understanding will aid in the design of more efficient activated carbon regenerators.

Leaders: H. E. Klei, Associate Professor, Chemical Engineering. D. W. Sundstrom, Professor, Chemical Engineering.

Planned Duration: July 1971 - June 1973.

Objectives: To determine rate expressions for loss of activated carbons during regeneration. To determine also the rate expression for removal of adsorbed species from activated carbon. To develop kinetic equations expressing the rates as functions of temperature, concentration of gas phase components, and residence time in the regenerator.

Accomplishments: Argon gas and distilled water vapor are fed into a small scale activated carbon reactor with temperatures maintained between 1,300°-1,700° F. The effluent gas, after being filtered and condensed, enters a mass spectrometer. Several runs at different water feed rates, temperatures, and residence times have been made and the total moles of gas leaving the reactor have been calculated by a material balance based upon the inert argon. From the measured rates of functions of CO and CO₂, the rate of carbon loss due to the reaction was found.

Future Plans: After the rate expression for the carbon loss has been achieved, the rate of removal of adsorbed organics will be determined by using C¹⁴ labeled compounds. From the above data kinetic equations will be developed which will correlate the rates of reaction of activated carbon and adsorbed materials in terms of temperature and gas phase concentrations. These kinetic equations can be incorporated into models for the design of activated carbon reactors.

Project Title: *Air Oxidation of Organic Compounds in Aqueous Solutions*

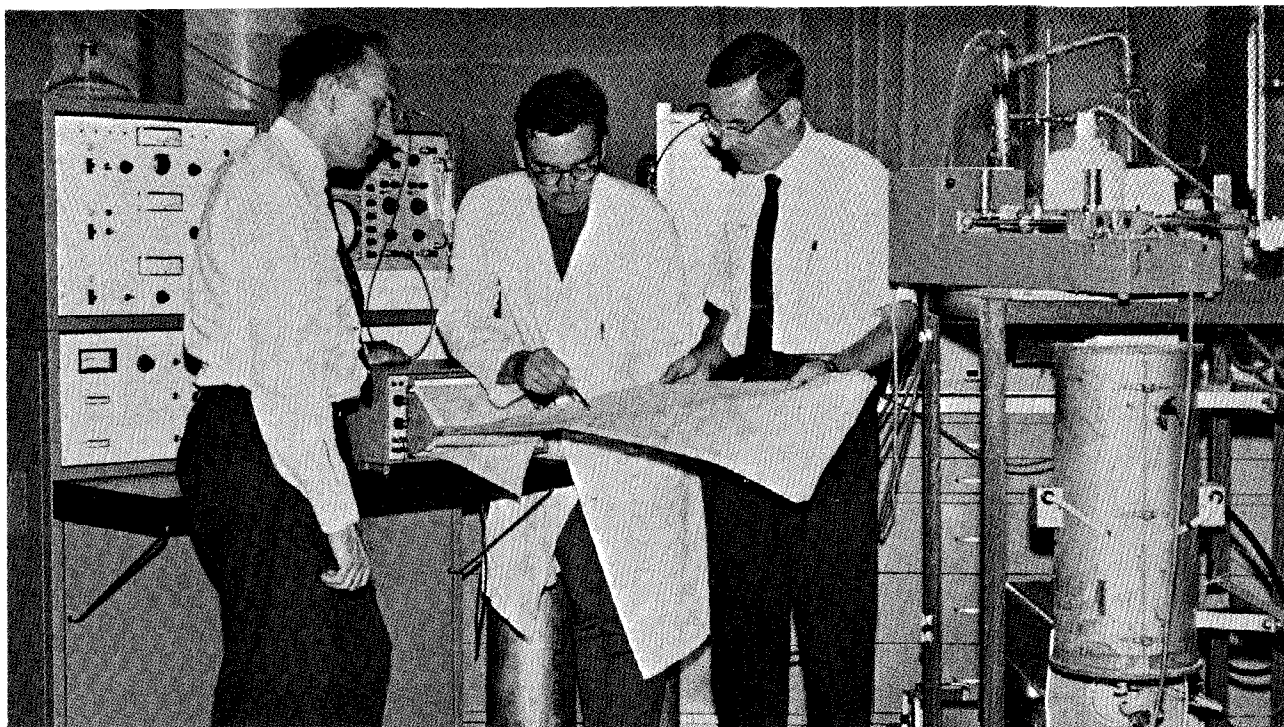


Photo Lab

Drs. H. E. Klei (l.) and D. W. Sundstrom (r.) and graduate student, J. Wason, examine data from mass spectrometer in rear.

Relevance to Water Resources Problems: Wet oxidation is a newer technique for disposal of industrial and municipal wastes. Since the process involves a chemical rather than a biological reaction, it is less sensitive to environmental changes. Because of its potential value in waste treatment, studies are needed to improve our understanding of the process.

Leader: D. W. Sundstrom, Professor, Chemical Engineering. **Assistant in Research:** A. Luciano.

Duration: July 1968 - June 1972.

Objectives: In order to define the factors that limit the destruction of organic compounds by wet oxidation, the rate and extent of oxidation of several organic compounds will be examined over a range of temperatures, pressures, and concentrations.

Accomplishments: Equipment used is a one liter autoclave with a variable-speed agitator which is versatile and can be operated as a batch, semi-batch or flow reactor. Appropriate instruments are used to measure temperatures, pressures, flow rates, and composition of the reacting materials. A gas chromatograph with a special Poropak packing is used for rapid and convenient analysis of dilute aqueous solutions.

The oxidation of carbon has been studied with

rotating discs of solid carbon, since this geometry permits separation of the chemical kinetic and mass transfer effects. Carbon has been found to be a refractory material in the wet oxidation process; it was unreactive at temperatures up to 600°F and gave a measurable reaction rate only in the presence of oxidizing nitric acid.

The wet oxidation of several plastics was also examined using the rotating disc reactor. Plastics are long chain organic molecules that are often difficult to degrade in a biological process. In particular, Nylon 6-6 was oxidized over a range of temperatures, pressures, and dissolved oxygen concentrations. The reaction was found to proceed rapidly at temperatures above 350°F.

Future Plans: The wet oxidation of soluble organic compounds will be studied in a flow reactor. The emphasis will be on the more oxidation-resistant materials such as acetic acid. Oxidation catalysts will be used if needed to increase the rates of the reactions.

Publication: Lo, R. J-D. 1972. "The Rate of Melting of Amorphous Polymers." M. S. Thesis, The University of Connecticut, 116 pp.

Luciano, A. J. 1972. "Wet Oxidation of Nylon 6-6 by the Rotating Disc Technique." M.S. Thesis, The University of Connecticut, 96 pp.

Project Title: *Chemical Analysis and Process Classification of Constituents of Effluents (Organic Nitrogen in Activated Carbon Effluents)*

Relevance to Water Resources Problems: There is an increasing and desirable trend toward the treating of sewage and industrial wastes. Such treatments, however, do not remove all of the materials from the effluent waters. One of the principal components of such effluents is nitrogen, which is sometimes a health hazard and which contributes to the speeding up of eutrophication processes. This study involves determining the classes of nitrogen-bearing residuals in effluents and leads to information for the development of further means of wastewater treatment and analysis.

Leader: T. Helfgott, Assistant Professor, Civil Engineering. **Assistants in Research:** K. E. Neumann and U. Asrani.

Planned Duration: March 1970 - June 1973.

Objectives: To determine the chemical and behavioral characteristics of the residual organic matter found in treated wastewaters and to confirm that these residual organics in the effluents of activated carbon treatment are nitrogen-bearing compounds.

Accomplishments: Sewage effluents from biological treatment plants are being collected and treated with activated carbon to remove adsorbable organics. This effluent is fractionated by various process techniques such as gravitational electrodialysis, and samples placed in a total nitrogen analyzer. This microcoulometric analytic technique verifies that nitrogen-bearing organics are present. Prior work showed that organics of high isoelectric value can escape primary, secondary, and activated carbon treatment. Comparison of nitrogen analyses by this total nitrogen microcoulombic technique is being made to other methods of nitrogen analysis as specified in *Standard Methods*.

Future Plans: There will be a continuation of the analysis of the collected effluents. Additional investigation in tracing the various forms of nitrogen through conventional and advanced wastewater treatment is planned. The analytic technique to determine nitrogen forms in wastewater is being developed, after which the correlation coefficients between various analytic techniques will be determined.

Publication: Helfgott, T. and K. E. Neumann. 1971. 'Measurement of Organic Pollutants in Wastewater Treatment Plant Operations,' in "What Wastewater Parameters Shall We Measure in the Automation of Wastewater Treatment Plants?" *Water 1971*, American Institute of Chemical Engineers, Symposium Series.

Project Title: *Water Quality Control with Synthetic Polymeric Flocculants: Effect of Metal Ions on Flocculation of Biocolloids*

Relevance to Water Resources Problems: The use of synthetic polymer flocculants has reached an important volume in many industrial and municipal waste treatment plants. That finely dispersed organic and inorganic solids are removed effectively by polymer flocculation has been demonstrated. The prevalence of high concentrations of metal ions in some wastewaters may alter flocculation by polymers. This study will shed light on the effect of metal ions on flocculation and will help to refine water pollution control procedures.

Leaders: J. K. Dixon, Associate Professor, Chemistry (Torrington Branch). R. C. Tilton, Associate Professor, Laboratory Medicine (Health Center). **Assistant in Research:** J. R. Murphy.

Duration: July 1970 - June 1972.

Objectives: To study the effects of ions of magnesium, calcium, copper, and zinc on the flocculation of algae and bacteria, and to correlate this study with previous work on polymeric flocculants.

Accomplishments: Algae and bacteria were grown in suitable nutrients to concentrations of 50-3000 mg/l and treated with cationic polymers under controlled conditions, including addition of varying amounts of the trace elements Ca^{+2} , Mg^{+2} , Cu^{+2} , and Zn^{+2} . The rate and degree of flocculation were measured by light transmission alone for Ca^{+2} , Cu^{+2} , and Zn^{+2} , and by light transmission and filtration rate for Mg^{+2} . All four trace elements were studied in an aggregometer and by atomic absorption. In the simple biocolloid systems studied, there was no effect of the metal ions on flocculation.

Publications: Tilton, R. C., J. Murphy, and J. K. Dixon. 1972. "The Flocculation of Algae with Synthetic Polymeric Flocculants," *Water Research*, 6:155-164.

Dixon, J. K., R. C. Tilton, and J. Murphy. 1972. "Measure of the Adsorption of ^{14}C -polyethyleneimine Polymers During Flocculation of Silica, Bacteria, and Algae," *Water Research* (In Press).

Project Title: *Shellfish Culture Using the Heated Effluent from Electric Power Plants*

Relevance to Water Resources Problems: Large quantities of Connecticut's water are committed to electric power plant usage, but multiple use is the most desirable goal for all available water everywhere. This study seeks to discover if the effluent from the power plants will enhance the production of shellfish, thus benefiting both the industry and the public.

Objectives: To determine the feasibility of using the heated water discharged by electric power stations to increase the efficiency of shellfish production. To obtain data on the growth rate and quality of growth of oysters as affected by increased water temperature.

Leaders: S. Y. Feng, Associate Professor, Biological Sciences. G. S. Campbell, Professor, Mechanical Engineering. Assistant in Research: G. Ruddy.

Planned Duration: March 1971 - June 1973.

Accomplishments: Using approximately 1,000 Long Island Sound seed oysters, one tray of 500 has been placed in the heated effluent from a Norwalk, Connecticut, power plant. The control group of 500 oysters has been kept in the intake area of the plant. Monthly histochemical and biochemical measurements on samples of 30 oysters are made from each group. Biochemical tests are measures of: condition index, protein, and glycogen content. Continuous temperature measurements are made with a thermograph at the tray locations. Sampling is also done monthly on the available supply of phytoplankton at each location. Particular interest is centered on the oysters in the heated effluent which have to maintain their regular metabolic activity in spite of the fact that the food supply of

phytoplankton is not available during the winter months.

Future Plans: If the oysters from the heated effluent show a marked degree of depletion in their reserve, then studies must be made to discover the exact point in time that the trays must be removed from this effluent and returned to it to gain the optimum value of both heat and hibernation for stimulating and conserving the shellfish growth.

Project Title: *Analysis of Tritium Oxide from Selected Areas of the Connecticut River*

Relevance to Water Resources Problems: The accurate delineation of levels of tritium oxide and its distribution in the Connecticut River will be highly desirable information about this important body of water. The Connecticut Yankee Atomic Power Plant on the river at Haddam Neck has been in operation since 1967, and a second nuclear power plant is operating at Millstone Point on Niantic Bay, while a third is under construction there. If the seasonal levels of tritium oxide contributed by the operation of these three power plants is found to be significantly high, then studies are indicated to examine the chronic toxicities in the aquatic organisms of the river.



Northeast Utilities

Graduate student G. Ruddy (l.) and Drs. S. Y. Feng (r.) and G. S. Campbell retrieve tray of seed oysters from power plant effluent.

Leader: D. M. Skauen, Professor, Pharmacy. Assistant in Research: F. DeSantis, Jr.

Planned Duration: July 1971 - June 1973.

Objectives: To evaluate methods for analysis of water samples with low levels of tritium oxide, with particular emphasis on enrichment and liquid scintillation techniques. To establish quantitatively the concentration of tritium oxide at selected sites in the Connecticut River. To analyze seasonal variations in conjunction with available hydrological data for possible trends.

Accomplishments: Direct liquid scintillation counting techniques are employed, using a Packard 3375 liquid scintillation spectrometer. After distilling, a 5 ml. aliquot of the sample is mixed with 20 ml. of scintillation solution (at present, a commercial solvent gelling agent, Instagel, is being tried). This solution is counted and suitable calculations are performed when activities are received. Samples are collected from selected sites on the Connecticut River near the Connecticut Yankee Atomic Power Plant and are processed as described above.

Future Plans: The data accumulated in this way will then be used in two ways. With the assistance of other workers on the river (geologists, hydrographers, etc.), the data will be analyzed to establish its usefulness for following such parameters as surface movement, current flow, and biological accumulation. The second use to which the data will be put is furnishing levels of T_2O in our immediate environment for future chronic or even acute toxicity studies in aquatic organisms.

Project Title: *Drinking Water Additives: Physical Growth and Behavioral Development of Mice Receiving Chlorine and Fluorine*

Relevance to Water Resources Problems: The results of these studies will have significant value in assessing the effect on mammals of chlorine and fluorine (singly and in combination). The investigations will evaluate several generations for long-term effects and may permit a permanent answer to the controversial question of the safety of these chemicals in drinking water.

Leader: J. Werboff, Professor, Behavioral Sciences and Community Health. Assistant in Research: R. A. Lewis.

Planned Duration: July 1971 - June 1973.

Objectives: To determine if additives of chlorine and/or fluorine used in drinking water have long-term effects on individual growth and behavioral development, and upon subsequent generations through accumulated usage.

Accomplishments: Laboratory mice of two different genetic strains (A/J and C57BL/6J) are being used. Chlorine and fluorine, singly and in combination, are added to the water. Control groups of the same two strains receive no additives. Amount of water intake has been recorded to determine the amount of the additives getting into the systems. Individual mice are evaluated in terms of the rate of growth and aspects of maturation. Individuals are also assessed on measures of performance on standardized behavioral tests. Determinations are made on the effects of behavioral development possibly caused by the chemicals in the water.

Future Plans: Successive generations of these mice will be followed to determine long-term genetic effects.

Project Title: *Variation in Diatom Morphology and Water Pollution*

Relevance to Water Resources Problems: The algae, especially the diatoms, are primary producers in the food chain and are key organisms to be studied. The hypothesis, if proven, that certain morphological types or morphological variations of diatoms can be used as indicators of the quality or chemistry of fresh water supplies will have great value in water quality control techniques.

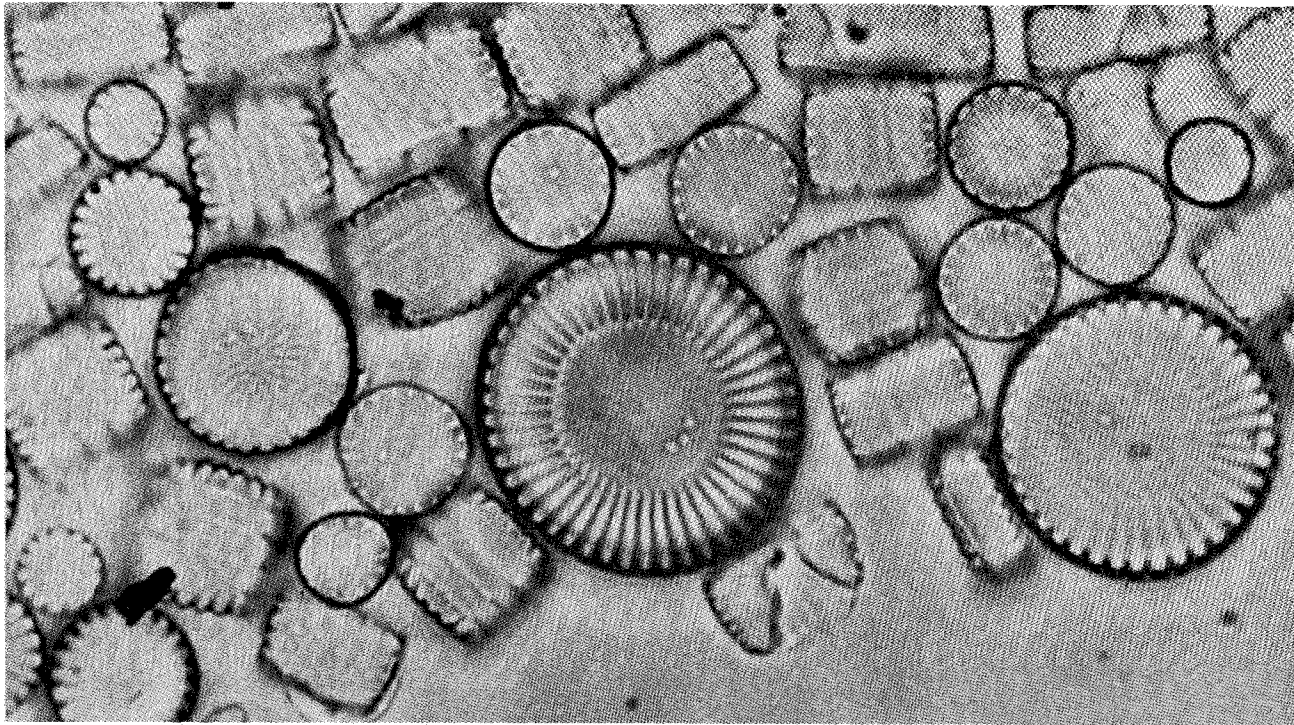
Leader: F. R. Trainor, Professor, Biological Sciences. Assistant in Research: M. E. Schultz.

Duration: February 1967 - June 1972.

Objectives: To determine whether the wall morphology of diatoms is altered by different environmental factors, or remains stable, by using culture technique to study the morphological and growth responses of fresh water diatoms to changes in the physical and chemical environment.

Accomplishments: Findings from culture studies show the wall morphology of the diatom species studied *not* to be stable in different environments throughout the organism's life cycle. The assumption that these structures were stable had previously been a basis for identification. It was found that four distinct biological species including *Cyclotella cryptica*, a brackish-water diatom, were capable of producing the wall pattern of *Cyclotella meneghiniana* in very low salinity or fresh water. *C. meneghiniana* also showed changes in the sexual process under Na^+ stress.

Publications: Schultz, M. E. and F. R. Trainor. 1970. "Production of Male Gametes and Auxospores in a Polymorphic Clone of the Centric Diatom *Cyclotella*," *Canadian Journal of Botany*, 48:947-951.



F. R. Trainor

Diatoms of the species Cyclotella cryptica showing variations in structure due to changes in water quality.

Schultz, M. E. and F. R. Trainor. 1968. "Production of Male Gametes and Auxospores in the Centric Diatom *Cyclotella meneghiniana*," *Journal of Phycology*, 4:85-88.

Schultz, M. E. 1971. "Salinity-Related Polymorphism in the Brackish Water Diatom *Cyclotella cryptica* Reimann, Lewin, and Guillard," *Canadian Journal of Botany*, 49:1285-1289.

Lylis, J. C. 1972. "A Study of *Cyclotella meneghiniana*, a Facultative Heterotrophic, Freshwater Diatom." Ph.D. Dissertation, The University of Connecticut, 99 pp.

Project Title: *Indicator Species in the Desmid Staurastrum*

Relevance to Water Resources Problems: Observation of changes in populations of *Staurastrum* (a species of green algae) will be a rapid and reliable technique for determining certain properties of water, thus indicating the state of chemical pollution, or lack of it, in bodies of water.

Leader: F. R. Trainor, Professor, Biological Sciences.
Assistant in Research: K. Conway.

Planned Duration: July 1971 - June 1973.

Objectives: To demonstrate that changes in populations

of *Staurastrum* species are actually indicators of an altered chemical environment. *Staurastrum* will be a more specific indicator and will be easier to work with than many diatom species and genera. To combine the best of both laboratory and field approaches to the problem.

Accomplishments: Attempts are being made to isolate axenic cultures of *Staurastrum*. When such cultures are achieved then observations will be made on the role of organic compounds and the utilization of phosphates on the growth of *Staurastrum*.

Future Plans: Studies will be made of the competition between mixed cultures of excess-phosphate-uptake- and phosphate-starved media. Field work will be weekly measurements of samples taken from the Fenton River. Observations will be made of the number and kinds of *Staurastrum*, of total phosphates available, and of total organics in solution.

Project Title: *Biotic Changes in the Willimantic/Shetucket River Associated with Improvement in Sewage Treatment*

Relevance to Water Resources Problems: The implementation of State and federal pollution abatement orders will result in many new and augmented sewage treatment plants. These treatment plants will continue

to discharge their effluent into streams, and it is logical to assume that the quality of the stream will improve, thereby improving the habitat of the aquatic life and water qualities for man's beneficial uses. In this study an excellent opportunity occurs to obtain adequate base line data since the investigators will study the stream for eighteen months before the new secondary treatment plant goes into operation, and for two years after. The results of this detailed, interdisciplinary investigation will have important applications for similar situations in many river systems throughout the United States.

Leaders: W. J. Widmer, Associate Professor, Civil Engineering. J. D. Buck, Associate Professor, Biological Sciences (Microbiology). F. R. Trainor, Professor, Biological Sciences (Phycology). W. R. Whitworth, Associate Professor, Plant Science (Fisheries).

Planned Duration: February 1972 - June 1975.

Objectives: To determine the current benthic biotic make-up of the Shetucket River from approximately three miles above to three miles below the outfall from the existing primary sewage treatment plant at Willimantic, Connecticut, and to determine the changes, if any, in this biota over a period of at least two full years of seasonal cycle following the completion of a new activated sludge treatment plant. Then, to correlate these biotic changes with chemical changes in the river and with changes in the quality of the effluent discharged into the river, and finally, to evaluate the success of this local stream pollution abatement program in terms of biotic characteristics and river improvement.

Future Plans: The investigation will involve field and laboratory studies. The general field area will be a six-mile stretch of the Willimantic/Shetucket River from three miles above the Willimantic sewage treatment plant to three miles below it. Six observation sites have been selected, and at each, one or more bottom quadrats will be staked out for observation of benthic organisms. Sampling will be done at two-week intervals. The stream flow-rate will be periodically measured as will surface and bottom temperatures. Analysis of water quality parameters will include pH, dissolved oxygen, suspended load, BOD, and nutrient factors, such as inorganic phosphates and nitrogen. The phytoplankton community will be studied for composition and diversity. Two algae have been selected for specific corollary investigation. They are *Selenastrum* and *Anabaena*. Bacterial flora from both bottom sediments and overpassing river water will be studied by standard microbiological field and culture procedures. Fish life will be monitored to define ecological effects of pollution and water quality changes on growth, habits, food sources, and habitat needs. A new method of observation will be

used in this study, that of closed-circuit TV monitoring, along with standard methods of photomicrography, direct visual observations, preserving samples, keeping records, and traverses of the six-mile reach by both boat and wading.

Project Title: *Ecological Evaluation of Multiuse Waters Receiving Primary Treatment Effluent Prior to a Major Flow Increase*

Relevance to Water Resources Problems: The coastal and estuarine waters of Connecticut, some of the State's most valuable assets, are becoming increasingly contaminated. Municipalities cope with ever-increasing wastewater by building more and larger treatment plants. The effluent from these goes into the streams and rivers which flow into estuaries and coastal waters. In this study the investigator will have the opportunity to study a Connecticut cove now receiving primary sewage treatment effluent prior to receiving a substantial increase of flow from a planned secondary treatment plant. The effect of the present effluent on the ecology will be assessed in order to make projections for the future of this cove.

Leader: J. D. Buck, Associate Professor, Biological Sciences. Assistant in Research: E. C. Pilcher.

Planned Duration: September 1970 - June 1973.

Objectives: To evaluate chemically and biologically the present status of an estuary currently used for both recreational purposes and as receiving water for effluent (0.25 MGD) from a primary sewage treatment plant. Within two years, effluent flow in the same area from a new secondary treatment plant will approach 5 MGD. To determine the suitability of various micro- or macro-organisms as indices of the presence of effluent.

Accomplishments: An adjacent estuary, hydrodynamically similar but receiving no significant flow of effluent, has been used as a control. Measurements have been taken at six sites every two weeks. Samples have been taken at surface, mid-depth, and/or sediment levels. Observations have been made on the following: 1) bacteria, both total heterotrophic and fecal, 2) phytoplankton, 3) BOD, 4) dissolved oxygen, 5) temperature, 6) benthic invertebrates, 7) salinity, and 8) nitrates and phosphates. Comparisons have been made with the control estuary.

Future Plans: Investigations will be made of laboratory cultures of dominant phytoplankton from selected stations and results of attempts to stimulate growth by addition of effluent and other materials. Further examinations will be made of fresh waters entering both coves. Appropriate statistical analyses of data will be made.

Publication: Buck, J. D. 1971. "Biological and Chemical Observations in Mumford and Palmer Coves (Groton, Connecticut) September 1970 - September 1971" Technical Report, The University of Connecticut and Connecticut Department of Environmental Protection, 61 pp.

Project Title: *A Covered Domestic Lagoon System for Natural Groundwater Recharge Near Metropolitan Areas*

Relevance to Water Resources Problems: Many rural areas of Connecticut are rapidly becoming semi-urbanized with piecemeal housing developments. The use of individual septic tanks for waste disposal is no longer efficient and desirable in such close groupings. Some method is needed of treating centrally the wastes from housing groups that is much less expensive than present municipal treatment plants. This study seeks to determine the feasibility of using a covered lagoon system for this purpose.

Leader: R. Laak, Associate Professor, Civil Engineering.
Assistant in Research: R. M. DeSouza.

Planned Duration: March 1971 - June 1973.

Objectives: To determine the feasibility of using a covered lagoon system for small housing groups in unsewered areas. To determine the efficiency of treat-

ment during the four seasons. To determine the suitability of the effluent for subsurface disposal by use of soil seepage beds.

Accomplishments: The pilot plant constructed at the University is a 5,000-gallon water-tight swimming pool tank buried in the ground and covered with a transparent plastic dome. Controlled air exchange in the lagoon system is maintained with a variable speed fan. The size of the plant is based on a theoretical 100-day retention in the tank. Raw sewage is pumped into the center of the tank. The liquid and air above is monitored for temperature and oxygen at different depths and locations. Effluent is analyzed for rate of oxygen uptake, BOD₅, suspended solids, total organic phosphates, and total nitrogen. In the seepage beds the soil-covered recharge bed is monitored once a month by confined percolation tests for rate of clogging. The quality of liquid is measured prior to entering the seepage bed and prior to entering the soil. Quality is defined in terms of suspended solids, BOD₅, nitrogen, and phosphates.

Future Plans: The lagoon loading will be increased so that anaerobic conditions develop, and all conditions will be similarly measured as outlined. All data will be analyzed to see if the following criteria for success are met: 1) no offensive odors by controlled ventilation, 2)



Dwight Thurston

Dr. R. Laak observes pumping station for sewage treatment covered lagoon at right rear.

minimal maintenance, 3) effluent readily accepted by seepage bed, 4) improved effluent quality by greenhouse effect and positive ventilation, 5) improved vector control.

Project Title: *Analysis of the Earthy-musty Odor in Water*

Relevance to Water Resources Problems: In striving to improve the quality of our environment, drinking water of high purity is a first mandate, but good flavor is important also. Since the problem of musty odors in public water supplies is widespread, studies such as this one, which seeks to identify the causes of mustiness, are of prime value in water management projects.

Leader: R. P. Collins, Professor, Biological Sciences.

Duration: July 1970 - June 1972.

Objectives: To identify the earthy-musty odors produced in water, especially those earthy-musty odors which are induced by microorganisms.

Accomplishments: Using previously developed instrumental techniques for analysis of trace organic constituents, three of the earthy-musty constituents of *Streptomyces odorifer* have been identified. *S. odorifer*, an actinomycete, had been implicated in taste and odor problems. The third earthy odor compound was found to be an entirely new compound and has been identified as a sesquiterpene alcohol, Cadin-4-ene-1-ol. Gas chromatography, and infrared and mass spectroscopy were used in the analysis and identification of the odor-causing compounds of *S. odorifer*.

Publication: A publication dealing with the earthy-musty odor constituents of *Streptomyces odorifer* is in press and will appear in *Phytochemistry* in 1972.

WATER RESOURCES PLANNING AND ENGINEERING

Project Title: *The Politics of Water Pollution*

Relevance to Water Resources Problems: Connecticut's 1967 Water Pollution Act is a milestone in the movement to improve water in the State. It is important that the forces at work in the politics of its implementation be examined in depth. Such information will then assist in the enactment and enforcement of future water quality control legislation.

Leader: D. M. Fox, Assistant Professor, Political Science.
Assistants in Research: T. Kucab, R. Hansen, D. McQuade.

Planned Duration: July 1971 - June 1973.

Objectives: To examine in depth and then to analyze the decision-making process involved in the politics of the implementation of Connecticut's 1967 Water Pollution Act through the calendar year 1970.

Accomplishments: Data have been acquired by two methods. Background information on the formal political leadership of the State in policy-making areas is obtained by research. Several key decisions dealing with water policy have been "reconstructed" to determine the individuals or groups most important in these decisions. These leaders in decision-making have then been interviewed for their opinions on the most important groups and individuals in selected areas of State policy-making.

Future Plans: The information gathered by these "decisional" and "reputational" methods will be tabulated and analyzed and a manuscript prepared for publication.

Project Title: *Use of Interactive Computer Graphics in Water Resources Planning*

Relevance to Water Resources Problems: The proper management of modern complex water resources systems requires a less fragmented approach than in the past. The interactive-computer-graphic methods will provide practical coordination of broad intercommunity water planning and development. It will also provide a dynamic information process to achieve flexibility and reliability in the on-going management of water resources.

Leader: Y. T. Chien, Associate Professor, Electrical Engineering. Assistant in Research: R. Farag.

Planned Duration: July 1971 - June 1973.

Objectives: To find a computer-graphics-oriented method for studying the dynamic effects of geometrical configurations on the interconnecting networks relevant to water resources planning and management, and to determine a possible means for evaluating the impact of such an interactive computer system on the water resources development process.

Accomplishments: A PDP-9 digital computer with a DEC display terminal and the Computek Graphic Tablet are programmed to have five capabilities: to graph theoretical representation of physical elements in a water resources system (i.e., reservoirs, irrigation developments, water treatment plants, water distribution plants, etc.), to represent with input data physical entities and domains (i.e., urban, suburban, and rural communities and specific areas within these), and to determine any dimension or attribute of the above elements or domains. Further, the computer is able to identify desired

sets of adjacent domains or elements, and to determine any dimensions or attributes of a set of domain elements.

Future Plans: Simulations will be made and the basic operations for generating alternative solutions for planning and managing a given water resources system will be derived. Possibly an IBM 2250 graphic display unit will be used if the implementation requires a larger data-processing unit than that of the PDP-9 computer.

Publications: Farag, R. and Y. T. Chien. 1972. "Real Time Analysis and Verification of Handwritten Signatures," Technical Report CS-72-1, Department of Electrical Engineering, The University of Connecticut, 69 pp. Chien, Y. T. and R. Ribak. 1972. "A New Data Base for Syntax - Directed Pattern Analysis and Recognition" *IEEE Transactions on Computers* (In Press)

Project Title: *A Study of Legal and Administrative Practices Relating to Lake Pollution in the Northeast*

Relevance to Water Resources Problems: The lakes of Connecticut (and most of the nation's lakes) have been a neglected resource, little considered in planning for the future. Connecticut's lakes total an area of 110 square miles and are being subjected to tremendous pressures by the State's industries and growing population. In this

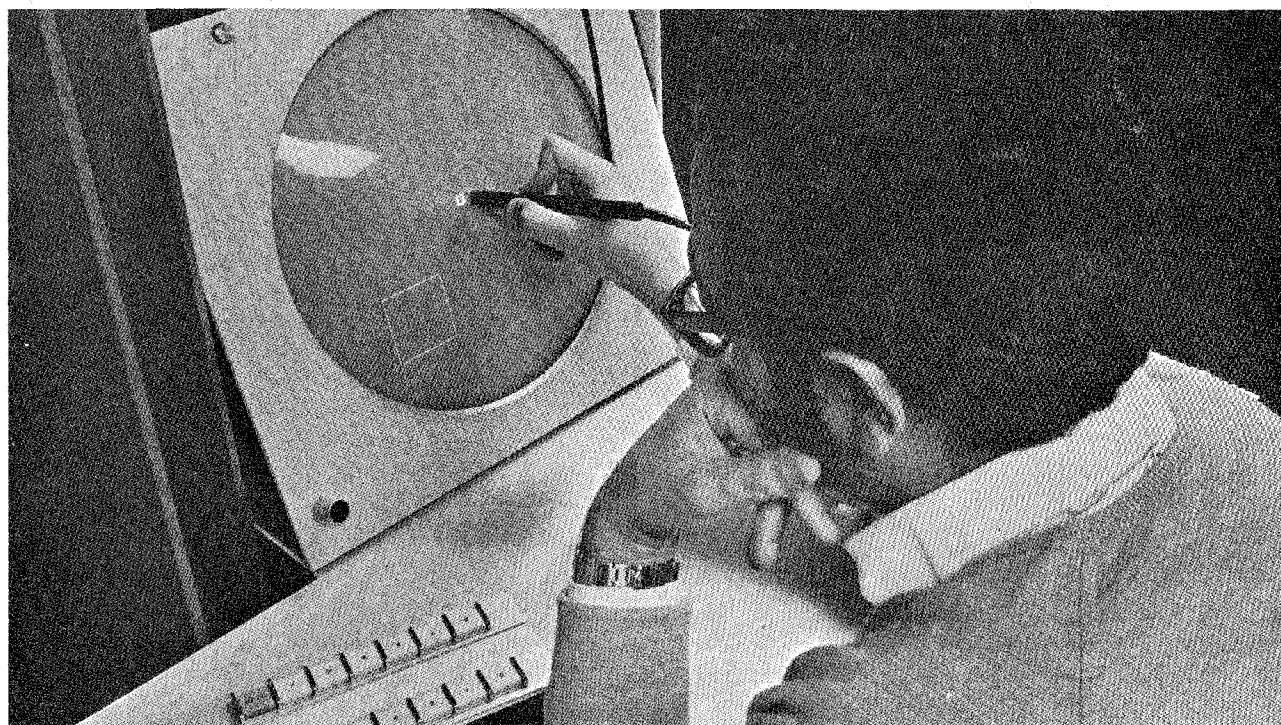
study, one of the principal problems, determining the legal aspects with regard to water quality, has been dealt with in depth. The results have widespread application for the northeast area of the United States.

Leaders: W. C. Kennard, Professor, Research Administration. R. I. Reis, Associate Professor, Law (State University of New York at Buffalo). P. Goldstein, Assistant Professor, Law (State University of New York at Buffalo).

Duration: July 1969 - June 1972.

Objectives: To identify major legal problems relative to lake pollution in the northeast United States, generally, and Connecticut in particular. To establish basic criteria for consideration in the formulation of policies and methodologies for the enactment of legislation in the area. To identify changes in statutory law and administrative structure needed to facilitate more extensive protection and utilization of lake waters.

Accomplishments: A detailed and exhaustive review has been made of judicial decisions applicable to water quality in lakes, and of legislative developments applicable to lake water quality in the United States. Particular reference has been given to Connecticut water jurisprudence and legislative developments in water quality control. Resources have been: state and federal reporter systems, state and federal statutes, federal proposals and



Graduate student R. Farag testing DEC 339 Graphic Display on PDP-9 computer.

Dwight Thurston

committee reports, relevant literature, and interviews with leading proponents of lake pollution control. An additional detailed exploration of thermal dangers to lakes was made and an analysis of thermal problems prepared. A basic inventory of legal techniques in the United States and the Northeast for lake preservation was compiled.

Publication: Reis, R. I. 1972. "Environmental Activism: Thermal Pollution—AEC and State Jurisdictional Considerations," *Boston College Industrial and Commercial Law Review*, 13(4):633-684. (Released under the same title as Institute of Water Resources Report No. 15.)

Project Title: *Efficient Pricing for Urban Wastewater Renovation*

Relevance to Water Resources Problems: Many social, economic, and political factors have caused a considerable increase in the amount of industrial wastes now being treated at municipal treatment plants. This increase places a heavy economic burden on the municipality. Some efficient method must be found to charge for the volume and kinds of industrial wastes added to a municipal plant. Such a pricing method, which this study seeks, would not only relieve the taxpayer but might induce industries to treat their own wastes in line with quality control criteria.

Leaders: R. L. Leonard, Assistant Professor, Agricultural Economics. R. Laak, Associate Professor, Civil Engineering. H. Kardestuncer, Associate Professor, Civil Engineering. **Collaborator:** M. E. Hupfer, Connecticut Water Resources Commission. **Assistants in Research:** J. Huang, J. Jhaveri, J. Pyrdol, T. Norvell.

Objectives: To identify for selected urban wastewater renovation plants the impact of each major industrial waste component on the effectiveness of the treatment process and on operation and maintenance costs. To develop pricing systems which will promote an effective and efficient combination of industrial waste control at the source, and final treatment at the municipal plant.

Planned Duration: July 1970 - December 1972.

Accomplishments: Intense analysis has been focused on a Connecticut water pollution control plant with a 2.5 MGD design flow. Batch samples of raw wastewater, streams between unit processes, and treated effluent have been analyzed for sixteen quality characteristics. A simulation model uses the volume and quality characteristics of the raw wastewater, along with design criteria, as input data. The model predicts the results of each unit process. Differences between these calculated results and laboratory data were studied through a comparison with a simulation of another Connecticut treatment plant

which receives only domestic sewage. Collection of data on operating costs has been accomplished despite wide variances in municipal accounting procedures.

Future Plans: The final adjustment of the simulation model will be made to reflect both the physical impact of industrial waste and cost increases resulting from treating such waste. Analysis of data and development of equations for a pricing system will follow.

Project Title: *Relative Pollution Strengths of Undiluted Waste Materials Discharged in Households and the Dilution Waters Used for Each*

Relevance to Water Resources Problems: Considerable quantities of water are used for the dilution and transport of human wastes, yet very little accurate information has been available on the pollutorial load and water volume used by various household plumbing fixtures. This study has investigated these factors and provides both practical information for redesign of fixtures and basic data relating to the level of pollutants, including phosphates and nitrates.

Leader: R. Laak, Associate Professor, Civil Engineering. **Assistant in Research:** A. I. Lin.

Duration: July 1969 - June 1972.

Objectives: To determine the pollutorial load and measure the dilution water used by each type of household plumbing fixture. To establish a method of estimating the pollution loads and to provide basic data for further studies concerning plumbing fixture redesigns and methods of transporting water and wastewater.

Accomplishments: The five households selected for study were near the University and had a range of family members and number of household fixtures. By keeping records, information was obtained on quantity and frequency of purchase of each waste ingredient (soaps, papers, detergents, etc.) and frequency of laundry, dishwashing, and baths. Plumbing fixtures were inventoried as to size, volume, etc., and counters were installed in toilet flush tanks. Samples of the same brands of waste ingredients were analyzed for COD, biodegradability, total inorganic phosphates, and total nitrogen in accordance with standard methods. Water capacities of all fixtures were calculated and/or measured. Weekly checks were made on counters, and samples from dishwashing, laundry, and bathtub were collected. All data were correlated with laboratory work and final analysis shows all objectives to have been achieved.

Future Plans: A manuscript is in preparation for publication in the *Journal of the Water Pollution Control Federation* or *Water and Sewage Works*.

Project Title: *Combined Buoyancy and Boundary Effects and Aeration Effects on Jet Spreading*

Relevance to Water Resources Problems: Heated water effluents from manufacturing processes and from cooling the reactors of nuclear-powered electric generating plants are becoming a matter of increasing concern. If these effluents are to be continued to be discharged into rivers and other bodies of water and if their effects are to be minimized, it is important that a detailed understanding of jet spreading and mixing be developed. This study should provide information for intelligent discharge design.

Leaders: E. K. Dabora, Associate Professor, Mechanical Engineering. R. L. Stoy, Associate Professor, Mechanical Engineering. Assistants in Research: A. H. Hsia, M. Stenhouse.

Planned Duration: July 1971 - June 1973.

Objectives: The effects of buoyancy and jet proximity to a surface will be studied both experimentally and analytically with the intent of determining jet spreading and mixing. In addition, aeration as it affects the jet properties will be assessed in an exploratory fashion.

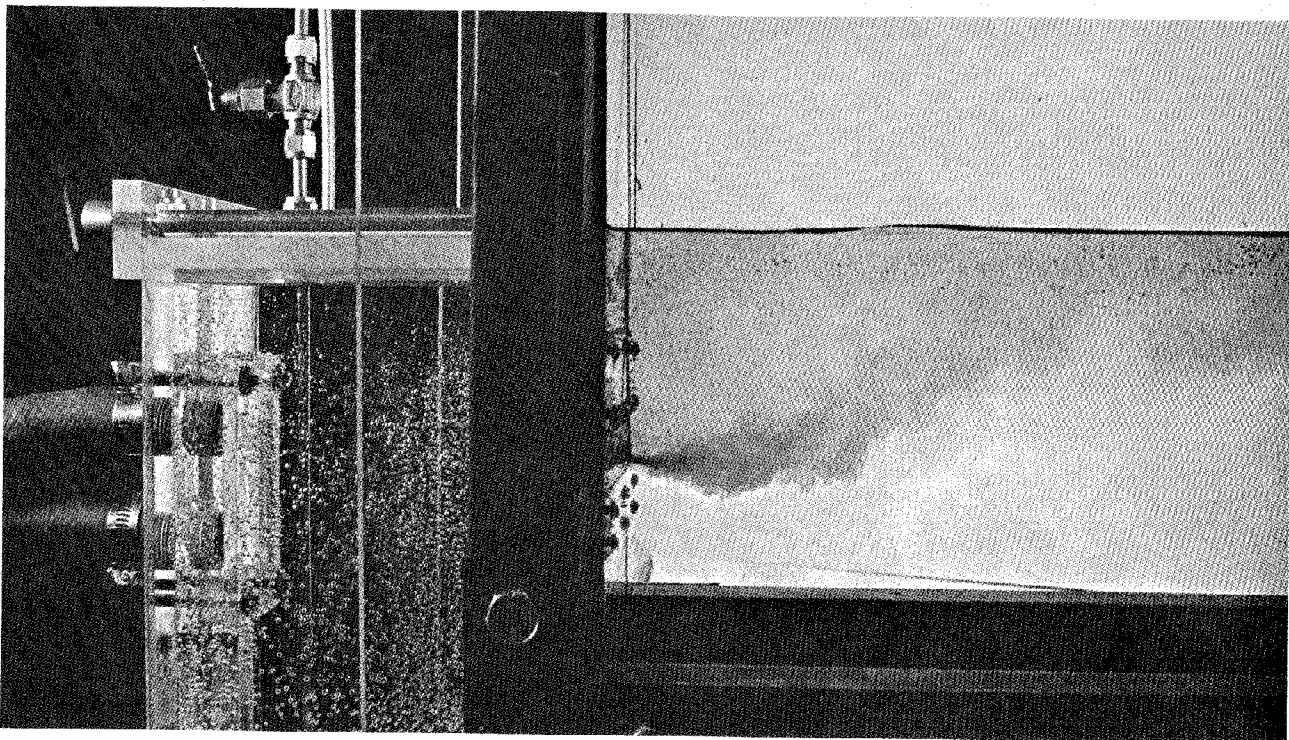
Accomplishments: A water tank ten feet long by five feet wide by one-half foot deep has been constructed,

and a constant-level free surface established by installing a smooth outfall downstream of the jet. A traversing mechanism for hot wire and thermocouple measurements is installed over the tank. Dye-tracing and photographic observation have been used to obtain a general view of the flow pattern. Several surveys of velocity distribution have been made using jets of temperature equal to the receiving water. Studies of four different methods of aeration have been made, one of which will be used in studies of the heated jet in receiving water of varied temperatures.

Future Plans: The temperature profiles of the jet, with and without aeration, will be studied, as will the velocity profile measurements to determine the effect of aeration on jet spreading. Analysis of data will be made by an integral method which has been used successfully in fluid amplifier studies. In the case of the buoyant jet near the bottom surface, this method—with buoyant forces included—should provide an interesting extension of the fluid amplifier analysis.

Project Title: *Stability Criteria for Bound-rock Erosion-proofing*

Relevance to Water Resources Problems: Erosion has been a serious problem in Connecticut water management. Previous studies by this investigator have shown



Dwight Thurston

Jet of dyed water is injected into tank to show water-flow pattern.

that an ancient device used by the Chinese, combined with a device of recent scientific research, could protect even the most erodible materials. These rock sausages (wire or plastic mesh tubes filled with small stones) when placed over an inverted filter are more effective in preventing erosion than the more expensive asphalt or concrete channel linings in present use. This study will furnish more information on these valuable and economical devices.

Leader: C. J. Posey, Professor, Civil Engineering. Assistant in Research: H. K. Soong.

Planned Duration: July 1970 - June 1973.

Objectives: To determine criteria which will enable the designer to select the size of rock sausage necessary to resist being moved by the given depth and velocity of flow to be expected in a given location.

Accomplishments: An inclined jet impingement apparatus with jet velocity capable of moving one-inch diameter sausages was first used; then apparatus twice as large in every dimension was built and tested with three- and six-inch diameter rock sausages. In each, comparisons were made with solid rocks of various shapes and sizes. Similar comparisons were made of resistance to high velocity flow in a wide flume and of settling or "fall" velocity in quiet water.

Future Plans: A larger number of field installations will be made in a variety of locations at the University and along state and federal highways. Ecologists will be asked to evaluate the environmental effects of the rock sausage installations as compared with concrete or asphalt linings. Definite specifications for rock sausage installation will be formulated to include, not only the relationships developed in this project, but also available soil mechanics techniques where steep slopes are involved.

Publication: Soong, H-K. "Rock Sausage Fall Velocity Measurement." M.S. Thesis, The University of Connecticut, 19 pp.

Project Title: *Effects of Simultaneous Variations of Diel Changes of Temperature, Dissolved Oxygen, Salinity, and a Pollutant on the Growth of White Catfish*

Relevance to Water Resources Problems: In the management of estuarine waters it is extremely important that information be obtained about the environmental factors that affect the health and growth of fish life. These studies of the effects of four environmental factors upon a common river dweller will be of particular value to those concerned with management of the estuaries of the Connecticut and Thames Rivers.

Leader: W. R. Whitworth, Associate Professor, Plant Science (Fisheries). Assistant in Research: D. R. Ostrander.

Planned Duration: July 1970 - June 1973.

Objectives: To estimate the effects of daily changes of temperature, dissolved oxygen, salinity, and a pollutant on the growth of white catfish.

Accomplishments: White catfish were obtained and acclimated for two weeks. An experimental apparatus containing 72 test vessels was set up. The experimental design is $2 \times 2 \times 3 \times 3$ with two replications (36 treatment combinations in 72 vessels). Levels of temperature, dissolved oxygen, and salinity were selected on the basis of data collected in the Thames Estuary during 1969-70 and levels of alum (aluminum sulphate) were based on 96-hour bioassay results. Alum is found in the effluent from paper and sewage treatment plants. Tests are run on various sizes of white catfish for two months with two temperature and dissolved oxygen levels fluctuating twice daily and the three pollutant and salinity levels fluctuating twice daily.

Future Plans: Other sizes of white catfish will be tested and the results will be analyzed as factorial arrangements in completely randomized block designs.

WATER CHARACTERISTICS AND WATER CYCLE

Project Title: *Solubilizing Effects of Amide-water Mixtures*

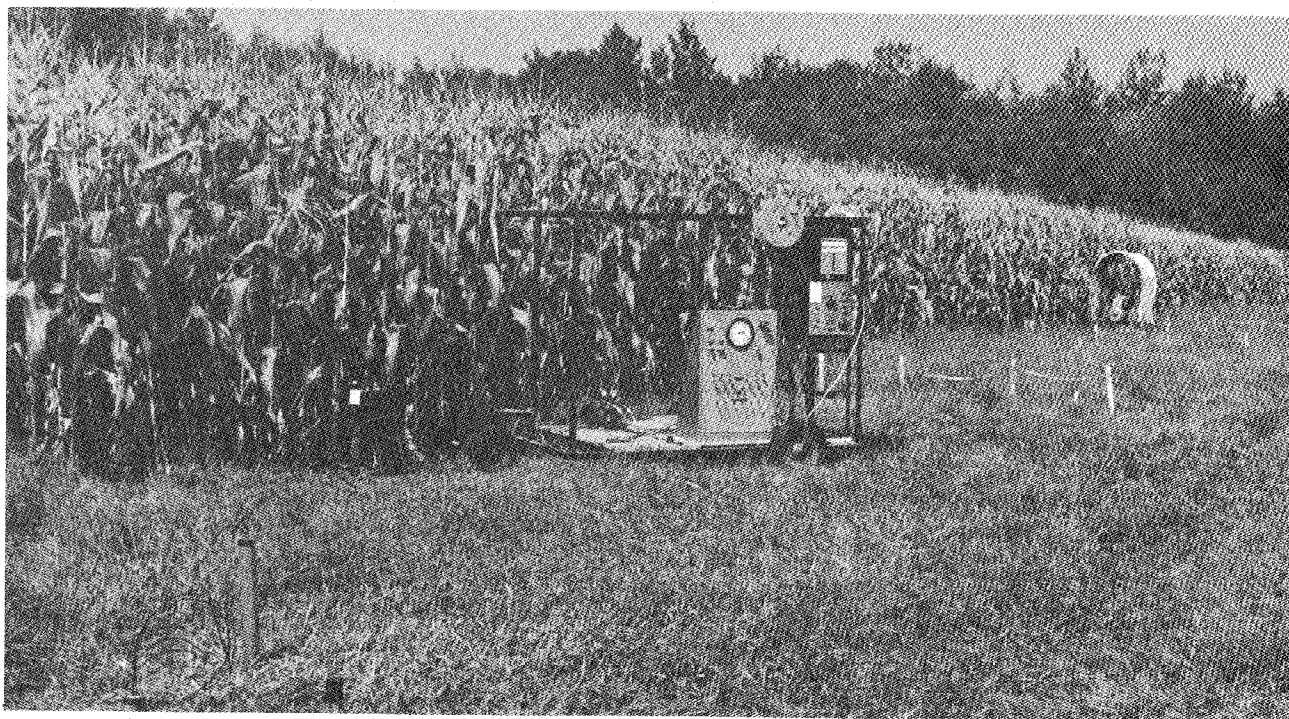
Relevance to Water Resources Problems: During the process of eutrophication, water supplies are enriched in compounds and life forms that are abundant in peptides (amides). It is probable that these materials create an environment which promotes the dissolving of herbicides and pesticides into the water. Therefore, a better understanding of solubility phenomena is of utmost importance in developing pollution control methods and procedures for natural water systems.

Leader: R. E. Lindstrom, Associate Professor, Pharmacy. Assistant in Research: A. R. Giaquinto.

Duration: July 1971 - June 1972.

Objectives: To correlate amide-water interactions, as manifested by variations in apparent molar volumes, with the solubilizing of aromatic hydrocarbons.

Accomplishments: The solubility of methyl paraben in amide-water mixtures is being studied as a function of amide concentration. A determination of the concentration of the paraben is made with a U.V. spectrophotometer. The ethyl, propyl, and butyl parabens are also



G. F. Griffin

Experimental cornfield treated with high and low levels of nitrogen fertilizer. Soil water samplers are seen in left foreground and automatic recording devices are on right.

being used in amide-water mixtures to enlarge upon apparently significant relationships which have been evidenced in the methyl phase of the investigation.

Future Plans: Where further rationalization is called for, representative solubility systems will be studied as a function of temperature in order to appraise the enthalpy and entropy changes associated with solution in those systems.

Publication: Giaquinto, A. R. 1972. "Structural Aspects of Amide-Water Systems." Ph.D. Dissertation, The University of Connecticut, 161 pp.

Project Title: *The Velocity Dependence of the Total Cross-section for Alkali-water Scattering*

Relevance to Water Resources Problems: In order to deal competently with the many aspects of water, its use, and its management, it is necessary that we understand the basic nature of the water molecule. These studies have led primarily to a better understanding of the interactions between water molecules and alkali atoms. The information obtained about the unique distribution of the electrical charge of the H_2O molecule will be useful in many applied problems.

Leaders: T. I. Moran, Associate Professor, Physics. E. Pollack, Associate Professor, Physics. Assistants in Research: J. Della Valle, A. Goldberger, and G. Lorient.

Duration: September 1968 - June 1972.

Objectives: To determine the magnitude and the nature of the interaction that exists between a water molecule and an alkali atom.

Accomplishments: Alkali atomic beams have been passed through water vapor and the intensity of the scattered alkali beam measured. Standard hot wire techniques have been used for detection of alkali beams and an electron multiplier, mass spectrometer, and counting techniques are currently available for the remaining measurement of currents obtained for sodium and lithium.

Future Plans: Data collected have been analyzed and interpreted and a manuscript is in preparation.

Publication: Della Valle, J. A. 1970. "The Velocity Dependence of the Total Cross-Section for K-Ar and K, Rb, Cs- H_2O Collisions." Ph.D. Dissertation, The University of Connecticut, 125 pp.

Project Title: *The Quantity and Movement of Nitrates in Soil Water in Two Connecticut Soils Treated with High and Low Levels of Inorganic Nitrogen Fertilizer*

Relevance to Water Resources Problems: Nitrate pollution is a serious problem; it is a factor in the eutrophication of lakes and streams, and can lead to methemoglobinemia (blue baby) in infants who drink the water. When the patterns of nitrate movement in soil and into groundwater have been established, then measures can be taken to reduce nitrate pollution where it does exist and to prevent it where it is not yet a problem.

Leaders: G. F. Griffin, Associate Professor, Plant Science (Agronomy). R. W. Wengel, Professor, Plant Science (Agronomy).

Planned Duration: March 1970 - June 1973.

Objectives: To measure the vertical and lateral movements of nitrates in soil water in the presence and absence of soil fragipans with regard to potential groundwater pollution, and to measure the distribution of nitrates in soil water at various depths resulting from applications of inorganic fertilizer. To establish the significance of fragipan soils affecting potential nitrate pollution of soil and groundwater.

Accomplishments: Two Connecticut fields, one with a fragipan and one without, have been used to study the distribution of the nitrates after the application of the nitrogen fertilizer. On the upper half of each field a randomized complete block design with four replications has been made. Treatment blocks and buffer blocks are planted in silage corn. Treatment plots have had fertilizer applied at the rate of 200 pounds per acre and in the buffers, zero pounds per acre. Lower slopes of each field are planted in rye-grass and have no nitrogen added. Suction lysimeters and access tubes for neutron moisture probes have been installed in each plot and in rye-grass area to measure both vertical (at one-, two- or fragipan, and four-foot depths) and lateral movements. Yields of corn and its nitrogen uptake have been determined.

Future Plans: Since the discovery of consistently high nitrate level (25-50 ppm) at the four-foot depth under both fertilized and unfertilized plots appears to be related to moisture studies showing saturation of this particular zone and to lateral movement of nitrates, this condition will be investigated by more sampling at the four-foot depth than was previously planned. Data obtained will be compared to previous data to determine if trends are the same or different.

Publication: Wengel, R. W., G. F. Griffin. July-August 1971. "Remote Soil Water Sampling Technique," *Soil Science Society of America Proceedings*, 35(4):661-664.

Project Title: *Hydrological Analyses Using Atmospheric Vapor Data*

Relevance to Water Resources Problems: A better understanding of the hydrological cycle will permit more realistic and effective regional water resources planning, a procedure made necessary by greater and more complicated demands on water resources due to the anticipated growth of population and industrialization. These studies are aimed at further knowledge of the far-reaching implications of the fundamental aspects of the hydrological cycle and for future rational planning of water resources use and development.

Leader: P. Bock, Professor, Civil Engineering. Assistants in Research: P. Magyar and A. N. Shahane.

Planned Duration: July 1970 - June 1973.

Objectives: To construct and analyze fields of hydrological parameters over large-scale regions of North America and the northern hemisphere using vapor flux analyses and classical hydrological procedures for comparisons.

Accomplishments: Using atmospheric vapor data, hydrological analyses of 50 of 74 drainage basins of the continental United States have been made. These units vary from 30,000 to 80,000 square miles, and previous studies indicated that the systematic error in the $\bar{\nabla} \cdot \bar{Q}$ (divergence of water vapor) did not allow the use of atmospheric vapor approach to units smaller than 200,000 square miles. In this work, techniques have been developed for adjustment of the $\bar{\nabla} \cdot \bar{Q}$ input and a computer program has been designed which calculates the adjusted $\bar{\nabla} \cdot \bar{Q}$. It then uses that value to find ΔW (change in precipitable water content of the air), ΔS (change in surface and subsurface storage) and E (evapo-transpiration).

Future Plans: The new method will be applied for all of the 24 remaining sub-regions which total 95 percent of the continental United States. Further statistical analyses will be carried out to determine the reliability and usefulness of the hydrological components obtained for use in large-scale design and prediction of hydrological changes.

Project Title: *Hydrogeologic Investigation of a Sanitary Landfill in a Stratified Drift*

Relevance to Water Resources Problems: The present restrictions in Connecticut on burning solid wastes has caused many municipalities in the State to turn to sanitary landfills for waste disposal. The distinct possibility exists that we are merely moving the pollution from the atmosphere to the subsurface. It becomes important then that we know the chemical composition of leachates from a sanitary landfill and the patterns of groundwater flow in the area. A framework can then be developed which will permit modeling of sanitary

landfill sites and make possible evaluation of potential sites without elaborate on-site studies.

Leader: T. L. Holzer, Assistant Professor, Geology and Geography. **Assistant in Research:** L. Chestnut.

Planned Duration: March 1971 - June 1973.

Objectives: To examine the groundwater hydrology of a sanitary landfill site located in a glacial deposit of a glacio-fluvial valley of eastern Connecticut and to determine the following: the nature, extent, and hydraulic properties of natural deposit underlying and surrounding the landfill; the local groundwater flow patterns; and the chemistry and migration of the leachate in the groundwater. To develop a framework for future modeling studies.

Accomplishments: The geologic units underlying and surrounding the landfill site have been defined by surficial mapping, refraction seismology, and borings. Hydraulic parameters have been determined by permeameter analyses of disturbed samples with known grain-size and sorting data. Test wells have been drilled to delineate local groundwater flow patterns, hydraulic parameters, and hydrogeologic boundaries. Emission spectroscopy and chemical analysis are being used to determine the concentration of leachate in the groundwater.

Future Plans: Collected data will be analyzed and interpreted, and a digital model of the landfill site will be constructed for future modeling studies.

Project Title: *Measurement and Analysis of Natural-type Surface Roughnesses Affecting Fluid Flow*

Relevance to Water Resources Problems: It is well known that bed roughness affects fluid flow, but until recently equipment has not been available for measuring and analyzing natural types of roughnesses. In this study a definitive quantitative technique capable of distinguishing one roughness from another should be achieved. Such data should be of great value in the planning and management of water resources, where energy loss through fluid friction is an important factor.

Leader: C. J. Posey, Professor, Civil Engineering. **Assistants in Research:** B. Bhattacharya and M. Joakim.

Duration: July 1968 - June 1972.

Objectives: To develop definitive, quantitative measurements of natural-type surface roughnesses and to analyze the profiles with a computer program previously developed.

Accomplishments: A digital computer evaluation has

been made of the cumulative frequency distribution of height, slope, and curvature of developing sand-bed profiles. Analysis shows that each distribution approaches a definite limit as the morphology of the bed nears a fully-developed state. The 95 percentile values of these three measures may be used to define the differences of natural-type roughnesses.

Future Plans: A manuscript has been prepared and submitted to the *Journal of the American Society of Civil Engineers*.

Project Title: *Interrelation of the Morphology and Physiology of a Plant and the Resistance to Flow of Water Within the Plant*

Relevance to Water Resources Problems: In the planning and management of agricultural water resources, it is necessary that the basic data on the response of plants to water stress be available. This study has led to a better understanding of the role that root systems play in supplying or limiting water uptake to plants. Such data are useful in manipulating water systems for increased water-use efficiency.

Leaders: B. E. Janes, Professor, Plant Science. G. W. Gee, Assistant Professor, Soil and Water Sciences (University of New Hampshire). **Assistant in Research:** H. Olvång.

Duration: July 1970 - June 1972.

Objectives: To investigate the influence of both root morphology and physiology upon the resistance to flow of water within the plant.

Accomplishments: Peppers and corn have been grown under controlled environmental conditions. Rooting volume has been confined so that accurate root zone water potential measurements can be made. Water potential in the root zone was measured by field type thermocouple psychrometers. The water potential of leaves and stems was estimated by use of the pressure bomb technique. Transpiration was monitored under controlled conditions also. Root resistance measurements have been evaluated in terms of rooting density and root surface area, and related to imposed environmental stresses.

Publication: A manuscript, "Measurement and Control of Water Potential in Soil Plant Systems" by Gee, G. W., W. Lui, H. Olvång, and B. E. Janes, has been accepted for publication in *Soil Science*. Additional data from this manuscript will be presented at the annual meeting of the American Society of Agricultural Engineers in June 1972.



Dwight Thurston
Dr. W. F. Bohlen retrieves Hydrolab probe from estuarine waters of Connecticut River.

Project Title: *An Investigation of Turbidity in Estuarine Waters*

Relevance to Water Resources Problems: In developing long-term water management schemes, many parameters are needed. This investigation will examine the relationship between turbidity and overall water quality. These data in combination with the proposed instrumentation provide a low-cost method for continuous quantitative assessment of water quality.

Leader: W. F. Bohlen, Assistant Professor, Geology and Geography. **Assistant in Research:** M. M. Smith.

Planned Duration: July 1971 - June 1973.

Objectives: To examine the relationship between total turbidity and its component parts (i.e., organic and inorganic constituents) at selected sites in the Connecticut River estuary. To develop the instrumentation to permit *in situ* measurements and analysis of turbidity.

Accomplishments: A sampling grid of twelve stations has been established across the mouth of the river and out into the adjacent area of Long Island Sound. Monthly sampling at each station has been used to obtain: 1) large volume samples from near surface and near bottom depths, and 2) measurements *in situ* with a Hydrolab probe to determine temperature, salinity, pH, and dissolved oxygen. Drawn water samples are analyzed in the laboratory for dissolved oxygen, BOD, nutrients, total suspended load, and relative percentages of organic and inorganic constituents in the suspensoid. Monthly samples are being supplemented by quarterly twelve-hour station checks to provide hourly data over a tidal cycle. The data obtained have served to establish the design criteria for the instrumentation for a permanent *in situ* installation. This consists of a Hydrolab and a recording nephelometry system. The nephelometer is expected to consist of a scattered light sensor to provide particle concentration and size information, and an absorption sensor to monitor the organic composition of the suspensoid.

Future Plans: The instrumentation and data acquired will be used to establish the causes of the observed variations in turbidity and to investigate the relationship between turbidity and selected water quality parameters. Initial emphasis will be placed on the degree of correlation between BOD and turbidity.

Publication: Bohlen, W. F. 1972. "Turbidity Measurements in Estuaries," (abstract) *E. & S. Transactions*, American Geophysical Union, 53(4):421

COMPLETED RESEARCH

The 21 terminated projects carried out by institute staff members are representative of the diversity of interests in, and the multidisciplinary approach to, water problems. The studies range from a basic inquiry into matters such as ion-molecule interactions, to the highly practical development of an extended aeration pump for individual waste disposal systems. Some studies reported here have led to further investigations which can be seen in the current research section. Published articles are listed for each effort.

WATER QUALITY AND MANAGEMENT

The Determination of the Engineering Thermo-physical Properties of Solutions Containing Dissolved Solids. D. A. Fisher, May 1965 - June 1969.

With increasing world population and decreasing supplies of pure drinking water, more and more attention is being given to obtaining fresh water from sea water. Process analysis and the engineering design and development of conversion equipment has been hampered in the past by the almost complete absence of authentic data on the engineering properties of sea water and its concentrates. In this project the enthalpy of sea water was experimentally determined by the use of a Bunsen Ice Calorimeter over a temperature range from 32°F to 400°F for concentrations ranging from one percent to 28 percent salinity, to an accuracy of approximately 0.05 percent. The entropy and specific heat capacity was calculated from the data. These three properties are presented in tabular form from a computer program.

Publications: Fisher, D. A., W. E. Hilding, and J. G. Daley. 1970. "Thermodynamic Properties of Seawater Concentrates," *Proceedings, Fifth Symposium on Thermophysical Properties*, American Society of Mechanical Engineers, Boston, 134-140.

Daley, J. G. 1970. "Thermodynamic Properties of Seawater Concentrates." Ph.D. Dissertation, The University of Connecticut, 96 pp.

Development of Instrumental Techniques for the Analysis of Trace Organic Constituents in Water. R. P. Collins, September 1968 - June 1970.

A limiting factor in the study of the problem of off-flavors and odors in drinking water (at the time that this study was undertaken) was the lack of adequate analytical techniques. As a result of the precise instrumental techniques developed in this investigation, two of the major odor producing constituents of *Streptomyces odorifer* were identified. Further study is being pursued in current project on page 13.

Publications: Collins, R. P. and K. Kalnins. 1969. "Sterols Produced by *Synura petersenii* (Chrysophyta)," *Comparative Biochemistry and Physiology*, 30:779-782.

Collins, R. P., L. E. Knaak, and J. W. Soboslai. 1970. "Production of Geosmin and 2-Exo-Hydroxy-2-Methylbornane by *Streptomyces odorifer*," *Lloydia*, 33(1):199-200.

Effects of Simultaneous Variations of Temperature and Dissolved Oxygen on the Resistance of Fishes to Controlled Pollutants. W. R. Whitworth, May 1965 - June 1969.

The quality of natural waters and the vigor of fish life are inseparable factors. In this study it was shown that a pollutant such as dissolved lead, when tested on fish in combination with variations of temperature and dissolved oxygen, did *not* adversely affect fish growth. However, because the investigator suspected that other, more prevalent pollutants together with other environmental factors may affect fish life, the project described on page 17 was activated.

Publications: Dorfman, D. and W. R. Whitworth. 1969. "Effects of Fluctuations of Lead, Temperature and Dissolved Oxygen on the Growth of Brook Trout," *Journal of Fisheries Research Board of Canada*, 20(9):2493-2501.

Dorfman, D. 1969. "Effects of Lead on the Growth of Brook Trout, *Salvelinus fontinalis*." M.S. Thesis, The University of Connecticut, 29 pp.

Voyer, R. A. 1967. "Influence of Dissolved Oxygen and Temperature on the Toxicity of Lead to *Notropis bierenatus* (Cope)." M.S. Thesis, The University of Connecticut, 28 pp.

Similarities of Periphyton Communities on Natural and Artificial Substrates in Streams. E. W. Hansmann, May 1969 - June 1971.

Among the most useful parameters for evaluating water quality and pollutional stresses have been the biodynamics of the algae which inhabit bodies of water. However, there was evidence that samples of algae taken from artificial habitats such as glass and plastic in water were not an index of the true development of the organism as in a natural habitat. The results of this detailed, comparative study indicate that there are considerable differences between communities of the same species of algae on an artificial and those on a natural substrate.

Publication: Hansmann, E. W. 1969. Research Project Technical Completion Report A-026-CONN, Institute of Water Resources, The University of Connecticut, 5 pp.



W. R. Whitworth

Laboratory apparatus for studying the effect of lead on fishes.

Water Quality Control with Synthetic Polymeric Flocculants. J. K. Dixon and W. Zielyk. May 1967 - June 1970.

In the continuing search for efficient and economical ways to improve the quality of used or polluted water, flocculation has been used extensively by industry. The objectives of this study were to determine the effects of the synthetic polymers used as flocculants on silica, algae, and bacteria under a wide range of conditions. The information obtained has had a wide range of application in water quality control, especially that pertaining to bacteria and algae, since the organisms studied are characteristic of the finely divided solids found in the effluents from activated sludge sewage plants.

Publication: Dixon, J. K. and W. Zielyk. 1969. "Control of the Bacterial Content of Water with Synthetic Polymeric Flocculants," *Journal of Environmental Science and Technology*, 3:551-558.

Studies on Phosphorus Transformations in Eutrophic Lakes. R. C. Tilton. July 1967 - June 1969.

Eutrophication is highly evident in many of the natural and man-made lakes in Connecticut. Considerable research has been done on the nitrogen regime in such lakes, but until this study was undertaken, very little was understood about the phosphorus transformations. The results of the investigations have led to a greater understanding of the role of bacteria in the metabolism of detergent phosphate, suggesting that bacteria utilize phosphate compounds in detergents up to a chain length of four. Such data are useful in improving the quality of lake waters.

Publications: Tilton, R. C. 1969. "Microbial Degradation of Detergent Phosphates," *Proceedings, New England Regional Antipollution Conference*, 22-26.

Tilton, R. C. 1970. "Microbial Degradation of Detergent Phosphates," *Journal of Environmental Health*, 32(5):523-527.

WATER RESOURCES PLANNING AND ENGINEERING

The Role of Regional Planning in the Public Management of Water Resources: The Case of the Farmington River Basin. R. E. Kasperson, May 1965 - June 1966.

The Farmington River Basin is a significant and populous watershed area of central Connecticut. This study sought to answer the question of how well the existing organizational structure and planning processes serve the public interest in the development of water resources in that area. A duplication of functions by state agencies

within the watershed was found, with overlaps particularly evident between agencies charged with multiple use and single use responsibilities. Policy conflicts were particularly common between water supply and recreational agencies, although there was an impressive amount of interagency communication. Most agencies were involved extensively in the data gathering stage but only intermittently in the evaluation and recommendation stages. Public interest was centered on recreational use of water resources and on preservation of the rural landscape and life in the valley.

Publication: Kasperson, R. E. 1967. *Political Organization and the Planning of Water Resource Development in the Farmington Valley: A Preliminary Profile*. Institute of Water Resources Report No. 5, The University of Connecticut, 20 pp.

Integration of Connecticut Water Rights Laws and Pollution Control Laws. R. L. Leonard, R. I. Reis, and T. H. Focht. July 1966 - June 1969.

Although Connecticut was one of the earliest states to legislate against the pollution problem, only the most minimal regulatory schemes were used to deal with the problem. Until this study was made there was no detailed and exhaustive review of existing water law and no attempts to evaluate laws and institutions, either from

the economic or judicial points of view. The results of this study were valuable publications which have been extremely useful to those concerned with legal aspects, planning, or management of Connecticut's water resources.

Publications: Focht, T. H. 1969. *Connecticut's Administrative Control of Water Pollution: The Fluid Administrative Process*, Institute of Water Resources Report No. 8, The University of Connecticut, 44 pp.

Leonard, R. L. 1970. *An Economic Evaluation of Connecticut Water Law: Water Rights, Public Water Supply, and Pollution Control*. Institute of Water Resources Report No. 11, The University of Connecticut, 67 pp.

Leonard, R. L. 1970. "Who Owns the Water in the Stream," *Milestones*, College of Agriculture and Natural Resources, The University of Connecticut: Fall-Winter 1970-71:3-4.

Reis, R. I. 1967. *Connecticut Water Law: Judicial Allocation of Water Resources*. Institute of Water Resources Report No. 4, The University of Connecticut, 215 pp.

Reis, R. I. 1967. "Policy and Planning for Recreational Use of Inland Waters," *Temple Law Quarterly*, 40(2):155-193.



Dwight Thurston

Recent legislation will have beneficial effects on Connecticut's waterways, including this typical stream.

Reduction of River Heat Pollution by Turbulence Stimulation. V. E. Scottron. July 1965 - June 1969.

A serious problem which arises from using rivers as receivers of the heated water from electrical generating plants is that the heated effluent can cause damage to the biological cycle in the river. This occurs when the effluent does not diffuse rapidly, but stratifies horizontally, causing high temperature zones. The chief objective of this study was to determine if producing heavier turbulence in the normal river motion by an artificial roughness would reduce zones of concentration of the heated effluent. It was discovered that typical dune-type roughnesses produce heavy turbulence immediately adjacent to the roughness, but that the general stream turbulence levels are not greatly affected by the bottom surface.

Publications: Prasuhn, A. L. and V. E. Scottron. 1969. "Reduction in River Heat Pollution by Turbulence Stimulation," Civil Engineering Department Report No. 60-22, The University of Connecticut. Reprinted from *Proceedings* of the Annual Northeastern Regional Antipollution Conference, July 22-24, 1968, University of Rhode Island.

Khanna, S. D. 1968. "An Experimental Investigation of Turbulence Due to Forms of Bed Roughness." Ph.D. Dissertation, The University of Connecticut (Available from University Microfilms, Ann Arbor, Michigan.) 115 pp.

Krueger, A. G. 1967. "Design and Construction of a Low Turbulence Wind Tunnel." M.S. Thesis, The University of Connecticut, 35 pp.

An Experimental Study of Air and Water Interfacial Interaction. J. D. Lin. May 1968 - June 1971.

It is necessary to the understanding of the dispersion, mixing, and diffusion of surface pollutants in large open bodies of water to know the mechanics of wind-generated waves under a variety of atmospheric conditions. The results of this study furnished much data on the dominant wave and wave energy spectra. Direct comparisons of the boundary layer over a smooth solid surface and over waves, and of the wind-generated waves with and without pressure gradients were carried out in this investigation.

Publications: Lin, J. D. 1971. Research Project Technical Completion Report A-021-CONN, Institute of Water Resources, The University of Connecticut, 4 pp.

Liang, H. C. 1972. "An Experimental Study of Wind Generated Waves With and Without Pressure Gradients." Ph.D. Dissertation, The University of Connecticut, 119 pp.

Individual Waste Disposal Systems. W. C. Wheeler, J. J. Kolega, R. P. Prince, B. J. Cosenza, and W. J. Widmer. May 1965 - June 1970.

In Connecticut approximately 40 percent of the population depends on home septic tank systems for waste disposal. Studies such as this one are vitally important to the improvement and modernization of individual household septic systems. One of the results of this study was the development of a highly useful extended aeration system for waste treatment.

Publications: Kolega, J. J., W. C. Wheeler, and G. W. Hawkins. 1966. "Current Septic Tank System Installation Practices in Connecticut," *Journal of the Water Pollution Control Federation*, 38(10):1592-1600.

Pillai, N. N., T. R. Chandrasekhara, and S. Venkatatamana. 1970. "On the Concept of Mean Hydraulic Radius," *Journal of the Hydraulics Division*, Proceedings of the American Society of Civil Engineers, 96(HY4):1066-1068.

Pillai, N. N., W. C. Wheeler, and R. P. Prince. July 1971. "Design and Operation of an Extended Aeration Plant," *Journal of the Water Pollution Control Federation*, 43(7):1484-1498.

Huang, J. C. 1970. "The Effect of Sewage Concentration on the Biodegradability Index and the Size of the Treatment Plant. M.S. Thesis, The University of Connecticut, 57 pp.

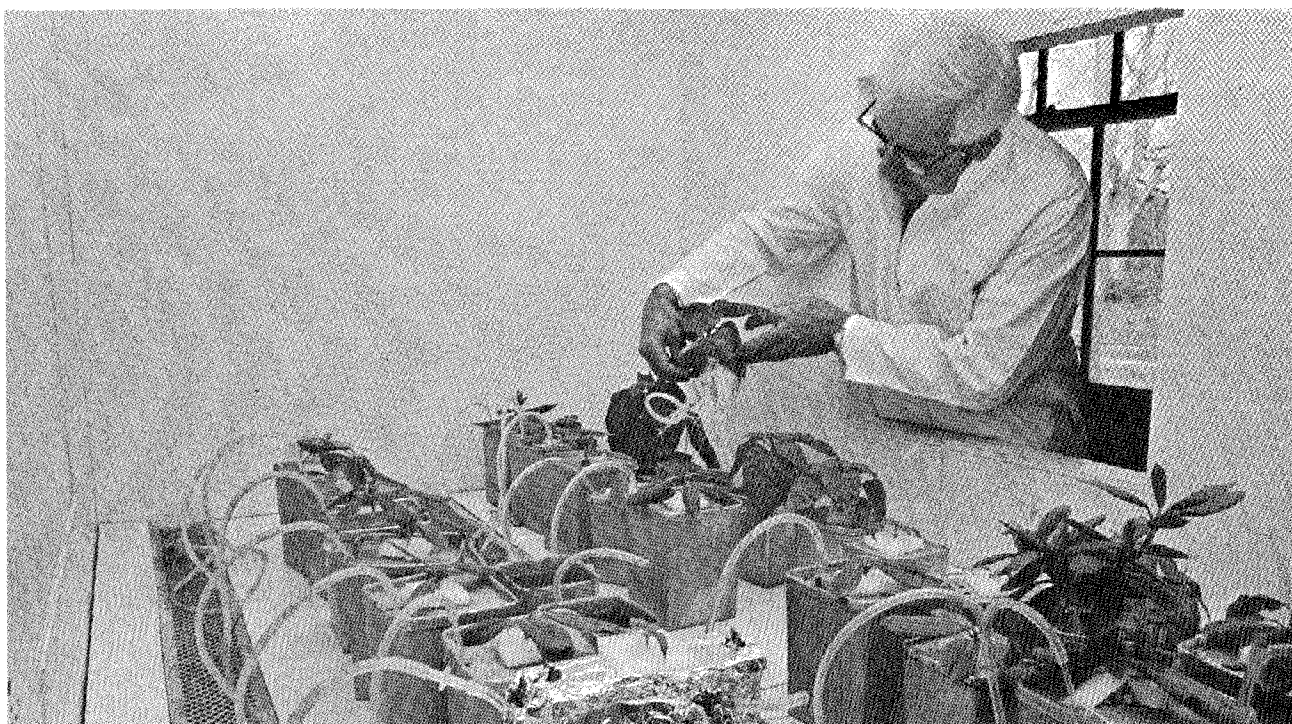
Shu, C. S. 1972. "Use of an Activated Sludge Process in Treating Chicken Manure Combined with Domestic Sewage." Ph.D. Dissertation, The University of Connecticut, 154 pp.

Reverse Filter Erosion Protection. C. J. Posey. May 1965 - June 1969.

In a state with plentiful rainfall and run-off, managing erosion and yet maintaining groundwater recharge is a serious problem. This project proved the great value of a reverse filter base with rock sausages as lining for drainage channels. Such channels are permeable for groundwater recharge but prevent erosion effectively and are less expensive to install and maintain than the usual impermeable asphalt or concrete types.

Publications: Posey, C. J. 1969. "Erosion Prevention Experiments," *Proceedings*, Thirteenth Congress of the International Association for Hydraulic Research, 2:211.

Posey, C. J. 1969. "Erosion Protection," Film, 30 min. silent, color, \$1.00 handling; available from Audio-Visual Center, The University of Connecticut.



Dwight Thurston

Dr. B. E. Janes observes pepper plants in growth chamber where environmental conditions are controlled.

WATER CHARACTERISTICS AND WATER CYCLE

Diffusion Through Multiperforate Septa. R. Lee. May 1965 - June 1966.

In the management of forest waters, it is important to understand the process of transpiration by plant canopies. In this research, evaporation under controlled laboratory conditions was compared with water loss through leaf stomata, and theoretical hydrological relationships were described. It was concluded that characteristic diffusion coefficients for leaf types, based on a careful study of leaf micro-structure, physiology, and seasonal variation, are a rational basis for cover-type conversions or biochemical controls to reduce water loss.

Publication: Lee, R. 1967. "The Hydrologic Importance of Transpiration Control by Stomata," *Water Resources Research*, 3(3):737-752.

Changes in Resistance to Flow of Water through a Soil-Plant System. B. E. Janes and G. W. Gee. July 1969 - June 1970.

The purpose of this study was to obtain information on the physical nature of barriers to water movement in plants growing in soil. Water potential gradients were

measured in soil-grown pepper plants. The root zone water potential agreed well with water potential measurements in the plant stem and plant leaves. It was found that the water potential in root-free soil adjacent to the root zone was higher than that in the root zone and that the observed gradient increased with decreasing root-zone water potential. This increased gradient was attributed to decreased soil water conductivity in the root-free soil and to increased flow resistance across a millipore membrane separating the root-free soil and the root zone. Such data are of assistance in determining economies in the use of scarce water supplies.

Publications: Janes, B. E. 1970. Research Project Technical Completion Report A-027-CONN, Institute of Water Resources, The University of Connecticut, 6 pp.

Oxygen Status of Soil-Air and Soil-Water as Influenced by Oxygen Transfer through the Soil Profile. R. W. Wengel. July 1967 - June 1971.

The biological degradation (or biodegradability) of wastewater is a matter of great importance in the control of water pollutants, especially that in groundwater, one of the links in the water cycle. Oxygen in soil-air and soil-water has much to do with the efficiency of biodegradation. In this investigation, made in actual soil samples, it was determined that oxygen consumption at

different soil levels could be calculated from measurements of diffusivity, soil moisture, bulk density, temperature, and oxygen concentration, thus making it possible to predict and classify a given soil as to its oxygen supplying potential.

Publications: Wengel, R. W. 1971. Research Project Technical Completion Report A-018-CONN, The University of Connecticut, 5 pp.

Linville, D. E. 1969. "Soil Oxygen Diffusivity." M.S. Thesis, The University of Connecticut, 44 pp.

Relation of Bedrock Fracture Systems to Underground Water Supplies in the Stafford Springs, South Coventry, Spring Hill, and Westford Quadrangles. J. M. Aitken. May 1965 - June 1969.

Bedrock fractures are important water carriers; they are the source of uncounted individual water supply systems in Connecticut. The detailed work in this study indicates that dominant joint intersections and joint-foliation intersections in bedrock play an important part in the movement of fluids through bedrock. This is invaluable information for well-site prediction and tracing of pollutants.

Publication: Aitken, J. M. 1969. Research Project Technical Completion Report A-004-CONN, Institute of Water Resources, The University of Connecticut, 4 pp., 3 maps.

Correlation of Trace Elements in Groundwater and Aquifers Within the Connecticut River Basin. H. C. Liese. May 1965 - June 1967.

The immediate objective of this study was to determine the concentrations of such trace elements as silver, barium, beryllium, copper, gallium, manganese, lead, tin, and zirconium in bedrock samples and groundwater samples from various parts of the Connecticut River Basin. Such information is useful in following the movements of pollutants through groundwater and for establishing correlation between groundwaters and aquifers. This type of information is sometimes used to establish correlation between the "good" or "poor" health records of communities with unusual variations of any of these trace elements in the drinking water supplies.

Publication: Liese, H. C. 1968. "Mineral Compositions of Selected Granites and Gneisses of New England," *Geological Society of America Bulletin*, 79:1859-1866.

Rate and Direction of Ground Water Circulation in Close-Spaced Bedrock, and Gravel Wells Under Non-

synchronous Pumping Time and Rates. L. Frankel and H. F. Thomas. May 1965 - June 1969.

In Connecticut's rural areas, housing developments proliferate and it becomes necessary to know what effect pumping in closely spaced wells has on the groundwater flow, especially in regard to contamination. From this project considerable data was obtained on the movement of groundwater in different sedimentary materials under seasonal differences in the water table and under different pumping conditions.

Publications: Frankel, L. and H. F. Thomas. 1969. Research Project Technical Completion Report A-005-CONN, The University of Connecticut, 3 pp.

Fischer, J. A. 1972. "A Hydrological Investigation of the Lee Farm Area of South Coventry, Connecticut." M.S. Thesis, The University of Connecticut, 60 pp.

Analysis of Quasi-periodic Weather Data. C. J. Posey. May 1965 - June 1967.

This investigation was undertaken to establish, from long-time records of daily maximum temperatures at three different locations, a means of identification of quasi-periodic records. The statistical measures determined could be likened to "fingerprints" by which a temperature time series might be identified. The computer program developed from this study has been a useful tool in other water investigations.

Publication: Posey, C. J. 1967. *Analysis of Quasi-Periodic Weather Data*, Institute of Water Resources Report No. 3, The University of Connecticut, 20 pp.

Ion-ion and Ion-molecule Interactions in Aqueous Salt Solutions. W. L. Masterton. July 1966 - June 1970.

Water pollution by pesticides is a matter of serious concern in Connecticut, for practically everyone uses pesticides in greater or lesser amounts. Until this study was undertaken there was very little information on the basic nature of the solubility of certain pesticides in water. The results of this detailed examination of the thermodynamic properties and structure of complex ion electrolytes indicate that pesticides form a very strong ion-molecule interaction in water and complicate extensively the problem of removing pesticide pollution.

Publications: Masterton, W. L., T. I. Munnely, and L. H. Berka. 1967. "Osmotic and Activity Coefficients of *cis*- and *trans*-Nitrobis (ethylenediamine) aminocobalt (III) Salts," *Journal of Physical Chemistry*, 71:942.

Masterton, W. L. 1967. "Osmotic and Activity Coefficients of *trans*-Chloroisothiocyanatobis (ethylenediamine) cobalt(III) Salts," *Journal of Physical Chemistry*, 71:2885 - 2889.

Masterton, W. L. and H. K. Seiler. 1968. "Apparent and Partial Molal Volumes of Water in Organic Solvents," *Journal of Physical Chemistry*, 72:4257.

Masterton, W. L., T. P. Lee, and R. L. Boyington. 1969. "The Solubility of Aromatic Hydrocarbons in Aqueous Solutions of Complex Ion Electrolytes," *Journal of Physical Chemistry*, 73:2761.

Masterton, W. L. and T. Bierly. 1970. "Ion Pairing in 2:2 Complex Ion Electrolytes," *Journal of Physical Chemistry*, 74:139.

Masterton, W. L. and T. P. Lee. 1970. "Salting Coefficients from Scaled Particle Theory," *Journal of Physical Chemistry*, 74:1776.

Welles, H. L., Jr. 1969. "The Apparent Molal Volume of *Trans*-chloro isothiocyanato bis (ethylenediamine)cobalt(III) Halides." M.S. Thesis, The University of Connecticut, 34 pp.

Lee, T. P. 1971. "Studies of the Salt Effect on Nonelectrolytes." Ph.D. Dissertation, The University of Connecticut, 97 pp.

Structural Aspects of Amide-water Systems. R. E. Lindstrom. July 1969 - June 1971.

This study was undertaken to shed more light on the complex interactions of biochemical water solutions, especially those solutions which contain amides (by-products of organisms) as a water contaminant. Such information is necessary if the causes and control of eutrophication are to be understood.

Publications: Lindstrom, R. E. and A. R. Giaquinto. 1970. "Salt Effects in Aqueous Solutions of Urea," *Journal of Pharmaceutical Sciences*, 59:1625.

Welles, H., A. R. Giaquinto, and R. E. Lindstrom. 1971. "Degradation of Urea in Concentrated Aqueous Solutions," *Journal of Pharmaceutical Sciences*, 60:1212.

SUMMARY

The 50 projects comprise the institute's research effort since its inception in 1964. In addition to the traditional water research disciplines of agriculture, biology, engineering, and geology, studies have been carried out in the legal, sociologic, economic, and political aspects of water resources use and management. Some of the investigations have been multidisciplinary or interdisciplinary, providing a mechanism for more effective and innovative research.

Publications document the accomplishments of completed research; statements of preliminary results and of future plans describe current research activities.

PUBLICATIONS OF THE INSTITUTE OF WATER RESOURCES

- Report No. 1 *Water Resources Research at The University of Connecticut*, Proceedings of the Second Annual Water Resources Conference, May 1966, 20 pp.
- Report No. 2 *Lectures on Law in Relation to Water Resources Use and Development*, ed. W. C. Kennard, March 1967, 27 pp.
- Report No. 3 *Analysis of Quasi-Periodic Weather Data*, Chesley J. Posey, June 1967, 20 pp.
- Report No. 4 *Connecticut Water Law: Judicial Allocation of Water Resources*, Robert I. Reis, 1967, 215 pp. \$3.00 plus tax.
- Report No. 5 *Political Organization and the Planning of Water Resource Development in the Farmington Valley: A Preliminary Profile*, R. E. Kasperson, October 1967, 20 pp.
- Report No. 6 *The Quality of Connecticut's Surface Waters*, Chester E. Thomas, Jr., July 1968, 11 pp.
- Report No. 7 *Lectures on Water Conservation*, ed. W. C. Kennard, October 1968, 36 pp.
- Report No. 8 *Connecticut's Administrative Control of Water Pollution—The Fluid Administrative Process*, Theodore H. Focht, April 1969, 44 pp.
- Report No. 9 *A Limnological Study of the Lower Farmington River With Special Reference to the Ability of the River to Support American Shad*, W. R. Whitworth and D. H. Bennett, February 1970, 57 pp.
- Report No. 10 *A Bibliography of Publications Relating to Water Resources in Connecticut, 1900-1970*, W. C. Kennard and J. S. Fisher, May 1970, 125 pp.
- Report No. 11 *An Economic Evaluation of Connecticut Water Law: Water Rights, Public Water Supply, and Pollution Control*, R. L. Leonard, July 1970, 67 pp.
- Report No. 12 *Water Resources Research Activities and Interests at The University of Connecticut*, W. C. Kennard and J. S. Fisher, September 1970, 55 pp.
- Report No. 13 *Proceedings of the Conference—Water Resources Research 1970*, ed. W. C. Kennard, September 1970, 20 pp.
- Report No. 14 *Inventory of Course Offerings in Water Resources—The University of Connecticut 1971-1972*, W. C. Kennard and J. S. Fisher, May 1971, 33 pp.
- Report No. 15 *Environmental Activism: Thermal Pollution—AEC and State Jurisdictional Considerations*, R. I. Reis, June 1972, 51 pp. (Reprinted from Boston College Industrial and Commercial Law Review, 1972, (13[4]:633-684).
- Brochure *Description of the Activities of the Institute of Water Resources, 1972.*

Brochure and Reports Nos. 4 and 7 through 14 are available upon request. There is a charge as noted for Report No. 4.

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