

SEVENTH ANNUAL REPORT

WATER RESOURCES RESEARCH CENTER

A Report of Activities Supported
By the Graduate School and the
Office of Water Resources Research
U.S. Department of the Interior
During the Fiscal Year Ending
June 30, 1971

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WATER RESOURCES RESEARCH CENTER
UNIVERSITY OF MINNESOTA
GRADUATE SCHOOL

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PREFACE

This is the seventh in a series of annual reports covering the activities of the Water Resources Research Center, University of Minnesota. The report indicates the nature of the program conducted in the twelve months beginning July 1, 1970, and ending June 30, 1971, with funds provided by the Graduate School and the Office of Water Resources Research in connection with the Water Resources Research Act of 1964. It also gives some insight into the potential of the Center for both research and training with Federal and non-Federal support. It is hoped that the academic community will continue to expand its service to the State and Nation by conducting competent research in relation to water resources and by assisting in training additional scientists for work in the field of water resources through research.

William C. Walton

Director

Water Resources Research Center

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UNIVERSITY OF MINNESOTA
GRADUATE SCHOOL

Report of Activities Supported by the
Graduate School and the Office of
Water Resources Research, U.S. Department of
the Interior During the Fiscal Year Ending
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DIRECTOR'S SECTION

Review of Center's Programs,
FY 1965 Through 1971

The Water Resources Research Center (WRRC) was established in the Graduate School, University of Minnesota on September 1, 1964. The Center has responsibility for stimulating University of Minnesota and State and private College water resources research through administration of funds associated with the Federal Water Resources Research Act of 1964; coordinating the research with programs of local, State and Federal agencies and private organizations throughout the State; and assisting in training additional scientists for work in the field of water resources through research. The following State and private Colleges are participating in the Center's programs: St. Mary's College, St. Cloud State College, Gustavus Adolphus College, Bemidji State College and Winona State College.

The Center does not conduct research nor does it have research facilities. It plans and arranges for Divisions of the University of Minnesota and State and private Colleges to conduct competent research of either a basic or practical nature in relation to the physical-biological-economic-social-political aspects of water resources. The Center strengthens research activities of Departments and Schools and assists in expanding interdisciplinary research and in molding multidisciplinary research into balanced overall water resources research programs.

One of the purposes of the Center is the stimulation and review of education offerings for students which will prepare them for careers in the field of water resources. The Center assists in recruiting students and in guiding them into appropriate programs of study. The Center has been helpful to the University of Minnesota in developing 48 new courses bearing on water resources, a new graduate option in hydrogeology, and a program of graduate education in water resources.

The Center has an Advisory Committee and a Consulting Council. The Advisory Committee consists of 15 faculty members from 15 Schools, Departments and Divisions of the University of Minnesota; the Consulting Council is composed of 19 representatives from organizations outside the University. The Center maintains close liaison with the various Schools, Departments and Divisions of the University of Minnesota, State and private research firms and Consultants and voluntary organizations through its Advisory Committee and Consulting Council, through its membership on the Water Resources Coordinating Committee, State Planning Agency and through its membership on the Intercollegiate Committee on Environmental Studies at the University of Minnesota. The present roster of the Center is given in table 1.

Table 1. - Roster of Center (1970-1971)

William C. Walton, Director
 John J. Waelti, Assistant Director
 Delrae Gunderson, Secretary

ADVISORY COMMITTEE

<u>Professor</u>	<u>Department, School, or Division</u>
A.G. Anderson	St. Anthony Falls Hydraulic Laboratory
W.J. Barrett	Department of Geography
R.G. Bond	School of Public Health
A.J. Brook	Department of Ecology and Behavioral Biology
B. Crawford, Jr.	Graduate School
W.J. Hueg, Jr.	Agricultural Experiment Station
P.W. Manson	Department of Agricultural Engineering
J.J. Waelti	Department of Agricultural Economics
W.P. Martin	Department of Soil Science
O.C. Peterson	Department of Public Administration
G.J. Schroepfer	Department of Civil Engineering and Hydraulics
P.K. Sims	School of Earth Sciences
A.C. Mace	School of Forestry
T.F. Waters	Department of Entomology, Fisheries and Wildlife
H.E. Wright	Limnological Research Center, School of Earth Sciences

CONSULTING COUNCIL

<u>Representative</u>	<u>Organization</u>
D.B. Anderson	U.S. Geological Survey, Water Resources Division
D.W. Barr	Consulting Hydraulic Engineer
A.D. Belmont	Research Division, Control Data Corporation
C.R. Collier	U.S. Geological Survey, Water Resources Division
J.Dobie	Minnesota Department of Natural Resources, Division of Game and Fish
H.M. Major	U.S. Department of Agriculture, Soil Conservation Service
G. Gere	Minnesota Department of Natural Resources, Division of Waters, Soils and Minerals
R. Haik	Attorney, Minneapolis
C.L. McGinnis	U.S. Army Corps of Engineers
E.A. Hickock	Consulting Hydrologist
S.E. Jorgensen	U.S. Bureau of Sport Fisheries and Wildlife
D. Krenik	Minnesota Association of Soil and Water Conservation Districts
D.S. Bryson	Environmental Protection Agency
L. Smith	Minnesota Pollution Control Agency
J.H. Strub	U.S. Department of Commerce
F.W. Thorstensen	Minnesota State Department of Highways
C.A. VanDoren	U.S. Department of Agriculture, Agricultural Research Service
E. Weiberg	Minnesota Water Resources Board
R.W. Merz	U.S. Department of Agriculture, Forest Service

The Center's research budget increased from \$52,297 in Fiscal Year 1965 to \$325,261 in Fiscal Year 1971 as shown below:

<u>Fiscal Year</u>	<u>Center's Research Budget</u>	<u>Non-Federal Contributions</u>	
		<u>Annual Allotment Program</u>	<u>Matching Grant Program</u>
1965	\$ 52,297	\$ 0	\$ 0
1966	153,952	28,907	46,971
1967	174,938	28,068	61,606
1968	182,723	34,010	49,179
1969	228,799	34,507	63,163
1970	295,270	39,221	114,358
1971	325,261	40,464	115,085

These funds have been obtained from the Office of Water Resources Research (OWRR), U.S. Department of the Interior, from the State through the University of Minnesota and from State and private Colleges. As indicated above, non-Federal contributions to the Center's budgets have been substantial. In the past, the Center has not sought funds from granting agencies other than the Office of Water Resources Research to avoid competition with other Divisions of the University of Minnesota. Hopefully, in the future, State agencies will find it possible to provide funds so that the Center can be more responsive to State water resources research needs.

Research conducted through the Center is relevant to water resources problems in Minnesota and the Nation. The main thrust of the Center's programs has been directed toward:

Establishing a practical baseline of water quality for Lake Superior through the use of the continuous plankton recorder technique; the analysis and interpretation of existing Federal, State, and local water resources legislation and court decisions and ways and means for improving water laws in Minnesota; ascertaining the physiological and ecological requirements of the algal species responsible for severe blooms on lakes scattered throughout the State to assist in controlling the excessive productivity of polluted lakes; determining methods for rain fall-runoff predictions which are based on the physical characteristics of ungaged small watersheds and rainfall characteristics of ungaged small watersheds; reconciling and integrating water quality management with the ecological and social-economic objectives of the total water resources management in Minnesota; determining the role of potholes in the groundwater recharge; formulation of an economic optimizing model for water quality and sewage disposal on selected stretches of the Upper Mississippi River; investigation of programs that appear to have special merit relative to hydrologic analysis for determination of design floods and for design of spillways and related structures; investigation of soil dynamic changes when interacting with water to assist in solving water problems such as infiltration, water spreading and flow properties in soils; determination of runoff-time distribution for a variety of watershed sizes and slopes; determining the role of bottom sediments in the phosphorus cycle for lakes of different types to assist in devising corrective measures for overfertilized lakes; development of techniques that will pinpoint polluted areas in reaches of the Upper Mississippi River where algacides might be profitably administered to control pollution; investigation of mist irrigation as a method of reducing water stress in potato crop production and thereby reducing

transpiration; and investigation of the mechanics of soil moisture movement and retention to assist water resources developers and managers in estimating recharge to groundwater reservoirs and the effect of soil moisture movement on surface water runoff; inventorying, appraising, and evaluating water resources administration in Minnesota to provide background information for legislative action concerning reorganization of State water resources agencies; biomass determination and productivity measurements in the west end of Lake Superior to assess the extent of eutrophication; investigation of the ecology of the periphyton in the wavewashed and near-shore areas of the west end of Lake Superior for detection of advancing eutrophication in the lake; study of citizens groups involved at the grass roots to improve the water resources environment in the Minneapolis-St. Paul, Miami and environs, and two other metropolitan areas and environs in the USA; and determining existing ecological conditions in the Mississippi River near Monticello, Minnesota before operation of a large nuclear power plant and monitoring environmental changes due to the thermal discharge from the power plant generator.

During the period Fiscal Year 1965 to 1971, the Center submitted to OWRR 21 Annual Allotment, 55 Matching Grant and 19 Title II research project proposals. About 31 percent of the Matching Grant proposals were funded by OWRR and 100 percent of the Annual Allotment proposals were funded. No Title II proposals were funded by OWRR. Annual Allotment and Matching Grant support was provided for research projects in the following FCST Categories: V. Water Quality Management and Protection, II. Water Cycle, IV. Water Quantity Management and Control, and VI. Water Resources Planning. The volume of support to FCST Categories was greatest in FCST Category V and least in FCST Category VI in the order given above. Research project proposal Center review is accomplished by the Center Director with the assistance of its Advisory Committee and Consulting Council.

The Center continuously compiles information on needed and neglected water resources research areas with the assistance of its Advisory Committee and Consulting Council. The selection of research projects to be sponsored gives due regard to changing research needs of the State and is approached on an interdisciplinary basis. During the winter months of 1966, about 350 people having an interest in water resources research in Minnesota were solicited by the Center for information concerning needed areas of water resources research. Expansions in research programs are required to solve existing and anticipated problems pertaining to: environmental quality improvement, including pollution control and prevention; provision of additional water-oriented recreation facilities and protection of natural resources; provision of adequate municipal water supplies; flood damage reduction; and soil and water management.

In 1969, a Task Force of the Center's Consulting Council conducted a survey to obtain information concerning efforts and expenditures for water resources research conducted in Minnesota 1963 through 1968. According to the survey, total research effort in terms of number of ongoing projects and man-years of effort reached a peak in 1967; financial support for water resources research has declined since then. The number of ongoing projects rose from 53 in 1963 to 96 in 1967 and was 73 in 1968. Total expenditures increased from \$629,000 in 1963 to \$1.8 million in 1967 and were \$1.5 million in 1968. Man-years of effort rose from 43 in 1963 to 98 in 1967 and was 81 in 1968.

The work of University and college student research assistants and research associates accounted for about 40 percent of the total man-years of effort in 1968. The work of professional and sub-professional employees of Federal, State, local and private organizations accounted for about 60 percent of the total man-years of effort. The average expenditure per project rose from about \$13,000 in 1963 to about \$21,000 in 1968.

In general, research effort by all measures has been consistently high in the following 4 research FCST categories: Water Cycle, Water Quantity Management and Control, Water Quality Management and Protection, and Engineering Works.

During the period 1963-68, the University of Minnesota was the organization conducting the greatest amount of research with Federal Agencies; State and private Colleges and private enterprises (others); and State Agencies following in that order. In 1968, expenditures by the University of Minnesota, Federal Agencies, State Agencies and others were \$637,000; \$506,000; \$46,000; and \$304,000, respectively. While the University of Minnesota conducts the largest amount of research, much of this research is funded by Federal Agencies and the State. For example, in 1968, funding of research projects conducted at the University of Minnesota was about as follows: Federal - \$525,000 and State - \$95,000.

The Department of Agriculture and the Department of the Interior are the Federal Agencies carrying on the bulk of water resources research programs in Minnesota, followed by the U.S. Army Corps of Engineers in the Department of Defense. The Agricultural Research Service and Forest Service account for the major share of research in the Department of Agriculture. The Geological Survey and Federal Water Pollution Control Agency account for the major portion of research by the Department of the Interior.

Within the University of Minnesota, water resources research has been carried on in 16 different divisions representing the biological, physical and social sciences. The St. Anthony Falls Hydraulic Laboratory has led in research effort followed by the Department of Agricultural Engineering, and the Department of Entomology, Fisheries and Wildlife. A significant increase in Research Effort over the period 1963 to 1968 has occurred in the Limnological Research Center.

The Center is funding about 43 percent of ongoing research in water resources at the University of Minnesota and about 23 percent of ongoing research in water resources in the State. Funds have been allocated by the Center to the following Divisions of the University of Minnesota: Department of Botany, Limnological Research Center, Department of Agricultural Engineering, School of Forestry, Department of Soil Science, School of Public Health, Minnesota Geological Survey, St. Anthony Falls Hydraulic Laboratory, Department of Agricultural Economics, Department of Horticultural Sciences, Department of Anthropology, Department of Sociology, and Department of Pharmacognosy. About 21 percent of the Center's funds in Fiscal Year 1971 were allocated to State and private Colleges.

About 65 percent of the Center's research expenditures are for salaries and wages; 8 percent are for non-expendable property and expendable materials and supplies; and 27 percent are for other costs including in-

direct costs and fringe benefits. About \$79,000 has been encumbered for non-expendable property assigned to Divisions of the University of Minnesota and State and private Colleges. Expenditures for salaries and wages have been equally divided between the categories of Principal Investigators and Director; Research Associates and Fellows; Graduate Students and Undergraduate Students, Technical Assistants, and Clerical Assistants.

For several years the Center has known that the need for research concerned with the social-economic-political aspects of water resources is great. However, in Fiscal Year 1967, not a single research project proposal concerned with these aspects was submitted to the Center. In contrast, the Center's Fiscal Year 1971 program includes 6 social-economic-political projects whose support constitutes about 36 percent of the Center's budget. This trend of increased emphasis of the Center's research program on social-economic-political aspects of water resources is expected to continue. Most of the research the Center has supported or will support in the future can be broadly classified as environmental research.

In Fiscal Year 1971, about 47 students receive part-time employment or other financial support through Center's programs. Fifty-three students have received financial support from the Center and have received advanced degrees. Of these, 39 went into water-related work; eighteen were employed by Federal agencies, 6 were employed by State or local governments, 8 were employed by Universities and 7 were employed by private enterprise. There are about 100 students at the University of Minnesota majoring in water resources related fields; about 42 water resources oriented students graduated in 1970-71. A large proportion of these students used Center equipment and received financial support from the Center. A total of 52 regular faculty members of the University of Minnesota are currently engaged in teaching, research and/or advising in water resources. The Graduate School Bulletin contains 98 courses of potential interest to graduate students oriented towards water resources. Two examples of former student research assistants who are now contributing importantly to the water resources field are: Dr. Wayland R. Swain, student research assistant for OWRR Project No.: A-011-Minn., is now Director, Division of Research and Education, University of Minnesota, Duluth; and Dr. U.P. Gibson, student research assistant for OWRR Project No.: A-018-Minn., is now an executive of a newly created Water Resources Development Agency in the country of Guiana.

The Center has published and distributed to 550 people throughout the State 24 quarterly Newsletters and 123 Information Circulars in an effort to disseminate information concerning water resources. Research projects supported by OWRR have generated 79 technical reports and theses. Upon request, the Center has distributed about 135 copies of its publications per month to people throughout the State and Nation. The Center has widely distributed 25,000 copies of 37 Bulletins describing the results of research projects. A Subcommittee of the Center's Advisory Committee in 1965 prepared a brochure on graduate education in water resources at the University of Minnesota. The brochure has been helpful in recruiting students to the University.

To provide an opportunity for professional people and students working in the field of water resources to meet and to exchange information,

the Center has sponsored 19 interdisciplinary Seminars since 1964. Attendance at the Seminars has averaged 50 people. The Center sponsored a 2 1/2-day Short Course on Ground Water Resource Evaluation in 1965. The course was attended by 50 people from Minnesota, Manitoba, North Dakota, Missouri and Iowa.

At Governor Rolvaag's request, the Center Director served on a 19-member Minnesota Water Resources Review Committee in 1966. The Center Director also attended the Special Midwestern Governor's Conference on Water Resources and Pollution at Lexington, Kentucky in 1966.

At Governor LeVander's request, the Center Director from 1967 to 1969 served part time as Water Resources Planning Director, Minnesota State Planning Agency, Minnesota's representative on the Souris-Red-Rainy Rivers Basin Commission, Great Lakes Basin Commission and Upper Mississippi River Coordinating Committee and Minnesota's alternate representative on the Missouri Basin Inter-Agency Committee. The Center Director also served as Vice Chairman of the Souris-Red-Rainy Rivers Basin Commission. With the assistance of the Center the Minnesota State Planning Agency has made considerable progress in preparing a statewide framework water and related land resources plan and in participating in Federal-State planning activities. Three documents have been completed with the assistance of the Center Director: "Background Information for Framework Statewide Water and Related Land Resources Planning in Minnesota," "Minnesota Water and Related Land Resources - First Assessment" and "Alternate Programs and Projects for Managing Minnesota's Water and Related Land Resources Through the Year 2020."

Through the Center Director, several faculty members of the University of Minnesota have been retained by the Minnesota State Planning Agency as consultants to prepare material for statewide and Federal-State water and related land resources planning. Members of the Center's Advisory Committee and Consulting Council have participated in planning activities by

supplying information and by reviewing and commenting on planning documents. Faculty members active in the Center's affairs have been exposed to a large amount of water resources information. Interest in water and related land resources planning in Minnesota has greatly increased. The need for additional research in the planning field has been brought to the attention of potential Principal Investigators. The relationship between faculty members and the State and Federal Agency employees has improved. Because water and related land resources planning involves many disciplines, the need for interdisciplinary research is now more fully appreciated by faculty members. Serving as Governor LeVander's representative on Federal-State planning organizations has made it possible for the Center Director with the council of faculty members to influence State water resource policies and to assist the State in strengthening its position in the water resources field.

The programs of the Center have been coordinated with the programs associated with Title III of the Water Resources Planning Act of 1965 through the Center's membership on the Water Resources Coordinating Committee, Minnesota State Planning Agency. The Committee assists the State Planning Agency in administering Title III funds and programs and it is composed of all State agencies with responsibilities in the water resources field.

The Center's activities have been made known to State Legislators through the Center Director's testimony before Senate and House Committees during each of the Legislative Sessions since 1964. The Center director served during 1970 as an Advisor to the Land and Water Resources Committee of the Minnesota House of Representatives. The Committee prepared a report recommending that the Legislature adopt an Act containing a comprehensive water and related land resources policy and implement the Act by reorganizing State water agencies. The contents of Center Bulletin 27 "Water and Related Land Resources State Administration, Legislative Process and Policies in Minnesota, 1970" related to OWRR Project No.: A-021-Minn. were helpful to the Committee and were used by Legislators in drafting bills to be introduced during the 1971 Session of the Legislature.

At the requests of University of Minnesota Presidents, the Center Director has served as a Technical Advisor on the Minnesota-Wisconsin Boundary Area Commission. The Center Director has served on the following organizations: Technical Division, National Water Well Association; Ground-Water Hydrology Committee, Hydrology Committee, Hydraulics Division, American Society of Civil Engineers; Groundwater Committee, Hydrology Section, American Geophysical Union; U.S. National Committee for the International Hydrological Decade, National Academy Sciences; Education and Research Committee, Universities Council on Water Resources; Committee on the Great Lakes, Committee on Institutional Cooperation; Water Resources Committee, League of Minnesota Municipalities; Advisory Committee on Water Data for Public Use, U.S. Geological Survey; Environmental Pollution Committee, League of Minnesota Municipalities; and Meinzer Award Subcommittee, Hydrogeology Division, Geological Society of America.

OWRR's Annual Allotment program has provided seed money which has multiplied research efforts at the University. For example, modest support for A-008-Minn. starting in FY 1967 has resulted in getting research concerned with the productivity of Minnesota lakes underway with such promising results that the Limnological Research Center at the University of Minnesota has been able to mount a continuously increasing research effort. Funds provided for non-expendable equipment items especially a mobile laboratory have been particularly helpful in this respect. Estimated research funds made available to the Limnological Research Center increased from \$9,500 in 1963 to \$64,550 in 1968. Partly because of annual allotment funding, the Limnological Research Center has been able to obtain funds from the Minnesota Resources Commission (about \$25,000 per year), National Science Foundation, and Federal Water Quality Administration.

Inflation has substantially reduced the Center's OWRR Annual Allotment research program and there is at present a lack of clear-cut authorization and funding for the additional activities necessary to effectively move the research results into the hands of the ultimate user. While substantial progress has been made in assuring the research results are made available to prospective users in forms that are comprehensible to the variety of disciplines and levels of skill involved in water resources, the Center's capability to transfer research results into practice needs to be strengthened. The present annual allotment is far too small for research alone, irrespective of related needs to facilitate the utilization of new research

information. The Center could use an additional \$150,000 in its OWRR Annual Allotment program as follows: \$60,000 for additional activities to more effectively move research results into the hands of the ultimate user, \$60,000 for more research participation from State and private colleges, and \$30,000 for expansion of research at the University of Minnesota. The primary pay-off from the additional funding would be adequate scientific information dissemination and increased participation in research activities by State and private colleges.

Director's Summary Statement, 1971

On a gross basis, the capabilities of Minnesota's water and related land resources exceed demands and needs associated with projected economic and population growths for at least the next 50 years. Past development and management practices in the State, as substantial as they are, have not kept pace with the steadily growing demands placed upon resources. Continuing pressures and demands can be expected to create an ever increasing need for acceleration in resource development. Expansion in resource programs are required to solve existing and anticipated problems pertaining to: environmental quality improvement, including pollution control and prevention; provision of additional water-oriented recreation facilities and protection of natural resources; provision of adequate municipal water supplies; flood damage reduction; and soil and water management.

The Center's program in FY 1971 was directed toward: formulation of an optimizing model for water quality improvement on selected stretches of the Upper Mississippi River (A-019-Minn.); determination of design floods for spillway and related structure analyses (A-020-Minn.); providing information for legislative action on reorganization of State water resources agencies (A-021-Minn.); assessment of the extent of eutrophication of the west end of Lake Superior (A-022-Minn.); predicting peak flow of small watersheds by use of channel characteristics (A-023-Minn.); mathematical simulation of a large watershed using the systems approach to quantity and quality analysis (A-024-Minn.); alleviation of lake pollution by utilization of aquatic plants for nutritional, medicinal or industrial purposes (A-025-Minn.); development of a mathematical model to predict the role of surface waters (B-012-Minn.); investigation of methods for reducing transpiration from crops (B-013-Minn.); study of the mechanics of soil moisture movement and retention (B-015-Minn.); investigation of the ecology of periphyton in nearshore areas of the west end of Lake Superior (B-020-Minn.); study of citizen's groups involved in improving the water resource environment in metropolitan areas (B-031-Minn.); determination of ecological conditions in the Mississippi River near Monticello, Minnesota before and after operation of a nuclear power plant (B-032-Minn.); spatial variation in the perception of water resources and water problems in South Central Minnesota (B-42-Minn.); area financing of water resource development (B-044-Minn.); social and economic factors in the adoption by industry of water pollution control measures (B-047-Minn.); and survey of attitudes towards the Mississippi river as a total resource in Minnesota (B-049-Minn.).

The Center's program during the next five years will involve completion of above mentioned projects and it will likely stress environmental considerations in water resources planning and management, restoration of lakes, groundwater basin management, water resource policies, thermal loading problems and urban and metropolitan water resources problems.

Results from projects A-009-Minn. on groundwater contribution to streamflow, A-001-Minn. on effect of pothole drainage upon groundwater resources, and B-002-Minn. on effect of natural sealing of potholes have assisted State and Federal agencies in evaluating groundwater recharge on a statewide basis. Information from projects A-007-Minn. on the use of

planktonic desmids as indicators of pollution of lakes, A-008-Minn. on water quality and organic productivity of lakes, A-011-Minn. on abundance on net plankton as an index of eutrophication in Lake Superior, B-001-Minn. on diatoms and zooplankton in Minnesota, B-010-Minn. on techniques for determining changes in phytoplankton, A-016-Minn. on primary productivity of Minnesota lakes, and B-009-Minn. on phosphorus in lake-bottom deposits is assisting water managers in controlling excessive productivity of polluted lakes. Results from projects A-010-Minn. and A-014-Minn. on recharge from induced streambed infiltration have been used in the U.S. and England to evaluate potential yields of aquifers. The Corps of Engineers has been assisted in their analyses of peak rates of runoff and flood routing by the results of project A-013-Minn. on review and analysis of watershed precipitation and runoff data. The Weather Bureau has been assisted in flood forecasting activities by information from project B-005-Minn. on soil moisture and A-004-Minn. on soil freezing in forests. The results of project A-015-Minn. on water laws in Minnesota have assisted the legislature in identifying deficiencies in statutes.

The Center has been helpful in developing 48 new water resources courses, a graduate option in hydrogeology, a program of graduate education in water resources, and recruitment of 27 new faculty members with an active interest in water resources. The following State and private colleges have participated in the Center's research program: St. Mary's College, St. Cloud State College, Bemidji State College, Winona State College, and Gustavus Adolphus College.

Management of the Center is vested in an Advisory Committee headed by the Dean of the Graduate School and made up of faculty members and 15 units of the University. A Consulting Council, composed of 20 representatives from organizations outside the University, counsels with the Center and assists in identifying needed research and providing public liaison. The State contributed about \$40,464 to the Center's OWRR Allotment program and about \$112,630 to the Center's OWRR Matching Grant program in FY 1971.

Members of the Center's Advisory Committee have participated in water and related land resources planning activities of the Minnesota State Planning Agency. The Center Director has served on several important State and national water resources committees.

Examples of Selected Research Findings and Their Actual or Potential Application to Water Resources Problems

First Example

Lake Minnetonka, an intensively developed lake in the Minneapolis-St. Paul suburbs, has been subjected to severe eutrophication due to man's activities. For several years, lakeshore owners, municipalities discharging treated sewage into the lake, and special purpose districts have been searching for an optimum rehabilitation management program that would improve the recreational use of the lake. Before OWRR Project No.: A-016-Minn. was started on July 1, 1967, available information concerning the productivity of the lake was not sufficient to permit the prediction of the effects of selected management practices.

The lake was studied by the Principal Investigator in cooperation with State agencies, municipalities, special purpose districts and several private engineering firms. It was demonstrated that phosphorus is the nutrient that limits algal growth during the summer, when very dense populations of nitrogen-fixing blue-green algae develop. A model of the photosynthetic system of the phytoplankton was developed. Computations based on a materials balance indicated that the mean annual phosphorus content of the lake's largest basin should decrease from 13 metric tons at present to a desirable 4 metric tons within 3 years if the phosphorus influx is reduced by stopping the influx of sewage.

Based on the results of the research project, a comprehensive lake watershed management plan was prepared. Sewage effluents are scheduled to be diverted from the lake within two years. The emphasis of OWRR Project No.: A-026-Minn., which started on July 1, 1971, will be to monitor the effect of stopping the flow of sewage into the lakes and thereby measure the effectiveness of the management plan.

Second Example

During the last 3 Legislative Sessions in Minnesota there have been numerous Committee hearings concerning water resources laws, administration and policies. In addition, two Governors appointed Committees to study the State's water resources statutes and government, and to make recommendations concerning needed changes. Prior to the start of OWRR Project No.: A-015-Minn. on July 1, 1967 and A-021-Minn. on July 1, 1969, the Legislature and Governors' Committees were greatly hampered in their efforts because of the lack of comprehensive reports on water resources laws, State administration, Legislative process, and policies.

Codified laws, uncodified Legislative enactments, and local laws bearing on water resources in Minnesota were collected, compiled and published. An analysis and interpretation was made of State and Federal statutes and court decisions and recommendations were made concerning ways and means for improving water resources laws. The Principal Investigator inventoried and appraised State water resources administration, Legislative process and policies as of December 1970. Recommendations were made con-

cerning reorganization of State agencies and needed State policies. The information generated by the research has filled large gaps in the understanding of Minnesota's water resources laws and government and the need to improve laws.

In 1970, the Principal Investigator served as an adviser to the Land and Water Resources Committee of the Minnesota House of Representatives and using the results of the research assisted the Committee in preparing a report on needed water resources legislation. The Citizens League, League of Minnesota Municipalities and numerous voluntary environmental organizations have sought the advice of the Principal Investigator in matters pertaining to water resources laws and government. Many recommendations resulting from the research were accepted by legislators and incorporated in bills introduced during the 1971 Session of the Minnesota Legislature.

Third Example

In the United States, only a fraction of one percent of small watersheds 1 to 100 square miles in size have stream gaging stations. Few of these have records of sufficient length for flow frequency analysis. Hundreds of culverts, bridges, channel improvements, stabilizing structures and detention reservoirs are being constructed each year on small watersheds. The hydrologic design for almost all of these structures is by means of some empirical technique or formula of unknown accuracy. Of the thousands of small watersheds, only a few can be gaged because of the limited national streamflow gaging programs. Thus, it is imperative that concerted efforts be made to develop new and better techniques for estimating stream runoff rates and frequencies for small, ungaged watersheds.

In planning water control projects, whether large or small, an estimate of peak stream flows in various parts of the watershed with and without the project is essential. The unit hydrograph method and other linear methods are widely used for this purpose. The results of OWRR Project No.: A-017-Minn. and B-007-Minn., based on mathematical model and laboratory experiments, provide evidence that peak discharges estimated by such methods should be adjusted upward by significant amounts in many cases to avoid underdesign.

The results of the research project are being used by the Principal Investigator and other hydrologists throughout the United States to develop new methods for peak streamflow determination for ungaged, small watersheds which will involve consideration of more watershed characteristics and avoid the use of the linearity assumption. The U.S. Soil Conservation Service in Minnesota has expressed great interest in the results of the research; and is revising its planning procedures in light of the new knowledge.

Information Dissemination

Increased attention is being given to making available to the public, governmental agencies and the research community the information produced by the Center's programs. One means of keeping the public and others concerned with water problems informed about developments in the water resources area is the preparation and distribution of newsletters. During FY 1971, the Center distributed to about 550 people mimeographed quarterly Newsletters. The Center's mailing list for Newsletters upon request is growing rapidly at the rate of about 10 percent per year.

Information is also disseminated through Information Circulars. During FY 1971, the Center distributed to about 650 people mimeographed Information Circulars covering the following subjects:

<u>Information Circular No.</u>	<u>Title</u>
110	National Environmental Policy Act of 1969
111	Summary of Information on Minnesota Department of Conservation
112	Water Resource Management Concepts: The State of the Art in the Minnesota River Basin
113	The Water Resources Planning Act: An Historical Perspective
114	Water Resource Management in Red-Rainy Rivers Basin, Minnesota
115	The New Environmental Demands
116	Factors to be Considered in Preparing Water and Related Land Resources Plans in Minnesota
117	Water and Related Land Resources State Administration, Legislative Process and Policies in Minnesota, 1970
118	Proposed New Procedures for Evaluating Water and Land Resources: Some Comments From an Academic Viewpoint
119	Major Information Deficiencies Associated With the Preparation of a Statewide Framework Water and Related Land Resources Plan for Minnesota
120	The Need for a State Environmental Policy
121	Water Resources Development and Hydrogeology
122	The University and National Water Policy
123	National Water Research Policy: A Critique

The Center has been effective in getting news stories of its activities into local newspapers. As an example, the contents of a recent article which appeared in the Minneapolis Tribune is given below:

Report Urges Single State Resources Unit

By Ron Way
Minneapolis Tribune Staff Writer

"A single department of natural resources should be created in Minnesota to overcome "structural fragmentation and obsolescence" that is impeding the state's effort at environmental protection, according to the University of Minnesota's Water Resources Research Center.

The center's report says there are presently "at least 46 departments, agencies, boards, commissions and committees which have primary or substantial responsibilities in the natural resources field."

It says the laws concerning the 46 units cover 640 pages.

Under the center's proposal, the lone department would be headed by a commissioner appointed by the governor and confirmed by the Minnesota Senate, with other key department officials to be appointed by the commissioner.

Author of report, William C. Walton, the center's director, said the governor's control over the present structure is "largely frustrated" and the present legislative committee approach is "piecemeal and fragmented."

Walton said that under the proposal the department would take over all powers and duties of the Department of Conservation, the Pollution Control Agency, the Soil and Water Conservation Commission and the Water Resources Board. In addition, the department would take over some duties of other departments, such as fertilizer and pesticide control now under the Department of Agriculture.

The department would have eight separate divisions with specialized responsibilities. In addition, it would have federal and state liaison committees and another advisory committee for special-interest groups.

In addition to the department there would be a commission on the environment, which would report directly to the governor and the Legislature.

Walton said the department would be patterned in part after recent actions taken by Wisconsin, Michigan, California and New York.

He said that although Minnesota faces "urgent demands for solution of difficult problems involving natural resources," the state "seems unable to satisfactorily cope with the complex and comprehensive nature of problems largely because a piecemeal and compartmentalized approach is being followed in the planning, development and management of natural resources."

He said that "competent government is a vital necessity if the state is to improve its environmental quality in response to strong public opinion."

The center's study is part of a three-year research program financed by the U.S. Department of Interior. The report has been sent to Gov. Harold LeVander and the Water Resources Commission, among others. "

The Center receives many requests for copies of its Bulletins, Newsletters and Information Circulars. A few excerpts from letters addressed to the Director of the Center expressing appreciation for the Center's publications are given below:

My heartiest congratulations to you on the publication of the Water Resources Research Center, Information Circular No. 104 "Recommendations Concerning the Improvement of State Government for Natural Resources".

Although this publication is bound to raise considerable controversy and discussion throughout the state it places an excellent focus on the problems of institutional and legal arrangements for natural resources management in Minnesota. It has stated very clearly and concisely some of the complex problems encountered by the various people in managing our resources and concluded with specific recommendations.

I know that you are intimately aware of the many water resource problems confronting us to insure adequate management of the resources and particularly the institutional arrangements. Although reorganization can not in itself solve all these many complex problems, it certainly provides a step towards their solution.

Again, congratulations.

Yours truly,

Eugene R. Gere, Director
Div. of Waters, Soils and Minerals
State of Minnesota
Department of Conservation
St. Paul, Minnesota 55101

This is to acknowledge the recent arrival of your Bulletin #20 on "The Potential Productivity of Fresh Water Environments as Determined By an Algal Bioassay Technique." by J.M. Johnson, T.O. Odlaug, T.A. Olson, and O.R. Ruschmeyer.

This is truly an example of a well-planned, well-executed and well-written report on a present much needed field of research. It has valuable data which can serve as guideline for such studies in other areas. It should be an inspiration to researchers in other areas to do likewise.

One of these times there will be sufficient data, when correlated, to give some broader guidelines and understanding to aquatic problems.

Thank you for the copy.

Sincerely,

William F. Hahnert, Ph.D.
Ohio Wesleyan University
Department of Zoology
Delaware, Ohio 43015

Thank you for the complementary copy of your WRRC Bulletin #13.

I have reviewed the bulletin contents. I complement you on an excellent publication. It will make a most useful addition to my technical library at work.

Very truly yours,

Edwin E. Crawford
California Regional Water
Quality Control Board
Central Valley Region
2424 Sixteenth Street
Sacramento, California 95818

I had the opportunity to review the newsletter from your Water Resources Research Center and find it very informational. Our office deals considerably with individuals and well drillers and other local governing bodies regarding both well water and surface waters. If I could be included in your mailing list for this newsletter or any other publication which you have available I would deeply appreciate it.

Sincerely yours,

Richard A. Peter
Public Health Sanitarian
Olmsted County Health Department
415 Fourth Street S.E.
Rochester, Minnesota 55901

The Director of the Center and others appeared several times on radio programs and, occasionally, on T.V. during FY 1971.

The number of Principal Investigators choosing to use the Center Bulletin series to publish the results of their research is steadily increasing. During FY 1971, the Center published and widely distributed 17 Bulletins.

Center's Involvement in Public Affairs
and Academic Activities

On December 10, 1970, Conference on Impact of Future Electric Power Requirements in the State of Minnesota - An Issue Analysis jointly sponsored by the Center, State Planning Agency, Pollution Control Agency, Department of Conservation, Department of Economic Development, Department of Health and St. John's University was held in the North Star Ballroom, Student Center, University of Minnesota, St. Paul Campus. Ninety-three people were in attendance at all or portions of the Conference.

The objectives of the Conference on Impact of Future Electric Power Requirements in the State of Minnesota--An Issue Analyses were: to discuss future electric energy needs in the State of Minnesota and alternative means for meeting these requirements and to identify issues associated with: impact of power plant and transmission line proliferation on the natural environment, impact of power plant and transmission line proliferation on the economics of the affected areas, on the life of the people; impact of power plant and transmission line proliferation on the politico-legal situation in the affected areas, and impact on State if power plants and transmission lines are not built.

The emphasis was on examination of all possible issues and not on problem solutions. The information generated by this Conference will be used in preparing an issue analysis report for consideration and possible action by the Executive Branch and the 1971 Legislature.

The program of the Conference is presented below:

8:30 -9:30 a.m. Registration and Coffee

SESSION I

9:30-9:45 Opening Remarks, Laurence F. Koll, Governor's Special Assistant for Environmental Affairs.

9:45-10:15 Power Generation and the Environment, S. David Freeman, Director of the Energy Policy Staff of the President's Office of Science and Technology.

10:15-10:45 Background Report on Energy Needs and Tentative Plans of Utilities to Meet These Needs, J.O. Grantham, St. John's University.

10:45-11:30 Panel Discussion on Ramifications of Tentative Plans, Ed Henry, Rollie Comstock, William Cunningham, Allan Brook, Oliver Perry, John Pegors.

11:25 Announcements and Adjourn for lunch.

11:25-1:00 p.m. Lunch

SESSION II

1:00-3:00	Work Group Meetings
3:00-3:15	Coffee
3:15-4:15	Work Group Reports
4:15-4:30	Summary and Concluding Remarks

The Conference was divided into two sessions. During the morning session, background papers were presented by prominent speakers. During the afternoon session, Conference participants divided into five work groups to exchange information on issues. Work group views were summarized at the end of the Conference.

Topics for Discussion during the Afternoon Work Group Sessions were:

1. Impact of power plant and transmission line proliferation on the natural environment.
 - a. Nature and ramification of potential water pollution
 - b. Nature and ramifications of potential air pollution
 - c. Nature and ramifications of potential solid waste disposal
 - d. Nature and ramification of transporting fuel
 - e. Nature and ramification on land management
 - f. Nature and ramification of radiation
 - g. Nature and ramification of depletion of natural resources
2. Impact of power plant and transmission line proliferation on the economics of the affected areas.
 - a. What happens to land values?
 - b. What are implications regarding taxes?
 - c. What happens commercially?
 - d. What about industrial growth?
 - e. What about implications of changes in electric rates?
 - f. What about research and development
3. Impact of power plant and transmission line proliferation on the life of the people.
 - a. Generation of new jobs (primarily and secondarily)
 - b. Public health implications
 - c. Alterations in life style
 - d. Effect on education
 - e. Community growth and development
 - f. Problem of noise
4. Impact of power plant and transmission line proliferation on the politico-legal situations in the affected area.
 - a. Local government problems
 - b. State legislation regarding land use and taxes
 - c. Conflicting authority
 - d. State regulation
 - e. Regional cooperation
 - f. Relations with federal government
 - g. International relations

5. Impact of limited development of power plants and transmission lines in the State.
 - a. Significance of blackouts and brownouts
 - b. Rationing and curtailment
 - c. Impact on life style
 - d. Impact on the economy

The following persons served as the Program Planning Committee for the Conference:

Joseph Sizer (Chairman), Minnesota State Planning Agency
George R. Koonse, Pollution Control Agency
Jerry Kuehn, Department of Conservation
Francis H. Geisenhoff, Department of Economic Development
Frederick Heisel, Department of Health
J.O. Grantham, St. John's University
William C. Walton, University of Minnesota

The proceedings of the Conference were published as a Center Bulletin. About 700 copies of the Bulletin were distributed to people throughout Minnesota.

The Minnesota Department of Natural Resources, U.S. Geological Survey and Water Resources Research Center sponsored a Seminar on Remote Sensing on April 27, 1971 from 9:30 a.m. to 11:30 a.m. The Seminar was held in the North Star Lounge, Student Center, University of Minnesota, St. Paul Campus.

James F. Daniel, U.S. Geological Survey Hydrologist in Charge of the Satellite Data Relay Project at St. Louis, Missouri, discussed the application of remote sensing imagery to the collection of hydrologic information. Mr. Daniel is EROS (Earth Resources Observational Satellite) Coordinator for Data Relay Systems. Since the fall of 1969 he has been involved in developing Department of Interior data relay experiments for ERTS-A, which are the Earth Resource Technology Satellites designated by NASA as a series of space flights to meet the needs of Interior and other departments. Mr. Daniel discussed applications of remote sensing in Minnesota.

Observation of the earth from space offers man the opportunity to monitor his environment and may revolutionize many of his concepts about the factors which are important to ecology. In the field of hydrology space observations can be used as an effective management tool which is sure to gain increasing importance. About 50 people attended the Seminar and participated in the discussion period.

Faculty Research at University of Minnesota Bearing on Water Resources,
1969-1970, in Addition to the Center's Program

INSTITUTE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATIONS

SUPPORT

NORTH CENTRAL SCHOOL AND EXPERIMENT STATION, Grand Rapids

Simonson, Lawrence
Lake of the Woods-Rainy Lake border water study M
Private campgrounds in Minnesota AES

NORTHWEST EXPERIMENT STATION, Crookston

Marx, George D.
Dairy cattle waste management CSRS/D/U

Miller, Eugene C.
Waste management studies: ground temperatures,
problems of ooze, material density, bedding, and
maintenance of a liquid manure tank for a dairy
herd in northern Minnesota AES

Soine, Olaf C.
Crop-weather records U
Crops new or little grown in Minnesota U
Land forming in Red River Valley U
Simulated hail damage to agricultural crops HIAR

SOUTHERN SCHOOL AND EXPERIMENT STATION, Waseca

Frazier, Russell D.
Agricultural climatology in southern Minnesota D/U

WEST CENTRAL SCHOOL AND EXPERIMENT STATION, Morris

Evans, Samuel D.
Corn irrigation: nitrogen and population variables D

AGRICULTURAL ECONOMICS

Blank, Uel
Economic analysis of northeast Minnesota AES/USDA
Economics of Minnesota camping industry AES/USDA
Economics of tourism-recreation industry AES
Tourism industry economic potentials in Lake of the
Woods-Rainy Lake area AES/D

Maki, Wilbur R.
Economic base and infrastructure in west central
Minnesota MSPA
Economic interdependence of Minnesota and North
Dakota M/ND

Impact of metropolitan growth on regional resource use AES
Dissertation supervision
Economic analysis of an urban center as
potential growth pole: an Argentinian case
Settlement alternatives for improving oppor-
tunity access in non-metropolitan areas

Snyder, Robert W.
Local government policy implications of seasonal home
ownership in Minnesota AXS/GAR

Stam, Jerome M.
Economic Analysis of Lake of the Woods-Rainy Lake
region of Minnesota AES

AGRICULTURAL ENGINEERING

Allred, Evan R.
Agricultural waste management and disposal AESR/CSRS
Effects of artificial mulching on irrigation
water efficiency HA
Solid settlement characteristics in oxidation
ditch USPHS
Water movement from subsurface irrigation tubes GAR
Dissertation supervision
Two-dimensional flow of water through
soils from a line source

Bates, Donald W.
Handling and disposal of dairy animal waste D

Boyd, Landis L.
Treatment and disposal of animal wastes AESR/CSRS

Larson, Curtis L.
Hydrologic characterization of small watersheds AESR/CSRS

Larson, Russel E.
Farm animal waste management USDA
Livestock production systems USDA

Manson, Philip W.
Durability of concrete pipe and drain tile CMDA
Effect of soil and water conservation practices on
water supplies CMDA

Moore, James A.
Disease hazards resulting from treatment on animal
waste in an oxidation ditch USPHS
Farm animal waste disposal AESR/CSRS

ENTOMOLOGY, FISHERIES AND WILDLIFE

Smith, Lloyd L., Jr.
Commercial fisheries on Red Lakes AES

Effect of H₂S on juvenile fish USDI
 Lake of the Woods commercial fisheries USDI
 Dissertation supervision
 Fish population differentiation in lakes
 Lake Superior fish population ecology
 Life history of buribat

Waters, Thomas F.
 Dynamics of fresh water stream invertebrate populations NSF
 Mechanisms of biological production in streams AES
 Dissertation supervision
 Ecology of a stream amphipod
 Production rates of stream insects

SCHOOL OF FORESTRY

Hansen, Henry L.
 Ecology of recreation areas AES/CSRS/GAR/HA/MRC/MSF
 Dissertation supervision
 Comparative dynamics of upland forest communities of Itasca State Park, Minnesota
 Maintenance of presettlement biotic communities as objective of management in Itasca State Park, Minnesota

Hughes, Jay M.
 Forest-based recreation supply and demand, north central region CSRS
 Forest resource economics GAR
 Forest resources in rural regional economies of Minnesota GAR

Merriam, Lawrence C., Jr.
 Campsite conditions in the Boundary Waters Canoe Area NCFES/USDA/USFS
 Recreation management and user satisfaction in several Minnesota park and forest areas MSF
 Role of outdoor recreation in management of Minnesota Memorial Hardwood Forest HA
 Dissertation supervision
 Complementary function of outdoor recreation in the Minnesota Memorial Hardwood Forest
 Interpersonal interaction in the forest environment: exploration of outfitter-camper relationships in the Boundary Waters Canoe Area

SOIL SCIENCE

Adams, Russel S., Jr.
 Adsorption and desorption of pesticides from soil colloids HA

Baker, Donald G.
 Regional radiation reception and distribution HA
 Soil heat and moisture characteristics related to evaporation from cropped land GAR/HA
 Urban climatology HA
 Dissertation supervision
 Plant geometry and energy distribution
 Spatial and temporal variation of local precipitation

Blake, George R.
 Soil structure: formation and alteration GAR/HA/U
 Storage and movement of water in soils GAR/USDI
 Dissertation supervision
 Role of quartz in soil matrix stability
 Soil water potentials during thixotropic aging of soil
 Stabilization of shear-generated aggregates

Farnham, Rouse S.
 Soil modification-Sand Plain Irrigation Station AES
 Soil survey and classification AES
 Waste water treatment: using peat as a filter AES/IRRC/M/USDI
 Dissertation supervision
 Water relations in organic soils

Larson, William E.
 Estimation of unsaturated water conductivity of soil from moisture characteristic curves USDA

COLLEGE OF BIOLOGICAL SCIENCES

BOTANY

Gorham, Eville
 Floristic zones in Minnesota (with T. Morley) GS
 Inorganic and organic chemistry of lake waters and sediments (with F. Cagle, J. Sanger) AEC/GS/NSF
 Microbial ecology (with D. Pratt) LRC
 Dissertation supervision
 Wetland ecology

ECOLOGY AND BEHAVIORAL BIOLOGY

Brook, Alan J.
 Population dynamics of planktonic desmids --
 Stratification of algal populations in lakes AEC
 Dissertation supervision
 Biology of Aphanizomenon flos aquae
 Ecology of algae in rivers
 Desmid distribution in lakes
 Microstratification of blue-green algae

Maxwell, Robert K.
 Environmental measuring system at Cedar Creek
 Natural History Area GS

Megard, Robert O.
 Origin of calcium carbonate in lake sediments --
 Photosynthesis of phytoplankton in lakes MPCA
 Regional limnology of Minnesota USDI
 Dissertation supervision
 Nutrition of phytoplankton

Tester, John R.
 Effects of ionizing radiation and other environmental
 factors on breeding behavior, activity patterns and
 movement of selected vertebrates AEC

FIELD BIOLOGY PROGRAM

Marshall, William H.
 Waterfowl breeding and production W
 Dissertation supervision
 Ruffed grouse
 Waterfowl production
 Woodcock

ZOOLOGY

Huver, Charles W.
 Effects of heated effluents on water quality SFI
 Environmental influences on sex differentiation in
 American eel, Anguilla rostrata SX
 Malignant melanomas in fishes ACS
 Periphyton growth in Lake Superior SC

Underhill, James C.
 Distribution of Minnesota fish --
 Variation in cyprinids GS
 Dissertation supervision
 Biology of Chrosomus neogaeus
 Biology of the cisco, Coregonus artedi
 Ecology and life history of the mink frog,
Rana septentrionalis
 Natural history of the green frog
 Pharyngeal bones and teeth of Minnesota
 cyprinids and catostomids

UNIVERSITY OF MINNESOTA DULUTH

DIVISION OF SOCIAL SCIENCES

Larsen, Arthur J. (History)
 History of Great Lakes-St. Lawrence Tidewater
 Association --

Wolff, Julius F., Jr. (Political Science)
 Legendry of the Quetico-Superior country --
 Minnesota Department of Conservation --
 Shipwrecks of Lake Superior --

COLLEGE OF LIBERAL ARTS

GEOGRAPHY

Brown, Dwight A.
 Analysis of the value of basin shape in hydrologic
 studies --
 Drainage network traffic problems GS

Skaggs, Richard H.
 Minnesota drought --
 Weather modification in Minnesota MSPA

SOCIOLOGY

Rickson, Roy E.
 Role of scientists in environmental policy making --
 Social-psychological conflicts in pollution control --

COLLEGE OF MEDICAL SCIENCES

ANATOMY

Abrahamson, Dean E.
 Computer-based inventory of pollutants and water
 quality information NSF
 Environmental effects of power generation SIPI
 Dissertation supervision
 Mercury levels in environment and effects
 on embryo
 Microspectrophotometry of normal and
 malignant tissue

SCHOOL OF PUBLIC HEALTH

Straub, Conrad P.
 Water quality and disease --

INSTITUTE OF TECHNOLOGY

CHEMICAL ENGINEERING

Isbin, Herbert, S.
 Nuclear reactor safety --

CIVIL ENGINEERING AND HYDRAULICS

Anderson, Alvin G.
 Erosion control in drainage channels NAS
 Flow in long vertical shafts USDI
 Dissertation supervision
 Generation of waves in an alluvial open channel
 Influence of spillway curvature on flow pattern

Bowers, C. Edward
 Mathematical model of urban runoff USDI
 Pressure fluctuations in the hydraulic jump NSF

Johnson, Walter K.
 Nitrogen removal by denitrification USDI
 Dissertation supervision
 Activated sludge bulking

Killen, John M.
 Feasibility study field for measurement of suspended sediment USDI
 Measurements of wall pressure fluctuations on rough surfaces in relative motion with water solutions of drag reducing polymers USN
 Wall pressure and shear fluctuations on smooth surfaces in relative motion with water solutions of drag reducing polymers USN

Maier, Walter J.
 Computer methods for design of waste water treatment system --
 Removal of colloidal materials by biological processes USDI
 Soluable carbon as a pollution parameter --
 Dissertation supervision
 Biological oxidation kinetics
 Water filtration in mixed media

Ripken, John F.
 Experimental study of the boundary layer structure of drag reducing polymer flows USN
 Multiple-jet control and dissipation system for high-head hydraulic structures NSF

Silberman, Edward
 Development of data acquisition system for installation at the St. Anthony Falls Hydraulic Laboratory NSF
 Friction tests of helical pipe --
 Model studies of intake and discharge structures, Zion Nuclear Station HEC
 Model studies of Lake Erie bulkhead BSC

Dissertation supervision
 Effect of polymer on velocity profiles in a commercially rough pipe
 Flow about a thin supercavitating hydrofoil with a flap or spoiler

Song, Chieh S.
 Internal waves USN
 Dissertation supervision
 Vibration of cavitating foils

Stefan, Heinz G.
 Design of experimental ponds with temperature control USDI
 Flow and dispersion of heated water in lakes and rivers --
 Wind-generated currents in density-stratified bodies of water --
 Dissertation supervision
 Mixing and entrainment in inverted internal hydraulic jump

GEOLOGY AND GEOPHYSICS (Earth Sciences, School of)

Bright, Robert C.
 Diatom ecology LRC/MNH
 Diatoms of Lake Superior MNH
 Fossil seeds manual GS/LRC
 Pleistocene geology of southeast Idaho --

Roy, Robert F.
 Geothermal studies in Minnesota and Wisconsin lakes GS

Shapiro, Joseph
 Dissolved organics in lake waters --
 Phosphate uptake by algae NSF
 Dissertation supervision
 Carbon sources for algae
 Cycle of arsenic in lakes
 Heterotrophic nutrition in algae
 Zooplankton/blue-green algae relationships

Wright, Herbert E., Jr.
 Community analysis in the littoral zone of lakes USDI
 Diatoms in lakes and lake sediments AEC
 Late-Quaternary environmental history beyond the glacial border NSF
 Late-Wisconsin landscape in the Minnesota area NSF
 Dissertation supervision
 Paleolimnology of Elk Lake, Itasca Park, Minnesota
 Peat Stratigraphy of Red Lake Bog, Minnesota

MECHANICAL ENGINEERING (Mechanical and Aerospace Engineering, School of)

Anderson, John E.
 Exploratory research on problems of effects of technology on human environment --

Jordan, Richard C.
Environmental control

ASHRAE

Center Director's Activities

Sparrow, Ephraim M.
Porous media flow

NSF

Sources of Support

ACS	American Cancer Society	IRRC	Iron Range Resources Commission
AEC	Atomic Energy Commission	LRC	Limnological Research Center University of Minnesota
AES	Agricultural Experiment Station, University of Minnesota	M	Minnesota, State of
AFSR	Agricultural Experiment Station, Rosemount, Minnesota	MNH	Museum of Natural History, University of Minnesota
ASHRAE	American Society of Heating, Refrigerating and Air Condi- tioning Engineers	MPCA	Minnesota Pollution Control Agency
AXS	Agricultural Extension Service, University of Minnesota	MRC	Minnesota Resources Commission
BSC	Bethlehem Steel Company	MSF	McIntire-Stennis Fund
CDMA	Concrete Draintile Manufactur- ers Association	MSPA	Minnesota State Planning Agency
D	Department or Division of which researcher is a member	NAS	National Academy of Science, National Research Council
GAR	General Agricultural Research Funds	NSF	National Science Foundataion
GS	Graduate School, University of Minnesota	SC	Sierra Club
HA	Hatch Act Funds	SFI	Sport Fishing Institute
HEC	Harza Engineering Company	SIPI	Scientist's Institute for Public Information
HIAR	Hail Insurance Adjustment and Research Association	SX	Sigma Xi
IRRC	Iron Range Resources Commission	U	University of Minnesota
		USDA	United States Department of Agriculture
		USDI	United States Department of Interior
		USN	United States Navy

During fiscal year 1971, the Center Director attended the following water resources meetings: July 2, 1970, Land and Water Resources Committee, Minnesota Legislature (L&WRC), St. Paul; July 10, L&WRC, St. Paul; July 16, Bemidji State College, Bemidji; July 20, L&WRC, St. Paul; July 26-28, Universities Council on Water Resources, Blacksburg, Virginia; July 30, L&WRC, St. Paul; Aug. 5, Henry Wolfe Radio Show, Minneapolis; Aug. 7, Minnesota Water Resources Coordinating Committee (WRCC), St. Paul; Aug. 21, WRCC, St. Paul; Aug. 27, L&WRC, St. Paul; Sept. 4, WRCC, St. Paul; Sept. 8, L&WRC, St. Paul; Sept. 11, Minneapolis Rotary Club, Minneapolis; Sept. 21, L&WRC, St. Paul; Oct. 5, St. Louis Park Rotary Club, Minneapolis; Oct. 9, WRCC, St. Paul; Oct. 18, Issac Walton League, Minneapolis; Oct. 15, St. John's University, Collegeville; Oct. 15, University YMCA Environmental Committee, Minneapolis; Oct. 22, University YMCA Environmental Committee, Minneapolis; Nov. 2-6, presented lectures on Environmental Matters at Oklahoma Baptist University, Shawnee, Oklahoma, Oklahoma State University, Stillwater, Oklahoma and Arkansas University, Little Rock, Arkansas; Nov. 16-17, Presented a paper "Water Resources Development and Hydrogeology" during 15th Annual Ground-Water Conference, Lincoln, Nebraska; No. 21, Presented a paper "The Need for a State Environmental Policy" during Conference on the Environment, Hudson, Wisconsin; Nov. 24, Presented a paper "Aspects of Water Resources Planning" to geology faculty and students at University of Chicago, Chicago, Illinois; Nov. 30, L&WRC, St. Paul, Minnesota; December 1, presented a paper "Water Resources Management Concepts: The State of the Art in the Minnesota River Basin" during Conference on Minnesota River Water Management and Development", New Ulm; Dec. 4, WRCC, St. Paul; Dec. 10, Participated in Conference on Impact of Future Electric Power Requirements in the State of Minnesota - An Issue Analysis", St. Paul; Dec. 17, Intercollegiate Committee on Environmental Studies, University of Minnesota, Minneapolis; Jan. 8, 1971, WRCC, St. Paul; Feb. 9, WRCC, St. Paul; Feb. 25, presented papers on water resources administration and management, Red River Valley Winter Shows, Crookston; Feb. 28, presented a paper on Environmental Legislation at Church of Way, Shoreview; March 9-10, presented lectures on Water Resources Planning and Water Resources Administration at University of North Dakota, Grand Forks, North Dakota; March 29-31, Annual Meeting of OWRR, Washington, D.C.; April 2, WRCC, St. Paul; April 27, sponsored a Seminar on remote sensing, St. Paul; April 29-30, meeting of Water Resources Research Center Directors, Kansas City, Missouri; May 3, presented a lecture on organization for water resources planning, University of Minnesota, Minneapolis; May 21, WRCC, St. Paul; May 26-28, Advisory Committee on Water Data for Public Use, San Francisco, California.

The following two books written by the Director of the Center were published:

W.C. Walton. 1970. Groundwater Resource Evaluation. McGraw-Hill Book Co. New York.

W.C. Walton. 1970. The World of Water. Weidenfeld and Nicolson. London.

The Director and Assistant Director of the Center, acting as Consultants, assisted the staff of the State Planning Agency in preparing a state-wide water and related land resources planning Bulletin entitled "Alternate Programs and Projects for Managing Minnesota's Water and Related Land Resources Through the Year 2020." The 245-page Bulletin contains summaries of: existing and possible future problems, programs and projects recommended by Federal-State regional organizations, alternative programs and projects from a State viewpoint, factors to be considered in selecting programs and projects, and existing State policy questions. The Bulletin assisted the 1971 Legislature in making decisions concerning needed water resources policies. The Director of the Center also served as an advisor to the State Planning Agency in matters pertaining to Federal-State planning activities.

The Director of the Center presented several talks on water resources and environmental factors. Excerpts from a few letters expressing appreciation for the Director's efforts are given below:

I am finally getting to some of the thank you letters for the many people who traveled to the Red River Valley to participate in the 1971 exposition.

A special thank you for your participation in the Water Resource Workshop. It was probably the most productive workshop, in terms of feedback and discussion, that we have ever held. I do believe that a level of sophistication relative to water resources planning and development is being developed by a few of the citizen-leaders in northwestern Minnesota. Dr. John Waelti, from the Department of Applied Economics at St. Paul, was quite impressed as he listened to the workshop group discussion.

Thank you!

B.E. Youngquist, President
Red River Valley Winter Shows
Board of Managers, Inc.
Crookston, Minnesota

In behalf of the personnel of the 5007th USAR R&D Unit, I want to thank you very much for the fine presentation which you gave us on Tuesday of this week. You will have recognized from the many questions which were addressed to you by our personnel that you stimulated and aroused their interest. I am sure that those who are employed in industry were particularly intrigued by the fact that the Graduate School takes an enterprise such as yours under its wing and that it is concerned with some real practical problems.

Very cordially yours,

M.O. Schultze, Col. MSC USAR
Commanding, 5007th R&D Unit

Thank you very much for the lecture you gave. I hope that the students present benefitted greatly from your talk and the following discussion. The department thoroughly enjoyed your talk.

Dr. Saleem asked me to convey his regrets that the strike threat prevented him from having dinner with you.

Sincerely yours,

A.F. Koster van Groos
Assistant Professor
Geological Sciences
University of Illinois at Chicago Circle
Department of Geological Sciences
Box 4348
Chicago, Illinois 60680

Water Resources Coordinating Committee, State Planning Agency; Advisory Committee on Water Data for Public Use, U.S. Geological Survey; Ad Hoc Intercollegiate Committee on Environmental Studies, University of Minnesota; and Environmental Pollution Committee, League of Minnesota Municipalities.

Information Concerning Research Project
Proposals Submitted to OWRR by Center, FY 1972

Lists of FY 1972 Annual Allotment, Matching Grant and Title II research project proposals submitted to OWRR by the Center are given below. A table summarizing the number of Center proposals funded or rejected by OWRR FY 1965-72 is also provided.

About 31 percent of Matching Grant proposals have been funded and 100 percent of Annual Allotment proposals have been funded. No Title II proposals have been funded.

List of Annual Allotment Research Project Proposals Submitted to OWRR by Center, Fiscal Year 1972

*(Proposals Funded)

*Phytoplankton Nutrition and Photosynthesis in Eutrophic Lakes - R.O. Megard, Department of Ecology and Behavioral Biology (A-026-Minn.)

*Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management - H.O. Pfannkuch, Department of Geology and Geophysics (A-027-Minn.)

List of Matching Grant Research Proposals Submitted to OWRR by Center, Fiscal Year 1972

*(Proposals Funded)

*A Hydromomic Analysis of Forest Management Alternatives for Environmental Quality: A Case Study of Itasca County, Minnesota - J.M. Hughes and A.C. Mace, School of Forestry (B-053-Minn.)

*Socio-Economic Implications of Alternative Water Resource Policies in Minnesota - J.J. Waelti, Department of Agricultural Economics (B-054-Minn.)

Socio-Economic-Political Impact of Changes in Environment, Especially Regarding Water Resources, Caused by Operation of a Nuclear Power Plant in Minnesota - J.O. Grantham, Center for the Study of Local Government, St. John's University, Collegeville, Minnesota

Role of the Scientist-Technician in Water Policy Decisions at the Community Level: A Study in Purposive Communication - R.E. Rickson, P.J. Tichenor and G.A. Donohue, Department of Sociology and School of Journalism

*Subsurface Irrigation with Heated Water, Its Management, and Application Toward Reduction of Thermal Pollution Problems - E.R. Allred, Department of Agricultural Engineering (B-057-Minn.)

Reducing Water Needs of Crop Plants by Identification and Exploitation of the Genetic Control of Water Stress - D.W. Davis, Department of Horticultural Science

A Model for the Integrated Analysis of Pollution and Pollution Control in a Rural Watershed in Central Minnesota - N.L. Ford, R.B. Fulton, P.E. Tix and J.M. Redmond, St. John's University

*Forecasting Rainfall and Snowmelt Floods on Upper Midwestern Watersheds - C.E. Bowers, St. Anthony Falls Hydraulic Laboratory, Department of Civil and Mineral Engineering (B-060-Minn.)

Organic Geochemistry of Oligotrophic Lakes and Streams of Northern Minnesota; A Baseline Study - F.M. Swain, Department of Geology and Geophysics

Phytoplankton Nutrition and Photosynthesis in Eutrophic Lakes - R.O. Megard, Department of Ecology and Behavioral Biology

A Study of Attitudes Toward the Red River and Rainy River as Total Resources in Minnesota, North Dakota, and Canada - J.B. Reed, Bemidji State College; I. Maung, Moorhead State College; C. Fortnay, Moorhead State College; E.C. Nordheim, Bemidji State College; and J.P. Ludwig, Bemidji State College.

Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basic Management - H. Olaf Pfannkuch, Department of Geology and Geophysics

List of Title II Research Proposal Submitted to OWRR by Center, Fiscal Year 1972

*(Proposals Funded)

Methodology for Accelerating Statewide Flood Plain Mapping in Minnesota - W.C. Walton, J.M. Wright, C. Edward Bowers and J.J. Waelti, University of Minnesota and Minnesota Department of Natural Resources

Number of Research Project Proposals Submitted to OWRR by Center and Funded or Rejected, Fiscal Years 1965 through 1972

Fiscal Year	Allotment			Matching Grant		
	Funded	Rejected	Total	Funded	Rejected	Total
1965	7	0	7	0	0	0
1966	2	0	2	5	2	7
1967	1	0	1	0	3	3
1968	4	0	4	2	1	3
1969	2	0	2	3	2	5
1970	2	0	2	3	15	18
1971	3	0	3	4	15	19
1972	<u>2</u>	<u>0</u>	<u>2</u>	<u>4</u>	<u>8</u>	<u>12</u>
Total	23	0	23	21	46	67

Fiscal Year	Title II		
	Funded	Rejected	Total
1968	0	2	2
1969	0	6	6
1970	0	9	9
1971	0	2	2
1972	<u>0</u>	<u>1</u>	<u>1</u>
Total	0	20	20

Expected Results From Projects Initiated in FY 1972

OWRR Project No.: A-026-Minn.

Project Title: Phytoplankton Nutrition and Photosynthesis in Eutrophic Lakes

FCST Research Category: V-A

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: Robert O. Megard, Department of Ecology and Behavioral Biology

The objective of this project is to analyse the nutritional requirements and the photosynthetic system of the phytoplankton in four Minnesota lakes that receive nutrients from different sources and produce dense populations of nuisance algae. Algal nutrition, photosynthesis, and population densities will be studied before and after the nutrient influx to one lake is reduced, whereas nutrient-abatement programs for the others are either being discussed or they are in various stages of implementation. Analyses of algal nutrition, photosynthesis, and population densities that were begun during a regional limnological survey will be continued, but the emphasis will be somewhat different at each lake.

The research will monitor the effects of stopping the flow of sewage on the productivity of Lake Minnetonka. Advanced sewage treatment as a lake-management procedure and its effectiveness compared to sewage diversion will be evaluated in Shagawa Lake studies. The effectiveness of diverting sewage effluent from Sallie Lake and using the effluent for spray irrigation will be appraised. The results of the research project should assist the State in solving its lake pollution problems.

OWRR Project No.: A-027-Minn.

Project Title: Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management

FCST Research Category: VII-A

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: Hans Olaf Pfannkuch, Department of Geology and Geophysics

In the management of groundwater systems geohydrological information concerning aquifer parameters, geological boundaries, and boundary conditions become of utmost importance in the decision-making process. This research project attempts to study the following questions: What data exactly are needed and are any of these critical to management problems? How much information and to what degree of accuracy while obtaining the data affect interdependent parameters in a multivariate field? Can any relationship between the cost of additional information and increase of overall benefits be established? The research procedure will comprise the conceptualization of a simple management model and its mathematical and analog computer manipulation. Model studies will be correlated with ongoing field studies. The research will determine whether optimum levels of investigation can be set for such groundwater reservoirs as the Twin

Cities Artesian basin. The results of the project will assist State, Federal and local agencies in designing future investigation programs.

OWRR Project No.: B-053-Minn.

Project Title: A Hydronomic Analysis of Forest Management Alternatives for Environmental Quality: A Case Study of Itasca County, Minnesota

FCST Research Category: VI-G

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Co-Investigators: J.M. Hughes and A.C. Mace, School of Forestry

The specific objective of the research project is to evaluate the use of input-output analysis to determine effects of alternative forest management systems on environmental quality in terms of water, aesthetic and economic parameters. Water use and environmental deterioration in Itasca County in northern Minnesota will be integrated into an economic system in order to provide planners and administrators with additional information on environmental effects so that alternative forest management systems can be evaluated. The research project will focus on the trade-offs resulting from the choice of one management system as opposed to another.

Estimates will be made of thermal pollution and increased nitrate and phosphate levels associated with alternative forest management systems. Estimates of deterioration of fish and migratory water fowl habitat and suitability for resort and summer homes as a result of different forest management systems also will be made. Subsequent impact of effects of environmental quality deterioration on individual sectors and the overall economy will be estimated using the input-output framework.

OWRR Project No.: B-054-Minn.

Project Title: Socio-Economic Implications of Alternative Water Resources Policies in Minnesota

FCST Research Category: VI-E

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: John J. Waelti, Department of Agricultural Economics

The objectives of this project are to: delineate the more immediate and crucial sets of water and related land resources planning policy alternatives being considered by the people of Minnesota, identify the economic and social consequences of alternative courses of action associated with possible future programs and projects, and evaluate the economic and social consequences of these alternative courses of action so that a rational basis for planning decision making can be presented. The Minnesota State Planning Agency with the assistance of all other State agencies is preparing a statewide framework water and related land resources plan. The plan with program and project priorities can not be formulated until the State adopts major planning policies. The information generated by this project will assist the State legislature and Executive Branch in making decisions concerning alternative planning policies.

OWRR Project No.: B-057-Minn.

FISCAL YEAR 1971 BUDGET

Project Title: Subsurface Irrigation with Heated Water, Its Management, and Application Toward Reduction of Thermal Pollution Problems

Annual Allotment Program

FCST Research Category: IV-B

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: Evan R. Allred, Department of Agricultural Engineering

The research project will provide valuable information as to the feasibility of utilizing irrigation and groundwater recharge as means for disposal of heated water from power plants or other sources in Minnesota. The basic objectives of this research are to: (1) utilize heated water for the subsurface irrigation of crops in Minnesota, and to determine its effect upon plant growth processes; (2) determine the optimum depth of placement of a subsurface water source, relative to the cooling rate of a soil mass and the heat tolerance of crops; (3) evaluate the economic feasibility of extended crop production in Minnesota through lengthening of the growing by use of heated water; and (4) determine the feasibility of subsurface irrigation as a method for disposing of heated water through groundwater recharge in selected Minnesota soils.

OWRR Project No.: B-060-Minn.

Project Title: Forecasting Rainfall and Snowmelt Floods on Upper Mid-western Watersheds

FCST Research Category: II-E

Project Began: July 1, 1971 Scheduled Completion: June 30, 1972

Principal Investigator: C. Edward Bowers, St. Anthony Falls Hydraulic Laboratory, Department of Civil and Mineral Engineering

The objective of this study is the development of analytical procedures and the correlation of hydrologic data to aid in the prediction and control of spring floods in large Upper Midwest watersheds. The study is divided into three phases. The present work (Phase I) will involve the assembly of meteorologic and hydrologic data concerning past spring floods and new data pertaining to floods during the project period. In future work under Phases II and III the data will be analyzed using available mathematical models, modification of such models, and new models to assist in synthesizing continuous runoff records, particularly for the spring season. The Upper Midwest is a relatively flat area compared to the mountainous regions of the country; a study of the contribution of snowmelt to spring floods and the critical combinations of hydrologic conditions that are characteristic of major floods in this area is urgently needed. Of special interest will be the water content of snow over large watersheds together with data concerning late winter and early spring values of precipitation, air temperature, soil temperature, frost depths, soil moisture, wind, antecedent conditions, and basin or watershed characteristics.

	<u>Budget Fed- eral Funds</u>
Center Director's Office	\$ 27,810
Economics of Water Quality Control in the Upper Mississippi River, Minnesota - J.J. Waelti, Dept. of Agric. & Applied Economics (A-019-Minn.)	15,850
Evaluation of Selected Computer Programs in Hydrology - C.E. Bowers, St. Anthony Falls Hydraulic Laboratory (A-020-Minn.)	7,767
Water Resources Administration in Minnesota - W.C. Walton, Graduate School (A-021-Minn.)	14,570
Zooplankton Biomass & Incipient Eutrophication in Lake Superior T.O. Olson, School of Public Health (A-022-Minn.)	9,000
Alleviation of Lake Pollution by Utilization of Aquatic Plants for Nutritional, Medicinal or Industrial Purposes - E.J. Staba, Department of Pharmacognosy (A-028-Minn.)	8,700
Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics - C.L. Larson, Dept. of Agr. Engr. (A-023-Minn.)	7,550
Mathematical Simulation of a Large Watershed Using the Systems Approach to Quantity and Quality Analysis - C.S. Song and C.E. Bowers, St. Anthony Falls Hydraulic Laboratory (A-024-Minn.)	<u>8,753</u>
TOTAL	\$100,000

Matching Grant Program

	<u>Budget</u>		
	<u>Federal Funds</u>	<u>Non-Federal Funds</u>	<u>Total Funds</u>
Influence of Mist Irrigation on Moisture Stress, Growth, Yields & Quality of Potatoes & Other Vegetable Crops - R.E. Nylund, Dept. of Horticultural Science (B-013-Minn.)	\$ 11,115	\$ 11,458	\$ 22,573
Characteristics of the Soil Matrix That Affect Water Storage & Movement - G.R. Blake, Dept. of Soil Science (B-015-Minn.)	18,212	18,813	37,025
Pollution & the Ecology of Nearshore Periphyton of Lake Superior - T.O. Olson, School of Public Health (B-020-Minn.)	16,094	16,617	32,711
Participatory Ecology: A Study of Citizen's Groups Involved at the Grass Roots to Improve Water Resources Environment - L.P. Gerlach, Dept. of Anthropology (B-031-Minn.)	11,824	11,784	23,608
Mississippi River Ecology Associated With Heated Power Plant Effluent - A.J. Hopwood, St. Cloud State College (B-032-Minn.)	14,422	14,983	29,405

Spatial Variation in the Perception of Water Resources and Water Problems in South Central Minn. - R.T. Moline, Gustavus Adolphus College (B-042-Minn.)	3,060	3,824	6,884
Area Financing of Water Resources Development - W.R. Maki, Dept. of Agric. & Applied Economics (B-044-Minn.)	11,956	12,199	24,155
Social & Economic Factors in the Adoption by Industry of Water Pollution Control Measures - R.E. Rickson, Dept. of Sociology (B-047-Minn.)	8,871	8,699	17,570
A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minn. - J.P. Ludwig, Bemidji State College (B-049-Minn.)	16,540	14,790	31,330
TOTAL	\$112,094	\$113,167	\$225,261

ANNUAL ALLOTMENT PROGRAM

Narrative Progress Reports

OWRR Project No.: A-019-Minn.

Annual Allotment Agreement No.: 14-31-0001-3223

Project Title: Economics of Water Quality Control in the Upper-Mississippi River - Minnesota

FCST Research Category: VI-B

Name and Location of University Where Project is Being Conducted:
Univ. of Minn., St. Paul, Minn. 55101

Project Began: July 1, 1968 Scheduled Completion: June 30, 1971

Principal Investigator: J.J. Waelti Degree: Ph.D.

Discipline: Agricultural Economics

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
Robert C. Lewis	M.S.	Agricultural Economics
Sandra Schultz	Undergrad.	Agricultural Economics
Robert Anderson	Undergrad.	Agricultural Economics

Description of Research Performed and Findings, Results or Conclusions Relating Thereto:

The objective of the study was to test the hypothesis that a minimum cost management scheme can be found which will maintain the current DO river standard in the study area in a manner that is both physically and economically feasible under existing conditions. This objective was accomplished by presenting a model which combines the predicted waste assimilation capacity of the river with the results of the cost survey, and then solving this model for the least cost management scheme for achieving the current river standard in the study area. If a physically and economically feasible solution is obtained then the hypothesis is accepted, otherwise it will be rejected.

An analytical framework for combining the DO sag curve, resulting from organic waste disposal in a river, with the cost of sewage treatment was presented. From this model the least cost methods of attaining alternative levels of DO in the river were estimated. The model is most useful in the case where several sewage treatment plants are located along a river in such a manner that the DO concentration in the river decreases between successive plants, and where the treatment plants are administered under one management whose primary objective is to maintain a given river standard at minimum cost. This model can be modified to be applied to various river basin configurations with any number of sources of treated or untreated organic wastes plus any number of tributaries.

The most serious limitation of the proposed model is the extensive data on the physical characteristics of the river that are needed to specify the DO sag curve and the waste assimilation capacity of the stream. Two previous studies had been completed on the waste assimilation capacity of the Upper Mississippi River and, as a result, the necessary physical data were available for the section of the river in and below the Twin Cities.

As formulated for this analysis, the model is only applicable to situations where the total annual cost function of each sewage treatment plant is linear in the relevant range of percent BOD removed. The available empirical evidence and the discussions with plant operators supported the contention that the cost function of each of the five sewage treatment

plants in the study area is approximately linear between 35% and 90% BOD removed. If in other situations the cost curves of the treatment plants are not linear a reformulation of the constraints would be necessary in order to obtain a least cost linear programming solution.

With the acceptance of the hypothesis it can be concluded that the change in the institutional structure adopted by the Minnesota Legislature will lead to a more efficient allocation of treatment expenditures at the five municipal treatment plants in the study area. This increase in the efficiency will make it possible for the river standard to be maintained with an increase of total annual treatment costs for this stretch of the river of less than 5%.

It was determined from the oxygen profile in the study area that the location of the outfall of waste dischargers with respect to the DO sag curve in the river is an important, but apparently neglected, facet of the river pollution problem. In this study it was found that only primary waste treatment would be required in order to maintain the current DO river standard at the St. Paul Park and Cottage Grove treatment plants since they are located downstream from the low point of the DO sag curve. However, even though secondary treatment at these two plants is not needed to maintain the current river standard, the benefits of secondary treatment at these plants may exceed the additional cost in which case it would be desirable to continue primary and secondary treatment.

The determination of the highest possible DO standard that can be maintained in the study area with existing facilities indicates that more waste removal than is currently possible will be required if the river standard is to be maintained at any level above 3.43 mg/l of DO at the SCD flow.

The solutions obtained under alternative water quality standards should be useful as a planning device. The increases in the amount of waste removal at the treatment plants will most likely occur in increments as expansion of the plants takes place. Upon the completion of each expansion of treatment facilities, the proposed framework of analysis can be solved under the new situation, and the results can be used to guide the future course of action. Thus, by utilizing the model, agencies like the proposed Sewer Service Board can zero in on the least cost management scheme.

Project Related Publications:

- Waelti, J.J. 1969. Understanding the Water Quality Controversy of Minnesota. Agricultural Extension Service, Univ. of Minn. 28 p., 16 fig., 2 tab., 18 ref.
- Waelti, J.J. and R.C. Lewis. 1969. Some Economic Aspects of Water Quality. In Minnesota Science, Agric. Experiment Station, Univ. of Minn., 2 p.
- Lewis, R.C. 1970. The Marginal Costs of Alternative Levels of Water Quality in the Upper Mississippi River. Univ. of Minn., Water Resources Research Center, Bull. 25. 59 p., 12 fig., 6 tab., 37 ref.

Statements of Project Work Remaining to be Accomplished: None

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

None

OWRR Project No.: A-020-Minn.

Annual Allotment Agreement No.: 14-31-0001-3223

Project Title: Evaluation of Selected Computer Programs in Hydrology

FCST Category: II-E

Name and Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1968 Scheduled Completion: June 30, 1971

Principal Investigator: C.E. Bowers Degree: M.S.

Discipline: Civil Engineering

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
A.F. Pabst	M.S.	Civil Engineering
S.P. Larson	B.S.	Civil Engineering
N.V. Pundarikathan	M.S.	Civil Engineering
L. Muller	B.S.	Civil Engineering
C. Henningsgaard	B.S.	Civil Engineering
H. Peterson	Undergrad.	Civil Engineering

Description of Research Performed and Any Findings, Results, or Conclusions Relating Thereto:

The objective of the study is an evaluation of some existing computer programs and mathematical models in the field of hydrology. Currently, many individuals and organizations are developing new models and programs. While this is commendable, there appears to be a need for wider use of these developments by design engineers. That this has not occurred is due in part to: (1) a lack of communication between the research and design groups; (2) failure to make some developments available in readily usable form; and (3) reluctance on the part of designers to depart from established techniques.

At the International Hydrology Symposium held at Fort Collins in 1967, considerable concern was indicated on the part of consulting engineers as to the lack of communication between the researchers and the practicing engineers. While the results of research are usually published, they may not be readily usable for design purposes. Further, considerable work is necessary to compare various programs, arrive at the selection of one which might be used for specific design problems, and develop confidence in the applicability of the program or method to critical design problems. As a result, the application of research lags very far behind the current research efforts.

In some instances, government agencies have prepared programs for specific areas in which they are interested, and have made them available to cooperating organizations. Examples of this are the Hydrologic Engineering Center of the Corps of Engineers, the U.S. Geological Survey, the Bureau of Public Roads, and the Soil Conservation Service. In some instances, the primary effort has involved preparation of digital computer programs to assist in the solution of established hydrologic procedures. In others, the established methods may be involved, with optimization techniques used to assure the best solution. In still others, new procedures are developed. Relative to the present project, the primary effort has been devoted to the following: (1) review of the literature and published information on programs in hydrology and hydraulics; (2) contacting of organizations and individuals relative to program listings and source decks; (3) review and study of programs received, and (4) use of selected programs to assist in

evaluating their characteristics. As a result of these efforts information has been received on approximately 200 programs. Of these 22 programs were selected for use on a CDC 6600 computer. Detailed abstracts on these plus several other programs have been prepared and included in a project report on this study. The report will be reproduced in very limited quantity with the recommendation that the Minnesota Water Resources Research Center reproduce it for distribution.

Results of the study indicate that many design oriented computer programs in hydrology are available and that substantial savings would result from sharing of these programs. In most instances programs generated by Federal agencies are available for use by cooperating agencies although a fee may be required to cover cost of preparation and mailing of source decks.

The Hydrologic Engineering Center of the Corps of Engineers deserves special credit for the documentation and availability of programs that they have developed and for the training courses that are provided for Corps of Engineers and other government employees.

With regard to specific programs, those concerning hydrograph computation and routing and water surface profiles by the HEC, SCS, TVA and the USBR were of special interest. These should be very valuable to both government and private engineers. Also of interest are the programs concerning the flood frequency analysis by the log-Pearson Type III method.

The programs actually implemented ranged up to 8000 input statements in size. As an illustration of some of the programs included in the review and described in the annotated list of programs, the following examples may be of interest:

SCS: TR 20 - Project Formulation Hydrology

This program was developed to assist planners in making complete studies of a watershed by analyzing a greater number of alternatives. Its aim is to cut down overall project costs by finding the most economical solution. The program is capable of computing surface runoff from sub-areas of a given watershed due to a natural or synthetic rainstorm. The runoff hydrographs can then be combined and routed through stream channels and/or reservoirs. Although the program is large (126000 storage locations), the input data is kept to a minimum and is easy to understand. This program would be very beneficial to individuals or agencies who wish to analyze rainfall-runoff problems.

HEC: Flood Hydrograph Package. No. 23-270. December 1968, by Leo R. Beard

All ordinary flood hydrograph computations associated with a single recorded or hypothetical storm can be accomplished with this package. Routines include rainfall-snowfall-snowpack-snowmelt determinations, computations of basin precipitation, unit hydrographs, and of hydrographs, routing by reservoir, storage lag, multiple-storage, straddle stagger, Tatum and M Muskingum methods, and complete stream system hydrograph combining and routing. Best-fit unit hydrograph, loss-rate, snowmelt, base freezing temperatures and routing coefficients can be derived automatically. Automatic plot routines are also provided.

Methods: Unit hydrograph derivation is done by the instantaneous unit hydrograph method and Snyder coefficients are obtained. Snowmelt determinations are made by either the degree-day method or the energy budget method. Loss rates are computed using either an initial and uniform loss rate coefficients or routing coefficients is accomplished by means of an optimization subroutine utilizing the Univariate Method.

Program Specifications: Written in FORTRAN IV

Equipment Details: Program utilizes about 32,000 words of core.

Input-Output: Card input and printer output.

Additional Remarks: This program is a combination of a number of smaller programs for more efficient use, maximum flexibility and ease of operational control. Also some routines have been developed which were not available in any of the other programs. Programs combined in this program are:

23-J2-L211, 23-J2-L226, 23-J2-L223-J2-L231, 23-J2L232, and 23-J2-L237.

U.S.B.R.: 133-Water Surface Profile Computation. (CDC 6600), File No. HY 204

Computes water surface profile of natural streams by utilizing Bernoulli's theorem to obtain a balance of energy within successive stream reaches. Ref. USBR Guide for Computing Water Surface Profiles. Author: Region 2, Language: Fortran IV, Storage: 200,000 words (Dec), Computer: CDC 6600.

TVA: Program SOCH, Simulated Open Channel Hydraulics - Data Originator Unsteady Flow Staff, Tenn. Valley Authority, Flood Control Branch, Knoxville, Tenn. Programmers: James W. Vinyard, Inda M. Smith, 205 OPO-C, Ext. 2031

The program uses the basic differential equations of continuity and momentum which are solved by a centered finite-differences scheme. It computes the stage (elevation), discharge, and velocity at predetermined intervals of time and space throughout a reservoir or river channel.

The Geometry of the stream or reservoir is described at fixed distance intervals (DX) by tables of flow area, (hydraulic radius)^{2/3} and width all versus elevation. The cross-sections used to make up these tables are equidistant apart and should represent fairly well the average cross-section for a reach 2DX long. The program is limited to 91 tables describing the geometry of 91 cross-sections. Each cross section is described in the table by a maximum of 21 entries of area, (hydraulic radius)^{2/3}, and width all versus elevation. A maximum of 3 different elevation increments can be used in the 21 entry tables.

The knowledge of the availability of computer programs covering a variety of topics in hydrology can lead to improved water resources management. As an example, the availability of flood frequency and water surface profile computer programs are of paramount importance to a realistic flood plain mapping project. Flow simulation programs may be used to study the effects of alternate methods to reduce flooding losses, or improve water quality.

Project Related Publications:

A Review of Computer Programs in Hydrology, by C. Edward Bowers, Arthur F. Pabst, and Steven P. Larson, St. Anthony Falls Hydraulic Laboratory, Project Report No. 124, June 1971 (200 p.)

Computer Program for Statistical Analysis of Floods by Log-Pearson Type III Method, by C. Edward Bowers, A.F. Pabst, and S.P. Larson. St. Anthony Falls Hydraulic Laboratory Computer Program No. 1, July 1970, 20 p.

Statements of Project Work Remaining to be Accomplished: None

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:
None

OWRR Project No.: A-021-Minn.

Annual Allotment Agreement No.: 14-31-0001-3223

Project Title: Water Resources Administration in Minnesota

FCST Research Category: VI-E

Name and Location of University Where Project is Being Conducted:
University of Minnesota, St. Paul, Minnesota 55114

Project Began: July 1, 1969 Scheduled Completion: June 30, 1972

Principal Investigator: W.C. Walton Degree: B.S.

Discipline: Water Resources Student Assistant: D.L. Hills

Degree: B.S. Discipline: Water Resources

Description of Research Performed and Findings, Results or Conclusions Relating Thereto:

The inventory and appraisal of State water and related land resources administration, legislative process and policies in Minnesota as of December 1970 were completed. Information generated by the research project was published as a Bulletin and widely distributed throughout Minnesota. Recommendations were made concerning reorganization of State agencies and needed State policies. The results of the research project assisted the 1971 session of the Legislature in its consideration of legislation pertaining to water and related land resources. Some progress was made in inventorying and appraising Federal water and related land resources administration and policies as they pertain to Minnesota.

Minnesota's State government contains at least 46 departments, agencies, boards, commissions, committees, etc. which have responsibilities in the water and related land resources field. There are over 640 pages of State statutes dealing with these organizations. The most active organizations are: Department of Conservation, State Planning Agency, State Board of Health, Water Resources Board, Resources Commission, State Soil and Water Conservation Commission, and Pollution Control Agency.

Total expenditures (State and Federal funds) by State agencies associated with water and related land resources programs increased from about \$5.7 million in fiscal year 1950 to \$31.9 million in fiscal year 1970. About 86 percent of expenditures in fiscal year 1970 were made by the Department of Conservation. About 83 percent of expenditures consisted of State funds. Total State agency staff complements associated with water and related land resources increased from about 1,100 in fiscal year 1960 to 1,400 in fiscal year 1970. In fiscal year 1970, about 84 percent of the total staff complement was in the Department of Conservation.

The Governor's and Legislature's control of the State administrative apparatus for water and related land resources is hampered through fragmented organization. No formal State mechanism exists for effectively coordinating the activities of Departments, Agencies, Boards, Commissions and Committees. More than one State agency has responsibilities in most functional areas and responsibilities of State agencies overlap. The Principal Investigator concludes that reorganization consisting of: the consolidation of major administrative functions associated with water and related land resources within the Department of Natural Resources, the creation of an Environmental

Quality Commission, the creation of an Environmental Council in the Governor's office, the broadening of the duties and responsibilities of the Minnesota Resources Commission, and the abolishment of the Pollution Control Agency, Water Resources Board and Soil and Water Conservation Commission.

In the State Senate, the prime responsibility for water and related land resources in 1969 rested largely with the following Standing Committees: Game and Fish, Public Domain, and Civil Administration and Metropolitan Affairs. In the House, prime responsibility rested with the following Standing Committees: Conservation, and Land and Water Resources. About 10 percent of all bills introduced in the 1969 Session of the Legislature (263 bills) pertained to water and related land resources. About 23 percent of these bills were enacted into law. Many bills would amend or repeal existing statutes and 77 percent of all water and related bills passed were associated with the activities of the Department of Conservation.

State water and related land resources policy in large part is scattered as formal declarations of policy and statements in existing codified and uncodified laws. There is need to consolidate major policies so their visibility can be improved, they can be considered as a whole body, and inconsistencies and deficiencies in light of environmental concerns can be minimized. There are many new specific policies which the State should consider including in a comprehensive policy Act. The absence in Minnesota of a comprehensive environmental policy leaves the State ill-equipped to exert desirable effect on environmental quality. A comprehensive water and related land resources policy must be part of an overall environmental policy which the State lacks. The State should adopt a broad environmental policy patterned after the National Environmental Policy Act of 1969 (Public Law 91-190).

Project-Related Publications:

W.C. Walton, and D.L. Hills. 1971. Water and Related Land Resources State Administration, Legislative Process and Policies in Minnesota, 1970. Water Resources Research Center, University of Minnesota. Bulletin 27. 344 p., 19 fig., 18 tab.

Statement of Project Work Remaining to be Accomplished:

The Principal Investigator must study and report on Federal water and related land resources administration and policies as they pertain to Minnesota, and the activities of environmental oriented voluntary organizations.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

A report on Federal water and related land resources administration and policies as they pertain to Minnesota will be completed.

OWRR Project No.: A-022-Minn.

Annual Allotment Agreement No.: 14-31-0001-3023

Project Title: Zooplankton Biomass and Incipient Eutrophication in Lake Superior

FCST Research Category: V-C

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1969 Scheduled Completion: June 30, 1972

Principal Investigator: T.A. Olson Degree: Ph.D.

Discipline: Public Health

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
John Conway	B.S.	Public Health
Robert Parker	M.S.	Public Health

Description of Research Performed and Findings, Results, or Conclusions Relating Thereto:

Preliminary zooplankton samples were collected with the Clarke-Bumpus nets in the Larsmont area (an area representing open-water conditions in Lake Superior). Special calibrations were completed on the Clarke-Bumpus units.

The validity of single samples and the uniformity of a series of samples obtained with the Clarke-Bumpus Plankton Sampler as well as the reliability and uniformity of this device from the standpoint of its mechanical operation has been questioned by a number of modern investigators. A sampler of this type was needed for studies. It seemed logical as an initial step to undertake a first hand investigation of the actual capabilities of this sampler. Since most of the critics had found fault with field operation, which related to the mechanical functioning of the sampler, this aspect was examined first. It was discovered that the sampler functioned perfectly well if one was willing to give it a minimum amount of attention including certain adjustments. The most important of these was the trigger spring tension. Instrument calibration was the next undertaking. These tests were conducted primarily at the St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis and at the Limnological Research Station, University of Minnesota, Duluth. Three Clarke-Bumpus instruments were calibrated. The volume filtered per revolution for these three instruments was 3.9, 5.0 and 4.5 liters respectively. At a velocity of one foot per second filtration efficiencies were 85 percent for a number two net, 81 percent for a number ten net and 70 percent for the number 20 net. When Mississippi River water was used, clogging was negligible with the number two and ten nets. However, with the number 20 net, clogging reduced the volume of water accepted by 12.5 percent. Shutter angles up to 12 degrees relative to the direction of flow did not affect the volume of water filtered. With methods and materials used, the attempts to calibrate instruments in the field were unsuccessful. A formula was developed which expresses the filtering efficiency of the Clarke-Bumpus sampler with various types of nets attached. This formula is based on the geometry of the net and the towing speed. In its simplest form it is written as follows:

$$\frac{Q_0}{Q_{POT}} = \frac{T^2}{1 + T^2(f + 1)} \cdot \frac{1}{2}$$

Lake Superior's zooplankton comprise one segment of its aquatic ecosystem which might be expected to undergo qualitative and quantitative transformations in populations as a response to enrichment of the waters. For this reason, it would appear desirable to study this group of organisms more intensively. Furthermore, it would be of special interest to determine whether or not detectable increases in biomass and differences in species composition occur in near shore areas of Lake Superior where localized regions of developing eutrophication may be anticipated. The investigations concerned with zooplankton biomasses may provide useful supplemental information on the relationship between productivity in open lake water conditions and the production in areas where moderately enriched zones may develop. The zooplankton data, together with other information already available, would provide a more complete picture of the lake's biota and its aquatic environment.

When the entire period of this study has been completed it is expected that the information can be related to practical and immediate problems such as pollution by tributaries and special waste contributions such as those made by industrial operations. The study will have its greatest value in establishing a baseline for the present period. Data from such studies may then be used for comparisons in evaluating potential advances in various types of eutrophication.

Project Related Publication:

Conway, J.B., F.R. Schiebe, T.A. Olson and T.O. Odlaug. June 1971. A Practical Evaluation of The Clarke-Bumpus Plankton Sampler and Suggestions for its Use. University of Minnesota, School of Public Health, Limresta, Research Report No. 1. 28 p., 5 fig., 4 tab., 17 ref.

Statements of Project Work Remaining to be Accomplished:

This is the second year of a three year study. On the basis of the first two seasons there seems to be no reason for a change in our procedures; therefore, we will continue with the original plan. As indicated at the outset the research proposed will be more detailed than the earlier background studies and will be restricted to the western arm of Lake Superior. Since a special effort will be made to relate the work to slight differences in water masses, three basic study areas have been selected:

The Duluth-Superior Harbor area represents a region which receives appreciable additions of St. Louis River water mixed with polluted water from the inner port areas and a considerable amount of industrial wastes originating far upstream. This is one region where studies will be done. In the second area at Larsmont, which better represents the open water conditions, we have a region which has been under observation for more than 12 years. Past studies have dealt principally with physical and chemical aspects of the water masses in that region.

During the summer of 1970, preliminary zooplankton samples were collected with the Clarke-Bumpus nets in the Larsmont area. Special calibrations have now been completed on the Clarke-Bumpus units and more intensive studies will be done in the Larsmont region in 1971. The data collected will be analyzed for their possible relationships with thermal regimes, light transmission and other water quality characteristics.

The third sampling area will be in the Grand Marais - Isle Royale region which represents the clearest water found in western Lake Superior. The latter station will be used for comparative purposes and the sampling program there will probably depend on Coast Guard cooperation and assistance. Contingent upon such arrangements the final schedule will be determined.

The work in this region planned for the summer of 1971 will be directed toward the examination of zooplankton populations and their relationship to the physical and chemical parameter which have previously been studied and are known. The speed of the water currents southward along the North Shore is known for earlier work. Using this information, attempts will be made to identify the Grand Marais - Isle Royale water mass when it arrives in the Larsmont area.

During the last year of the project, the area of the lake adjacent to the Duluth-Superior harbor will be investigated. Zooplankton data from this region will be compared with results from the Grand Marais - Isle Royale vicinity and from the Larsmont stations. Such comparisons will be of interest in interpreting and evaluating water quality conditions as reflected by zooplankton concentrations.

In the studies envisioned, biomass determination and productivity measurements will be carried on throughout the open water season and total wet volume, organic matter of the biomass, enumeration and general identification of organisms and other pertinent determinations will be made on the samples. Data obtained by the use of the Clarke-Bumpus sampler can then be compared with previous results of zooplankton analyses which utilized the Miller High Speed sampler, Hardy Plankton Indicators, and the C. P.R. (see related publications list). If this is properly done it should be possible to profitably relate the work to the geographically more extensive C.P.R. studies already completed by us on the lake as a whole.

Supplementary studies which can be helpful in the interpretation of data and complementary to the main effort will include vertical phytoplankton profiles in selected areas and a limited number of associated pigment (chlorophyll) analyses. In part some of this work has already been carried out and results presented in an earlier report.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

The summer and fall period is the time usually devoted to field work and sample collecting. It is expected that the processing of the zooplankton samples, i.e., taxonomy and tabulation of data will be done during the winter period. It is anticipated that summer sampling will provide the basic materials to provide a body of data which is representative and meaningful and which will make it possible next year to successfully conclude the study.

OWRR Project No.: A-023-Minn.

Annual Allotment Agreement No.: 14-31-0001-3223

Project Title: Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics

FCST Research Category: II-E

Name and Location of University Where Project is Being Conducted:
University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1970 Scheduled Completion: June 30, 1972

Principal Investigator: C.L. Larson Degree: Ph.D.

Discipline: Agricultural Engineering

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
Alfred G. Pennell, Jr.	B.S.	Agricultural Engineering
Russell G. Mein	M.S.	Agricultural Engineering
Eugene Thies	Undergraduate	Agricultural Engineering
Terry Hüntrods	Undergraduate	Agricultural Engineering

Description of Research Performed and Findings, Results or Conclusions Relating Thereto:

The first phase of the project is an inventory of watershed rainfall-runoff records for possible use in the study. Several months were devoted to this and this phase of the project has been completed. The work was carried out mainly by studying existing publications of the various federal agencies concerned with hydrology or water resources. The hydrologic data collected and published by the Agricultural Research Service were found to be very useful because:

- (1) Small watershed runoff measurements have been made on a regular basis over substantial period of time, up to about 30 years.
- (2) Several research watersheds are used in each of a number of study areas located in different sections of the U.S. Each study area has more or less uniform hydrologic conditions.
- (3) The rainfall measurements associated with each runoff event are given along with the runoff event.
- (4) The rainfall and runoff data are tabulated by small time increments as needed for hydrologic analyses on small watersheds.

The inventory prepared for the project includes a listing of the research location, data collecting agency, watershed name or number, watershed size, period of record and number of significant runoff events. The inventory was prepared in two groupings: watersheds under 100 acres and those of 100 acres or more.

Analysis has been underway to evaluate the hydrograph parameter time to virtual equilibrium (T_{ve}) proposed and developed in earlier studies with mathematical models. A procedure has been developed for determining the approximate time distribution of runoff supply (rainfall excess) and representing this by either a rectangular or triangular time distribution, as appropriate. Those events with a peak flow exceeding 50% of the mean supply rate are analyzed further to evaluate T_{ve} and/or T_{50} , the time to

50% of equilibrium, and their variation with supply rate. Results to date indicate that the latter may be used either directly or as a means of determining time to virtual equilibrium. Analyses have been completed on the ARS watersheds over 100 acres in size at Coshocton, Ohio and at Riesel, Texas and analyses at other locations are being carried forward.

The results of this study will be part of a continuing effort by the Principal Investigator and associates to develop a reliable method for predicting peak watershed runoff by the use of rainfall data and measurable watershed characteristics. Such a method is badly needed to improve the design of the hundreds of highway culverts, small bridges, erosion control structures, channel modifications, grass waterways, storm sewers, etc., installed each year in the United States.

Project Related Publications: None

Statements of Project Work Remaining to be Accomplished:

The analysis of data for evaluation of the watershed time parameter will be completed for several additional locations. This may require travel to one or more of the locations to obtain the use of the original records. Additional data on key physical characteristics of the watersheds will be collected and related to the watershed parameter. The analyses of the runoff data as applied to the peak flow method remains to be completed. In this phase of the study, observed peak flows will be compared to predicted values for testing and modifications, if necessary, of the general method.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

The analysis of data for evaluation of the watershed time parameter will be completed for several additional locations. Additional data on key physical characteristics of the watersheds will be collected and related to the watershed parameter.

OWRR Project No.: A-024-Minn.

Annual Allotment Agreement No.: 14-31-0001-3223

Project Title: Mathematical Simulation of a Larger Watershed Using the Systems Approach to Quant. and Qual. Analysis

FCST Research Category: VI-A

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973

Principal Investigators: C.S. Song and C.E. Bowers Degrees: Ph.D. & M.S.

Discipline: Civil Engineering

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
A.F. Pabst	M.S.	Civil Engineering
S.P. Larson	B.S.	Civil Engineering
Eart Bancroft	Undergrad.	Civil Engineering
Gary Lake	Undergrad.	Civil Engineering

Description of Research Performed and any Findings, Results, or Conclusions Relating Thereto:

It is generally recognized that a river basin or a watershed may be considered as a natural unit for which the water resources system may be studied. This is particularly true when the engineering aspect of the water resources system is considered. Recognizing the importance of the optimum use of the water resources and encouraged by the Office of Water Resources and other governmental agencies, research activities related to the water resources management have increased in the recent years. Because of the extremely complex nature of the problem much more research effort is needed.

Much progress has been made on simulation of the quantity of the surface water flows in artificial and natural waterways after rain storms. However, these mathematical models are usually quite complicated but not general enough to take into account, for example, seasonal variation of the land use, physical condition of the land as influenced by the previous precipitation, snow, and frost. Different models are usually required for flood routing and long range water yield simulation. Ground water flow and storage which is an important part of the overall water movement also greatly complicates the problem. The progress in the simulation of the quality of water in a watershed is even slower. Since the movement of the pollutants is intimately related to the quantity of the flow, the simulation of the quality cannot be separated from the simulation of quantity. Furthermore, as the occurrences of precipitation and pollutants as well as the physical condition of the watershed are stochastic in nature, a meaningful simulation or optimization of a water resources system must also be stochastic in nature. It is therefore necessary to develop a comprehensive model based on the deterministic physical principle of the fluid motion as applied to stochastic inputs and constraints.

Therefore, it is the objective of this study to develop a mathematical model of a watershed, including the quantity and the quality of water and considering variables such as the surface and ground water flow, the storage, municipal and agricultural use, municipal and industrial wastes, agricultural pollutants, and the stochastic nature of rainfall and snow. The

model will be developed with the specific example of the Minnesota River watershed in mind to facilitate verification and application. The immediate objectives are twofold:

- a. To develop a comprehensive simulation technique for the engineering aspect of water resources systems which may be applicable to many medium sized watersheds, and
- b. Direct application of the model to Minnesota River watershed for the verification and continual improvement of the model as well as to benefit the state of Minnesota.

During the first year of the study and in accordance with the research plan, available literature on the subject has been reviewed, including available mathematical models that may be of interest in this study. Of special interest is the SSARR model developed by the Corps of Engineers and the National Weather Service. To date this model has been applied to several large watersheds in the Pacific Northwest and in Southeast Asia. It has been used to simulate streamflow on a continuous synthesis basis for planning, design, operation and forecasting purposes.

To date, a source deck has been obtained and the model compiled on the University's CDC 6600 computer system. A test problem supplied with the program has operated satisfactorily and the model is apparently ready for operation. Data are now being assembled and placed on computer cards for the first year's operation.

The initial objective will be to properly simulate a large midwestern watershed, the Minnesota River watershed. If satisfactory results can be obtained in the simulation of water quantity, work will be undertaken on water quality simulation. This may provide more of a problem than quantity due to the fact that input data for the model are quite limited.

Associated with the overall development of this and related studies, the National Weather Service and the U.S. Geological Survey have been contacted relative to procurement of input data on magnetic tape. So far this does not seem to be within the financial limitations of the project.

In addition to the SSARR model consideration has been given to other existing models and to the development of a special model as part of this study. Further development along this line will depend on results with the SSARR model and on studies of optimum time increments to be used in input and analysis of data.

The mathematical model can be used as a tool for forecasting the quantity and quality of flow at selected locations for studying the systems response to future water resources projects, and for systems analysis to achieve optimum management.

Project Related Publications: None

Statement of Project Work Remaining to be Accomplished:

- a. Final selection or development of quantity simulation model.
- b. Addition of quality relationships to the model.
- c. Statistical analysis of precipitation, runoff, and the quality of water in the system using all available records. Response of the system model to the stochastic input and its comparison with the runoff data.

d. Perform systems analysis using the mathematical model as the basic tool and the cost-benefit ratio as the objective function. Political, sociological, and economical aspects of the system will not be studied in detail but will be considered in defining the constraints.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Items a and b above will be emphasized during the remainder of the calendar year.

OWRR Project No.: A-025-Minn.

Annual Allotment Agreement No.: 14-31-0001-3223

Project Title: Alleviation of Lake Pollution by Utilization of Aquatic Plants For Nutritional, Medicinal or Industrial Purposes

FCST Category: V-E

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973

Principal Investigator: E.J. Staba Degree: Ph.D.

Discipline: Pharmacognosy

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
K. Su	B.S.	Pharmacognosy
S.L. Bechdolt	Undergraduate	Pre-Med
D. Mills	Undergraduate	Biology
R. Tukey	Undergraduate	Biology
J.K. Weston	Undergraduate	Biology

Description of Research Performed, and Findings, Results or Conclusions Relating Thereto:

Twenty-two aquatic plants were collected from various Minnesota lakes. Extracts were made and studied for the presence of alkaloids, flavonoids, steroids and lipids. Alkaloids are present in Nymphaea tuberosa and Nuphar variegatum. Flavonols and flavanones were often present in the plants studied whereas anthocyanidine and aurones were not. Beta-sitosterol was present in eight and saponin in five of the plants studied, but neither cardenolides nor 3- or 17-oxo-steroids were present in the plants surveyed. Potamogeton natans, Sagittaria latifolia and N. tuberosa contained relatively higher total lipid contents (5.35, 5.24 and 3.91 weight % of dried plant material, respectively).

Skellysolve F, chloroform, 80% ethanol, acidic and basic water extracts of 22 Minnesotan aquatic plants were studied for their pharmacological potentials. The most toxic plants were 50% ethanol extracts of Nymphaea tuberosa and Ceratophyllum demersum with LD₅₀ values of 6±1.88(leaf), 3±1.13 (stem) and 4.25±0.68 gm of dried plant material/kg, respectively on Swiss Webster mice. In vivo anti-neoplastic activity of extracts was studied on golden Syrian hamsters transplanted with melanoma cells. Stem extract of N. variegatum contained a degree of anti-neoplastic activity. The results of CCNSC (Cancer Chemotherapy National Service Center) screening indicate that N. tuberosa (stem) extract had some effect against L-1210-lymphoid leukemia in CDF₁ mice but was toxic. Extracts of C. lacustris, Myriophyllum exalbescens, N. tuberosa and N. variegatum prolonged both prothrombin and partial thromboplastin time of Swiss Webster mice blood.

Project Related Publication:

G. Su. June 12, 1971. Phytochemical, Pharmacological and Antimicrobial Screening of Minnesotan Aquatic Plants. Ph.D. Thesis, University of Minnesota, Department of Pharmacognosy. 158 p., 25 tabs, 13 figs., 343 ref.

Statements of Project Work Remaining to be Accomplished:

To date, initial chemical and biological screens have been applied to approximately 24 Minnesotan aquatic plants. Detailed chemical, nutritional, and Pharmacological tests remain to be done on those plants that

appear most promising. Encouraging results have appeared in the area of anticoagulant and antimicrobial activity.

Additional Project Progress Contemplated for the Remainder of the Calendar Year:

A study of 24 Minnesotan aquatic plant for possible use in animal nutrition is planned. Data revealing dry matter, crude protein, lignin, cellulose content, etc., and estimated apparent digestability values will be obtained. If the data is encouraging, nutritional experiments with ruminants (sheep) will be designed.

OWRR Project No.: A-026-Minn.

Project Title: Phytoplankton Nutrition and Photosynthesis in Eutrophic Lakes

FCST Research Category: V-A

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: R.O. Megard Degree: Ph.D.

Discipline: Limnology

Project Progress Contemplated for the Remainder of the Current Year:

Analyses of algal nutrition, photosynthesis, and population densities in Lake Minnetonka, Lake Shagawa, Lake Sallie and Lake Shetek will be made. Some progress will be made in evaluating nutritional status and the kinetics of nutrient uptake.

OWRR Project No.: A-027-Minn.

Project Title: Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management

FCST Research Category: VII-A

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: H.O. Pfannkuch Degree: Ph.D.

Discipline: Hydrogeology

Project Progress Contemplated for the Remainder of the Current Year:

Some progress will be made in constructing a simple decision model for a hypothetical groundwater basin. Available information concerning what data is needed in groundwater resources investigations will be collected and processed.

MATCHING GRANT PROGRAM

Narrative Progress Reports

OWRR Project No.: B-012-Minn.

Matching Grant Agreement No.: 14-01-0001-1914

Project Title: Development of a Mathematical Model to Predict the Role of Surface Runoff and Groundwater Flow in Overfertilization of Surface Waters

FCST Research Category: V-B

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1968 Project Ended: December 31, 1970

Principal Investigator: C.P. Straub Degree: Ph.D.

Discipline: Public Health

Student Assistants: Degree: Discipline:
Jack D. Johnson M.S. Public Health

Description of Research Performed and Any Findings, Results, or Conclusions Relating Thereto:

A nutrient enrichment accounting mathematical model was devised for the New Prague watershed in Minnesota. The New Prague watershed is 23.3 square miles in area and is predominately a rural watershed. Model input data was collected over a 2 1/2-year period from a stream gaging station and two automatic sampling stations. Over 800 water samples were analyzed. Extensive effort was placed on better understanding the nitrogen and phosphorus cycles. It is evident that the spring runoff process and accumulative winter fertilizer applications constitute the major portion of diffuse sources of nutrients in the watershed. Point sources from feedlots and municipal and industrial effluents contribute only 11 percent of the annual EN (total nitrogen, four components) and 7 percent TP (total phosphorus). Disperse sources accounted for 89 percent of EN and 93 percent of TP, with spring runoff in the two months of March and April accounting for 79 percent of the annual EN and 64 percent of the TP. The nutrient output from the watershed could be decreased by increasing penetration of the large amounts of EN and TP in snowpacks into the soil through land terracing to retard rapid spring runoffs and sub-surface drains to allow rapid drainage during the crop season.

Project Related Publication:

Johnson, J.D. and C.P. Straub. 1971. Development of a Mathematical Model to Predict the Role of Surface Runoff and Groundwater Flow in Overfertilization of Surface Waters. Univ. of Minn., Water Resources Research Center, Bulletin 35. 176 p., 57 fig., 65 tab., 78 ref.

Statements of Project Work Remaining to be Accomplished: None

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

None

OWRR Project No.: B-013-Minn.

Matching Grant Agreement No.: 14-01-0001-1915

Project Title: Influence of Mist Irrigation on Moisture Stress, Growth Yields, and Quality of Potatoes & Other Vegetable Crops

FCST Category: V-B

Name & Location of University Where Project is Being Conducted:
Univ. of Minn., St. Paul, Minn. 55101

Project Began: July 1, 1968 Scheduled Completion: December 31, 1971

Principal Investigator: R.E. Nylund Degree: Ph.D.

Discipline: Horticulture

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
Douglas Sanders	Ph.D.	Horticulture
Ronald Schaefer	M.S.	Horticulture
John Arneman	Undergrad.	Horticulture
Barbara Soderholm	Undergrad.	Home Economics

Description of Research Performed and Any Findings, Results, or Conclusions Relating Thereto:

The influence of mid-day irrigation on the reduction of environmental water and temperature stresses in growing plants and on the plants' growth and development was studied for a third year. A growth-chamber study was conducted during the winter of 1970 to determine the influence of various time intervals (5, 10, 15, and 20 minutes) between 5-second mist applications on leaf temperature depression and recovery. Based on the results of this study, the misting interval used in the field study of 1970 was 5 seconds mist every 15 minutes (in contrast to the arbitrarily selected 8 seconds every 8 minutes used in 1969). Thus, under comparable conditions, only one-third as much water was applied using the longer time interval and shorter misting time, i.e. 0.27 cm in contrast to 0.8 cm on a typical hot, bright day of low humidity. Mist was applied only between the hours 1100 and 1500 CDT on days when the temperature during that time period was above 80°F, solar radiation intensity was greater than 1500 foot candles and leaf surfaces were dry.

Test crops grown were potatoes and snap beans. Misted, furrow-irrigated, and misted plus furrow-irrigated plots were compared with non-misted, non-irrigated plots of both species. Air temperatures in the plant canopy and leaf surface temperature were recorded in misted and non-misted plots as were periodic determinations of soil moisture and plant growth rates.

Of the data analyzed to date, the following statements can be made. In snap beans, total and marketable yields of pods were significantly increased by mist irrigation alone. Yields from plots both misted and irrigated were no higher than those from non-misted, non-irrigated controls possibly because the former may have been adversely affected by excessive soil moisture. Bean plant growth measured by plant weight was not affected by the mist and/or irrigation treatments. With potatoes, in contrast, mist alone had no effect on yields but mist irrigation increased yields over those from the other three treatments. Temperature and soil moisture data are still to be analyzed.

If it can be shown that mist irrigation during periods of high temperature and water stress prevents reduction of crop yields, such mist irrigation could conserve ground water supplies by reducing the need for conventional irrigation. Growers presently apply 1.5 inches of water every 5 days in growing crops on our sandy soils. Mist irrigation during a similar 5-day period, if applied every day, would consume approximately only one-third as much water. However, this possibility needs to be tested on sandy soils.

Project-Related Publications:

Sanders, Douglas C. 1970. "Studies on the influence of mist irrigation on the microenvironment, growth and development of the potato (*Solanum tuberosum*)". Ph.D. thesis. 112 pages, 19 tables, 12 figures, 165 references.

Sanders, D.C. and R.E. Nylund. 1970. "The influence of mist irrigation on the potato: I. Micro-environment and leaf water relations". 31 pages, 2 tables, 8 figures, 17 references. (Submitted for publication in the American Potato Journal).

Sanders, D.C. and R.E. Nylund. 1970. "The influence of mist irrigation on the potato: II. Growth and development". 20 pages, 7 tables, 14 references. (Submitted for publication in the American Potato Journal).

Sanders, D.C., R.E. Nylund and E.C. Quisumbing. 1970. "The influence of mist irrigation on the potato: III. Nutrient content of leaves". 21 pages, 7 tables, 31 references. (Submitted for publication in the American Potato Journal).

Sanders, D.C., R.E. Nylund, E.C. Quisumbing and K.V.P. Shetty. 1970. "The influence of mist irrigation on the potato: IV. Tuber quality factors". 24 pages, 3 tables, 4 figures, 18 references. (Submitted for publication in the American Potato Journal).

Sanders, D.C., P.H. Li, and R.E. Nylund. 1971. "The influence of evaporation cooling on the distribution of ¹⁴C in potato plants". 9 pages, 2 tables, 8 references. (Submitted for publication in "Plant and Cell Physiology").

Statements of Project Work Remaining to be Accomplished:

One immediate goal remains to be accomplished during the summer of 1971: to study the influence of mist irrigation on growth and productivity of snap beans and potatoes on sandy soils. A more long-range goal is to design a system of irrigation (mist and conventional) on a practical basis to maximize plant growth and yield without adversely affecting quality and that will minimize water use by plants.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

A mist irrigation experiment will be conducted on sandy soil at the University of Minnesota Sand Plain Experimental Farm at Elk River. Potatoes and snap beans will be the test crops. Three treatments will be applied: (a) mist, (b) mist and conventional sprinkler irrigation, and (c) conventional irrigation. Both mist and conventional irrigation will be applied

with two specially build plot irrigators which should provide precise control of amount and distribution of applied water. In snap beans, special attention will be paid to the influence of mist irrigation on flower bud initiation, flowering, and fruit set. In potatoes, the effects of mist irrigation on tuber initiation, tuber external characteristics, and tuber internal quality will be of special interest.

The results of the above study and the 1970 studies will be written in the form of an M.S. thesis. The papers written in 1970 will, hopefully, be published by the end of the calendar year.

OWRR Project No.: B-015-Minn

Matching Grant Agreement No.: 14-01-0001-1916

Project Title: Characteristics of the Soil Matrix that Affect Water Storage and Movement

FCST Category: II-G

Name & Location of University Where Project is Being Conducted:

Univ. of Minn., St. Paul, Minn. 55101

Project Began: January 1, 1969 Scheduled Completion: June 30, 1972

<u>Principal Investigator:</u> George R. Blake	<u>Degree:</u> Ph.D.	<u>Discipline:</u> Soil Science
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<u>Student Assistants:</u> Victor Fuentes Lalit Arya Jiwan Palta	<u>Degree:</u> M.S. M.S. B.S.	<u>Discipline:</u> Soil Science Soil Science Soil Science
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Description of Research Performed and any Findings, Results, or Conclusions Relating Thereto:

Infiltration studies were made on asphalt barrier plots by Jiwan Palta. Continuous soil moisture tensions were recorded at different depths after application of large quantities of irrigation water. The asphalt barrier was found to be less effective in increasing water storage capacity in Hubbard sandy due to presence of a coarse sand-gravel layer at 24" depth, which itself acts as a barrier until completely saturated. In Zimmerman sand, water storage capacity doubled on barrier plots, and corn yield where no irrigation was applied showed a significant increase. On Hubbard sandy loam, crop yields on barrier plots were not significantly different. However, irrigation increased yields of all crops over no irrigation.

To characterize those properties of an asphalt barrier that influence water movement, a laboratory study was conducted on samples taken from an asphalt barrier formed at a depth of two feet in Zimmerman sand. Observations of the relative stabilities of water and alcohol drops when placed on the surface of an initially dry barrier suggested that the contact angle for the pores in the asphalt barrier was greater than zero. Further observations of water transfer across the barrier showed that this transfer occurs through cracks or fissures in an otherwise impermeable layer. Laboratory experiments on water movement through a sample of an asphalt barrier, showed that, under steady state conditions, the conductivity of the barrier will be affected by the capillary potentials in the soil above and below the barrier. However, for the test sample the interdependence of flow rate and capillary potentials was limited to capillary potentials was limited to capillary potentials greater than -25 cm H₂O. When the capillary potential below the barrier was less than -25 cm H₂O, it had no apparent effect on the rate of flow nor on the equilibrium capillary potential above the barrier (~5 cm H₂O). These findings are interpreted as indicating hysteresis in the critical wetting and drying potentials needed to maintain liquid continuity within the barrier. The results of this laboratory study are in reasonable agreement with field observations of the water redistribution profiles after irrigation. The field profiles show that from three to six days after infiltration the capillary potential of the soil above the barrier remains relatively constant at ~-22 cm H₂O whereas the capillary potential at this same depth

(60 cm) in the control plot with no barrier varies from ~ -50 cm to ~ -60 cm H₂O.

Lalit Arya began a study of water extraction patterns from the soil by soybeans in the summer of 1970. He set up a 10 cm X 10 cm grid of tensiometers under soybean plants in a 90 cm X 40 cm (depth x width) place and measured soil moisture suction by means of mercury manometers. Observations were made in cycles. In each cycle first the crop was heavily irrigated and then allowed to go through a drying period over a number of days. To make sure that no additional water was received by the crop from rains, plots were covered with a shelter whenever rain was expected. During the drying period, soil moisture suction at each point (45 grid points) was recorded every 24 hours. Root distribution and soil bulk density were obtained near the end of the growing season. These studies are being expanded in the summer of 1971.

The profitable use of sandy soils for agricultural purposes is often limited by their low water holding capacity. Such soils need to be irrigated frequently but the rapid percolation of water renders surface methods of irrigation inefficient. Because many sandy soils are otherwise well suited to profitable farming several techniques for reducing deep percolation by the placement of relatively impermeable horizontal barriers within the soil are being explored. Barriers of bentonite clay or plastic film have been used but the difficulties of making continuous barriers with such materials often make them impracticable. More recently a reliable technique for forming continuous asphalt barriers down to soil depths of 60 cm has been developed.

Asphalt barriers increase water storage capacity of soils by altering hydraulic flow characteristics in the soil profile. Increases in storage capacity due to the barrier have been increased about 15 percent in Hubbard loamy sand and doubled in Zimmerman fine sand. Prolonged drought periods may not be accommodated with such increases through corn yields were increased on Zimmerman soils. It becomes evident we need more precise measurements of storage with and without barriers and then to determine on a probability basis what kinds of drought day reductions barriers will effect with and without irrigation.

The uptake patterns by soybean roots extend the known knowledge by concentrating on precise and detailed measurements. This knowledge will aid in knowing the depth and extent of exploitation of plant available water from the soil.

Project-Related Publications:

Stabilization of Newly - Formed Aggregates. L.M. Arva and G.R. Blake. 1971. 16 pages, 2 tables, 5 figures, 8 reference. Submitted to Agronomy Journal.

Water Transmission Properties of an Asphalt Barrier. J.P. Palta, G.R. Blake and D.A. Farrell. 1971. Paper prepared for presentation at Annual Meeting, Am. Soc. Agron., to be published in Soil Sci. Soc. Proc.

Statements of Project Work Remaining to be Accomplished:

A study concerning the probabilities of drought reduction by using asphalt barrier in the sandy soils of Minnesota will be made. A thesis entitled "Water Transmission Properties of an Asphalt Barrier" will be written. Field testing of asphalt barriers with respect to crop yields and water retention will be continued.

An experimental study of moisture extraction pattern of soybean plants in which shoot of our genotype have been grafted on the roots of another type have been laid out. Soil moisture suction with time will be obtained for different shoot/root combinations. Leaf water potentials at various times will be measured to establish the relationship between soil and leaf water potential. Root distribution for each combination will be obtained at the end of the experiments to see if differences in root systems significantly change the extraction pattern or whether it is the shoot system that is important. These along with transpiration data will be obtained in growth chambers to obtain the plant resistance for flow of water in different shoot/root combinations.

Additional Project Progress Comtemplated for the Remainder of the Calendar Year:

A Thesis will be prepared by Jiwan Palta, and Lalit Arya will obtain a second years data on water extraction patterns of grafted soybeans.

Matching Grant Agreement No.: 14-31-0001-3095

SUMMER 1970

Project Title: Pollution and the Ecology of Nearshore Periphyton of Lake Superior

Phylum Chrysophyta

FCST Category: V-A

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1969 Scheduled Completion: June 30, 1972

Principal Investigator: Degree: Discipline:
T.A. Olson Ph.D. Public HealthStudent Assistants: Degree: Discipline:
Robert R. Nelson M.S. Public Health
Robert D.R. Parker M.S. Public Health
Jonathan Vomachka Undergrad. Public Health
Jerrold Vitek Undergrad. Public HealthDescription of Research Performed and Findings, Results, or Conclusions
Relating Thereto:

The specific objective of this study is to determine the changes which take place in Lake Superior periphyton when polluting or enriching substances are added to the lake water. To this end, two natural rock basins have been constructed at the lakeside near Castle Danger for the purpose of exposing naturally grown periphyton to various concentrations of enriching substances; namely, phosphates and nitrates. These gabbro rock basins, situated in a clean area along the north shore, receive a constant flow of fresh water and are exposed to the same isolation and general climatic conditions as the lake itself. One pool serves as a normal lake-water control, whereas the other is the test pool, into which nutrients are added.

In carrying out this study it was necessary to undertake a detailed taxonomic identification of the organisms constituting the periphyton. This identification work was carried out on the periphyton in both pools as well as in Lake Superior itself. Since no references dealing with periphyton organisms of the area exist in the literature, it was felt that the publication of such information would be helpful to Great Lakes Investigators in general. As a result, we have prepared the checklist below to indicate the nature of the species makeup of the periphyton along Minnesota's North Shore. Since the test pool was artificially fertilized, this checklist is based entirely on organisms found in the control pool and the lake itself. The list, so restricted, should provide useful information on the natural periphyton populations of the North Shore area south of the Canadian border.

Although much has been written concerning the effects of pollution on water quality in the Great Lakes there is, with the exception of certain Canadian studies, relatively little knowledge of the role which filamentous algae growing along the shore may have in the eutrophication phenomenon. Hopefully one outcome of this study will be the implementation of a rapid method for the evaluation of the extent of eutrophication of a body of water based on shoreline characteristics of the filamentous periphyton.

Class Bacillariophyceae

Acnantes lanceolata (Brebisson) Grunow
Acnantes microcephala (Kuetzing) Cleve
Amphiprora ornata Bailey
Amphora ovalis Kuetzing
Asterionella formosa Hassall
Ceratoneis arcus (Ehrenberg) Kuetzing
Cocconeis group:
C. flexella (Kuetzing) Cleve
C. pediculus Ehrenberg
C. placentula Ehrenberg
Cyclotella antiqua Wm. Smith
Cyclotella bodanica Eulenstein
Cymatopleura solea (Brebisson) Wm. Smith
Cymbella group:
C. cistula (Hemprich) Grunow
C. lanceolata (Ehrenberg) Van Heurck
C. leptoceros (Ehrenberg) Grunow
C. parva (Wm. Smith) Cleve
C. prostrata (Berkeley) Cleve
C. ventricosa Kuetzing
Denticula thermalis Kuetzing
Diatoma hiemale (Lyngbye) Heiberg
Diatoma vulgare Bory
Diploneis puella (Schuman) Cleve
Epithemia turgida (Ehrenberg) Kuetzing
Eunotia monodan Ehrenberg var. major (Wm. Smith) Hustedt
Eunotia pectinalis (Kuetzing) Rabenhorst var. minor (Kuetzing) Rabenhorst
Fragilaria capucina Desmazieres
Fragilaria crotenensis Kitton
Frustulia viridula (Brebisson) Detoni
Gomphonema herculeana (Ehrenberg) Cleve
Gomphonema group:
G. angustatum var. obtusatum (Kuetzing) Van Heurck
G. constrictum Ehrenberg
G. geminatum (Lyngbye) C.A. Agardh
G. gracile Ehrenberg var. dicotoma (Kuetzing) Grunow
G. olivaceum (Lyngbye) Kuetzing
G. olivaceum var. calcareum Cleve
Melosira granulata (Ehrenberg) Ralfs
Melosira varians C.A. Agardh
Navicula group:
N. dicephala (Ehrenberg) Wm. Smith
N. dicephala var. elignensis (Gregory) Cleve
N. oblonga Kuetzing

*Based on studies of the near-shore areas of Lake Superior's North Shore and the Castle Danger Control Pool.

N. pupula Kuetzing
N. radiosa Kuetzing
N. reinhardtii (Grunow) Van Heurck
N. tuscula Ehrenberg
Nitzschia group:
N. denticula Grunow
N. dissipata (Kuetzing) Grunow
N. hungarica Grunow
N. linearis (Agardh) Wm. Smith
N. palea (Kuetzing) Wm. Smith
N. vermicularis (Kuetzing) Hatzsch
Pinnularia group:
P. cardinalis (Ehrenberg) Wm. Smith
P. major (Kuetzing) Wm. Smith
P. viridis (Nitzsch) Ehrenberg
Rhizosolenia eriensis H.L. Smith
Rhoicosphenia curvata
Stauroneis anceps Ehrenberg var. anceps
Stauroneis obtusa Lagerst
Stephanodiscus sp.
Surirella angusta Kuetzing
Surirella linearis Wm. Smith
Surirella sp.
Synedra group:
S. acus Kuetzing
S. rumpens Kuetzing
S. ulna (Nitzsch) Ehrenberg
Tabellaria fenestrata (Lyngbye) Kuetzing
Tabellaria flocculosa (Roth) Kuetzing

Class Chrysophyceae

Dinobryon sertularia Ehrenberg
Dinobryon sp.

Phylum Chlorophyta

Chlamydomonas spp.
Cosmarium sp.
Mougeotia sp.
Oedogonium sp.
Pediastrum duplex Meyen
Pithophora sp.
Scenedesmus obliquus (Turpin) Kuetzing
Scenedesmus quadricauda (Turpin) Brebisson
Schizomeris leibleinii Kuetzing
Selenastrum sp.
Staurastrum sp.
Ulothrix tenerrima Kuetzing
Ulothrix zonata (Weber & Mohr) Kuetzing
Stigeoclonium subsecutum Kuetzing

Phylum Cyanophyta

Aphanothece microspora (Menegh) Rabenhorst
Chroococcus minor (Kuetzing) Naegeli
Lynbya martensiana var. calcareo Tilden
Merismopedia convoluta Brebisson
Oscillatoria tenuis C.A. Agardh
Oscillatoria sp.
Plectonema wollei Farlow

Project Related Publications: None

Statements of Project Work Remaining to be Accomplished:

The work which remains to be done will consist primarily of a quantitative analysis of the effect of artificial enrichment on the periphyton succession and biomass production in experimental pools charged with Lake Superior water.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Most of the field activities have been essentially completed. For the remainder of the calendar year, major efforts will be directed toward an analysis and evaluation of the data including periphyton counts, chlorophyll determinations, and the analyses of the organic matter produced in the pools.

OWRR Project No.: B-031-Minn.

Matching Grant Agreement No.: 14-31-0001-3096

Project Title: Participatory Ecology: A Study of Citizens Groups Involved at the Grass Roots to Improve the Water Resources Environment

FCST Research Category: VI-B

Name and Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1969

Scheduled Completion: June 30, 1972

Principal Investigator:

L.P. Gerlach

Degree:

Ph.D.

Discipline:

Anthropology

Student Assistants:

Virginia H. Hine

Degree:

M.A.

Discipline:

Anthropology

Susan Iskander

M.A.

Anthropology

Description of Research Performed and Findings, Results, or Conclusions Relating Thereto:

The Principal Investigator completed final form of his "You and Ecology" questionnaire. He has administered this questionnaire to samples of population in industry, engineering, education and Ecology Movement groups ranging from conservative to radical. The Principal Investigator has also administered the questionnaire to church groups and community action groups. Perhaps most significantly it was published in NATURAL HISTORY magazine and answered by over 10,000 readers. It is now being used in a variety of foreign countries. The Principal Investigator is presently analyzing the results of the questionnaire administered to a sample of an entire community in White Bear Lake, Minnesota. Data are being requested by scholars and concerned citizens across the country. He has been collecting and analyzing mass media data on the Ecology Movement to determine this impact on the development of ecology ideology. Furthermore, he has been continuing his observation of ecology action groups in Minnesota, Tennessee and Miami, and is analyzing this data.

Data will enable government education and citizens' groups to evaluate public attitudes and to determine public desires in water resource use. A new means of communicating water resource problems and prospects via multi-media form has been developed. It relates technical capabilities to socio-economic reality.

Project Related Publications:

Filmstrip: WHAT IS A SYSTEM?, University of Minnesota, Audio-Visual Resources.

ECO-COMMUNICATION multi-media package, University of Minnesota, Audio-Visual Resources.

Statements of Project Work Remaining to be Accomplished:

Work remaining to be accomplished includes: a. further use of questionnaire, b. continued evaluation of the development of the ideology of ecology, c. assessment of the impact of the Ecology Movement on our cultural system, d. analysis of response of the established order, e. publication of book on above subjects, and f. assessment of the tourist impact on water resource use and their response to the Ecology Movement.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Items a, b, c, d and f above will be completed during the period July 1, 1971 through December 31, 1971.

OWRR Project No.: B-032-Minn.

Matching Grant Agreement No.: 14-01-0001-3097

Project Title: Mississippi River Ecology Associated with Heated Power Plant Effluent

FCSI Category: V-C

Project Began: July 1, 1969 Scheduled Completion: December 31, 1972

Name and Location of University Where Project is Being Conducted:
St. Cloud State College, St. Cloud, Minnesota 56301

Principal Investigator: Degree: Discipline:
Alfred J. Hopwood Ph. D. Limnology

Student Assistants: Degree: Discipline:
Ralph O. Morgenweck B.A. Limnology

Description of Research Performed and Any Findings, Results, or Conclusions Relating Thereto:

1. Forage fish: Work continued on the definition of forage fish populations and natural history principally of the minnows (Cyprinidae) inhabiting the Mississippi River above and below the NSP-Monticello Nuclear Generator. Six sampling stations, two above and four below the plant, were established where fish were captured by seining in shallow water. Substrate materials consisted of silt, sand, gravel, and rubble. Water depths varied from 0 to 32 inches and averaged 9.0 inches. Water current velocity ranged from 0 to 4.3 feet per second and averaged 1.1 feet per second. Species captured and representative percentages of the total catch for the six stations were: Catostomus commersoni, 3.3; Etheostoma nigrum, 6.0; Hybopsis biguttata, 2.5; Moxostoma sp., 0.1; Notemigonus crysoleucas, 0.1; Notropis cornutus, 3.5; N. dorsalis, 27.7; N. hudsonius, 0.2; N. spilopterus, 18.5; N. stramineus, 17.9; Pimephales notatus, 11.8; Rhinichthys atratulus, .6; R. cataracte, 4.6; Semotilus atromaculatus, 0.3; Pomoxis nigromaculatus, 0.1; Ameiurus sp., 0.1; Ambloplites rupestris, 0.1; Micropterus dolomieu, 2.6. Dominance of the population varied between stations as follows: Upstream station 1, Notropis dorsalis 44.5%; upstream station 2, N. stramineus, 28.0%, downstream station 1, Pimephales notatus, 25.8%; downstream station 2, N. dorsalis, 32.3%; downstream station 3, N. spilopterus 30.8%; downstream station 4, N. dorsalis, 41.2%.

2. Other fish: Work continued on the determination of migratory activity, population sizes, species composition and physical condition of fishes captured by electrofishing. In May, 1971, a study on the utilization of food by fishes other than small minnows was initiated. Samples of stomach contents were obtained by autopsy. Quantitative and qualitative analyses of stomach contents are currently underway.

3. Invertebrates: Work continued on the quantitative analysis of the aquatic insects above and below the power plant. Approximately 500 samples were taken, with the aid of artificial substrate samplers, from eight transects, two upstream and six downstream with reference to the power generator discharge. During 1970, the macroinvertebrate population was composed of 52% caddisflies, 12% mayflies, 31% dipterans and 5% other miscellaneous taxa. Monthly percentages were computed for seven index groups; the caddisflies; Hydropsyche and Cheumatopsyche, and Macronemum; the stoneflies, Baetis, and Stenonema; the mayfly, Ephemera; blackflies, Simuliidae; and

the midges, Chironomini; so that the relative abundance per station of each group could be compared for pre- and post-operational time periods. The physical condition of the invertebrates in the study area was estimated as the mean weight per organism. Weight per organism, the monthly qualitative composition of the benthos at each station, total sample weight, and the number of organisms per unit area of substrate are the major baseline parameters for invertebrates in this study.

Because the number of stoneflies captured with cement block samplers was low, a study was designed to estimate the density of benthic fauna, particularly stoneflies, in the river substrate. With the aid of a Surber net, 80 samples were taken from four transects, two above the power plant, and two downstream. Each of the transects were divided into 20 sections. Flow velocity, depth, and air and water temperatures were taken. Of the invertebrates captured, stoneflies made up approximately 4.3%, compared to 37.8% mayflies and 17.9% caddisflies. Most of the stoneflies were Neoperla, the other genera comprising less than 20% of all stoneflies captured. Dipterans made up 21.2% of the captured sample. The remaining 18.8% was composed of leeches, snails, beetle larvae and crayfish.

4. Water quality: Water samples were taken every two weeks from four stations in the study area. Dissolved oxygen, biological oxygen demand, alkalinity, phosphate, and total solids (by conductivity as sodium chloride) were determined for each sample. Water temperature was monitored continuously with a thermograph at each of nine stations, two above and seven below the power plant. Flow velocity and water depth were observed at specific sites for biological collection each time the biota was sampled.

Project Related Publication: None

Statement of Project Work Remaining to be Accomplished:

Further work will include a continuation of the studies designated Water Quality, Invertebrates, Forage Fish, Other Fish, and Aquatic Plants. Forage fish studies will include population estimates by the catch, mark, and recapture method. An attempt will be made to ascertain the quality and quantity of benthic fauna used as food by large fish. Plant growth and distribution studies will continue above and below the power plant.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

During the summer months, work will be concentrated on fish food utilization, forage fish distribution and population estimates, benthic fauna samples and aquatic plant studies. Laboratory analysis of samples taken during the summer will continue during the remainder of 1971.

OWRR Project No.: B-042-Minn.

Matching Grant Agreement No.: 14-31-0001-3292

Project Title: Spatial Variation in the Perception of Water Resources and Water Problems in South Central Minnesota

FCST Category: VI-B

Name and Location of University Where Project is Being Conducted:

Gustavus Adolphus College, St. Peter, Minnesota 56082

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973

<u>Principal Investigator:</u>	<u>Degree:</u>	<u>Discipline:</u>
R.T. Moline	Ph.D.	Geographv

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
James V. Anderson	Undergrad.	Biology-Chemistry
Mary Olin	Undergrad.	English
Sharon Braun	Undergrad.	Education

Description of Research Performed and Findings, Results, or Conclusions Relating Thereto:

Since the goal of the project is to determine and analyze the areal variation of attitudes toward water resources, water problems, and solutions to those problems, the emphasis during this first year has been in structuring a proper sample population, preparing a suitable questionnaire, and securing responses to the mailed questionnaire. After some initial anxiety about the small size of the area first selected for the study (the ten county planning region in southcentral Minnesota), it was decided to enlarge the area to include the entire Minnesota River basin covering some 16,000 square miles. Two principal reasons emerged for this action. First, the enlarged study area now covers enough diverse topographic and water resource areas to make variation in attitude more likely, more apparent, and more easily studied. Secondly, there have been few attitude studies directed at entire drainage basins, perhaps none covering so large an area as this. Any large scale, detailed planning to be made for the basin will, or should, cover all of the area, not simply a small part of it. Successful, comprehensive, basinwide planning requires a knowledge of attitudes held by people all over the basin, not one section only.

It was decided to develop a stratified random sample for collection of the perceptions and attitudes. Surveyor's townships were used as the basic areal unit. There are 36 sections in each township and a computer-derived random selection of 3 sections in each of the approximately 550 townships in the basin provided the initial sample location. County platbooks and directories were then used to locate a specific farm or house closest to the center of each of the selected sections. Addresses were obtained from the platbooks and directories and the farms and houses selected were plotted on the appropriate county highway maps. This procedure provided relatively even areal coverage throughout the entire basin but selected predominantly rural residents as potential respondents.

The Principal Investigator was determined to keep the questionnaire short and to construct it in such a way to make it as painless as possible to answer and return. In addition to the introductory, personal, and detailed locational information, the questionnaire contained several general questions about water problems. The bulk of the questionnaire consisted of a series of statements about water, water problems, solutions to water prob-

lems, and planning procedures. The respondents merely indicated whether they agreed or disagreed with the statement by circling 1 of 5 items in a Likkert-type scale. The questionnaire was pretested and subsequently revised.

Approximately 1450 revised questionnaires were mailed; 502 responses have been received. All responses have been coded and are ready for card-punching. Results of the questionnaires have not been tabulated or examined. "In order to effectively plan and implement programs for water resource management, awareness of the perceptions and attitudes of the natives is desirable if not essential. Through the efforts of communication media, particularly the newspapers, the perceptions of small segments of the population can be aired. However, no large scale effort to gather and analyze opinion of a broad spectrum of persons has been undertaken. This project would be the first to collect and gather data of this kind and it would seem to have value both as an applied study and also for establishing a conceptual model." "Data collected will be regularly offered to the major planning agencies currently undertaking studies in the basin, namely the Soil Conservation Service and Corps of Engineers."

Project Related Publications: None

Statements of Project Work Remaining to be Accomplished:

Responses from the mailed questionnaires will be analyzed. An extensive personal interview program will be undertaken with city and county officials and other "influentials." Results of both the interviews and questionnaires will be used to develop a preliminary model of areal variation in perception of water resources and water problems. Recommendations will be made regarding the nature of a citizen's participation program in water resource planning.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Analysis of the questionnaire responses will be completed and the personal interview program will begin in the western part of the basin.

OWRR Project No.: B-044-Minn.

Matching Grant Agreement No.: 14-31-0001-3293

Project Title: Area Financing of Water Resource Development

FCST Research Category: VI-B

Name and Location of University Where Project is Being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1970

Scheduled Completion: June 30, 1972

Principal Investigator:

W.R. Maki

Degree:

Ph.D.

Discipline:

Agricultural Economics

Student Assistants:

John Holdorph

Degree:

B.S.

Discipline:

Civil Engineering

James Anderson

Undergraduate

Agricultural Economics

Description of Research Performed and any Findings, Results, or Conclusions Relating Thereto:

Work focused on financing water resource development in a 14-county study area in West Minnesota, emphasized in FY 1971 was the delineation and evaluation of an interrelated complex of four environmental issues, namely, sewage disposal, solid waste management, municipal and industrial water systems, and parks and public access. Citizens, community leaders and public officials in the 14-county area were consulted as part of the research effort.

Work on the project has proceeded in a way that builds upon related field work on industry location and population redistribution in the 14-county area. Emphasized in FY 1971 was a seven-county subarea, historically known as the Park Region which extends from Glenwood to Detroit Lakes and Park Rapids and includes both Fergus Falls and Alexandria -- two early and well-known summer vacation centers now serving a seasonal population of over 40,000. In addition, Fergus Falls serves as the principal growth center, apart from Fargo-Moorhead, for the 14-county environmental planning area.

Completed in FY 1971 was (1) inventory and evaluation of public financing in the 14-county area and (2) preparation and use of a 28-sector input-output model of the 14-county area. These two reports are being reviewed for publication in 1972. Findings of the two reports provide the basis for the area financing issues approached in this study.

Besides the research activities undertaken primarily at St. Paul, a complementary educational thrust was being formulated in cooperation with staff of institutions of higher education and other organizations in the 14-county area. Professor Charles Sargent, on leave from Purdue University, prepared a community development approach for environmental management and planning that will be reviewed by an ad hoc advisory task force composed of specialists and other resource people from the 14-county area. The community development effort represents the outreach function of the total project and is an integral part of the feedback structure for relating research findings to decision processes in environmental area planning and development.

Specific features of the project were developed in FY 1971 as follows:

- (1) Preparation of a preliminary research design for comprehensive local water resource development;
- (2) Estimation of critical parameters and variables in expanded input-output model of subarea (i.e., seven east counties in 14-county West Minnesota study area);
- (3) Linkage of current study design with (a) related studies of economic base and infrastructure in West Minnesota and (b) research outreach function encompassed by community development model for environment management and planning.

Because the current work was not initiated until late in FY 1971, no research findings are available, except those reported elsewhere (in the two studies cited earlier. Present indications point, however, to extremely critical financing gaps in local and area water resource development that must be closed substantially to protect existing jobs and amenities in the seven-county recreational subarea of the 14-county study area. Hence, the preparation and testing of methodologies for assessing financing alternatives in area water resource development is viewed, not only as a challenging research effort in its own right, but also as a critical phase in the total environmental planning and management process.

In summary, the focus on area financing of water resource development is achieved as follows:

- (1) Water resource problems in the seven-county subarea are identified specifically in the four issue areas cited earlier -- sewage disposal, solid waste management, municipal and industrial water systems, and parks and public access;
- (2) Alternative engineering and economic solutions for dealing with the four problem areas are translated into capital and manpower requirements;
- (3) Local organizations, including Minnesota's institutions of higher education are consulted particularly on the manpower development implications of the projected capital and manpower requirements in implementing alternative engineering and economic solutions to the water-related problems in the study area.
- (4) Financing implications of the solution alternatives are assessed and different financing arrangements are being devised and tested as a primary thrust of the total research effort.
- (5) Simulation-gaming concepts are deployed in testing the financing alternatives and simulation-gaming laboratory is being developed in conjunction with both on-campus and off-campus teaching in resource development.

The last two steps in the research effort were initiated in FY 1971 but the major share of work involved is scheduled for FY 1972. Specific phases of the study are cited with reference to potential users of the information forthcoming from the research.

- (1) Economic and engineering coefficients: multi-county and area-wide planning and development organizations with specialist competencies.

- (2) Area financing alternatives: state-level, multi-county and local governmental bodies seeking additional revenue sources or an improved rationale for internalizing externalities of area-wide resource development projects.
- (3) Simulation-gaming laboratory for water resource development planning: civic groups and students in resource management and development in St. Paul and off-campus in West Minnesota (and elsewhere).
- (4) Community development models: educators and community organizers concerned with problems of financing water resource development.

Project-related Publications: None

Statements of Project Work Remaining to be Accomplished:

Financing implications of the engineering-economic solution alternatives proposed for the seven-county subarea in the 14-county study area will be studied in FY 1972. Also, the simulation-gaming laboratory (scheduled as part of a graduate level course, i.e., Agricultural and Applied Economics 5-630, taught during the winter quarter) will be complemented and tested in FY 1972.

Finally, a monograph on "Area Financing of Water Resource Development" will be prepared.

Additional Project Progress Contemplated for the Remainder of the Calendar Year:

Engineering and economic coefficients used in translating area environmental needs into capital and manpower budgets will be verified and their use in the expanded area input-output models will be tested. These coefficients, along with the related equation systems, will be used in simulative environmental changes in the simulation-gaming laboratory activities.

OWRR Project No.: B-047-Minn.

Matching Grant Agreement No.: 14-31-0001-3294

Project Title: Social and Economic Factors in the Adoption by Industry of Water Pollution Control Measures

FCST Research Category: VI-E

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1970 Scheduled Completion: June 30, 1973

<u>Principal Investigator:</u> R.E. Rickson	<u>Degree:</u> Ph.D.	<u>Discipline:</u> Sociology
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<u>Student Assistants:</u> Jane Rodenkirchen Charles E. Simpkins Mary Cloyd Hong I.K. Chung Kathy Schilling Pam Lanoue	<u>Degree:</u> B.A. M.A. M.A. M.A. B.A. B.A.	<u>Discipline:</u> Journalism Sociology Sociology Sociology Social Work Sociology
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Description of Research Performed and Any Findings, Results, or Conclusions Relating Thereto:

Data were collected on the technology used by industries to control their effluent. A measure was developed so that what industries are using could be compared with what kinds of technology is available. This is our chief measure of technological innovation. Analysis of the data was undertaken with the goal of testing the validity and reliability of the measure. This is still being done. Besides the above data, we gathered information on the size, location (rural, urban, small town), and economic status of industries in Minnesota. Specific cases were selected for analysis. Analysis of individual industries was carried out for the purpose of sharpening the goals of our study design. The data collected during the second year will be more reliable and valid with the work completed in the study's first year.

Industries in urban areas and small towns generally control their pollution better than industries in rural areas. The findings indicate that an urbanized or small town setting is more capable of controlling water pollution than are highly rural areas. One reason, of course, is that industries in urban areas can connect with central sewage systems. This finding lends confirmation to contentions by planners that industrial parks are needed in rural areas so that industrial production can be centralized. Whether industrial parks or the urbanization of rural industry is needed, the finding does indicate that centralized facilities or management is more conducive to the control of water pollution than is decentralized management. From a sociological point of view, one might contend that social technology is more important than physical technology in the control of water pollution.

Project Related Publications:

R.E. Rickson and C.E. Simpkins. Industrial Organization and the Ecological Process: The Case of Water Pollution. December, 1970. The paper will appear in Philip Kunz and Merlin Brinkerhoff, Organizations and their Environment: A Reader Dubuque, Iowa: Brown Publishing Company. 1971. 30 p., 40 ref.

Statements of Project Work Remaining to be Accomplished:

The most important data will be collected during the second year of the project. Data will be collected on the social characteristics of approximately one-hundred industries in Minnesota. The main dependent variable is how industrial managers view the regulatory role of pollution control agencies. An interview schedule and questionnaire has been developed that will be administered to industrial managers and/or owners. The demographic data already collected allows us to sample from categories of size, economic status, location, nature of ownership, and product.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

About one-half of the data will be collected by the end of this calendar year.

OWRR Project No.: B-049-Minn.

Matching Grant Agreement No.: 14-31-0001-3295

Project Title: A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota

FCST Research Category: VI-B

Name and Location of University Where Project is Being Conducted:
Bemidji State College, Bemidji, Minnesota 56601

Project Began: July 1, 1970 Scheduled Completion: September 30, 1972

<u>Principal Investigator:</u>	<u>Degree:</u>	<u>Discipline:</u>
J.P. Ludwig	Ph.D.	Ecology

<u>Student Assistants:</u>	<u>Degree:</u>	<u>Discipline:</u>
<u>Bemidji State College</u>		

Joel Ward	B.A.	Sociology
Pamela Berg	Undergrad.	Psychology

<u>St. Cloud State College</u>		
David Ostenso	Undergrad.	Geography
Hans Christensen	Undergrad.	Geography
James Sandusky	Undergrad.	Geography

Description of Research Performed and any Findings, Results, or Conclusions Relating Thereto:

Research on this project began with a series of consultations between the investigators from the St. Cloud State and Bemidji State Colleges in June 1970. Dr. James A. Swan, a consultant from the University of Michigan Survey Research Center, assisted the research team to develop an appropriate instrument. Throughout the summer of 1970, E. Hanlon (SCSC) surveyed the pertinent literature, collecting copies of relevant materials, or condensing information when this was most practicable. An extensive project bibliography and sources deposition has been made at the St. Cloud and Bemidji libraries as a result of this effort.

Mr. Joel Reed (BSC) spent summer and fall months of 1970 on the pre-testing and refining of the survey instruments. Seven pre-tests were made on several categories of people who represented "kinds" of people that were to be incorporated in the final universe for the attitudinal survey. By March, 1971 Mr. Reed produced a polished, detailed general mail questionnaire which was printed preparatory to distribution. Separate student and professional educator questionnaires (especially aimed to ascertain their involvement with environmental education) have also been prepared and pre-tested on both student and teachers in high schools and college.

Dr. Philip Tideman, chairman, Department of Geography (SCSC) assisted by Mr. David Ostenso, contributed to the research project by gathering data on detailed survey of land use in the 23 Minnesota counties through which the Mississippi flows. This aspect of the project is being augmented by a study of riparian ownership patterns along the river basin. Dr. Tideman also administered pre-test questionnaires to groups resident in the Minneapolis - Brainerd portion of the river basin.

Dr. Tideman and Mr. Reed obtained 10,000 randomly selected Minnesota motor vehicle owners names and addresses. The major (general) attitudinal questionnaire universe was selected from the 10,000 names obtained. 6,201

address labels were printed; the 23 Minnesota River basin counties possessed 61.3% of the state's population as reported in the 1970 census. The general mail questionnaire was mailed during June, 1971 to 5000 persons.

Mr. Reed, Mr. E. James Cecil (BSC), and Mr. Norman J. Baron (WSC) are currently occupied this summer by series of in-depth interviews of various classes of users of the river as a resource (approximately 120 detailed interviews are expected to result from this effort.) A major portion of interviews will be made on recreational users of the river. It is expected that this information together with analysis of returned general survey questionnaires will enable the research team to determine those areas needing more work for FY 1972.

Dr. James P. Ludwig, Director of the BSC Center for Environmental Studies, and principal investigator on this project served as an administrator-coordinator for this tri-campus program. Dr. Ludwig advised and assisted Mr. Reed in the early stages of this program when the general questionnaire was developed.

It would be premature to suggest results of the general survey questionnaire. However, fascinating leads are suggested by pre-test results are:

- 1) the priorities of the general populace of Minnesota regarding the river and their environment are not static (or what they were guessed to be); the environmental movement seems to be having an impact (polarizing opinion?);
- 2) electrical energy is demanded by nearly everyone--without consideration of environmental priorities. Our pre-test data suggests that the attitudes of persons toward electricity are the least influenced by environmental arguments, and that Minnesotans would choose this energy source above all others.

Findings should be of great interest to politicians and public servants of many kinds. These data should be useful to indicate at least the following: 1) the priorities of Minnesotans - that practical information which will give the water manager the general man's desires on how the river can be best used; 2) where "water" education efforts are needed (our pretest questionnaires identify some surprising areas of ignorance); 3) changing patterns of use (or disuse), ownership, and land use in the river's basin. These data are vitally needed by Minnesotans.

Project Related Publications: None

Statements of Project Work Remaining to be Accomplished:

- a. The analysis of the general questionnaire data awaits work in FY 1972.
- b. Analysis of interview data must be accomplished as well as administering-analysis of special-group questionnaires.
- c. Compilation of land use, land ownership patterns and associated geographical data remains to be accomplished.
- d. A major task of FY 1972 is the generation of an adequate computer program, and computerization of the data collected by this project.
- e. Preparation of the final report (to be completed in the first quarter of FY 1973) will also begin.

Additional Project Progress Contemplated for the Remainder of the Current Calendar Year:

Considerable progress on items a, b, c and d above will be made during the period July 1, 1971 through December 31, 1971.

OWRR Project No.: B-053-Minn.

Project Title: A Hydronomic Analysis of Forest Management Alternatives for Environmental Quality: A Case Study of Itasca County, Minnesota

FCST Research Category: VI-G

Name and Location of University Where Project is Being Conducted:
University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: J.M. Hughes Degree: Ph.D.

Discipline: Forestry

Project Progress Contemplated for the Remainder of the Current Calendar Year:

Some progress will be made in estimating water-demand coefficients using an available input-output analysis of Itasca County. Additional data pertaining to water requirements will be obtained from U.S. Government publications and from industries.

OWRR Project No.: B-054-Minn.

Project Title: Socio-Economic Implications of Alternative Water Resources Policies in Minnesota

FCST Research Category: VI-E

Name and Location of University Where Project is Being Conducted:
University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: J.J. Waelti Degree: Ph.D.

Discipline: Agricultural Economics

Project Progress Contemplated for the Remainder of the Current Calendar Year:

The literature on water and related land resources planning and policy in Minnesota will be reviewed. Crucial policy issues will be identified together with policy alternatives.

OWRR Project No.: B-057-Minn.

Project Title: Subsurface Irrigation with Heated Water, Its Management, and Application Toward Reduction of Thermal Pollution Problems

FCST Research Category: IV-B

Name and Location of University Where Project is Being Conducted:
University of Minnesota, St. Paul, Minnesota 55101

Project Began: July 1, 1971 Scheduled Completion: June 30, 1974

Principal Investigator: E.R. Allred Degree: M.S.

Discipline: Agricultural Engineering

Project Progress Contemplated for the Remainder of the Current Calendar Year:

Pertinent literature and information on the effects on crops of using heated water for irrigation will be reviewed. A subsurface irrigation system will be installed in a selected area of light-textured soil. Some observations will be made on the effects of introducing heated water within the soil.

OWRR Project No.: B-060-Minn.

Project Title: Forecasting Rainfall and Snowmelt Floods on Upper Midwestern Watersheds

FCST Research Category: VI-G

Name and Location of University Where Project is Being Conducted:
University of Minnesota, Minneapolis, Minnesota 55455

Project Began: July 1, 1971 Scheduled Completion: June 30, 1972

Principal Investigator: C.E. Bowers Degree: M.S.

Discipline: Civil Engineering

Project Progress Contemplated for the Remainder of the Current Calendar Year:

Studies of rainfall-snowmelt floods in medium and large Upper Midwest watersheds will be initiated. Existing data from Federal and State agencies will be procured and stored in a form readily used by computer programs.

New Courses DevelopedUniversity of MinnesotaSoc 3-402 Ecology, Technology and Society. (3 cr; no prereq)

A Survey course intended to provide a balanced, integrated perspective on major problems and approaches to solutions of problems related to the interaction between man, technology and nature.

Ecol 3-101 Ecology for Engineers and Physical Scientists. (3 cr; no prereq)

An introductory ecology course designed for students in engineering and the physical sciences and hence is more quantitative than other beginning ecology courses.

Law 5-215 Environmental Regulation. (1 cr; no prereq)

Basic environmental problems are covered, including such topics as air and water pollution, preservation of open spaces and wilderness areas, population control, ... The discussion of each subject begins with an introductory explanation of the relevant nonlegal materials, as background for an analysis of legal doctrines.

Geog 5-900 Environmental Alterations. (3 cr; prereq sr or #)

The spatial extent and nature of pollution is considered.

Geog 5-811 Environmentalism, Environment and the Quality of Life. (3 cr; prereq Geog 3-361 or #)

A survey of ideas on environmentalism with special emphasis on those that lead to the organization of the physical environment into human settings (rural and urban) in the belief that they affect life's ideals.

Ag En RCD 1-010 Issues in the Environment (3 cr; no prereq)

An interdisciplinary offering designed to explore five areas of environmental concern: aspects of environmental design which provide maximum compatibility of man with his environment, sources of water pollution, and managed use of forest resources to maintain environmental quality.

Geo 1-005 Environmental Geology (4 cr; prereq geo 1-001; geo 1-006)

Geological applications in resource management, land use planning, technology, and conservation. Geological evolution of the biosphere and the impact of man's activities on land, sea, and air resources. Geological hazards. The Twin Cities metropolitan area as a geological environment. Lectures, labs, and field trips.

Geol 1-006 Geology and Man (4 cr; no prereq; geo 1-005)

An introductory course concerned with man in his physical environment; Geological hazards (e.g. earthquakes); the nature and use of natural resources; geological aspects of pollution, recreation and land use; the effect of the composition of rocks and soils on nutrition and disease. An introduction to the broad nature of earth science. Lectures, labs, and field trips.

PA 8-130 Seminar: Science, Technology, and Public Policy. (3 cr; prereq #)

Analysis and discussion of major public policy issues in the areas of science and technology, including assessment of effectiveness of existing programs; consideration of policy alternatives and analysis of their consequences.

PA 8-140 Seminar: Natural Environment Policy. (3 cr; prereq #)

Analysis and discussion of major public policy issues concerning the natural environment, including water and air pollution; assessment of the effectiveness of existing programs; consideration of policy alternatives and analysis of their consequences.

Ag En 167 (5-720) Advanced Agricultural Structures. (3 cr; prereq 97, ME 133, ME 160A, #) Jordan

Study of the functional requirements of farm structures with respect to man, animals, and crops, and development of the means of providing structures which fulfill the functional requirements. Application of the science and art of engineering in the solution of environmental problems. Advanced planning in the integration of structural environmental design.

Me Ag 106 (5-010) Agricultural Waste Management. (3 cr; prereq Phys 1, GeCh 5, Biol 1)

Characteristics of various animal manures, plant materials, and processing wastes. Sanitary collection, storage, treatment, and utilization of disposal of liquid and solid agricultural waste.

Ent 118 (5-400) Experimental Ecology. (3 cr; prereq 9 cr general biology or equiv, 3 cr animal or plant ecology, #; for companion lab course. see 201) Chiang

Experimental approach to study of environmental factors affecting animal populations.

Ent 151 (5-451) Ecology of Fishery Populations. (3 cr; prereq Ecol 50 or equiv, Zool 121, Ecol 119 or 128, Math 40 or equiv, or #) Smith

Relationship of fishery populations to limnological conditions; factors influencing strength of year classes; influence of climatological factors on fish growth; species interaction as related to population structure; influence of natural and fishing mortality rates on structure and yield of exploited populations; fishery yield models.

Geo 132 (5-612) Analytical Geohydrology. (3 cr; prereq Math 31 or 107A, CE 101A or equiv, or #) Pfannkuch

Microphysics of flow through porous media; geological factors in aquifer performance; equations for groundwater flow; analysis of pumping tests; potential theory in groundwater flow; computer and analog models of aquifers; groundwater basin analysis.

CE 165 (5-403) Lake, Reservoir, and Ocean Hydrodynamics. (3 cr; prereq 101A or equiv)

Transport and dispersion of mass, momentum, and heat in large natural bodies of water. Hydrodynamics and design of water withdrawal and recharge facilities.

CE 5-420 Introduction to Water Resources Management. (3 cr)

The need for management of the water resource. Hydrologic cycle. Patterns of water use. Floods and droughts. Organizations for data acquisition and information retrieval. Quantity and quality, problems and requirements--shortages, aquatic life, health considerations, eutrophication, pollution, natural recovery processes. Relationship to land and other resources. Organization for planning. Economic analysis. Legal constraints. Social and other non-technical considerations. Systems analysis. Metropolitan planning versus river basin planning. Political aspects--the public interest. Planning in Minnesota. Types of action-legislation, de-

sign, construction, court injunction, inaction. Organizations. Training, operation, enforcement, maintenance. Who does the managing?

For 160 (5-258) Outdoor Recreation Economics. (3 cr; prereq 143 or 157, AgEc 3 or #) Hughes

The role of economic analysis in outdoor recreation; analysis of alternative methodologies for valuation and choice problems, including both supply and demand aspects; discussion and analysis of major trends and issues. Lectures, readings, discussions, reports.

For 161 (5-259) Recreation Land Amenities and the User. (3 cr; prereq 143, #) Merriam

Concepts and management of parks, forests, and other recreation areas for recreation visitors. The role of interpretive education, use preference in relation to administrative objectives. Principles of area management, individual and group influences. Lecture, discussion, reports, reading.

For 162 (5-260) Advanced Management of Recreational Lands. (3 cr; prereq 143, Ecol 50 or equiv, #) Merriam

Discussion of relationship of man as recreationist to the natural environment. Principles of manipulation of plant and animal communities for outdoor recreation objectives. Lectures, reading, discussion, reports. Field trips.

Steady-State Earth: An Interdisciplinary Seminar, Institute of Technology, University of Minnesota, Minneapolis, Minnesota, 1970-71. Professors from social science and physical science departments participated in the development of a year long seminar dealing with the physical and social basis of pollution and its control. Graduate students from the different departments and undergraduates enrolled in the course for regular credit.

CE 5-401 - Water Resources Engineering (5 cr)

CE 5-402 - Hydraulic Analysis (4 cr)

CE 5-405 - Hydrology (4 cr)

CE 5-410 - Open Channel Hydraulics (4 cr)

CE 5-435 - Intermediate Fluid Mechanics (4 cr)

Bemidji State College

Pollution Ecology, Biology 468-568. Discussion of the cultural basis of environmental pollution, the types of pollutants and their ecological effects, and the methods of pollution control. Lecture and Laboratory. Prerequisite Biology 113 or 123.

Gustavus Adolphus College

Geography 300b Seminar: Water Resource Problems.

The course examines the spatial variation in water resource management problems using both library materials and field observation. Emphasis is on the socio-economic aspects of water resource development including perception of the water resource, water rights, public administration of water resources, and planning. Comprehensive plans for development of several of the world's major river basins are critically examined. Summary comments and recommendations resulting from student projects and discussion may be forwarded to appropriate public officials. Visiting discussants are employed. Open to all students. Offered spring semesters.

The following new water resources related courses were outgrowths of P.L. 88-379 program activities: CE 5-420 at the University of Minnesota and Geography 300B at Gustavus Adolphus College.

Additional Water Resources Related Staff Members Added

University of Minnesota

Lee Christensen, Ph.D., Civil Engineering
Carlos M. Fetterolf, Jr., M.S. (Visiting Lecturer), Biology
Arnold M. Hanson, M.S. (Visiting Lecturer), Biology
Michael L. Adess, M.S. (Instructor), Biology

None of these staff members receive salary from P.L. 88-379 funds.

New Water Resources Research and Training Facilities Other Than Research Equipment Items

At Bemidji State College a \$98,000, 6,000 - 7,200 square foot Center for Environmental Studies Laboratory building has been funded by the Minnesota legislature. Construction is expected to begin in late summer or fall 1971.

INTERDEPARTMENTAL, INTERUNIVERSITY OR REGIONAL AGREEMENTS

CONSUMMATED WITH RESPECT

TO IMPROVED RESEARCH AND TRAINING CAPABILITIES

The Center and the University of Minnesota entered into written agreements with Gustavus Adolphus College and Bemidji State College to permit those Institutions to participate in the Center's activities. The memorandums of Agreement given below were executed in connection with approved fiscal year 1971 Matching Grant projects.

MEMORANDUM OF AGREEMENT BETWEEN REGENTS OF THE UNIVERSITY OF MINNESOTA AND GUSTAVUS ADOLPHUS COLLEGE

WHEREAS: The Regents of the University of Minnesota wish the collaboration of Gustavus Adolphus College with the Water Resources Research Center, University of Minnesota, in conducting the research project entitled "Spatial Variation in the Preception of Water Resources and Water Problems in South Central Minnesota."

AND

WHEREAS: Gustavus Adolphus College is willing to cooperate with the University of Minnesota Water Resources Research Center in carrying out this research.

THEREFORE: Subject to the award of grant funds from the U.S. Department of the Interior, Office of Water Resources Research in support of this study, the collaboration between the parties to this agreement during the period from July 1, 1970 to June 30, 1973, will be governed by the terms and conditions as follows:

1. Integration of the research with that of the Center: In keeping with the spirit of the law under which the Center was established, the proposed program has been selected for inclusion in the activities of the Center upon the recommendation of the Center Director, in consultation with the Advisory Committee of the Center. Further Planning and work performance in connection with the study will be coordinated through the Center Director's Office.
2. Institute responsibility for the planning, work performance, and reporting of the project: The Center Director or his authorized representative will conduct periodic site visits to consult with the principal investigator and furnish such advice and assistance as will best promote the purposes of the Center program.

Gustavus Adolphus College will provide the University of Minnesota with annual progress and financial reports and other periodic reports as required in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

Grant funds will be forwarded to Gustavus Adolphus College, pursuant to its vouchers, on a quarterly basis only in such amounts as are required to liquidate liabilities connected with the research due and payable during the time period to which the voucher pertains.

Expenditures of grant funds shall be made in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

GUSTAVUS ADOLPHUS COLLEGE

REGENTS OF THE UNIVERSITY OF MINNESOTA

MEMORANDUM OF AGREEMENT BETWEEN REGENTS OF THE UNIVERSITY OF MINNESOTA AND BEMIDJI STATE COLLEGE

WHEREAS: The Regents of the University of Minnesota wish the collaboration of Bemidji State College with the Water Resources Research Center, University of Minnesota, in conducting a research project entitled "A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota."

AND

WHEREAS: Bemidji State College is willing to cooperate with the University of Minnesota Water Resources Research Center in carrying out this research.

THEREFORE: Subject to the award of grant funds from the U.S. Department of the Interior, Office of Water Resources Research in support of the study, the collaboration between the parties to this agreement during the period from July 1, 1970 through June 30, 1972, will be governed by the terms and conditions as follows:

1. Integration of the research with that of the Center: In keeping with the spirit of the law under which the Center was established, the proposed program has been selected for inclusion in the activities of the center upon the recommendation of the Center Director in consultation with the Advisory Committee of the Center. Further planning and work performance in connection with the study will be coordinated through the Center Director's Office.
2. Institute responsibility for the planning, work performance, and reporting of the project: The Center Director, or his authorized representative will conduct periodic site visits to consult with the principal investigator and furnish such advice and assistance as will best promote the purposes of the Center program.

Bemidji State College will provide the University of Minnesota with annual progress and financial reports and other periodic reports as required in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

Grant funds will be forwarded to Bemidji State College, pursuant to its vouchers, on a quarterly basis only in such amounts as are required to liquidate liabilities connected with the research due and payable during the time period to which the voucher pertains.

Expenditure of grant funds shall be made in accordance with the Rules and Regulations pursuant to the Water Resources Research Act.

BEMIDJI STATE COLLEGE

REGENTS OF THE UNIVERSITY OF MINNESOTA

Number of students receiving employment as research project or program assistants through the P.L. 88-379 program.

Category of Students	No. by Scientific Discipline or Major Field of Study (Engineering, Biology, Economics, etc. 2/	
	Scientific Discipline of Student	Number
(1) <u>Undergraduates</u>	<u>University of Minnesota</u>	
	Agricultural Economics	3
	Agricultural Engineering	2
	Biology	3
	Pre-Med	1
	Home Economics	1
	Horticulture	1
	Civil Engineering	3
	Public Health	2
	<u>Bemidji State College</u>	
	Psychology	1
	<u>St. Cloud State College</u>	
	Geography	3
	<u>Gustavus Adolphus College</u>	
	Biology	1
	English	1
Education	1	
(2) <u>Master's Students</u>	<u>University of Minnesota</u>	
	Sociology	1
	Civil Engineering	6
	Agricultural Engineering	1
	Public Health	1
	Pharmacognosy	1
	Social Work	1
	Journalism	1
	Soil Science	1
	<u>St. Cloud State College</u>	
	Limnology	1
	<u>Bemidji State College</u>	
	Sociology	1
(3) <u>Doctoral Students</u>	<u>University of Minnesota</u>	
	Agricultural Economics	1
	Agricultural Engineering	1
	Public Health	4
	Horticulture	1
	Soil Science	2
	Civil Engineering	3
	Anthropology	2
	Sociology	3
(4) <u>Postdoctoral Students</u>	<u>University of Minnesota</u>	
	Horticulture	1

2/This refers to educational background prior to employment as research assistant on P.L. 88-379 projects--not to departments in which projects are being conducted.

Employment status of majors in water-related fields who graduated during the school year ending about June and who receive P.L. 88-379 support.

EMPLOYMENT STATUS	CATEGORY OF SCHOOL YEAR GRADUATE BY DEGREE OBTAINED			
	Bachelor's Degree	Master's Degree	Doctoral Degree	Total
1. No. employed in water-related positions in:				
Total		3	2	5
Federal Agencies		1	2	3
State & Local Agencies		1	0	1
University of College		0	0	0
Other - Including private enterprise		1	0	1
2. No. graduates returning to school for advanced degree	2	3	0	5
3. No. going into military service		0	0	0
4. No. unemployed or working in other fields		0	0	0
5. No. status unknown	3	0	0	3
6. Totals	5	6	2	13

Type of employment of those school year graduates who received P.L. 88-379 support and who are known to have gone into water-related positions.

CATEGORY OF SCHOOL YEAR GRADUATE
BY DEGREE OBTAINED

Number of Graduates Engaged in Water-Related Work in:	Bachelor's Degree	Master's Degree	Doctoral Degree	Total
<u>1A. Federal Agencies:</u>				
a. Primarily Research	0	1	1	1
b. Primarily Planning	1	0	1	1
c. Primarily Development	0	0	0	0
d. Primarily Operations	0	0	0	0
e. Primarily Management	0	0	0	0
f. Other or not known	0	1	1	1
<u>1B. State & Local Agencies:</u>				
a. Primarily Research	0	0	0	0
b. Primarily Planning	0	0	0	0
c. Primarily Development	1	0	1	1
d. Primarily Operations	0	0	0	0
e. Primarily Management	0	0	0	0
f. Other or not known	0	0	0	0
<u>1C. University or College:</u>				
a. Primarily Teaching	0	0	0	0
b. Primarily Research	0	0	0	0
c. Primarily Research and Teaching	0	0	0	0
d. Other or not known	0	0	0	0
<u>1D. Other - Including Private Enterprise:</u>				
a. Primarily Research	0	0	0	0
b. Primarily Planning	0	0	0	0
c. Primarily Development	0	0	0	0
d. Primarily Operations	0	0	0	0
e. Primarily Management	1	0	1	1
f. Other or not known	0	0	0	0
Totals	3	2	5	

Selected summary of above data--from the "Total" column:

Research (1Aa, 1Ba, 1Cb, 1Cc & 1Da)	1
Planning (1Ab, 1Bb & 1Db)	1
Development (1Ac, 1Bc & 1Dc)	1
Operations (1Ad, 1Bd & 1Dd)	0
Management (1Ae, 1Be & 1De)	1

Identify by name and discipline and briefly describe instances, if any, in which the institute program, in the past year, has resulted in individuals, other than students, doing research or teaching in the water resources field, who, previously, were not involved in water work.

University of Minnesota

Four of OWRR Project No.: B-047-Minn. Principal Investigator's colleagues are now developing ideas for further research in the area of natural resource management. Together with the Principal Investigator they have an established research group that is now devoting most of its attention to the social basis of pollution and its control. These individuals include: Professor George A. Donohue, Professor Clarice Olien, Professor Charles E. Ramsey, and Professor Phillip J. Tichenor. They are not new staff members but have turned their attention to the study of pollution control.

Final arrangements are pending on an agreement with the University of Hohenheim, Stuttgart, Germany for Dr. Volker Schweible to come to Minnesota for a year beginning September 1971. He will be supported by P.L. 88-379 funds in connection with OWRR Project No.: B-015-Minn. and by supplementary University of Hohenheim funds provided a travel grant, now pending, is given by the Deutsche Forschungsgemeinschaft.

Cite any instances you know of, in which individuals who previously served as student research assistants on P.L. 88-379 projects, are now serving as professional investigators of P.L. 88-379 projects following graduation. Do not include individuals reported in this category last year or before.

None

Reports

- Allred, E.R., Manson, P.W., Schwartz, G.M., Golany, P., and Reinke, J.W. 1971. University of Minnesota, Agricultural Experiment Station, Tech. Bull. 274. 62 p., 33 fig., 45 tab., 30 ref.
- Anon. 1970. Sixth Annual Report Water Resources Research Center. University of Minnesota, Water Resources Research Center, Bull. 24. 90 p.
- Anon. 1970. Proceedings of Conference on Ongoing Water Resources Research in Minnesota, March 1970. University of Minnesota, Water Resources Research Center, Bull. 21. 56 p., 6 fig., 1 tab.
- Anon. 1970. Lake Eutrophication - Water Pollution Causes, Effects and Control. University of Minnesota, Water Resources Research Center, Bull. 22. 61 p.
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