

WRRC

Water Resources Research Center  
University Of Minnesota  
Room 107, Hubbard Building  
2675 University Avenue  
St. Paul, Minnesota 55114

Bulletin 54

# **Eighth 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, 1972

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Public Law 88-379

AUGUST 1972  
Minneapolis, Minnesota

WATER RESOURCES RESEARCH CENTER  
UNIVERSITY OF MINNESOTA  
GRADUATE SCHOOL

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## PREFACE

This is the eighth 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, 1971, and ending June 30, 1972, 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.

This Bulletin is related to the Center Director's Office fiscal year 1972 program and to OWRR Annual Allotment Agreement No.: 14-31-0001-3523.

FCST-COWRR Research Category: 09-D

### Publication Abstract:

The fiscal year 1972 budget of the Center was \$449,704. The Center supported 20 research projects involving 21 faculty members. These research projects were concerned with: water resources administration, zooplankton biomass in Lake Superior, mathematical watershed system analysis, aquatic plants, eutropic lakes, groundwater basin information, mist irrigation, watershed runoff, soil water movement, near-shore periphyton, environmental movement, Mississippi river ecology, perception of water resources problems, financing of water resources development, water pollution social factors, water resources attitudes, forest management, water resources policies, subsurface irrigation, and flood forecasting. About 67 students received employment through the Center's program. During fiscal year 1972, there were 25 reports generated through research projects.

### Publication Descriptors:

\*Research/ \*Water Resources/ \*Minnesota/ Education/ Projects/ Expenditures  
Manpower/ Water Management/ Water Pollution/ Water Resources Research Act

### Publication Identifiers:

\*Researchers/ \*Applied Research/ \*Basic Research/ Physical-Biological-  
Economic-Social Aspects/ Faculty

## WATER RESOURCES RESEARCH CENTER UNIVERSITY OF MINNESOTA GRADUATE SCHOOL

Annual Report to  
Office of Water Resources Research (OWRR)  
for Fiscal Year ending June 30, 1972  
Part I - Narrative Progress Reports

### DIRECTOR'S SECTION

#### Introduction

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 many 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 Colleges, 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; through its membership on the All-University Environmental Council at the University of Minnesota; and through its membership on the Citizens Advisory Committee to the Governor's Environmental Quality Council.

The Center's research budget increased from \$52,297 in Fiscal Year 1965 to \$449,704 in Fiscal Year 1972 as shown below:

| Fiscal Year | Center's<br>Research<br>Budget | Non-Federal Contributions   |                           |
|-------------|--------------------------------|-----------------------------|---------------------------|
|             |                                | Annual Allotment<br>Program | Matching Grant<br>Program |
| 1965        | \$ 52,297                      | \$ 0                        | \$ 0                      |
| 1966        | 195,032                        | 28,580                      | 46,971                    |
| 1967        | 216,039                        | 28,601                      | 61,606                    |
| 1968        | 216,864                        | 34,140                      | 49,179                    |
| 1969        | 262,644                        | 33,845                      | 63,163                    |
| 1970        | 331,506                        | 36,236                      | 114,359                   |
| 1971        | 335,967                        | 36,031                      | 107,366                   |
| 1972        | 449,704                        | 38,712                      | 156,237                   |

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 ungedaged small watersheds and rainfall characteristics of ungedaged 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 algicides 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; 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; spatial variation in the perception of water resources and water problems in South Central Minnesota; area financing of water resource development; social and economic factors in the adoption by industry of water pollution control measures; and survey of attitudes towards the Mississippi river as a total resource in Minnesota; estimating thermal pollution and increased nitrate and phosphate levels associated with alternative forest management systems; delineating the more immediate and crucial sets of water and related land resources planning policy alternatives being considered by the people of Minnesota; determining the feasibility of utilizing irrigation and groundwater recharge as means for disposal of heated water from power plants; and developing analytical procedures and the correlation of hydrologic data to aid in the prediction of spring floods.

#### Director's Summary Statement, 1972

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 1972 was directed toward: 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.); monitoring the effects of stopping the flow of sewage on the productivity of Lake Minnetonka (A-026-Minn.); determining whether optimum levels of investigations can be set for such groundwater reservoirs as the Twin Cities Artesian basin (A-027-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-043-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.); estimating thermal pollution and increased nitrate and phosphate levels associated with alternative forest management systems (B-053-Minn.); delineating the more immediate and crucial sets of water and related land resources planning policy alternative being considered by the people of Minnesota (B-054-Minn.); determining the feasibility of utilizing irrigation and groundwater recharge as means for disposal of heated water from power plants (B-057-Minn.); and developing analytical procedures and the correlation of hydrologic data to aid in the prediction of spring floods (B-060-Minn.).

The Center's program during the next five years will involve completion of above mentioned projects and it will likely stress indices for evaluating water quality status and trends in Minnesota, 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-021-Minn. on water resources administration in Minnesota has assisted the Legislature and the Executive Branch in formulating an environmental policy for the State and in reorganizing State agencies.

The Center has been helpful in developing new water resources courses, a graduate option in hydrogeology, a program of graduate education in water resources, and recruitment of 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 from 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. 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 aegal 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 as 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 will 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 concerning 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 and 1972, the Principal Investigator served as an adviser to Committees of the Minnesota Senate and House of Representatives and using the results of the research assisted the Committees in preparing reports 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. Several 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 watershed.

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.

#### Compliance With Consultation and Collaboration Provisions of Section 100(b) P.L. 88-379 as Amended by P.L. 92-175

This section pertains to compliance with consultation and collaboration provisions of Section 100 (b) P.L. 88-379 as amended by P.L. 92-175. Information concerning the procedures or actions that the Center has established or taken, and the arrangements and actions contemplated to be taken during fiscal year 1973 and before the fiscal year 1974 allotment request is due for submittal is provided below.

Since the Center was established on September 1, 1964, it has operated with the assistance of 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 Advisory Committee counsels with the Center Director, helps identify research needs, assists in selecting research projects the Center will sponsor, assists in determining the activities the Center will undertake, assists in the preparation of progress and accomplishment reports requested by OWRR and others, and provides public liaison. The Consulting Council counsels with the Center Director, assists in identifying needed research, assists in integrating and coordinating University research with water resources projects outside the University within the State, assists in acquainting the Center with water resources activities and references pertaining to water resources in the State, and provides public liaison. Formal appointments include provision for rotation of representatives from various Schools, Departments, Divisions, and organizations having a vital interest in the work of the Center, by use of one, two and three-year terms appropriately staggered. The present roster of the Center is given below.

#### Roster of Center (1971-1972)

William C. Walton, Director  
John J. Waelti, Assistant Director  
Elizabeth Hermansen, 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  |
| R.E. Cox              | 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  |
| I. 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                                   |

Joint meetings of the Advisory Committee and Consulting Council have proven successful and it has been deemed appropriate that the Center consolidate the Committee and Council into a single Advisory Committee. The membership of the new Advisory Committee, to be activated in fiscal year

1973 or 1974, will reflect the need for greater representation from the social sciences, State and Private Colleges, Interest Groups, and State Agencies. Changes in the Advisory Committee membership will be made to improve coordination between faculty members and Federal, State and Private organizations, and to assure that the annual programs submitted by the Center to OWRR are developed in close coordination and collaboration with leading water resources officials within the State. Thus, the Center is increasingly being responsive to the provisions of the Water Resources Research Act of 1964.

It is anticipated that the new Advisory Committee will meet at least once every 3 months; rotation of some members will occur each year to provide widespread representation. The Advisory Committee will: review the Center's programs and make recommendations concerning activities and research needs and priorities; assist the Center in coordinating its programs with water resources programs of other organizations within the State; provide public liaison; and assist the Center in information dissemination.

Possible candidates for the new Advisory Committee are listed below:

| <u>Name of Representative</u> | <u>Representative's Affiliation</u>                            |
|-------------------------------|--|
| D.E. Abrahamson               | Center for Studies of the Physical Environment, Univ. of Minn. |
| to be named                   | Minn. Public Interest Research Group                           |
| J.J. Anderson                 | Watermation, Inc.  |
| V.L. Arnold                   | School of Public Affairs, Univ. of Minn.                       |
| D.G. Baker                    | Dept. of Soil Science, Univ. of Minn.                          |
| R.G. Bond                     | School of Public Health, Univ. of Minn.                        |
| A.J. Brook                    | Dept. of Ecology & Behavioral Biology, Univ. of Minn.          |
| D.P. Bryden                   | Law School, University of Minn.                                |
| C.E. Collier                  | U.S. Geological Survey   |
| G.L. Englund                  | Minnesota Department of Health                                 |
| N.A. Fattu                    | Dept. of Political Science, Univ. of Minn., Duluth             |
| F.H. Geisenhoff               | Minnesota Dept. of Economic Development                        |
| L.P. Gerlach                  | Dept. of Anthropology, Univ. of Minn.                          |
| G. Hollenstein                | Minn. Dept. of Natural Resources                               |
| A.J. Hopwood                  | Dept. of Biology, St. Cloud State College                      |
| S.K. Hunt                     | Environmental Science Foundation                               |
| S.E. Jorgenson                | U.S. Bureau of Sport Fish. & Wildlife                          |
| L.E. Kelly                    | Minn. Association of Watershed Districts                       |
| F. Lamm                       | Metropolitan Council   |
| C.L. Larson                   | Dept. of Agricultural Eng., Univ. of Minn.                     |
| to be named                   | U.S. Army Corps of Engineers                                   |
| to be named                   | Center for Environmental Studies, Bemidji State College        |
| R.T. Moline                   | Dept. of Geography, Gustavus Adolphus College                  |
| D. Norgard                    | League of Minn. Municipalities                                 |
| L.E. Richie                   | Minn. Pollution Control Agency                                 |
| R.E. Rickson                  | Dept. of Sociology, Univ. of Minn.                             |
| J.E. Shapiro                  | Limnological Research Center, Univ. of Minn.                   |

Edward Silberman  
P.K. Sims  
J.E. Sizer  
C.A. Van Doren  
D.B. White  
to be named

St. Anthony Falls Hydraulic Lab., Univ. of Minn.  
Minnesota Geological Survey  
Minn. State Planning Agency  
U.S. Agricultural Research Service  
Institute of Agriculture, Univ. of Minn.  
Environmental Protection Agency

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 Inter-collegiate Committee on Environmental Studies at the University of Minnesota. In addition, the Center Director serves on Governor Anderson's Citizens Advisory Committee to the Environmental Quality Council. 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 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. That 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. For several years, the Center Director served as the chairman of the Water Resources Coordinating Committee.

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.

On October 5, 1965, the Consulting Council of the Center established a Task Group on Water Resources Research Needs in Minnesota. The Task Group's purpose was to identify technical needs and priorities in various research and related data categories. Members of the Task Group were: G.H. Hollenstein, Minn. Dept. of Conservation, Division of Waters; R.W. Maclay, U.S. Geological Survey, Water Resources Division; M. H. Tourin, Litton Systems, Inc., Minneapolis; C.A. Van Doren, U. S. Dept. of Agriculture, Agricultural Research Service; W.C. Walton (Chairman), Water Resources Research Center; and S. Weitman, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station. The Task Group met several times during fiscal year 1966 to discuss research needs. People throughout the State having a vital interest in water resources research were solicited for information concerning research needs. Plans were made to hold a Conference on Water Resources Research Needs in Minnesota.

A Conference, sponsored by the Center, was held November 15-16, 1966, in the North Star Ballroom, Student Center, University of Minnesota, St. Paul Campus. The Conference was planned with three major objectives in mind. One was to offer a forum to leading scientists in the water resources field from which they could express their appraisals of water resources research and educational needs in Minnesota from their respective viewpoints. Another was

to provide an audience of people interested in water resources research and education in Minnesota. The third was to draw upon the audience for some indication of future water resources research and educational needs and problems. The program was subdivided into seven sections dealing with the major aspects of water resources research and education. The general pattern for each one-hour section program was a principal paper dealing with the whole subject and brief prepared statements by three persons who had read the principal paper in advance and could supplement its content. A discussion period for both speakers and audience was provided. The Conference brought together 110 people interested in Minnesota's water resources research and educational programs.

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. A list of 160 research subjects bearing on water supply, water pollution, floods, land and water, lakes and water-based recreation, and social-economic aspects was compiled. A questionnaire containing these research subjects was distributed to each Conference participant. The questionnaire was designed to give some indication of future research need priorities. Those in attendance were requested to assign one of the following priorities to each research subject: 1) high priority, 2) medium priority, 3) low priority, and 4) not needed. Forty Engineers, Geologists, Biologists, Administrators, representatives of Private Industry, Planners, University faculty members, and laymen responded to the questionnaire. Based on the results of the questionnaire and considering water resources problems in Minnesota, additional research is needed most in areas bearing on social-economic aspects, water pollution, and floods, about in that order. The Conference proceedings and the results of the questionnaire were published in the Center's Bulletin 5 entitled "Water Resources Research and Educational Needs in Minnesota" and distributed to about 700 people throughout Minnesota in March 1967. The Bulletin has served as a guide for the Center's research programs over the past 5 years. The Center published and distributes to 550 people throughout the State, including many State Officials, quarterly Newsletters in an effort to widely disseminate information concerning the Center's research programs.

A research project (OWRR Project No.: A-028-Minn) entitled "Developing a Water Resources Research Plan for Minnesota" will start on July 1, 1972 and is scheduled for completion on June 30, 1974. The Principal Investigator of the research project is the Center Director.

The objective of this project is to develop a long-range comprehensive plan for water resources research in Minnesota. Research programs and projects which will assist in solving existing and projected water resources problems will be identified. Guidelines for improving the coordination of research efforts throughout the State will be formulated. Research costs and manpower needs will be estimated and funding opportunities will be reviewed. The capabilities of existing water resources researchers in Minnesota will be evaluated and needed future capabilities will be projected. The results of the results of the research should assist the State in increasing the efficiency and relevance of water resources research efforts, improving the timely dissemination of research results, and scheduling expansions in research capabilities in advance of demands. Information concerning future research needs, manpower requirements, and costs should



assist the State Legislature in formulating legislation concerning water resources research funding. The results of the research should further assist the Center in administering research funds associated with the Water Resources Research Act of 1964.

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 63 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. In general, research effort by all measures has been consistently high in the following 4 research ECST categories: Water Cycle, Water Quality 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.

In fiscal year 1971, the Center was 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.

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.

Members of the Center's Advisory Committee and Consulting Council were informed of the requirements that the Center's program be developed in consultation and collaboration with them during a joint meeting held on April 28, 1972. In addition, through a Newsletter about 550 people in Minnesota were informed of these requirements.

In response to the provisions of the amended Water Resources Research Act, the Center Director prepared tentative material for possible submission to the OWRR in regard to the Center's fiscal year 1974 request for funds. This material was distributed to members of the Center's Advisory Committee and Consulting Council on April 28, 1972 and to 550 people throughout Minnesota in June 1972. Members of the Advisory Committee and Consulting Council and readers of the newsletter and their colleagues were urged to review the Center's tentative fiscal year 1974 request for funds and to send or phone in before October 1, 1972 any comments they wish to make concerning the request. The next joint meeting of the Center's Advisory Committee and Consulting Council will be held during the first week of October, 1972 at which time a final fiscal year 1974 request for funds will be formulated based on the tentative request and comments received.

The Center has encountered little difficulty, in obtaining cooperation and collaboration with water resource officials in the past. Established close relationships will be further enhanced by the additional actions contemplated to be taken by the Center and outlined in this section.

#### 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. The Center has published and distributed to 550 people throughout the State 28 quarterly Newsletters and 128 Information Circulars in an effort to disseminate information concerning water resources. Research projects supported by OWRR have generated technical reports and theses. Upon request, the Center has distributed about 140 copies of its publications per month to people throughout the State and Nation. The Center has widely distributed 33,000 copies of 50 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 20 interdisciplinary Seminars since 1964. Attendance at the Seminars has average 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.

Information concerning scientific information dissemination activities during fiscal year 1972 of all personnel (Director, P.I.'s, other researchers, graduate assistants, etc.) associated with the Center's program is summarized below.

| Item  | Number of Events | Average Audience Size      |
|---|------------------|----------------------------|
| Technical Publications Issued                     | 35               | 700                        |
| Popular Articles Published                        | 20               | 1,000                      |
| News Letters                                      | 4                | 575                        |
| Press Releases                                    | 12               | unknown                    |
| Technical Lectures                                | 78               | 35                         |
| Popular Talks                                     | 97               | 50                         |
| Sponsorship of Seminars                           | 41               | 25                         |
| Correspondence and Telephone Inquiries (Estimate) | 500              | 1                          |
| Costs   | Dollars          | Source of Funds            |
| Printing and Page Charges                         | 13,000           | OWRR, Univ. of Minn.,      |
| Distribution                                      |                  | State and Private Colleges |

During FY 1972, the Center distributed to about 650 people mimeographed Information Circulars covering the following subjects:

| Information Circular No. | Title  |
|--------------------------|--|
| 124                      | Information on Some Environmental Issues   |
| 125                      | International Regional Federal-State, Interstate and Federal Organizations with Water and Related Land Resources Programs in Minnesota, 1971 |
| 126                      | Papers on Status of Research in Hydrology  |
| 127                      | Some Facts Concerning Status and Trends of Water Quality in Minnesota, 1971  |
| 128                      | Water and Related Land Resources Data Acquisition and Handling Programs in Minnesota, 1971   |

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

We have just looked over Bulletin 30 of your Center, Effects of Areal and Time Distribution of Rainfall on Small Watershed Runoff Hydrographs by

Tsong C. Wei and Curtis L. Larson. This is a fine publication and a meaningful contribution to our better understanding of the ultimate rainfall-runoff process. Scientific hydrology is certainly well-served by contributions of this calibre.

We hope all is going well for you.

Sincerely,  
ILLINOIS STATE WATER SURVEY

John B. Stall  
Engineer

I just finished reading your paper entitled "Factors to be Considered in Preparing Water and Related Land Resource Plans in Minnesota." It looks as though it might be a statement prepared for a legislative presentation.

In any case, I want to say that it is an extremely concise and meaningful statement. Thanks for sending it to me.

Sincerely,

John R. Borchert  
Director and Professor of Geography  
University of Minnesota  
Center for Urban and Regional Affairs

This is to acknowledge the receipt of and to express my thanks for the copy of "The ecology of periphyton in Western Lake Superior" Part I - Taxonomy and distribution" which came in a few days ago.

The paper seems, from what time I have been able to give it, like an excellent piece of work and exposition on a subject of very great importance at this time of emphasis of work on pollution and trends toward it. The data bears out the statement frequently appearing in the literature that Lake Superior is still a very clean lake.

It will be most useful to me, as parttime worker in the Ohio Biological Survey, School of Natural Resources at Ohio State University, which has been conducting a somewhat comparable study on western Lake Erie; this body of water is not described as a clean lake.

Yours truly,

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

I would appreciate receiving copies of your bulletins No. 3, 7, 13, and 14. I recently received No. 14 but would very much like having a second copy of this well prepared report.

Thank you.

Very truly yours,

R. Weldon Larimore  
Aquatic Biologist  
Illinois Natural History Survey

The Public Administration Library has received many copies of Water Resources Research Newsletter that your organization has sent to the League of Minnesota Municipalities-Municipal Reference Bureau. We have found your newsletter quite useful to our students, faculty, and other patrons. We would very much appreciate receiving Water Resources Research Newsletter and would like the below address put on your mailing list.

Thank you so much for your cooperation.

Sincerely yours,

(Mrs.) Barbara A. Browman  
Librarian, Public Administration Library  
365 Elegen Hall  
University of Minnesota

Thank you for sending me the "Publications Related to Water Resources Research Center 1965-71."

I think it will help us greatly at the Legislature in the future.

Sincerely,

Jack H. LaVoy  
State Representative  
State of Minnesota  
House of Representatives

I wish to acknowledge, with my great thanks, receipt of the reports with which you have recently provided me. Your generous cooperation in furnishing this valuable and interesting material is greatly appreciated.

Very truly yours,

Henry C. Eichhorn  
Chief Limnologist  
State of Wisconsin Department of Natural  
Resources

Thank you very much for the two publications - Bulletin 42 and Bulletin 45 - on Water....groups etc.....

It is amazing to see the potential for inter communication yet frustrating to realize that few know where and what is available.

I hope your courtesy to me can be indirectly beneficial to you through our effort (to educate or share what knowledge contained in the 2 bulletins) locally to reach some decision-makers.

Sincerely,

Marjorie Gray Vogel  
999 Kingman  
Red Wing, Minn.

Center's Involvement in Public  
Affairs and Academic Activities

On March 20, 1972, a Conference on Inland Lake Renewal and Shoreland Management was held in the North Star Ballroom, Student Center, University of Minnesota, St. Paul Campus. The Conference was sponsored by the Center and the Department of Natural Resources, Division of Waters, Soils and Minerals. Eighty three people were in attendance at all or portions of the Conference.

The objective of the Conference was to disseminate information concerning inland lake renewal and management programs in Minnesota and Wisconsin. The morning session included 1) an overview of Wisconsin's Inland Lake Renewal and Management Demonstration Project, 2) reports on selected land renewal and related activities, and 3) a showing of the Project Documentary Film. The afternoon session focused on selected shoreland management and development activities. There was sufficient time for discussion, and questions and answers.

The program of the Conference is presented below:

Monday, March 20, 1972

Morning

9:00-9:30 a.m. Registration

9:30-9:40 Welcome - E.R. Gere, Dir., Div. of Waters, Soils & Minerals, Minn. Dept. of Natural Resources.

9:40-10:15 1. An Introduction and Overview of the Program of the Inland Lake Demonstration and Shoreland Management Project of Wisconsin - S.M. Born, Univ. of Wisc. Project Leader.

10:15-10:30 Coffee

10:30-10:55 2. Reports on Selected Lake Renewal activities  
a. Chemical Inactivation of Nutrients - Tom Wirth

10:55-11:10 b. Nutrient Exclusion/Dilutional Pumping - Tom Wirth

11:10-11:35 c. Rehabilitation of a Small Flowage, People Part of Environmental Action Programs - Marion Millpond, Rd Brick.

11:35-11:45 d. Waupaca Urban Runoff Study - Jim Peterson

11:45-12:00 Questions and Answers

12:00-12:30 p.m. 3. Inland Lake Documentary Film

12:30-1:30 Lunch

Afternoon

4. Reports on Selected Shoreland Management and Development Activities

1:30-2:20 p.m. a. A Resource-Protective Approach to Shoreland Development, Including Innovative Private Controls for Recreational Land Development - Steve Born & Doug Yanggen

2:20-2:30 b. A Study of the Rate, Magnitude, and Nature of Shoreland Development in Northern Wisconsin - Doug Yanggen

2:30-2:50 c. Nation-wide Survey of Lake Rehabilitation Legislation and Programs - Jon Kusler

2:50-3:10 Coffee

3:10-3:40 5. Shoreland Management Educational Programming - Doug Yanggen & Steve Born

3:40-4:10 Progress of Minnesota's Shoreland Program and Activities in Lake Demonstration Projects - Mike Hambrock

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

During the week of April 10-14, 1972, Conferences were held at Bemidji, St. Cloud, and Winona. The conferences were concerned with the preliminary results of OWRP Project No.: B-049-Minn., and they were jointly sponsored by Bemidji State College, St. Cloud College, and Winona State College. The Center Director assisted Principal Investigators in making arrangements for the Conference and he participated in the Conference. Cumulatively, over 350 people attended the Conferences. The Conferences were covered by local newspapers and TV. The programs of the Conferences are given below:

MISSISSIPPI RIVER HEADWATERS RESEARCH CONFERENCE  
April 10, 1972  
9 AM to 4:30 PM  
CLASSROOM AUDITORIUM  
BEMIDJI STATE COLLEGE

PROGRAM OF EVENTS

8:30-9:00 Registration, Hallway Entrance to Classroom Auditorium

9:00 Welcome and Introductions -- James P. Ludwig, Director  
The Center for Environmental Studies

9:05-9:40 New and Revised Federal Programs and Laws Influencing  
Water Quality Management in Minnesota -- The Honorable  
Robert Bergland, U.S. Congressman 7th District Minnesota

|             |  |      |  |
|-------------|--|------|--|
| 9:40-10:20  | Comprehensive Planning Efforts for the Mississippi River Basin -- William C. Walton, Director, Water Resources Research Center   |      | Public Information Seminar   |
| 10:20-10:40 | Coffee break   |      | MINNESOTANS LOOK AT A NATURAL RESOURCE:<br>THE MISSISSIPPI RIVER<br>Saint Cloud State College<br>Tuesday, April 11<br>1 - 8 P.M.<br>Centennial Hall<br>Room 100  |
| 10:40-2:00  | Reports relating to OWRR Project B-049-Minn.   |      |  |
| 10:40-10:55 | Strategy of the Project and Organization of the Research Staff -- James P. Ludwig, Principal Investigator, Director, Center for Environmental Studies  |      | SEMINAR PROGRAM<br>Centennial Hall, Room 100   |
| 10:55-11:20 | The Study Universe -- Dr. Philip Tideman, Chairman<br>Department of Geography, SCSC  | 1:00 | "The Role of Federal and State Planning for the Upper Mississippi River" - William C. Walton - Director, Water Resources Research Center, The Graduate School, University of Minnesota                             |
| 11:20-11:55 | Selected Preliminary Results of the General Attitudinal Survey of all Minnesotans Towards the Mississippi River as a Multiple-use Resource -- E. James Cecil, Assistant Professor of Political Science, BSC  | 1:30 | Reports on a Joint Research Effort. "A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota" - Introduction to the Project - James Ludwig - Biologist, Bemidji State College         |
| 11:55       | Luncheon Break. Lunch for Speakers and Invited Guests in The Viking Room of Student Union  |      |  |
| 1:00-1:20   | Results of Interviews of Minnesotans Towards the Use and Development of the Mississippi River -- Norman Baron, Associate Professor of Geography, WSC   |      | Backgrounding the Study Universe - Philip Tideman - Geographer, St. Cloud State College  |
| 1:20-1:40   | A Comparison of River-Fronting Land Use Along the Mississippi River in 1940 and 1970 in Beltrami and Morrison Counties of Minnesota -- Mr. David Ostenso   |      | Thirty Years of Change in Riparian Land Use in Morrison County - David Ostenso - Geography, Graduate Student, St. Cloud State College  |
| 1:40-2:00   | Open Session for Questions directed to the Research Staff of OWRR Project B-049-Minn.  |      | Attitudes Towards the River - James Cecil - Political Scientist - Bemidji State College  |
| 2:00-2:30   | Activities and Responsibilities of the State Planning Agency Relating to Use of the Mississippi River -- Joseph Sizer, Director, Environmental Section of the Minnesota State Planning Agency                |      | Attitudes of Special Interest Groups - Norman Baron - Geographer - Winona State College  |
| 2:30-2:45   | Coffee Break   | 3:00 | Coffee Break -- Hosts: Geography Club, SCSC  |
| 2:45-3:15   | The Ecological Problems Associated With Power Plant Siting and Heated Effluents -- A. Joseph Hopwood, SCSC, Professor of Biology   | 3:30 | "An Industrial Use of the River: The NSP Monticello Plant" - Alfred Hopwood - Biologist - St. Cloud State College  |
| 3:15-3:45   | Preliminary Report on the Effects of the Culture of Wild Rice on Water Quality -- Kenneth R. Lundberg and Pat Trihey, Associate Professor of Chemistry and Assistant Professor of Biology respectively - BSC | 4:00 | "Agricultural Practices and Surface Waters" - Orville Barry - Area Conservationist, Soil Conservation Service, U.S. Department of Agriculture  |
| 3:45-4:15   | The Impact of Snowmobiles on Northern Minnesota Vegetation -- Wallace J. Wanek, Associate Professor of Biology, BSC  |      | "A City Uses the River" - John Miller - Chief Planner, City of St. Cloud and the Metropolitan Planning Commission  |
| 4:15-4:30   | Concluding Remarks and Conference Adjournment -- James P. Ludwig   | 5:30 | The above three topics have been selected as they are of special importance along the Middle Reach of the Mississippi River here in Central Minnesota.<br>Dinner - Atwood College Center - St. Cloud State College |

7:00 Seminar Featured Speaker

"Minnesota State Water Policy and the Minnesota Water Permit System" - Gene Hollenstein, Chief Hydrologist, Division of Minerals and Waters, Department of Natural Resources, State of Minnesota

MISSISSIPPI RIVER RESEARCH CONFERENCE

Winona State College

Thursday, April 13

9 a.m. - 3 p.m.

Kryzsko Commons

Rooms F and G

PROGRAM

9:00 Reports on A Joint Research Effort

"Strategy of the Tri-College Study of the Mississippi River and Organization of the Research Staff" - James P. Ludwig - Director, Center for Environmental Studies, Bemidji State College

9:30 "The Mississippi in Minnesota: An Overview" - Phillip Tideman, Geographer, St. Cloud State College

10:45 Coffee Break

11:00 "Attitudes of Minnesota Residents Toward the Mississippi River" - Norman Baron, Geographer, Winona State College

12:00 Luncheon for Participants

1:00 Federal-State Planning in Upper Mississippi River Basin - William C. Walton, Director, Water Resources Research Center

1:20 "The Metropolitan Sewer Board's Water Quality Monitoring Program" - Russell Susag - Manager of Quality Control, Metropolitan Sewer Board

2:00 "Pre-operational Studies are a Necessity" - Edward Miller, Research Associate, NSP Prairie Island Nuclear Site, St. Mary's College

During fiscal year 1972, the Center Director served on the All-University Council on Environmental Quality. In the fall of 1969 Vice-President Shepherd appointed the ad hoc Intercollegiate Committee on Environmental Studies (InCESt) on which the Center Director served. This committee was charged to (1) examine existing programs in the University of Minnesota, (2) explore needs, and (3) suggest possible new or revised programs at the all-university level relating to the environment. The committee conceptualized the environment to include (1) natural physical and biological systems which comprise the surroundings of man and can operate without human input, and (2) human technological and

organizational systems which interact with the natural systems with resulting modification of both.

InCESt, made up of faculty members from various units of the Minneapolis and St. Paul campuses and chaired by Prof. John Borchert, met regularly during the 1969-1970 academic year and in June 1971 submitted its report, "Report of Findings and Recommendations," to Vice President Shepherd. The report recommended the formation of a Council on Environmental Quality and also recommended that the Council be given various responsibilities.

In October 1971, Vice President Shepherd acted on the recommendations of InCESt and appointed the members of the first All-University Council on Environmental Quality. The first Council chairman is Dean E. Abrahamson, Director of the Institute of Technology Center for Studies of the Physical Environment, and Associate Professor of Anatomy and Physics. At present, the Council has representation only from the Minneapolis and St. Paul campuses of the University. Steps are now being taken to assure Council representation from the other campuses of the University as well.

The first activity of the Council was to publish a University of Minnesota Bulletin of Environmentally Related Courses and Programs. This bulletin had been prepared by the Center for Urban and Regional Affairs and the IT Center for Studies of the Physical Environment with the cooperation of the InCESt committee.

The Council's responsibilities are briefly reviewed below:

I. Information

- a. Compiling and updating descriptions of courses and programs pertaining to environmental quality and management. Preparation of a special bulletin.
- b. Referring students to proper advisors and assisting them in designing environmental programs.
- c. Coordination of faculty and/or student research proposals.

II. Instruction

- a. Arrangement and funding of multi-disciplinary, undergraduate and graduate seminars dealing with specific environmental problems.
- b. Make available directed and independent studies for undergraduate students.
- c. Encouragement and funding of new approaches to multi-disciplinary learning especially in environmental studies.
- d. Seek the development and continuous review of a university undergraduate distribution requirement on environment and/or population.
- e. Explore the development of introductory courses which lead into four-year environmental, problem-oriented undergraduate programs.

III. Public Service

- a. Develop and fund a public, continuing education, lecture series.
- b. Develop a work-study program involving public and private organizations which could benefit from the employment of students on specific environmental problems.
- c. Use all University resources to extend environmental knowledge to schools and act as a clearing house for state and local government request for consultant opinions on environmental questions.

#### IV. Administration

- a. Assist in the arrangement of student credit for innovative, multi-disciplinary study.
- b. Encourage proper recognition and fiscal support for work done by cooperating faculty in new multi-disciplinary courses and seminars.
- c. Yearly evaluation by student/faculty group.

On April 12, 1972 Governor Anderson appointed the Center Director to serve on the Citizens Advisory Committee of the State Environmental Quality Council. The Council is composed of the Governor and the Heads of the State Planning Agency, Department of Natural Resources, Pollution Control Agency and Department of Highways. There are 24 members on the Committee.

The Committee's responsibilities are to: recommend possible agenda items for the Council, assist in establishing Council Task Forces, hold public meetings to sample opinions concerning environmental issues, assess the operation of the Council, assess Federal environmental legislation, and make recommendations concerning institutional arrangements for environmental affairs. One of the first matters considered by the Committee was power plant siting.

The Center Director served as an Advisor to the Minnesota House Natural Resources Committee, Subcommittee on Waters and Drainage; Senate Agriculture Committee, Subcommittee on Drainage; and Senate Natural Resources and Environment Committee, Subcommittee on Water Permits. He assisted these Subcommittees in preparing a joint report concerning needed legislation in the water and related land resources field.

The Center Director served on the Water Resources Coordinating Committee, State Planning Agency. He assisted the Committee in preparing three reports entitled "Reaction to Water and Related Land Resources Planning Policy Questions During the Period November 1970 Through June 1971", "A Statewide Water and Related Land Resources-Data System", and "Digest of Planning Information for the Southern Minnesota Rivers Basin".

#### Center Director's Activities

During fiscal year 1972, the Center Director attended the following major water resources meetings: July 7-8, 1971 - Presented lectures on groundwater resource evaluation at University of Wisconsin, Madison, Wisconsin; July 16 - Attended a Conference meeting with officials of the U.S. Fish and Wildlife Service, Minneapolis; Aug. 1 to 4 - Acting as Delegate from University of Minnesota, attended Annual Meeting of Universities Council on Water Resources, Corvallis, Oregon; Aug. 6 - Attended meeting of Water Resources Coordinating Committee, St. Paul; Sept. 10 - Attended meeting of Water Resources Coordinating Committee, St. Paul; Oct. 1 - Attended meeting of Water Resources Coordinating Committee, St. Paul; Oct. 13 to 15 - Presented a paper on groundwater-surface water interrelationships at Annual Meeting of Midwestern Groundwater Conference, Madison, Wisconsin; Nov. 5 - Attended meeting of Water Resources Coordinating Committee, St. Paul; Nov. 15 - Attended meeting of All-University Council on Environmental Quality, Minneapolis; Nov. 19 - Presented a paper on water and related land resources administration, development and management in Minnesota to Subcommittee of Natural Resources Committee, Minnesota House of Representatives, St. Paul; Nov. 29 - Spoke on watershed districts during meeting of Minnesota Association of Watershed Districts, Alexandria; Dec. 8 - Attended meeting of All-University Council on Environmental Quality, Minneapolis; Dec. 17 - Attended meeting of Minnesota House Committee on Natural Resources, Subcommittee on Waters and Drainage, St. Paul; Dec. 20 - Presented a paper on "Expenditures for Natural Resources Programs" to Citizens League State-Local Fiscal Planning Committee; Jan. 7, 1972 - Presented lectures on water resources and environmental concerns at University of South Dakota, Vermillion, South Dakota, Jan. 10 and 11 - Presented lectures on water resources and environmental concerns at Northern State College, Aberdeen, South Dakota; Jan. 14 - Testified before Minnesota House Committee on Natural Resources, Subcommittee on Waters and Drainage, St. Paul; Jan. 22 - Presented a paper on Water Law and Environmental Impact Dimensions Associated with Future Expansions in the Wild Rice Industry at 1972 Annual Meeting of Wild Rice Growers Association, Grand Rapids; Jan. 25 - Testified before Minnesota House Committee on Environmental Preservation, Subcommittee on Environmental Policy and Organization, St. Paul; Feb. 2 - Presented a lecture on groundwater to Agricultural Engineering students, St. Paul; Feb. 4 - Testified before Minnesota House Committee on Environmental Preservation, Subcommittee on Monitoring and Enforcement, St. Paul; Feb. 14 - Presented a lecture on groundwater to Civil Engineering students, Minneapolis; Feb. 15 - Presented a paper entitled "Some Comments Concerning Watershed Planning in Minnesota" at Joint Seminar on Watershed Planning sponsored by Metropolitan Council and Minnesota Association of Watershed Districts, Inc., Minneapolis; Feb. 18 - Presented a lecture on groundwater to Geology students, Minneapolis; Feb. 25 - Testified before Minnesota Senate Natural Resources and Environment Committee, Subcommittee on Water Permits; Feb. 28 - Presented a lecture on water resources to students majoring in Liberal Arts; March 9 - Presented a paper on Water Resources Administration in Minnesota during a meeting of Minnesota Section, American Water Resources Association, Minneapolis; March 14 to 16 - Presented lectures on Groundwater Resources and Water Resources Administration at University of Arizona, Tucson, Arizona; March 20 - Conducted a Conference on Inland Lake Renewal and Shoreland Management, St. Paul; March 21 to 22 - Attended Seventh Annual Meeting of Water Resources Research Center Directors, Washington, D.C.; March 23 - Attended meeting of

All-University Environmental Council, Minneapolis; April 9, 11 and 13 - Presented a paper on "Water and Related Land Resources Planning in Upper Mississippi River Basin" during Conferences on "Attitudes Towards the Mississippi River as a Total Resource in Minnesota", Bemidji, St. Cloud, and Winona; April 17-18 - Attended Annual Meeting of Mid-Continent Water Resources Research Center Directors, Kansas City, Missouri; April 28 - Chaired Annual Meeting of Center's Advisory Committee and Consulting Council, St. Paul; May 5 - Presented a lecture on "Water Resources Planning Administration in Minnesota" to students in CE5-420, Minneapolis; May 22 to 24, attended Seventh Meeting of Advisory Committee on Water Data for Public Use, U.S. Geological Survey, Washington, D.C.; May 24 - Attended first meeting of Citizens Advisory Committee to the Governor's Environmental Quality Council, St. Paul; June 8 and 13 - Attended meetings of Citizens Advisory Committee to the Governor's Environmental Quality Council, St. Paul.

During fiscal year 1972, the Center Director served on the following Committees: Advisory Committee on Water Data for Public Use, U.S. Geological Survey; Delegate - University Council on Water Resources; All-University Environmental Council, University of Minnesota; Water Resources Coordinating Committee, State Planning Agency; Citizens Advisory Committee to the Governor's Environmental Quality Council.

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

It has been my pleasure to work with you the last few days on our information seminars. In particular, I want to thank you for the appearance here in St. Cloud yesterday and the very fine presentation which you gave to the group assembled. I look forward to having further contact with you and with your office in the future. You might be interested to know that our registration exceeded the 100 level, which is somewhat satisfying in view of the fact that we really were operating in the dark in terms of estimates.

Thanks again for your very informative contribution to the seminar program.

Very sincerely yours,

Philip Tideman, PhD  
Chairman  
Department of Geography  
St. Cloud State College

In behalf of the students and staff in the Environmental Package in the General College, I want to thank you for your visit and discussion with the class. We greatly appreciate your interest and effort to make the program a success during the winter quarter 1972.

The package program served as an excellent model for studying important issues from both an interdisciplinary and problem-oriented approach. Many of the field-work projects conducted by the students have proved to be helpful to other members of the community in solving environmental problems. In effect, the program successfully served to bridge the gap between the community and the formal academic classroom.

Thank you again, and I hope to discuss the merits of this type of program with you in the near future.

Sincerely,

Allen B. Johnson  
Instructor and Program Coordinator  
General College  
University of Minnesota

Thank you again for your participation in the visiting lecture series for advanced groundwater students. The feedback from the students has indicated that the program was of outstanding value and a genuine reinforcement to the scheduled curriculum. Each student felt privileged to have personal communication with such a leading professional person as yourself, and many students expressed appreciation for the opportunity to share the reality of your experiences and expertise in groundwater projects.

The contribution of outstanding professional persons who have given generously of their time has enabled the University to maintain an outstanding groundwater resources study program, and we sincerely appreciate your participation.

Best personal regards,

John W. Harshbarger  
Professor  
College of Earth Sciences  
Department of Hydrology and Water Resources  
The University of Arizona

The Joint Seminar on Watershed Planning held on February 15, 1972, was a success as indicated by the large attendance, the active participation from the floor and the kind comments made by the attendees.

I want to thank you personally and express my appreciation for your very important contributions to the meeting as one of the principal speakers.

Well Done!

Sincerely,

Frank Lamm, P.E.  
Environmental Engineer  
Metropolitan Council



I want to thank you personally and on behalf of the Association for your excellent talk at our annual meeting. Your most kind response helped me out of a very tight position. But of far more importance, it has opened an area of discussion of increasingly vital interest to the paddy rice industry. Yours is the ideal organization to assist us in securing the information needed to move ahead properly. The new president, Mr. David Rued, and the board of directors will be calling on you again I am certain.

We feel wild rice paddies can and will be a major economical asset in an area of our state and nation badly needing all the economic assistance it can get. We also want this industry to develop as a favorable factor in the ecology--not a problem. Our water usage and needs can and should fit a program for the best utilization of Minnesota's water resources. The Soil Conservation Service has gone on record praising proper paddy management as achieving their best aims. And the growers do it with their own money rather than government funds.

As a wild rice consultant and grower, I definitely want to keep in personal touch with you. The Association will be asking you for more information and assistance in the future. Again our deepest thanks for your fine presentation. Please remember to send me your paper for the proceedings as soon as possible.

Sincerely yours,

Erwin R. Brooks  
Wild Rice Growers' Association, Inc.  
Grand Rapids, Minnesota

Thank you for being so well prepared for our session Monday night. I knew you'd come through with an excellent performance as you always have in the past.

Sincerely,

Paul A. Gilje  
Research Director  
Citizens League

Just a brief note to thank you again for taking the time to journey up to Alexandria to speak at our meeting of watershed district people.

You succeeded very well in gearing your presentation to your audience and I sincerely hope that a majority of those present will heed the challenge that you so ably laid down for them.

I also hope that some of the people involved in the watershed movement learned their lesson when the results of the election were announced.

Cordially,

Larry Kelley  
Minnesota Association of Watershed  
Districts

Thank you for your excellent presentation at the recent Midwest Ground Water Conference here in Madison. Your talk was very informative and did much to make the program a success.

Very truly yours,

For the Program Committee  
Perry G. Olcott

On behalf of the University of Wisconsin, University Extension I would like to thank you for your participation in the National Science Foundation supported short course, "Flow Through Porous Media With Applications to Groundwater Hydrology."

According to the comments on the evaluation sheets, your two presentations were very infomative, well presented, and very well received. We cannot express enough appreciation for such an excellent contribution.

Also, it was indeed a pleasure meeting and working with you on this program. Perhaps in the future, we may do so again on a similar basis.

Yours truly,

Donald E. Baxa  
Program Director  
University Extension  
The University of Wisconsin

Dr. William C. Walton, Director of the University's Water Resources Research Center, recently attended the sixth meeting of the Advisory Committee on Water Data for Public Use at San Francisco. I was privileged to chair this meeting and was impressed with the effective manner in which Dr. Walton participated.

The Committee provides advice to the Department of the Interior, and the Geological Survey, on matters relating to the development of a national water data system that will assure an adequate water data base for all users. Discussion at the sixth meeting focused on three main areas of interest: (1) development of standard methodology for water data acquisition; (2) design characteristics for a national system to store, retrieve, and disseminate water data; and (3) environmental quality and water-data requirements. Dr. Walton joined an ad hoc group

in consideration of the first area and contributed significantly to the deliberations of the group and to its report. Beyond this he participated actively in the discussions of the full Advisory Committee.

I wanted you to know how much I appreciate the services of Dr. Walton as a member of the Committee. It is through such close working arrangements that government is better able to meet the needs of our Nation.

Sincerely yours,

W.A. Radlinski, Chairman  
Advisory Committee on Water Data  
for Public Use  
United States Department of the Interior  
Geological Survey

Information Concerning Research Project

Proposals Submitted to OWRR by Center, FY 1973

Lists of FY 1973 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 1965-73 is also provided.

About 30 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 1973

\*(Proposals Funded)

\*Developing a Water Resources Research Plan for Minnesota

List of Matching Grant Research Proposals Submitted to OWRR by Center, Fiscal Year 1973

\*(Proposals Funded)

Policy Differences and Effective Coordination of Federal and State Agencies Concerned With Protecting Lake Superior

Management Methods and Techniques in Protecting the Groundwater Resources of Rochester, Minnesota

\*Role of the Scientist-Technician in Water Policy Decisions at the Community Level: A Study in Purposive Communication

\*Spatial and Temporal Variation of Precipitation of a Concentrated Network in Both Urban and Rural Environments

Thermal Pollution and Lake Superior Periphyton

A Geographic Climatology of United States Drought

Reducing Water Needs of Crop Plants by Identification and Exploitation of the Genetic Control of Water Stress

Development of a Dynamic Model of Nutrient and Phytoplankton Cycles in Minnesota Lakes

Mathematical Modeling of Subsurface Irrigation, Its Management, and Application Toward Reduction of Water Pollution and Thermal Pollution Problems

Predicting the Hydrologic Effects of Watershed Modification by Watershed Modeling

Techniques for Determining the Pollutational History of Minnesota Lakes

Ecology Movement, System Response, and Sociocultural Change: A Study of Interactions, explorations and Adaptations to Improve Water Resources Environment

FISCAL YEAR 1972 BUDGET

ANNUAL ALLOTMENT PROGRAM

\*Forecasting Rainfall and Snowmelt Floods on Upper Midwestern Watersheds

A Study of Attitudes Toward the Red River and Rainy River as Total Resources in Minnesota, North Dakota and Canada

List of Title II Research Proposal Submitted to OWRR by Center, Fiscal Year 1973

\*(Proposals Funded)

Establishing a Model to Evaluate the Political Viability of Alternate Engineering Water Resources Development Plans

Number of Research Project Proposals Submitted to OWRR by Center and Funded or Rejected, Fiscal Years 1965 through 1973

| 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        | 2         | 0        | 2     | 4              | 8        | 12    |
| 1973        | 1         | 0        | 1     | 3              | 11       | 14    |
| Total       | 24        | 0        | 24    | 24             | 57       | 81    |

Title II

| Fiscal Year | Funded | Rejected | Total |
|-------------|--------|----------|-------|
| 1968        | 0      | 2        | 2     |
| 1969        | 0      | 6        | 6     |
| 1970        | 0      | 9        | 9     |
| 1971        | 0      | 2        | 2     |
| 1972        | 0      | 1        | 1     |
| 1973        | 0      | 1        | 1     |
| Total       | 0      | 21       | 21    |

|   | Budget Federal Funds \$ |
|---|-------------------------|
| Center Director's Office  | 28,640                  |
| Water Resources Administration in Minnesota - W.C. Walton, Graduate School (A-021-Minn)   | 16,000                  |
| Zooplankton Biomass and Incipient Eutrophication in Lake Superior - T.A. Olson, School of Public Health (A-022-Minn)  | 9,000                   |
| Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics - C. L. Larson, Department of Agricultural Engineering (A-023-Minn)  | 8,450                   |
| 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) | 11,000                  |
| Alleviation of Lake Pollution by Utilization of Aquatic Plants for Nutritional, Medicinal or Industrial Purposes - E.J. Staba, Department of Pharmacognosy (A-025-Minn)                   | 11,000                  |
| Phytoplankton Nutrition and Photosynthesis in Eutrophic Lakes - R. O. Megard, Department of Ecology and Behavioral Biology (A-026-Minn)   | 9,029                   |
| Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management - H.W. Franckuch, Department of Geology and Geophysics (A-027-Minn) | 6,881                   |
| TOTAL   | 100,000                 |
| Annual Allotment Non-Federal Contribution   | \$ 38,712               |

Matching Grant Program

|  | Budget           |                      |                |
|--|------------------|----------------------|----------------|
|  | Federal Funds \$ | Non-Federal Funds \$ | Total Funds \$ |
| Influence of Mist Irrigation on Moisture Stress, Growth, Yields, and Quality of Potatoes and other Vegetable Crops - R.E. Nylund, Department of Horticultural Science (B-013-Minn) | 1,251            | 5,848                | 7,099          |
| Characteristics of the Soil Matrix that Affect Water Storage & Movement - G.R. Blake, Department of Soil Science (B-015-Minn)  | 15,583           | 17,722               | 33,305         |
| Pollution & the Ecology of Nearshore Periphyton of Lake Superior - T.A. Olson, School of Public Health (B-020-Minn)  | 16,094           | 16,030               | 32,124         |

|  |               |               |               |
|--|---------------|---------------|---------------|
| Participatory Ecology: A Study of Citizens Groups Involved at the Grass Roots to Improve the Water Resources Environment - L.P. Gerlach, Department of Anthropology (B-031-Minn)           | 11,790        | 11,448        | 23,238        |
| Mississippi River Ecology Associated with Heated Power Plant Effluent - A.J. Hopwood, Department of Biology, 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 Minnesota - R.T. Moline, Department of Geography, Gustavus Adolphus College (B-043-Minn)        | 3,850         | 4,095         | 7,945         |
| Area Financing of Water Resources Development - W.R. Maki, Department of Agricultural Economics (B-044-Minn)   | 13,011        | 13,325        | 26,336        |
| Social & Economic Factors in the Adoption by Industry of Water Pollution Control Measures - R.E. Rickson, Department of Sociology (B-047-Minn)   | 11,320        | 10,865        | 22,185        |
| A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota - J.P. Ludwig, Center for Environmental Studies, Bemidji State College (B-049-Minn)                   | 16,314        | 15,435        | 31,749        |
| A Hydronomic Analysis of Forest Management Alternatives for Environmental Quality: A Case Study of Itasca County, Minnesota - A.C. Mace, School of Forestry (B-053-Minn)                   | 11,333        | 11,056        | 22,389        |
| Socio-Economic Implications of Alternative Water Resource Policies in Minnesota - J.J. Waelti, Department of Agricultural & Applied Economics (B-054-Minn)                                 | 8,240         | 8,090         | 16,330        |
| 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) | 15,190        | 10,983        | 26,173        |
| Forecasting Rainfall and Snowmelt Floods on Upper Midwestern Watersheds - C.E. Bowers, St. Anthony Falls Hydraulic Laboratory (B-060-Minn)   | <u>16,357</u> | <u>16,357</u> | <u>32,714</u> |
| TOTAL  | 154,755       | 156,237       | 310,992       |

Faculty Research at University of Minnesota Bearing on Water Resources,

1970-1971, in Addition to the Center's Program

INSTITUTE OF AGRICULTURE

COLLEGE OF AGRICULTURE

Department of Agricultural and Applied Economics

- Blank, O. Uel  
Economics of the tourism/recreation industry  
University of Minnesota Agricultural Experiment Station
- Jensen, Harald R.  
Impact of metropolitan growth on regional resource use (with W. Maki and W. Bryant)  
University of Minnesota Agricultural Experiment Station
- Maki, Wilbur R.  
Impact of metropolitan growth on regional resource use (with H. Jensen and W. Bryant)  
University of Minnesota Agricultural Experiment Station
- Raup, Philip M.  
Analysis of public investments in natural resources within Minnesota (with L. Martin)  
University of Minnesota Agricultural Experiment Station  
Economic problems in the use, allocation, and pricing of water  
University of Minnesota Agricultural Experiment Station
- Snyder, Robert W.  
Local government and policy implications of seasonal home ownership in rural areas  
University of Minnesota Agricultural Experiment Station
- Stam, Jerome M.  
Economic analysis of the Lake of the Woods/Rainy Lakes region of Minnesota  
University of Minnesota Agricultural Experiment Station
- Waldo, Arley D.  
Economics of public services in nonmetropolitan areas (with W. Bryant)  
University of Minnesota Agricultural Experiment Station

Department of Agricultural Engineering

- Allred, Evan R.  
Durability of concrete drain tile and irrigation pipe (with P. Manson)  
University of Minnesota Agricultural Experiment Station and Minnesota Concrete Drain Tile Manufacturers Association

Precision plot irrigator requirements and design  
Supplemental irrigation in Minnesota (with J. Gilley)  
University of Minnesota Agricultural Experiment Station

Goodrich, Phillip R.  
Hydrology of small watersheds (with C. Larson)  
University of Minnesota Agricultural Experiment Station

Larson, Curtis, L.  
Hydrology of small watersheds (with P. Goodrich)  
University of Minnesota Agricultural Experiment Station

Department of Entomology, Fisheries, and Wildlife

Beer, James R.  
Upland game bird population dynamics and habitat requirements  
University of Minnesota Agricultural Experiment Station

Cook, Edwin F.  
Biological and systematic studies on aquatic arthropods  
University of Minnesota Agricultural Experiment Station and  
National Institutes of Health

Gullion, Gordon W.  
Forest Wildlife relations  
University of Minnesota Agricultural Experiment Station and  
State of Minnesota Department of Natural Resources

Heyerdahl, Eugene G.  
Lake of the Woods commercial and sport fishing investigations  
(with L. Smith)  
University of Minnesota Agricultural Experiment Station and  
State of Minnesota Department of Natural Resources

Marshall, William H.  
Minnesota wildlife studies  
University of Minnesota Agricultural Experiment Station  
Productivity of artificial duck ponds  
State of Wisconsin Department of Conservation

Smith, Lloyd L., Jr.  
Causes of population changes in Red Lake commercial fish species  
University of Minnesota Agricultural Experiment Station and  
United States Department of the Interior  
Dynamics of separate intralake fish populations  
University of Minnesota Agricultural Experiment Station  
Influence of water pollutants and water quality on early life  
history and population dynamics of Minnesota fishes  
University of Minnesota Agricultural Experiment Station and  
Environmental Protection Agency  
Lake of the Woods commercial and sport fishing investigations  
(with E. Heyerdahl)  
University of Minnesota Agricultural Experiment Station and  
State of Minnesota Department of Natural Resources

Waters, Thomas F.  
Mechanisms of biological production in streams  
University of Minnesota Agricultural Experiment Station

Department of Horticultural Science

Kuska, James  
Development of design and utilization criteria for Minnesota  
natural resources  
University of Minnesota Agricultural Experiment Station

Department of Soil Science

Arneman, Harold F.  
Minnesota soil survey and soil characterization (with R. Rust  
and R. Farnham)  
University of Minnesota Agricultural Experiment Station

Baker, Donald G.  
Soil heat and moisture characteristics related to evaporation from  
cropped land  
University of Minnesota Agricultural Experiment Station  
Urban Climatology  
University of Minnesota Agricultural Experiment Station  
Weather information for agriculture  
University of Minnesota Agricultural Experiment Station

Blake, George R.  
Soil structure and crop growth  
University of Minnesota Agricultural Experiment Station

Farnham, Rouse S.  
Minnesota soil survey and soil characterization (with  
R. Rust and H. Arneman)  
University of Minnesota Agricultural Experiment Station

Grigal, David F.  
Role of soil properties in the forest ecosystem  
University of Minnesota Agricultural Experiment Station

Rust, Richard H.  
Improvement of soils developed under forest vegetation  
University of Minnesota Agricultural Experiment Station  
Minnesota soil survey and soil characterization (with H.  
Arneman and R. Farnham)  
University of Minnesota Agricultural Experiment Station  
Productivity of dominant Minnesota soil types  
University of Minnesota Agricultural Experiment Station

College of Forestry

Gregersen, Hans M.  
Determinants of forest resource, supply, benefits, and management  
levels in Minnesota forests (with J. Hughes and R. Skok)  
University of Minnesota Agricultural Experiment Station

Forest resources in the economic development of northeastern  
Minnesota (with J. Hughes and R. Skok)  
University of Minnesota Agricultural Experiment Station

Hansen, Henry L.  
Ecomanagement of forest vegetation on parks and wilderness areas  
University of Minnesota Agricultural Experiment Station

Mace, Arnett C., Jr.  
Watershed values in forest management  
University of Minnesota Agricultural Experiment Station

Merriam, Lawrence C., Jr.  
Relationships between recreation land management and user satisfaction  
University of Minnesota Agricultural Experiment Station and College  
of Forestry

Meyer, Merle P.  
Remote sensing in resources management  
University of Minnesota Agricultural Experiment Station and College  
of Forestry

#### COLLEGE OF BIOLOGICAL SCIENCES

##### Department of Botany

Bland, Robert D.  
Desmid distribution in Lake Calhoun in association with aquatic  
macrophytes  
Laboratory manual for general biology  
Spatial distribution of desmids in certain northern Minnesota lakes

Cagle, Fred R., Jr.  
Geochemical studies on the history and evolution of Minnesota lakes  
and their bearing upon eutrophication (with E. Gorham)  
National Science Foundation

Gorham, Eville  
Chemical studies on waters and soils of lakes and wetlands,  
with reference to minor elements  
National Science Foundation  
Distribution of athiorhodaceae in natural environments of Minnesota  
(with D. Pratt)  
University of Minnesota Limnological Research Center  
Biochemical studies on the history and evolution of Minnesota  
lakes and their bearing upon eutrophication (with J. Sanger)  
National Science Foundation  
Thermonuclear tritium as an indicator of water movement in wetland  
soils and lake sediments  
Atomic Energy Commission

##### Department of Ecology and Behavioral Biology

Bright, Robert C.  
Diatoms of forty Minnesota lakes  
University of Minnesota Limnological Research Center  
Diatoms of Lake Superior  
Paleoecology of Michaud Lake, southeast Idaho  
Paleoecology of Whimpy Lake, Wyoming  
Pleistocene Lake Thatcher, southeast Idaho

Brook Alan J.  
Biology of algae in rivers  
Northern States Power Company  
Ecological studies on dynamics of planktonic blue-green algae  
with special reference to their microstratification  
Atomic Energy Commission

Megard, Robert O.  
Algae and nutrients in Shagawa Lake  
United States Department of the Interior  
Phytoplankton, photosynthesis, and phosphorus in Lake Minnetonka  
State of Minnesota Pollution Control Agency

Siniff, Donald B.  
Development of equipment and methods in the fields of bioelementary  
and data analysis for water fowl research  
United States Department of the Interior Bureau of Sport Fisheries  
and Wildlife  
Rainbow trout movement and behavior  
State of Minnesota Department of Natural Resources

Tester, John R.  
Development of techniques in the field of biotelemetry and data  
analysis for behavioral and ecological research  
United States Department of the Interior  
Effects of ionizing radiation and other environmental factors  
on breeding behavior, activity patterns, and movement of selected  
vertebrates  
Atomic Energy Commission  
Vertebrate ecology and behavior  
National Institutes of Health

#### COLLEGE OF LIBERAL ARTS

##### Department of Anthropology

Gerlach, Luther P.  
Extension and maximization of use of questionnaire, "You and  
Ecology," first published in Natural History, June 1970  
University of Minnesota Graduate School Grant-In-Aid of Research  
Movements of personal transformation and revolutionary social change:  
structure, functions, and dynamics, including a comparison of the  
ecology movement and the black power movement  
Hill Family Foundation  
"Participatory ecology:" Interaction between this movement, other  
social movements, and the established order  
University of Minnesota Graduate School Grant-In-Aid of Research

Department of Geography

Skaggs, Richard H.

Spatial patterns of drought in the United States  
Synoptic and dynamic climatology of the 1958-59 drought in Minnesota  
University of Minnesota Graduate School Grant-In-Aid of Research  
Urban heat-island of the Twin Cities

Tuan, Yi Fu

Attitudes to physical environment  
Environmental attitudes  
Environmental psychology  
Geography, phenomenology, and the study of human nature  
Man and nature  
Association of American Geographers

LAW SCHOOL

Bryden, David P.

Lakeshore zoning in Wisconsin: an empirical study of administrative  
and enforcement problems and trends  
University of Minnesota Graduate School Grant-In-Aid of Research

SCHOOL OF PUBLIC HEALTH

Olson, Theodore A.

Lake Superior periphyton in relation to water quality  
United States Department of the Interior

Straub, Conrad P.

Effect of treatment in removal of trace substances in water  
treatment plant sludge

INSTITUTE OF TECHNOLOGY

Department of Chemical Engineering and Materials Science

Isbin, Herbert S.

Nuclear reactor safety  
Radiation chemistry: recombination of hydrogen and oxygen, and  
radialysis of water solutions

Department of Civil and Mineral Engineering

Johnson, Walter K.

Denitrification process kinetics  
Environmental Protection Agency

Schroepfer, George J.

Future sewage works requirements  
Metropolitan Sewer Board  
Water supply and pollution control  
United States Department of the Interior

Maier, Walter J.

Carbon analysis of Minnesota waters  
Removal of colloidal matter by biological processes  
United States Department of the Interior  
Use of digital computer programs for preliminary design of waste  
water treatment systems

St. Anthony Falls Hydraulic Laboratory

Anderson, Alvin G.

Boundary survey, Red River watershed district  
State of Minnesota Water Resources Board  
Erosion control in highway drainage channels  
National Academy of Sciences  
Flow in long vertical dropshafts  
Environmental Protection Agency  
Geomorphology of stream meanders

Bowers, C. Edward

Evaluation of computer programs in hydrology  
United States Department of the Interior Office of Water  
Resources Research  
Flood plain data processing  
State of Minnesota Department of Natural Resources  
Mathematical simulation of a large watershed using the systems  
approach for quantity and quality analysis  
United States Department of the Interior Office of Water  
Resources Research  
Pressure fluctuations in the hydraulic jump  
National Science Foundation  
Rainfall-snowmelt flood forecasting in the Upper Midwest  
United States Department of the Army  
Report on hydraulic model studies on Priest Rapids Dam,  
Columbia River, Washington  
Grant County Public Utility District, State of Washington  
Storm runoff studies  
Horner and Shifrin, Inc.

Hayden, John W.

Hydraulic model studies of Zion Nuclear Power Plant discharge  
outlets  
Harza Engineering Company  
Hydraulic model tests of Encina Power Plant circulating water  
intake system  
Pioneer Service and Engineering Company  
Permeability tests on taconite coarse and fine tailings  
United States Steel Corporation

Killen, John M.

Evaluation of acoustic attenuation method for determining gas  
bubble nuclei size distribution in water  
United States Department of the Navy  
Influence of drag reducing polymer additives on surface pressure  
fluctuations on rough surfaces  
United States Department of the Navy

Influence of drag reducing polymers on radiated flow noise  
United States Department of the Navy  
Influence of drag reducing polymers on surface pressure fluctuations  
United States Department of the Navy

Ripken, John F.

Channel flow studies  
United States Department of the Navy  
Guri hydroelectric project spillway bucket study  
Harza Engineering Company  
Hydraulic disintegration of rock for rapid excavation  
United States Department of the Interior Bureau of Mines  
Multiple-jet control and dissipation system for high head structures  
National Science Foundation  
Tempering water pumping studies  
Northern States Power Company

Silberman, Edward

Development of a data acquisition system for the St. Anthony  
Falls Hydraulic Laboratory  
National Science Foundation  
Development of a new instrument for measuring the cavitation  
susceptibility of water  
United States Department of the Navy  
Friction factors in corrugated aluminum pipe  
Chamlin and Associates, Inc., and City of LaSalle, Illinois  
Model studies of Lake Erie Bulkhead  
Bethlehem Steel Corporation  
Prairie Island nuclear plant studies  
Northern States Power Company

Song, Charles C.S.

Cavity flow in gravity field  
Watershed simulation  
United States Department of the Interior Office of Water Resources  
Research  
Waves in stratified fluids

Stefan, Heinz G.

Controlled temperature regimes in outdoor experimental ponds  
United States Department of the Interior Federal Water Quality  
Administration  
Heat budget of central Minnesota waters  
Mixing and dispersion at a warm water outlet  
Environmental Protection Agency

Department of Geology and Geophysics

Pfannkuch, Hans-Olaf

Correlation of hydrological parameters for porous media flow with  
microscopic pore morphology measurements  
University of Minnesota Graduate School Grant-In-Aid of Research  
Electrical conductivity in saturated porous systems and its correla-  
tion with hydrologic flow parameters  
National Science Foundation

Evaluating effects of urbanization on selected watersheds by a  
public participatory data collection program  
Hydrogeologic studies of groundwater in selected areas of the Twin  
Cities metropolitan area  
University of Minnesota / Minnesota Geological Survey  
Hydrologic study of proposed Ham Lake airport site  
University of Minnesota / Minnesota Geological Survey  
Lake pollution program (with J. Shapiro)  
State of Minnesota Planning Agency and City of Minneapolis  
Department of Parks and Recreation

Shapiro, Joseph

City lakes study  
City of Minneapolis  
Phosphate absorption  
National Science Foundation

Swain, Frederick M.

Biogeochemistry of Delaware Bay  
Biogeochemistry of marsh sediments  
United States Department of the Navy  
Mesozoic-Cenozoic Ostracoda, Atlantic coastal plain  
United States Department of the Interior Geological Survey  
Micropaleontology of deep sea deposits  
University of Delaware Research Foundation  
Microstructure of ostracode family cyprididae and its relationship  
to taxonomy  
University of Minnesota Graduate School Grant-In-Aid of Research

Wright, Herbert E., Jr.

Community analysis in the littoral zone of lakes  
Environmental Protection Agency  
Development of lakes and landscapes on stagnant glacial ice in  
the Yukon  
National Science Foundation  
Diatoms in lakes and lake sediments as an index to environment  
Atomic Energy Commission  
Late-Quaternary environmental history beyond the glacial border  
National Science Foundation  
Late-Wisconsin landscape in the Minnesota area (with E. Cushing)  
National Science Foundation  
Natural environment of early agriculture in the Near East  
University of Minnesota Office of International Programs

UNIVERSITY OF MINNESOTA, DULUTH

Division of Science and Mathematics

Department of Biology

Ahlgren, George E.

Wild rice (*Zizania aquatica*): its culture and physiology with  
emphasis on development/temperature relationships (with J. Carlson)



and H. Hanten  
National Science Foundation

ANNUAL ALLOTMENT PROGRAM

Narrative Progress Reports

Form OW-1 (1972)

Carlson, John B.  
Wild rice morphological development (with G. Ahlgren and H. Hanten)  
National Science Foundation

Collins, Hollie L.  
Comparative protein analyses of known strains and wild populations  
of anadromous Lake Superior rainbow trout (*Salmo gairdneri*)  
Preferential care of young in cichlid fishes

Odlaug, Theron O.  
Pesticide inputs and levels of north shore streams tributary to  
Lake Superior (with T. Olson)  
State of Minnesota Pollution Control Agency

Robinson, Andrew F., Jr.  
Pollen analysis of Olson Bog

Department of Geology

Matsch, Charles L.  
Geomorphology of the north shore area, Lake Superior

Department of Political Science

Olsen, Dale W.  
Planning and development in the Arrowhead region (with W. Jesswein)  
Politics and environment  
The politics of Voyageurs National Park

UNIVERSITY OF MINNESOTA, MORRIS

Division of Science and Mathematics

Abbott, Robinson S. (biology)  
Limnological survey of Eagle Lake

Brauer, Clemens P. (geology)  
Bedrock geology of west central Minnesota  
Environmental geology of Stevens County, Minnesota

Latterell, Joseph J. (chemistry)  
Accumulation of phosphates in water (with R. Halt and D. Timmons)

Straw, Thomas E. (biology)  
Eagle Lake pollution control, project coordinator  
Eagle Lake Improvement Association; Kandy County Soil and Water  
Conservation District; and Willmar Sportsman's club

OWRR Project No. A-021-Minn.

Agreement No. 14-31-0001-3523

Project Title: Water Resources Administration in Minnesota

FCST-COWRR Research Category: 06-E

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, St. Paul, Minnesota 55114

Project Began - July 1, 1969 To be Completed - June 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u> | <u>Discipline</u> |
|-------------------------------|---------------|-------------------|
| William C. Walton             | B.S.          | Civil Engineering |

| <u>Student Assistants</u> | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
|---------------------------|--------------------|--|
| D.L. Hills                | B.S.               | Civil Engineering                        |
| Nadim Shamat              | B.S.               | Civil Engineering                        |

Narrative Statements

(A) Research Project Accomplishments.

A study of Federal water and related land resources administration as it pertains to Minnesota was completed. The activities of Interest Groups in the field of water and related land resources were inventoried.

In 1970, Minnesota's State government contained at least 21 departments, agencies, boards, commission, committees, etc. with water and related land resources responsibilities. Expenditures by these organizations increased from \$5.7 million in 1950 to \$31.9 million in 1970. About 86 % of expenditures were made by the Department of Conservation. Total State agency staff complements increased from 1,100 in 1960 to 1,400 in 1970. Prime responsibility for water and related land resources programs rested in 3 Committees of the Senate and 2 Committees in the House. The Governor's and Legislature's control of the State's administrative apparatus is hampered through fragmented organization. A recommended plan of reorganization centers on consolidation of major functions within a Department of Natural Resources. There is need for the Legislature to enunciate a comprehensive environmental policy for the State.

In 1970, there were 5 International, 5 regional, 3 interstate, and 4 Federal-State organizations with programs in the State. Federal responsibilities in water and related land resources planning, development and management in Minnesota was divided among 30 units in 8 executive departments and agencies; 6 independent agencies; 6 units in the executive office of the President; 9 other boards, committees, councils and commissions; and 1 quasi-official agency. In fiscal Year 1970, Federal outlays for water and related land resources activities in the State totaled about \$75 million or 2.3 percent of total Federal outlays in Minnesota of about \$3.3 billion.

There were about 1,300 Federal employees residing in Minnesota in fiscal year 1970 with assignments pertaining to water and related land resources.

In 1971, there were at least 49 Interest groups in Minnesota with major water and related land resources programs, 4 Leagues and Associations with minor water and related land resources programs, at least 80 organizations that tend to have a continuing interest in water and related land resources issues, and at least 150 National organizations concerned with water and related land resources programs which have or could have members in the State. The Minnesota Senate 1971 registration files for lobbyists listed 110 lobbyists in the field of water and related land resources; the House files listed 138 lobbyists. Of the 53 Interest groups (49 Interest Groups and 4 Leagues and Associations mentioned above), 40 were conservation-preservation oriented, 8 had the word environmental in their name, and 5 were development and management oriented. Taking into consideration multiple memberships, it is estimated that approximately 25,000 citizens in Minnesota were members of the 53 Interest Groups in 1971. Membership in individual Interest groups ranged from 13 to 12,000. Expenditures in 1971 for water and related land resources programs of the 53 Interest groups probably totaled in excess of \$250,000. Annual expenditures by individual Interest groups ranged from \$100 to in excess of \$35,000. These figures do not include the thousands of hours of volunteer time by members. The sources of income were dues, contributions, donations and grants. The affairs of 45 of the 53 Interest groups were under the direction of Officers; 8 Interest groups had Boards; and 14 Interest groups had staffs. It is estimated that the number of water and related land resources Interest groups increased from about 16 in 1950 to 25 in 1960 to 33 in 1965 to 53 in 1971.

In the past, there has been considerable activity in Minnesota associated with the development and management of water and related land resources. For example, water-supply and sewage treatment plants have been constructed at most cities and villages as well as by many industries. Water-oriented recreation facilities have been provided in connection with parks, waysides, reserves, and monuments, etc. scattered throughout the State. Fish management programs have been extended to many areas and hundreds of wildlife management areas have been developed. Wetland waterfowl production areas are being managed. Agricultural lands have been drained in extensive areas and farmers have made considerable progress in the installation of conservation practices to reduce and control soil erosion. Some flood control and prevention has been accomplished as soil and water conservation projects and as projects of the U.S. Army Corps of Engineers. Extensive improvements of rivers and harbors for navigation are located along the Mississippi River and in the Duluth-Superior area. Past development and management practices, as substantial as they are, have not kept pace with the steadily growing demands placed upon water and related land resources. Not only does Minnesota have catch up problems to contend with in the future, continuing pressures and demands for enhancement of the environment and improved economic well-being can be expected to create steadily growing demands for water and related land resources. There exists many water and related land resource problems associated with such matters as: pollution of streams, lakes and groundwater; water-oriented recreation; water supply; flooding; navigation; and land use.

Responsibilities for water and related land resources data acquisition and handling in Minnesota are shared among many Federal, State, local and private organizations. The diffusion of responsibility makes it difficult to launch a comprehensive attack on environmental and other problems. Divided responsibility means that some needed data acquisition and handling programs slip between the cracks and disappear from view. One such program is the development of a statewide water and related land resources - data system. A statewide water and related land resources - data system is needed to improve the coordination of data acquisition and handling responsibilities, to improve the efficiency of data programs, and to upgrade and fill deficiencies in data programs. Institutional arrangements must be devised to design the system.

A State Environmental Policy Bill, H.F. No. 2405, introduced by Messrs. Dunn, Norton, Becklin, Munger and Knutson passed the House on May 21, 1971 with a vote of yeas 117 and nays 12. A companion bill, S.F. 2048, introduced by Messrs. Gage, Gustafson, and Popham and referred to the Committee on Civil Administration was not reported out-of-Committee. H.F. No. 2405, passed by the House, was introduced in the Senate on May 22, 1971. The bill was never read for the third time, thus, it never came up for vote in the Senate. This bill addressed itself to many existing water and related land resources planning policy questions as did a report approved by the Land and Water Resources Committee, House of Representatives on November 30, 1970. During 1971 and 1972, several Subcommittees of Committees of the State Senate and House held joint hearings on water and related land resources issues. Governor Anderson in April 1972 established an Environmental Quality Council with a Citizens Advisory Committee. These actions could lead to the passage of a State Environmental Policy Act during the 1973 Session of the Legislature and to the improvement of government for water and related land resources programs in Minnesota.

#### (B) Publications.

Walton, W.C. and D.L. Hills. 1971 International Regional, Federal-State, Interstate, and Federal Organizations With Water and Related Land Resources Programs in Minnesota, 1971. Water Resources Research Center, University of Minnesota. Bull. 42. 262 p., 16 fig., 13 tab., 22 ref.

Walton, W.C. and D.L. Hills. 1972. Interest Groups with Water and Related Land Resources Programs in Minnesota, 1971. Water Resources Research Center, University of Minnesota. Bull. 45. 96 p.

Walton, W.C. 1972. Water Resources Administration in Minnesota, 1972. Water Resources Research Center, University of Minnesota. Bull. 49. 188 p., 15 ref. (Research Project Technical Completion Report).

#### (C) Project Status.

The project has been completed.

#### (D) Application of Research Results.

The information generated by this research will assist the 1973 session of the Legislature in its consideration of legislation pertaining to water and related land resources. The results of the research also should assist citizens and State, local and Federal agency personnel in better understanding their government for water and related land resources.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No. A-022-Minn.

Agreement No. 14-31-001-3523

Project Title: Zooplankton Biomass and Incipient Eutrophication in Lake Superior

FCST-COWRR Research Category: 05-C

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1969 To Be Completed - June 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| T.A. Olson                    | Ph.D.              | Public Health                            |
| <u>Student Assistants</u>     | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| John B. Conway                | B.A.               | Public Health                            |
| Jonathon Vornachka            | Undergrad.         | Public Health                            |
| Jerrold Vitek                 | Undergrad.         | Public Health                            |

Narrative Statements

(A) Research Project Accomplishments.

During the period June 21 to November 11, weekly samples were collected at both the half mile and two mile Larsmont stations. From June 28 to September 3, biweekly samples were collected at the half mile and two mile Stony Point stations. Monthly samples were collected at the Little Marais station, July to September. Zooplankton samples were collected from six depths at each station. A 200 foot bathythermograph was used to determine the water temperature. A submarine photometer was used to measure light radiation at selected intervals and to a depth of 25 meters.

Samples were taken to the laboratory where the zooplankters were identified, enumerated and reported in terms of numbers per 100 liters. Ten Limnocalanus macrurus were selected randomly from each sample and the length of each was measured to the nearest 0.01 millimeter (mm). The sex of each copepod was also determined. Finally, after a ten milliliter (ml) aliquot had been removed for reference purposes, the sample was ashed to determine the organic weight which was reported in milligrams (mg) per 100 liters of water.

A preliminary examination of the data shows that:

- 1) The greatest numbers of zooplankton occur when the water is warmest (15 C); this means late August and early September.
- 2) The greatest zooplankton biomass occurred with the warmest water.

- 3) If temperature is plotted against depth, it will be found that the 11 C isotherm marks the upper limit of L. macrurus distribution. Few of these copepods were ever found in water warmer than 11 C.
- 4) The largest L. macrurus (length) were found in the deepest water.
- 5) A regression line was plotted for the lengths and weights of adult L. macrurus. The formula for this line is:

$$Y = 3.55X - 4.73.$$

where Y = weight in mg/100 an d

X = length in mm.

Such a regression line makes it possible to visualize the relationship which exists between the two parameters, in this instance length and weight.

A preliminary evaluation of the data indicates that as had been anticipated and in terms of biomass, Limnocalanus macrurus will be the most typical representative of the grazing community. Because studies have been conducted only during the months, June through November, the findings relate primarily to copepodid stages IV, V and VI. Of these, only copepodid state VI represents the sexually mature form. It will be remembered that the total length of the L. macrurus life cycle is a calendar year and therefore, the absence of forms proceeding stage IV indicates that the development of this species is seasonal and there are no staggered populations. With regard to vertical distribution, although only a small part of the data has been examined in detail, it appears that the position occupied by zooplankton is related to the time of day and that between 900 and 1400 hours the zooplankters are most commonly found at the 10 meter level. Horizontal distribution is also of interest, but this factor has not yet been evaluated. However, it has been observed that a station one half mile from shore seems to have a consistently higher number of zooplankters than a station two miles out. When dry and organic weight is taken as the parameter, it appears that there will be a good correlation between this yardstick and the total number of zooplankters.

(B) Publications.

Addess, M., Nelson, R., Schlottman, L. and Parkos, W. 1971. A study of the potential of periphyton organisms as components of Lake Superior plankton. Limresta, Research Report No. 2.

(C) Project Status.

The project has been completed.

(D) Application of Research Results.

The investigations, focusing on zooplankton biomasses, should be helpful in assessing the extent of eutrophication of the west end of Lake

Superior. Knowledge concerning the effects of pollution on the growth response, species replacement, and productivity of flora and fauna in the aquatic habitat of the west end of Lake Superior should be useful. Information concerning eutrophication will assist the State in enforcing water quality standards.

The purpose of this study is to deal with one small element of the great unknown which still characterizes our scientific knowledge of Lake Superior. In this instance, the research which has been carried out, has dealt with the zooplankton population; its distribution, its make-up, its general ecology and its biomass. In this study, special attention has been given to the relict copepod, Limnocalanus macrurus (Sars).

Each trophic level in an aquatic food chain is related to the one below it. Therefore, a change in any level will affect all the levels above it. Much of the research in western Lake Superior has involved the first trophic level, the diatoms and algae. This investigation when completed will characterize the second level, the zooplankton. Quantitative values for zooplankton productivity will then be available and this information should make possible better estimates of the total biomass that can be supported at the next trophic level. An added advantage is that a base line will be established for zooplankton in Lake Superior which in future studies of this kind can be used as a reference point.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No. A-023-Minn.

Agreement No. 14-31-0001-3523

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

FCST-COWRR Research Category: 02-E

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

Project Began - July 1, 1970 To Be Completed - June 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| C.L. Larson                   | Ph.D.              | Agricultural Engineering                 |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| Ronald F. Gronwald            | B.S.               | Agricultural Engineering                 |
| Charles E. Rice               | M.S.               | Agricultural Engineering                 |
| Terry Huntrods                | Undergrad.         | Agricultural Engineering                 |

### Narrative Statements

#### (A) Research Project Accomplishments.

The major effort of the project has been devoted to developing procedures for predicting peak flows for small watersheds by using a watershed time parameter that can be evaluated from easily measured physical characteristics of the watershed. To develop such a method, the parameter must also be determined hydrologically, i.e., from observed runoff events, to test its validity and accuracy. In addition, calculated peak flows need to be compared to observed peak flows for the same purpose.

##### (a) Watershed Time Parameter by Hydrologic Analysis

Numerous observed hydrographs were analyzed for 28 experimental watersheds of the Agricultural Research Service at Coshocton, Ohio, Oxford, Mississippi and Riesel, Texas, varying in size from 100 to 32,000 acres (0.15 to 50 sq. mi.). For the 380 events analyzed, it was found that 50% of equilibrium flow ( $T_{50}$ ) was reached in 138 or 36% of the cases, providing this many values of the time parameter,  $T_{50}$ , to work with. Values of  $T_{50}$  for a given watershed tended to decrease with flow rates, as expected, but exhibited considerable variability.

##### (b) Channel Characteristics - Data Collection and Analysis

Several channel cross-sections as well as the channel profile were needed for each watershed. At Coshocton, Ohio, these were not available and were obtained by making field surveys. At Oxford, Mississippi, they were obtained from the files at the research station with the assistance of station personnel. For the Riesel, Texas station, cross-sections (a smaller number) were obtained by correspondence.

Various regressions were attempted to relate hydraulic channel characteristics to easily measured physical characteristics. It was found that, for a given region, bankfull area can be expressed as a simple function of the product, depth x topwidth, and that wetted perimeter can be given as a constant times topwidth, with relatively small error. Thus, simple measurements of depth and topwidth can be substituted for complete cross-sections.

##### (c) Watershed Time Parameter - Hydraulic Approach

Methods of predicting the time parameter ( $T_{50}$ ) by use of channel characteristics and calculated flow velocities were studied as a means of making hydrologic predictions for ungaged watersheds. Flow velocities were based on bankfull discharges. As expected, the travel time for bankfull flow was consistently lower than the hydrologic parameter,  $T_{50}$  which is associated with the initial (smaller) flow rates. The ratio of these two quantities varied considerably but showed no trend with respect to watershed size. Other hydraulic approaches were studied also, and comparisons are now being made.

##### (d) Peak Flow Predictions

Peak flows are being predicted for the various experimental watersheds using the analytical peak flow equation developed earlier but inadequately tested by the use of mathematical watershed models. The time-parameter,  $T_{50}$ , is being substituted for time to virtual equilibrium,  $T_{ve}$ , since the latter cannot be evaluated from observed hydrographs. Work is continuing on this phase of the study.

##### (e) Hydrograph Routing in Open Channels

In an independent but closely related study, existing methods of routing runoff hydrographs were studied and two additional routing methods were developed and evaluated. Special emphasis was given to methods applicable to ungaged watersheds, i.e., to methods that do not require fitted coefficients. A main channel system patterned after small watersheds in S.E. Minnesota was formulated as a model. Various inflow hydrographs were routed through the channel by means of the dynamic equations of unsteady, free-surface flow, solved by the method of characteristics with specified time interval. These simulation model results were used as the data base for testing and developing various storage routing methods, each of which relies on one or more major assumptions.

Of the three existing storage routing methods studied, only the Muskingum method gave good results, except for relatively low channel slopes. However, this method requires observed inflow and outflow hydrographs for evaluating the coefficients. The accuracy of the Puls method was found to be good only if the length increment is within a certain range, neither too long or too short.

New Method A, using fitted coefficients, gave good to excellent results for all conditions, including relatively low slopes. With analytical coefficients, however, results were dependent on the proper choice of reach length, an obvious disadvantage. New Method B as developed for use without fitted coefficients and gave good results except at low channel slopes, and was not sensitive to the length increment used.

The "direct" and "explicit" methods for solution of the dynamic, unsteady flow equations were studied also. Both gave excellent results and required much less computer time than the method of characteristics, but more than the storage routing methods. A junction routing procedure was used in another series of tests with the simulation model (method of characteristics) to represent the backwater effects of tributary inflow. In terms of discharge, direct addition of the tributary and main channel flow rates gave resultant hydrographs approximating those of the simulation model. If water surface profiles are desired for dynamic backwater situations, however, the method of characteristics should be used.

(B) Publications.

"Methods for Routing Hydrographs Through Open Channels" by Charles E. Rice and Curtis L. Larson, University of Minnesota Water Resources Bulletin 51, June 1972, 132 pages, 44 figures, 21 tables, 36 references.

"Predicting Peak Flow of Small Watersheds by Use of Channel Characteristics", by Curtis L. Larson and Ronald F. Gronwald, University of Minnesota, Water Resources Research Center Bulletin 52, August, 1972 (in preparation).

(C) Project Status.

The project has been completed.

(D) Application of Research Results.

It is expected that the results under Parts 1(a) - 1(d) will partially fill the serious deficiency in methods for predicting peak flows for ungauged watersheds in the range from about 1 to 50 sq. mi., i.e., for hydrologic design of the numerous highway culverts, small bridges, erosion control structures and channel modifications installed each year. The results of the current study are only partial (as planned) since it deals only with the channel or routing phase of runoff. Predicting the input to the channel system (the runoff volume) is equally important and difficult.

The results of the study on channel routing methods appear to be of immediate use to engineers involved in design of watershed flood control projects and similar activities. The comparison of various routing methods will be helpful in choosing a method for a given problem situation by providing information on relative accuracy and cost. The new method of storage routing without fitted coefficients (Method B) appears to be a significant improvement of existing methods for ungauged watersheds and, as such, is expected to be of considerable benefit.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No. A-024-Minn.

Agreement No. 14-31-000-3523

Project Title: Mathematical Simulation of a Large Watershed using the Systems Approach to Quantity and Quality Analysis

FCST-COWRR Research Category: 06-A

Name and Location of University where Project is being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1970

To Be Completed - June 30, 1973

| <u>Principal Investigators</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|--------------------------------|--------------------|--|
| Charles C.S. Song              | Ph.D.              | Civil Engineering                        |
| C.E. Bowers                    | M.S.               | Civil Engineering                        |
| <u>Student Assistants</u>      | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| A.F. Pabst                     | M.S.               | Civil Engineering                        |
| Gary Lake                      | B.S.               | Civil Engineering                        |
| David Ford                     | Undergrad.         | Civil Engineering                        |

Narrative Statements

(A) Research Project Accomplishments.

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.

Considerable 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 in-

puts 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 the 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 was 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.

As part of this study as well as other research concerned with quantity of runoff, the SSARR has been operated with input data covering up to one-year periods. This has involved precipitation, temperature, and other meteorological data over a 16,000 square mile area plus measured streamflow data for 15 sub-watersheds and three main stem gaging stations in the watershed. Output depends on a fitting or optimization process relative to various parameters in the model for each of the 15 sub-watersheds. Very good results have been obtained relative to computed discharges, but further study is needed on evaluating parameters in a form suitable for extreme hydrological events as well as the more normal occurrences.

Relative to quality of runoff, a mathematical model of the quality of flow has been written for use with the final choice of quantity-of-flow model. This requires the procurement of data on water quality as a function of both time and location along a given stream, and a fitting of the model to available data for each quality variable such as water temperature, BOD, DO, and some chemical characteristics. Initial studies were performed to determine the input water temperature at various locations in the main stream using a regression analysis to relate water temperature to air temperature for preceding periods. A correlative coefficient of about 0.95 was achieved for the developed relationship between air and water temperature.

Work will now be started on other quality variables using a similar technique. Initially it was thought that some field measurements of water quality would be desirable, but adequate data has been obtained from the Environmental Protection Agency.

(B) Publications.

None.

(C) Project Status.

The project will continue in progress in fiscal year 1973.

(D) Application of Research Results.

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.

(E) Work Remaining, and Progress Contemplated During Next Year.

- 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 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 economic aspects of the system will not be studied in detail but will be considered in defining the constraints.

OWRR Project No. A-025-Minn.

Agreement No. 14-31-0001-3521

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

FCST-COWRR Research Category: 05-E

Name and Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1970 To Be Completed - June 30, 1973

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| E.J. Staba                    | Ph. D.             | Pharmacognosy                            |
| <u>Student Assistants</u>     | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| S.L. Bechdolt                 | B.S.               | Medical School                           |
| D. Mills                      | B.S.               | Biology                                  |
| M.K. Lindahl                  | B.S.               | Chemistry                                |
| J. Linn                       | B.S.               | Animal Nutrition                         |

Narrative Statements

(A) Research Project Accomplishments.

Twenty-two freshwater aquatic plants were analyzed to determine their potential feeding value for ruminants. Proximate analyses (mean +/- standard deviation), on a dry matter basis were: crude protein 12.7 +/- 4.4; ether extract 1.46 +/- 0.98; crude fiber, 19.2 +/- 6.4; ash, 2.05 +/- 1.24 and NFE, 64.6 +/- 6.5. NDF, ADF and ADL contents averaged 41.6 +/- 13.4, 32.0 +/- 9.6 and 6.35 +/- 2.76, respectively. Mineral contents (mean +/- standard deviation) of the 22 aquatic plants were: P, 0.25 +/- 0.18%; Ca, 1.74 +/- 1.63%; K, 1.51 +/- 0.89%; Na, 0.33 +/- 0.26%; Mg, 0.30 +/- 0.16%; Fe, 893 +/- 712 ppm; Zn, 76.4 +/- 93.4 ppm; Cu, 13.0 +/- 32.6 ppm; Mo, 19.0 +/- 9.6 ppm and Mn, 258 +/- 151 ppm. Van Soest's estimated apparent digestibilities ranged from 49.2% to 78.0%. Two groups of four lambs each received rations consisting of 50% dehydrated alfalfa and 50% of the aquatic plant Myriophyllum exalbescens or Potamogeton pectinatus, plus minerals and water. Another group of four lambs received only dehydrated alfalfa so that the digestibility of the lake plants could be calculated by difference. Digestion coefficients of the dehydrated alfalfa and the individual aquatic plants Myriophyllum exalbescens and Potamogeton pectinatus, as determined by difference, were 50.8%, 43.8% and 43.4% for dry matter, 58.3%, 46.0% and 44.1% for crude protein and 49.2%, 53.7% and 47.4% for energy, respectively. TDN values, on a dry matter basis, were 40.2%, 37.1% and 51.5%, respectively. Dry matter and crude protein digestibility favored dehydrated alfalfa (P less .01). Energy digestibility was higher (P less .05) in Myriophyllum exalbescens than Potamogeton pectinatus or dehydrated alfalfa. These results indicate that aquatic plants may be an adequate forage for ruminants if economic and palatability problems are overcome.

Nuphar variegatum and Myriophyllum exalbescens continue to be examined both chemically and biologically in mice for their anticoagulant principal. The anti-coagulant property of the compound(s) appear to be directly or indirectly related to death in the mice.

(B) Publications.

Lee, Su. K. and E.J. Staba. 1972. Aquatic Plants from Minnesota Part 1 - Chemical Survey. Water Resources Research Center, University of Minn., Bull. 46. 50 p., 3 fig., 11 tab., 147 ref.

Lee, Su. K. and E. J. Staba. 1972. Aquatic Plants from Minnesota Part 2 - Toxicity, Anti-Neoplastic, and Coagulant Effects. Water Resources Research Center, University of Minn., Bull. 47, 24 p., 4 fig., 5 tab., 73 ref.

Lee, Su. K., E. J. Staba, and Y. Abul-Hajj. 1972. Aquatic Plants from Minnesota Part 3 - Antimicrobial Effects. Water Resources Research Center, Univ. of Minn., Bull. 48. 36 p., 6 fig., 9 tab., 145 ref.

(C) Project Status.

The project will continue in progress in fiscal year 1973.

(D) Application of Research Results.

The objective of the research is to find a nutritional, medicinal or industrial use for the unwanted aquatic plants in lake shoreline areas. It is possible that some aquatic plants may contain industrially useful gums-mucilages, or new useful antimicrobial, anticoagulant, or antineoplastic therapeutic principles. Aquatic plants will be collected from various lakes in Minnesota, identified, processed and phytochemically screened for useful compounds. Microbial and animal studies will be conducted. If a good industrial, medicinal, or nutritional use for aquatic plants can be discovered, the results of the research could provide an economic incentive for aquatic plant collection and control. The successful completion of the project might significantly assist the State and Nation in partially solving their lake pollution problems.

(E) Work Remaining, and Progress Contemplated During Next Year.

Sheep ruminant studies were sufficiently encouraging that a large scaled effort is planned for cattle ruminant studies. Anticoagulant properties from Nuphar variegatum and Myriophyllum exalbescens are reproducible. The extract fraction most responsible for this action is toxic. Efforts will be made to identify the compound(s) in this fraction responsible for the toxicity or anticoagulant effect. Arrangements are now being made with Mr. Al Smith, Minneapolis Park Board; Mr. Winston Larson, Detroit Lakes; and Dr. Robert Bright, University of Minnesota, for large scale plant collection and processing.



OWRR Project No. A-026-Minn.

Agreement No. 14-31-0001-3523

Project Title: Phytoplankton Nutrition and Photosynthesis in Eutropic Lakes

FSCT-COWRR Research Category: 05-A

Name and Location of University Where Project is Being Carried Out.

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1971 To Be Completed - June 30, 1974

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| Robert O. Megard              | Ph.D.              | Limnology                                |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| Helen Bayer                   | M.S.               | Ecology                                  |
| Arlo Knoll                    | B.S.               | Ecology                                  |
| Walter Combs                  | M.S.               | Chemistry                                |

Narrative Statements(A) Research Project Accomplishments.

The research on Lake Minnetonka, near Minneapolis, is proceeding essentially as it was proposed. Sewage effluents from two villages that contributed about 80% of the annual phosphorus influx to the largest basin of Lake Minnetonka were diverted from the lake during the winter of 1971-72. Concentrations of phosphorus and chlorophyll at depth intervals are being measured at bi-weekly intervals in an attempt to ascertain whether or not the lake is responding according to predictions made on the basis of an analysis of the phosphorus budget before the effluents were diverted.

One basin of Lake Minnetonka that receives its nutrients from sources other than sewage will be studied more intensively than was anticipated, however. Population densities of phytoplankton in this basin increase exponentially during blooms that develop each year during June and July. The specific rate of increase by the phytoplankton has been virtually identical during the past two summers, with a doubling-time for chlorophyll concentrations of approximately 7 days. Since this is an annual phenomenon it represents a unique opportunity to determine the mechanism that regulate population densities of nuisance blue-green algae. Consequently an intensive sampling program has been undertaken at this basin, which was not anticipated when the project was initially proposed.

It was initially planned to continue studies of the nutrition and photosynthesis of phytoplankton in three other lakes -- Shagawa Lake in northeast Minnesota, Sallie Lake in northwest Minnesota, and Shetek Lake in southwest Minnesota. An Environmental Protection Agency laboratory at Ely on the shores of Shagawa Lake now has personnel who can perform the studies that were planned.

Furthermore the Environmental Protection Agency is also sponsoring a study of Sallie Lake by limnologists at the University of North Dakota. The village of Fairmont, in southern Minnesota requested a study of the chain of 5 lakes that lies within its city limits in order to help provide a basis for a watershed management plan. We have therefore discontinued the potentially redundant studies of Shagawa and Sallie Lakes in order to concentrate instead on the lakes at Fairmont. Shetek Lake also will not be studied because it is like the Fairmont lakes in so far as it is enriched with nutrients from agricultural drainage. The research strategy at Fairmont is essentially the same as that proposed for the other three lakes, but the study will be much more intensive than would have been possible on the others, which are very far apart.

(B) Publications.

Megard, R.O. 1972. Phytoplankton, photosynthesis, and phosphorus in Lake Minnetonka, Minnesota. *Limnol. Oceanogr.* 17 (1): In Press. (supported in part by OWRR Project A-016-Minn.)

\_\_\_\_\_. 1972. Mechanisms that regulate the population densities of phytoplankton in Shagawa Lake. 84 p. Final report for EPA Project 1610-DEG, supported in part by OWRR Project A-016-Minn.

Bradbury, J. and R.O. Megard. 1972. Stratigraphic record of pollution in Shagawa Lake, northeastern Minnesota *Bull. Geol. Soc. Amer.* (accepted for publication).

(C) Project Status.

The project will continue in progress in fiscal year 1973.

(D) Application of Research Results.

The research programs at Lake Minnetonka and Fairmont are of interest to the local communities because the lakes are important aesthetic and recreational resources for both areas; in addition, the lakes at Fairmont are used for the municipal water supply. Algicides have been used for years to control nuisance algae in the Fairmont lakes, but now the community feels that a more permanent and comprehensive means of controlling algal growth is desirable.

The Minnesota State Pollution Control Agency and the Lake Minnetonka Conservation District were major sponsors of the earlier limnological and engineering studies of Lake Minnetonka, which were performed during the development of a comprehensive management plan. The plan is unique for Minnesota, and the nature of the lake's response should help provide a basis for state-wide policy by the Pollution Control Agency. The lake's response should also influence the actions of other agencies and citizens groups throughout the state.

The research involves techniques for assessing the population densities, growth rates, and nutrition of phytoplankton. It is to be hoped, therefore, that these studies will demonstrate to consulting engineering firms that these techniques are valuable and that they should be used routinely to diagnose problems of water quality in lakes.

Although these studies should have immediate practical value, it should be emphasized that the basic objective of the project is to improve our general understanding of the growth and nutrition of phytoplankton and that any practical applications are incidental to this objective.

(E) Work Remaining, and Progress Contemplated During Next Year.

The work at Lake Minnetonka involves an analysis of the response to the diversion of sewage effluents from the lake's largest basin. There was a linear relationship between concentrations of total phosphorus and chlorophyll during mid-summer in this basin before sewage effluents were diverted. An analysis of the phosphorus budget indicated that the annual mean concentration of total phosphorus should decrease exponentially to a new steady state within 3-5 years after the effluents were diverted. Consequently a major aspect of the work at Minnetonka will be to determine the degree to which the response conforms to prediction.

The research on the basin of Lake Minnetonka that is not affected by sewage diversion involves an attempt to determine the steady state population densities of the plankton and the specific rates of production and loss. The basis for the analysis is a balance equation for the quantity of particulate organic carbon in the mixed layer that was developed during the study of Shagawa Lake (see publications above).

The research on the lakes at Fairmont will also involve measurements of nutrient concentrations, population densities of phytoplankton, and rates of photosynthesis. However, these lakes receive large quantities of nitrogen from agricultural land, so special attention will be devoted to the concentrations of nitrate, ammonia, and to the environment of  $N_2$  fixation.

A watershed management program for Fairmont involves political and economic problems that did not prevail at Lake Minnetonka. Water quality in most of Lake Minnetonka is relatively easy to control because the area is served by a metropolitan sewer system. There is no regional sewer system at Fairmont, so diversion is not a feasible alternative, if for no other reason than the water from the agricultural land is required to maintain lake levels. Thus it is extremely important to establish the relationship between nutrients and phytoplankton in order to devise a management program which reduces nutrient inputs without reducing water inputs and which is politically and economically feasible.

OWRR Project No. A-027-Minn.

Agreement No. 14-31-0001-3523

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

FCST-COWRR Research Category: 07-A

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1971 To Be Completed - June 30, 1974

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| H.O. Pfannkuch                | Ph.D.              | Geology                                  |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| Eric Madsen                   | M.S.               | Hydrogeology                             |
| Bruce Lakno                   | B.S.               | Hydrogeology                             |

Narrative Statements

(A) Research Project Accomplishments.

The main thrust of the research performed has been to set up a mathematical model for the simulation of an aquifer system and to gather basic information from local watershed districts as well as case histories. This information is to be used as a realistic input into the theoretical system. In addition further literature research on optimum effort distribution and the optimum compromise between information and the cost of exploration in other areas of natural resources have been carried out. The Basic model has to be quite versatile in order to adequately simulate a wide range of aquifer conditions. An iterative digital model was chosen which permits to simulate the responses of both confined and unconfined aquifers of irregular shape and non-homogeneous flow characteristics. The model is based on Pinder's U.S.G.S. program which will also accommodate infiltration from surface water bodies and leaky aquifer situations. The program has been rewritten for the 6600 CDC system and for small grid sizes. Incorporation of procedures from an Illinois State Water Survey model (Prickett and Lonquist, 1971) have been tried.

The bulk of the work was directed towards the computerization of changes in the hydraulic characteristics of the aquifer on a continuous and randomized basis. In essence, sequential exploitation or pumping schemes are run for which information is either removed at each node point, or for which original information at a given node is replaced and exchanged by hydrologic information of the spatially preceding node point. This is equivalent to the loss of definition, where in the extreme one single value of the hydrologic characteristics is taken as representative for the whole aquifer. Combining the fluid mechanics scheme with economic constraints of pumping and exploration

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schemes is under way. The sensitivity of the model to changes in the number of iterations and time steps as well as to the level of error criteria has been tested. Concurrently basic data were collected and a case history approach is carried out in order to obtain a feeling for the real constraints in water resources management systems, and to use the data as input for the model under consideration.

(B) Publications.

"On Optimum Levels of Hydrogeologic Information for Ground-Water Basin Management in the Exploratory Phase", Hans-Olaf Pfannkuch, paper presented at the 7th American Water Resources Conference, October 24, 1971, Washington, D.C. (Paper of same title under preparation for publication in Water Resources Bulletin).

(C) Project Status.

The project will continue in progress in fiscal year 1973.

(D) Application of Research Results.

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 inter-dependent 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.

(E) Work Remaining, and Progress Contemplated During Next Year.

After an economic model and scheme for water pumping from a number of different aquifer systems has been established in form of a cost function, this function will be minimized by linear or dynamic programming methods for a system with a 100% information level. Subsequently, information will be removed or made available with much less resolution on a spatial scale than in the fully determined model. Cost of obtaining information against loss by mismanagement or unrealized benefits for cases of operation at less than the 100% information level will be compared and analyzed in order to determine if the curve shows an optimal point or region.

OWRR Project No. B-013-Minn.

Agreement No. 14-01-0001-1915

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

FCST-COWRR Research Category: 05-B

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, St. Paul, Minnesota 55101

Project Began - July 1, 1968 To Be Completed - December 31, 1971

| <u>Principal Investigator</u> | <u>Degree</u> | <u>Discipline</u> |
|-------------------------------|---------------|-------------------|
| R.E. Nylund                   | Ph.D.         | Horticulture      |

| <u>Student Assistants</u> | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
|---------------------------|--------------------|--|
| Douglas Sanders           | Ph.D.              | Horticulture                             |
| Ronald Schaefer           | M.S.               | Horticulture                             |
| John Arneman              | Undergrad.         | Horticulture                             |
| Barbara Soderhold         | Undergrad.         | Home Economics                           |

Narrative Statements(A) Research Project Accomplishments.

A mist irrigation experiment was conducted on sandy soil at the University of Minnesota Sand Plain Experimental Farm at Elk River. Potatoes and snap beans were the test crops. Three treatments were applied: (a) mist, (b) mist and conventional sprinkler irrigation, and (c) conventional irrigation. Both mist and conventional irrigation were applied with two specially built plot irrigators which provided precise control of amount and distribution of applied water. In snap beans, special attention was 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 were of special interest.

It has been shown that mist irrigation during periods of high temperature and water stress prevents reduction of crop yields; such mist irrigation can 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 sandy soils. Mist irrigation during a similar 5-day period, if applied every day, would consume approximately only one-third as much water.

(B) Publications.

Sanders, D.C. and R.E. Nylund. 1972. The Influence of Mist Irrigation on the Potato I. Micro-Environment and Leaf Water Relations. American Potato Journal. April 1972, Vol. 49, No. 4. 15 p., 8 fig., 2 tab., 17 ref.

(C) Project Status.

The project has been completed.

(D) Application of Research Results.

In most parts of Minnesota, evapotranspiration exceeds precipitation during July and August. The research results provide a method for preventing drought injury by reducing evapotranspiration rather than by supplying large quantities of supplemental irrigation water. The research results should assist farmers in the State in conserving groundwater supplies and improve the quality of vegetables produced by minimizing temperature fluctuations at the leaf surface during plant development.

(E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No. B-015-Minn.

Agreement No. 14-01-0001-1916

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

FCST-COWRR Category: 02-G

Name and Location of University Where Project is Being Conducted:

University of Minnesota, St. Paul, Minn. 55101

Project Began - January 1, 1969 To Be Completed - December 31, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| George R. Blake               | Ph.D.              | Soil Science                             |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| Volker Schweikle              | Ph.D.              | Soil Science                             |
| Lalit Arya                    | M.S.               | Soil Science                             |
| Jiwan Palta                   | M.S.               | Soil Science                             |
| John Basgen                   | Undergrad.         | Botany                                   |
| John Corser                   | Undergrad.         | Biology                                  |
| Jay Mathisrud                 | Undergrad.         | Soil Science                             |
| Mahesh Naithani               | Undergrad.         | Business Administration                  |

Narrative Statements(A) Research Project Accomplishments.

Dr. Volker Schweikle continued work on thixotropic changes in pressed soil began earlier and reported as progress in the 1969 and 1970 annual reports. He determined that decreases in water potential with aging time at water contents less than 27% by weight reported earlier were due to leakage in the transducer-scanivalve system. Refining the sensitivity of the measuring system, Schweikle found increases in suction (decreases in water potential) with time in all cases. Suction increases of about 50-75 mb (reorientation pressures) were found to depend on ion species associated with the clay and with clay mineral type. Montmorillonite mixed with soil gave higher reorientation pressures than soil also, the clay of which is about half illite and half expandable clay. Reorientation pressures were also in the order Ca-soil > Na-soil >> H-soil. Mr. Lalit Arya obtained a second years measurements on soil water extraction by soybean roots and is currently making exhaustive measurement of the soil hydraulic properties in order to relate water fluxes to root density patterns that he also measured. Numerous computer-assisted calculations were necessary to describe the system. These are now being completed and data analysis and summary are in progress.

(B) Publications.

Stabilization of newly-formed soil aggregates. L.M. Arya and G.R. Blake. 1972. 4 pages, 2 tables, 4 figures, 8 references. Agronomy Journal 64:177-180.

Water transmission properties of an asphalt barrier. J.P. Palta, G.R. Blake and D.A. Farrell. 1972. 8 figures, 8 references. Accepted by S.S.S.A. Proceedings Vol. 36.

Effect of an asphalt barrier on water redistribution after infiltration in sand soils. M.S. thesis by J.P. Palta, 1971. 67 pages, 3 tables, 16 figures, 16 references.

(C) Project Status.

The project will continue in progress in the next fiscal year.

(D) Application of Research Results.

Thixotropic reactions of soils are important in determining matrix characteristics and to an understanding of the basic behavior of soil physical characteristics. Water extraction patterns of plant roots as they relate to root distribution and density and to soil hydraulic characteristics are designed to better understand this link in the water cycle. Considering that the great proportion of precipitation remains in the soil surface horizons and moves into the atmosphere by evaporation and transpiration, a knowledge of water flux to roots and sink strengths due to root patterns is important to water management.

(E) Work Remaining, and Progress Contemplated During Next Year.

Papers will be written on (1) effect of asphalt barriers on water storage and drought probability, (2) thixotropic reactions in soils and their significance, and (3) shrinkage induced soil anisotropy and water recharge. Data on water extraction from soil by soybeans will be analyzed and a thesis will be written. Hydraulic properties of Waukegan soils with reference to water redistribution will be determined and compared to water distribution patterns.

OWRR Project No. B-020-Minn.

Agreement No. 14-31-0001-3095

Project Title: Pollution and the Ecology of Near-Shore Periphyton of Lake Superior

FCST-COWRR Research Category: 05-A

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1969 To Be Completed - June 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u> | <u>Discipline</u> |
|-------------------------------|---------------|-------------------|
| T.A. Olson                    | Ph.D.         | Public Health     |

| <u>Student Assistants</u> | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
|---------------------------|--------------------|--|
| Robert R. Nelson          | M.S.               | Public Health                            |
| David B. Drown            | M.S.               | Public Health                            |
| Jonathon Vormachka        | Undergrad.         | Public Health                            |
| Jerrold Vitek             | Undergrad.         | Public Health                            |

Narrative Statements

(A) Research Project Accomplishments.

Since the periphyton of Lake Superior contributes significantly to the nearshore primary productivity of the lake it was thought that this segment of the lake ecosystem would be a logical starting point for a study of the local effects of heated discharges. During the summer of 1971, four 330 gallon stock tanks lined with epoxy resin were installed at a previously selected site on the lake shore near Castle Danger, Minnesota. Three of the tanks were designated to hold periphyton-laden rocks taken from near shore waters within 500 meters of the experimental installation. These tanks were equipped with underdrain systems covered by gravel and clay tiles, an arrangement which provided good circulation of water and prevented stagnation or temperature stratification. The fourth tank was used as a heat reservoir. A one and one-quarter inch iron fintube radiator was installed in this tank to serve as a heat exchanger. This exchanger was coupled to a 63,000 BTU output, propane-fired, hot-water boiler. The boiler was controlled by a system of Aquastats which maintained the reservoir temperature at 80 - 90 F. With this general arrangement, desired temperatures could be maintained in the experimental tanks within a range of six degrees F. over a 24-hour period.

During the first summer, the control tank was held at lake temperatures. A flow rate of 600 gallons per hour (gph) was sufficient to hold the tank at incoming water temperature. This is equivalent to approximately two overturns per hour. Like the experimental tank, the control was seeded with periphyton rocks from the lake, some of these rocks were denuded

to provide a basis for a regrowth study. The primary experimental tank was heated to approximately 75 F. by recirculating a part of its water at the rate of 450 gph through the reservoir tank. In other terms this amounts to approximately 1.2 overturns per hour. The system was replenished with fresh lake water at the rate of 180 gph. At this rate of addition, the water in the recycled system was replaced every 3 hours and 20 minutes. Changes in lakewater temperatures at varying flow rates and the response of the system to other modifications was checked by observations made on a third tank. This provided information which was used in modifications of the principle experiment and as a basis for needed alterations in the experimental design.

Lake water for this study was supplied at the rate of 50,000 gallons per day by a one-half horsepower Crane-Deming centrifugal pump. The water intake, located eight feet below the surface of the lake, was screened to prevent entry of unwanted materials that might damage the pump. Temperatures, in all three experimental tanks, were continually monitored with a model 47 Yellow Springs Instrument Co. (Y.S.I.) eleven channel Scanning Tele-Thermometer. Results were recorded by a Y.S.I. Model 80 Laboratory Recorder. The thermistor probes were strategically placed in each tank to afford the best possible record of any temperature variations. All pumps, electrical fixtures, and monitoring equipment were housed in a reinforced toolbox-type structure built on a platform solidly anchored to the rock substrate. The hot water boiler was housed separately to avoid exposure of the other equipment to excessive heat.

To ascertain changes caused by the heated water, weekly analyses were made of the periphyton. Two "seed" rocks and two regrowth rocks were taken from each tank and were stripped of all periphyton. From each sample, aliquots were taken for chlorophyll analysis, dry weight and ash-free biomass determinations. An aliquot was also preserved for quantitative taxonomic purposes. Observations indicated that a marked change took place in the heated tank. For example, it was noted that in the heated tank periphyton on the "seed" rocks was greatly reduced; in some cases to the point where for practical purposes, the rocks were devoid of growth. The change was gradual extending over a period of several weeks. This phenomenon did not occur in the basic control tank.

#### (B) Publications.

D.B. Brown, T.A. Olson, and T.O. Odlaug. 1972. Pollution and The Ecology of Nearshore Periphyton of Lake Superior: The Effects of Calcification on Periphyton. Limnosta, Research Report No. 3, Lake Superior Limnological Research Station - Duluth. 6 p., 1 fig. 2 ref.

The first draft of a completion report has been prepared.

#### (C) Project Status.

The project has been completed.

#### (D) Application of Research Results.

There have been extensive investigations of water pollution sources and continuing water quality studies on the Great Lakes. However, the effect of changes in water quality on the attached, filamentous periphyton development in the Great Lakes and eutrophication processes appears to be very sketchy. It is anticipated that results from this investigation will provide fundamental information about the present quantity, composition, growth and distribution of the near shore, attached algae in Western Lake Superior. These data will be useful as baseline information in the future. Hopefully, the data obtained may also provide information useful in the development of a supplemental means for more rapid assessment of water quality of Lake Superior as reflected by transformation in species composition, characteristics and growth of the nearshore periphyton in response to future environmental perturbation.

#### (E) Work Remaining, and Progress Contemplated During Next Year.

None.

OWRR Project No. B-031-Minn.

Agreement No. 14-31-0001-3096

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

Name and Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1969      To Be Completed - June 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| L.P. Gerlach                  | Ph.D.              | Anthropology                             |
| <u>Student Assistants</u>     | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| Virginia H. Hine              | M.A.               | Anthropology                             |

Narrative Statements

(A) Research Project Accomplishments.

We explored the structure and function of movements of change, in particular participatory ecology, black power, the charismatic renewal. Most attention has been directed to our description of these movements as being segmentary, polycephalous, and reticulate. (S PR). That is, it is comprised of many active competing groups, each having many often competing leaders, but with these various segments interweaving through overlapping relationships to comprise a network. We have compared this structure with a centralized bureaucracy and have argued that while the latter may be well adapted to maintaining society and affecting developmental change S PR structure is well adapted to generate revolutionary change. In our publications, we have explained the capabilities which participatory ecology derives from S PR, noting that redundancy, duplication, and overlap as well as internal competition help generate growth, facilitate multipenetration of the social order and afford protection.

We also stressed the importance to movement growth of the "commitment process." We postulated that "participatory ecology" would really grow as new participants engaged in highly emotional, often risky activities to protect the environment from ruin by visible foes. To some extent this has happened although not the degree we hypothesized. We do have some very interesting cases in which people have become highly sensitized to the beauties of nature and to the threat of pollution. For example, we filmed a group of young adults experiencing the beauty and majesty of the Everglades, by hiking through it in water up to their waists; then we filmed them continuing their hike to the gates of the proposed jetport, where they could hear the bulldozers at work making the pilot training landing strips. We recorded their statements and have followed up the involvement of several in continued ecology activities. We have some interview-type evidence of identity change following commitment.

Using our "You and the Ecology Movement Questionnaire" we have attempted to gain some measure of commitment by act and/or experience and to gauge the behavioral consequences of this. In our paper "Many concerned, few committed," we report our findings - which are just that - that many respondents evidence great concern, but few demonstrate what we call "commitment". On the other hand, if few show that they are committed by what they do, few report having had an identity altering experience or being involved in a "bridge-burning" activity.

The term "ecology" has become a loaded word. Through movement action and established order response the term has been popularized. It is a framework for ideas, a viewpoint, a concept about interdependence and synergism, a socio-political rallying cry. It is because we sensed this popularization-movementization of the concept and term ecology that we called the movement "participatory ecology." The ecology term and some of its meaning is spreading across all walks of American life more rapidly than we imagined.

Involvement of many people in seeking answers to environmental problems has brought to realize that large-scale systems - human eco-systems - are very complex. People have found, for example, that while phosphates affect water in undesirable ways, the new eco-substitutes for phosphates may even be more of a health and environmental problem. People learn that while DDT has serious harmful consequences as it moves through the "food chain", not using DDT can lead to some devastating insect and health problems, while DDT substitutes also pose new and often unforeseen problems. People learn that while recycling is desirable to save resources and perhaps combat littering and waste disposal problems, the energy and often the chemicals needed to recycle also have an undesirable environmental impact. And on it goes... The concerned American is getting at first hand a feel for the implication of system interdependence. While this could encourage some simply to drop out of eco-concern, perhaps even to splurge while the splurging is good, it could also drive home to others a fuller understanding of the problem, a deeper realization of what "ecology" means, a greater desire to strive cautiously and through trial and error for new adaptations.

Interestingly enough, the response of industry is beginning to play an important role in this generation of eco-system interdependence and finite resource concepts. For varying reason, executives in industry, power companies and the like explain that they are constrained in what they do by varying factors in the sociocultural and ecological system. They note that to meet all known projections of consumption and given present technological capabilities their enterprise will of necessity impost a cost upon the environment. But they also warn of the public cost of not meeting this presumed need. This may arouse the ire of environmentalists, especially those who still hope that through technology or some other miracle we can have our cake and eat it too. But it does stimulate greater public awareness of System interdependence and of finite resources and limited good. And when, as in one of our documented cases, a leading power company executive declared that a fundamental reduction of environmental impact will be possible only if there is a much broader and fundamental change in American values and structures, he was further driving home some of the radical views of eco-activists. Of course, he may be doing this thinking that the public will resist any such full scale change. Hence this will get his firm off the hook and limit the demands placed on them. But no matter what his motive is, we suggest, contributing to the concept of system

and system change, and encouraging more people to think about the need for fundamental change. Perhaps through such assault upon conventional wisdom, conventional search for solution, more people both affected firms and concerned public will be encouraged to think of bold new ways to tackle the problem. In short, social change is a consequence of action and interaction by many groups.

As we can expect, high growth rates are associated with man over nature views, and vice versa. This is an important subject and in our "You and Ecology" questionnaire we have used a number of items which seek to gauge the respondents views or values about man's place in or over nature. We will continue to examine this dimension, using the questionnaire in interview and in media survey and seek to gain perspective on changing values. In one recent analysis of our data we compared man-nature responses of persons according to occupation, education and religious involvement. As we are reporting in forthcoming publications our findings seem to accord with the White, Kluckhohn and economics development propositions. Successful businessmen, engineers, and high religious involvement individuals do seem to feel that man is master of his environment somewhat more than others.

In earlier formulations we have argued that the eco-evangelist threat of ecological doomsday was a useful initial shock, to jar people into awareness and environmental concern. But we proposed that once made aware, once frightened, most people could then only be motivated to continue eco-action and to change their own life ways if they received positive reinforcement, and gained a sense that their actions were useful. We continue now to look for examples in which movement participants do gain such positive reinforcement, such encouragement; and we seek to compare these instances with the opposite situation, namely where ecology movement participants experience failure and disillusionment. As yet we detect no clear pattern and the most that we can say is that people react differently to different sets of reward factors. Some individuals are motivated to continue in eco-action primarily because they like working in this area with fellow participants. Others are stimulated by facing up to a powerful opposition. Yet others do fade away in the face of failure - but on the other hand, we have at least as many examples of people who dropped out of action once their group had achieved its objectives. Jetport issues, one in South Florida and one in Minnesota provided this range of example.

Environmental pollution and resource management problems are often very complex, involving many interdependent systems and often mutually incompatible interests and goals. In such problems there are often many constraints on any action or decision, and the gain of one person or interest is often at the cost of others. People increasingly recognize that in such case no matter what is done to "solve" one problem, something else or someone else will be affected in undesirable ways. In short, there is no single relatively permanent solution, as such. Problem solving is problem generating. Herein lies both excuse for giving up, for apathy, or motivation for exploration and new discovery. To illustrate this we mention one experiment in "open planning". We do not suggest that it is an ideal example, or even a classical one.

#### (B) Publications.

Gerlach, L.P. 1971. The Ecology Movement and Revolutionary System Change. Spirit Magazine, Concordia Press, June/July 1971.

Gerlach, L.P. Movements of Revolutionary Change: Some Structural Characteristics. in special issue on General Systems Theory, edited by Bertram Gross, American Behavioral Scientist, July/August 1971.

#### (C) Project Status.

The project has been completed.

#### (D) Application of Research Results.

Our research was designed to provide crucial information on the structure and process of the ecology-environmental movement, particularly as it relates to water resource issues. It analyzes the dynamics of ecology movement thrust, established order response and resulting patterns of trial and error experimentation and adaptation in water resource management. Hopefully it will contribute to the ability of concerned Americans to utilize more effectively such capacity for exploration and for fundamental change so that this time of environmental crisis will become our time of adaptive transformation.

In connection with present research and reported findings the principal investigator has been asked to contribute to various UCOWR conferences, projects, and committees. Also he has been asked to join as a participant in an Engineering Foundation Conference on "Urban Water Policy" to review the preliminary findings of the National Water Commission staff.

#### (E) Work Remaining, and Progress Contemplated During Next Year.

None.



OWRR Project No. B-032-Minn.

Agreement No. 14-31-0001-3097

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

FCST-COWRR Research Category: 05-C

Name and Location of University Where Project is Being Conducted:

St. Cloud State College, St. Cloud, Minnesota 56301

Project Began - July 1, 1969 To Be Completed - December 31, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| Alfred J. Hopwood             | Ph.D.              | Limnology                                |
| <u>Student assistants</u>     | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| Robert A. Andersen            | B.S.               | Biology                                  |
| Ralph O. Morgenweck           | B.A.               | Biology                                  |
| Jane M. Nemanick              | B.A.               | Biology                                  |
| Stephen V. Thrune             | B.A.               | Biology                                  |

Narrative Statements(A) Research Project Accomplishments.

The Northern States Power Company Monticello Nuclear Generator was originally scheduled for completion in February, 1970. According to the research plan for this project, more time was available for post-operative than for pre-operative investigations. However, operation of the plant was delayed until January 23, 1971, so that much less post-operational data will be available at the end of the current study than was expected from the outset. The following report contains some of the results of pre-operational studies. A comparative analysis of the aquatic habitat before and after operations began will appear in a subsequent report.

1. Forage Fish: Work continued on the natural history of the minnows (Cyprinidae) inhabiting the Mississippi River above and below the NSP-Monticello Nuclear Generator. Effort was concentrated on the food habits, fecundity, and the relation of age, annulus formation and length of the species present. Studies were based on 7,248 fish, representing 15 species which were seined from two stations above the plant and four downstream stations. In order of decreasing abundance, the minnow species were: Notropis dorsalis, N. spilopterus, N. stramineus, Pimephales notatus, Etheostoma nigrum, Nocomis biguttata, Rhinichthys cataracte, Notropis cornutus, N. hudsonius, Rhinichthys atratulus, Semotilus atromaculatus, Notemigonus crysoleucas. A food analysis was performed on 1,080 minnows and darters representing 11 species collected during 1969 and 1970. Insects (usually parts) found in these fish stomachs were identified and counted. Insect groups found were Coleoptera, Diptera, Ephemeroptera, Hemiptera,

Homoptera, Odonata, Plecoptera and Trichoptera. Dipterans (mostly simuliids) occurred most frequently, percent of occurrence ranged from 86.2% in the johnny darter and 53.7% in the common shiner, to 18.2% and 21.3% in the creek chub and bluntnose minnow, respectively, and were found in 43.3% of all stomachs. Trichopterans were found in 29.7% of the stomachs, ranging from 50.8% and 39.7% in the hornyhead chub and johnny darter, to 13.5% in the bluntnose minnow and 7.4% in the spottail shiner. Ephemeropterans occurred in 50.7% of the johnny darters and 43.5% of the daces, 17.5% of the common shiners and sand shiners, and 3.9% of the bluntnose minnows. Among all stomachs collectively 27.6% contained mayflies. Miscellaneous items were identified, such as algae, plant remains, organic material, inorganic material, unidentified insect parts and other animal remains. Developed eggs from 41 bigmouth shiners, 26 bluntnose minnows, 33 sand shiners and 23 spotfin shiners were counted. Correlation coefficients were determined for the relationship between total length and the number of developed eggs; bigmouth shiner 0.817, bluntnose minnow 0.692, and shiner 0.913, spotfin shiner 0.685. Total length ranges and averages for each of the four species were as follows: bigmouth shiner 45.0-67.5 mm, 56.8 mm average; bluntnose minnow 46.0-60.0 mm, 53.8 mm average; sand shiner 46.0-72.0 mm, 56.1 mm average; spotfin shiner 43.5-79.0 mm, average 58.6 mm. The number of eggs ranged as follows: bigmouth shiner 115-1133, average 499; bluntnose minnow 150-428, 286 average; sand shiner 89-1652, 510 average; spotfin shiner 112-1003, average 413. Gravid females were found in all species on May 26, 1970. Dates when gravid females of each species were last found were: Bluntnose minnow, August 3, 1970; spotfin shiner, August 6, 1970; bigmouth shiner, August 17, 1970; sand shiner, August 23, 1970.

2. Other fish: Work continued on the determination of relative abundance and species composition of fish captured by electrofishing. Percentage composition was: Moxostoma macrolepidotum 39.5%, M. anisurum 6.8%, Cyprinus carpio 26.9%, Pomoxis nigromaculatus 5.0%, Catostomus commersoni 4.7%, Micropterus dolomieu 10.1, Stizostedion vitreum vitreum 4.2%, Esoc lucius 0.5%, miscellaneous species 1.3%.

The stomach contents of 131 northern redhorse and 101 carp were analyzed. The numerical and volumetric contribution of each item in the stomach was determined. Major percentages of the volume in redhorse stomachs were: mayflies 26%, trichopterans 61%, dipterans 7%. In the carp the principal food item by volume was Cladophora 56%, but the diverse diet included oligochaetes 6%, crayfish 3%, mayflies 7%, trichopterans 12%, dipterans 1%, detritus 11%. Samples were taken during the ice-free period, April through November. Carp fed mostly on Cladophora and other algae from July through October. At other times, the diet became more diversified. The northern redhorse fed in accordance with the species composition of the benthic fauna.

3. Invertebrates: Work continued on the quantitative analysis of the aquatic insects. Two separate programs were conducted during 1971, both involving the use of concrete artificial substrates. Monthly sampling continued as in 1969 and 1970. A total of 464 samples were recovered from eight transects in the Mississippi River, two upstream and six downstream with reference to the power plant. The percentage distribution of the dominant benthic groups in 1971 remained about the same as in the two previous years; caddisflies 49%, mayflies 15.9%, dipterans 24.6%, miscellaneous groups 10.5%. No significant changes in benthic standing crop were noted in the

results of comparisons of upstream to downstream samples, and in the comparison of samples across the same transect, half of which was effected by heated effluent water from the plant.

In July 1971, a program of weekly sampling was begun. At each of two stations, one upstream and the other just below the discharge from the plant, five sets of four concrete artificial samplers were placed in the river bottom. After one week, the first set of four blocks were pulled up, the bottom fauna were collected and taken to the laboratory for examination. In each subsequent week, a set of four substrates were removed from each of the two locations. Replacement of the samplers coincided with the removal of the sets which had been in place for five weeks. The main objective of this study is to determine the colonization and growth rates of benthic organisms on artificial substrates in the river above the plant, and to compare those upstream data to the same parameters from the station at the end of the discharge canal. As this study is just now nearing completion, data is presently unavailable.

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 temperatures were monitored continuously with a thermograph at each of nine stations, two above and seven below the power plant discharge. Flow velocity and water depth were observed at specific sites for biological collection each time the biota were sampled.

5. Birds: A study of the resident bank swallow population in the vicinity of the Monticello Nuclear Generator was begun on June 14, 1971. The general objectives were to determine the nature and extent of use by bank swallows of the Mississippi River in the area of the power plant. Secondary objectives were to determine the size of the resident bank swallow population, determine habitat preference for nesting, and to determine preferred foraging areas and diet preference. Various measurements were taken on burrows such as height, depth and width, distance above the water, distance below the top of the bank, and soil type. Birds were captured periodically in 42 ft. 4-shelf mist nets, and were banded and released. The two species present were the bank swallow Riparia riparia riparia L., and the rough-winged swallow Stelgidopteryx ruficollis serripennis Aud. in a ratio of about 3:1. Of 291 birds banded in 1971, 5.1% were recovered as of June 26, 1972. One hundred seventeen birds have been banded so far in 1972. The birds were first seen in the study area this year on April 23. During 1971 numbers dwindled from mid-August to early September when the swallows were last seen.

#### (B) Publications.

1. Hopwood, Alfred J. 1972. Monticello Ecological Monitoring Program: Progress Report Covering 1971. Northern States Power Company. Minneapolis. 40 p.

2. Morgenweck, Ralph O. 1971. A survey and distribution study of the Cyprinid minnows (Family Cyprinidae) in the Monticello region of the Mississippi River. Master's Thesis. St. Cloud State College. 63 p.

3. Hopwood, Alfred J. 1971. Monticello Ecological Monitoring Program: An assessment of the impact of the NSP-Monticello Nuclear Generator on aquatic ecology in the first six months of operation. Engineering Department, Northern State Power Company, Minneapolis. 25 p.

#### (C) Project Status.

The project will continue in progress in the next fiscal year.

#### (D) Application of Research Results.

Information generated by this project was used by the Atomic Energy Commission in the preparation of an environmental statement and recommendations for licensing referred to below:

United States Atomic Energy Commission, Directorate of Licensing.  
May 1971. Draft Environmental Statement on the Northern States  
Power Company Monticello Nuclear Generating Plant. Washington,  
D.C. 170 p.

#### (E) Work Remaining, and Progress Contemplated During Next Year.

Further work will include the completion of studies on the distribution of fish relative to the effects of the heated power plant effluent. Studies on invertebrate benthic fauna and water quality will be concentrated on the comparison of pre- and post-operational data. Projects on the recolonization of benthic fauna, and birds will be completed during the current calendar year.

OWRR Project No. B-042-Minn.

Agreement No. 14-31-0001-3292

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

FCST-COWRR Research Category: 06-B

Name and Location of University Where Project is Being Carried Out:

Gustavus Adolphus College, St. Peter, Minnesota 56082

Project Began - July 1, 1970 To Be Completed - June 30, 1973

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| Robert T. Moline              | Ph.D.              | Geography                                |
| <u>Student Assistants</u>     | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| Jame V. Anderson              | Undergrad          | Pre-med                                  |
| Sue Weber                     | Undergrad          | Nursing                                  |
| Sabine Lobitz                 | Undergrad          | --                                       |

Narrative Statements

(A) Research Project Accomplishments.

During this second year of the project progress has been slower than expected. Only the most preliminary analysis of last years questionnaire has been made. We have had some difficulty with our computer program but this should be remedied during the late summer months. A second questionnaire has been prepared and has been mailed to a selected list of water resource managers and decision-makers including Federal, State, and local officials and citizen's groups. Approximately 700 questionnaires have been mailed and responses are presently being received. Since the views of these people are especially important to the study, we plan to be somewhat aggressive in seeking the return of the completed survey forms. Prof. Roy Rickson, University of Minnesota, has offered some helpful suggestions in this regard.

The principal investigator and/or student assistants attended a number of water resource meetings in the basin during the year and two national symposia dealing in part with citizen participation in water resource planning. The meetings and symposia were helpful as sounding boards for discussion of our project and we plan to continue this through the next year as well. We have been surveying a selection of basin newspapers for editorial comment on water resources without much success. Fiscal 1972 was not an active water year at least in the opinion of basin editors.

(B) Publications.

None

(C) Project Status.

The project will continue in progress in fiscal year 1973

(D) Application of Research Results.

The research results should assist the Southern Minnesota Rivers Basin Commission and the Upper Mississippi River Basin Commission in assessing public opinion concerning water and related land resources plans being developed for the Minnesota river basin.

(E) Work Remaining, and Progress Contemplated During Next Year.

The responses from the second questionnaire will be coded and card punched this summer so that by September, 1972 all project data will be on cards. Student help will then be used in the analysis of the results of both surveys. Additional base maps for plotting the data will be prepared later this summer facilitating our study of the spatial pattern of the results. The spatial variation of attitudes is of course the basis of the final presentation. Plans are to complete most of the analysis during the Fall Term and also to complete any additional interviews. The final report will be drafted and completed during the spring of 1973.

OWRR Project No. B-044-Minn.

Agreement No. 14-31-0001-3293

Project Title: Area Financing of Water Resource Development

FCST-COWRR Resource Category: 06-B

Name and Location of University Where Project is Being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began - July 1, 1970 To Be Completed - June 30, 1973

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| W.R. Maki                     | Ph.D.              | Agricultural Economics                   |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| John Holdorph                 | B.S.               | Civil Engineering                        |
| James Anderson                | Undergraduate      | Agricultural Economics                   |

Narrative Statements(A) Research Project Accomplishments.

The project period was extended an additional 1 year, through June 30, 1973, without additional Federal or Non-Federal funding. The Principal Investigator was unable to complete the project by June 30, 1972 because of heavy pressures to complete a critical phase of the Minnesota rural research project on development potentials in the Red River Basin. Completion of related work while delaying completion of the water resource financing study, adds to the scope and application of the latter study because of the role of West Minnesota as an important recreational area within the larger development region.

During Fiscal Year 1972, the Principal Investigator has been in the field in the study area and has assembled primary and secondary data in financing procedures and burdens in the study area. As part of related research, the Principal Investigator has completed an overall study of public financing in West Minnesota that allows him to relate water resource financing procedures, problems and potentials to the total public financing situation. He is in a strong position, therefore, to undertake the final phases of the research in Fiscal Year 1973 and to accomplish the project objectives as originally conceived and reported.

(B) Publications.

None.

(C) Project Status.

The project will continue in progress in the next fiscal year.

(D) Application of Research Results.

By focusing on alternative public financing in an area government setting, the study makes possible an extension of community development efforts to the area level of public intervention in water-resource planning and development. Also the scope and depth of community participation in water-resource development is being extended to the environmental community that is a minimum-size spatial unit for capturing the externalities of water resource development. Moreover, because of the investment decision orientation of the study, resource investment strategies recently prepared by Carruthers (In: "An Analysis of Public Investments in Iowa State Parks and Recreation Areas," Unpublished Ph.D. Thesis, Iowa State University, 1968) can be extended to the environmental area in coordinated state and area planning activities. Finally, involvement of resident task forces as data users and, also, as participants in problem formulation, makes possible the testing of alternative approaches to problem-oriented research in the water resources field.

(E) Work Remaining, and Progress Contemplated During Next Year.

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 major share of work involved is scheduled for FY 1973. 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.

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 1973. 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 1973.

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.

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

OWRR Project No. B-047-Minn.

Agreement No. 14-31-0001-3294

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

FCST-COWRR Research Category: 06-E

Name and Location of University Where Project is Being Conducted:

University of Minnesota, Minneapolis, Minnesota 55455

Project Bagan - July 1, 1970 To Be Completed - June 30, 1973

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| R.E. Rickson                  | Ph.D.              | Sociology                                |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| Christine Lohr                | B.A.               | Sociology                                |
| Mary Cloyd                    | B.A.               | Sociology                                |
| Charles E. Simpkins           | B.A.               | Sociology                                |
| Hong Ik Chung                 | B.A.               | Sociology                                |
| Margaret Cawley               | Undergrad.         | Sociology                                |
| Barbara Bender                | Undergrad.         | Political Science                        |
| Pam Lanoue                    | Undergrad.         | Sociology                                |

Narrative Statements

(A) Research Project Accomplishments.

During the last fiscal year, 128 water-using firms were studied. The size of the industrial firms ranged from a low of five to a high of three thousand employees. Types of companies included were meat processing and packing, milk processing, metal plating, oil companies, food processing, chemical companies and pulp processing companies. Most of the companies used water for production purposes and all used large amounts of water for production, cooling and disposal of waste. This report must be considered as preliminary since not all of the data that has been collected has been analyzed. Furthermore, a few more companies have been added to the sample since this report was written. The total research project will include an analysis of these companies at two different time periods. The first analysis is concerned with the internal characteristics of the companies. The second analysis will be devoted to studying the relationship that companies have with agencies responsible for regulation of production and waste disposal. The latter will be completed in summer and fall of 1972.

We will present two tables in this report. The first table shows the extent to which companies in Minnesota legitimated alternative roles of state regulatory agencies. How production managers perceived the role of state pollution control agencies was one of the main dependent variables of this study. For this report, we present only a descriptive picture of how managers perceive agency regulation of industrial and community water use.

TABLE I

PERCEPTION BY PRODUCTION MANAGERS OF ROLE OF  
STATE REGULATORY AGENCIES

Recently, public agencies, e.g., the Minnesota Pollution Control Agency, have assumed more responsibility for the management of water resources than they have had in the past. How much do you agree with the following statements about the role of such agencies? (We are not interested in the present role of these agencies but in what you think their role should be.)

|   | Not<br>at<br>all.<br>1 | To a<br>very little<br>extent.<br>2 | To<br>some<br>extent.<br>3 | To a con-<br>siderable<br>extent.<br>4 | To a very<br>great<br>extent.<br>5 | TOTAL          |
|---|------------------------|-------------------------------------|----------------------------|--|------------------------------------|----------------|
| a. Research function only--collecting data for industries and communities when they want it.  | 55%<br>(70)            | 5%<br>(7)                           | 24%<br>(31)                | 13%<br>(16)                            | 3%<br>(4)                          | 100%<br>(128)  |
| b. Consulting--helping communities and companies identify and resolve water pollution control problems when they feel they need it. | 17%<br>(22)            | 4%<br>(5)                           | 22%<br>(28)                | 39%<br>(50)                            | 18%<br>(23)                        | 100%<br>128    |
| c. Planning with communities and companies in the establishment of programs, facilities, and standards for water pollution control  | 10%<br>(10)            | 4%<br>(5)                           | 17%<br>(22)                | 41%<br>(52)                            | 30%<br>(39)                        | 102%*<br>(128) |
| d. Enforcement of water quality standards.  | 2%<br>(3)              | 5%<br>(7)                           | 20%<br>(26)                | 41%<br>(52)                            | 31%<br>(40)                        | 99%*<br>(128)  |
| e. Control over most industrial and community water use.  | 14%<br>(18)            | 9%<br>(12)                          | 30%<br>(39)                | 24%<br>(31)                            | 22%<br>(28)                        | 99%*<br>(128)  |

\*Percentages are not 100% because of rounding.

Table I shows that production managers in Minnesota are in favor of state regulatory agencies taking a vigorous role in the management of industrial and community water use. On a similar item not shown in the table, eighty-seven percent disagreed with the assertion that no public agency was necessary for the regulation of water resources.

TABLE II

NATURE AND EXTENT OF CHANGE IN 128 WATER USING FIRMS

To what extent have there been changes in the following activities in your organization during the past ten years?

|   | None<br>at<br>all.<br>1 | To a<br>very little<br>extent.<br>2 | To<br>some<br>extent.<br>3 | To a con-<br>siderable<br>extent.<br>4 | To a very<br>great<br>extent.<br>5 | TOTAL          |
|---|-------------------------|-------------------------------------|----------------------------|--|------------------------------------|----------------|
| a. In your product line.  | 14%<br>(18)             | 16%<br>(20)                         | 20%<br>(26)                | 34%<br>(43)                            | 16%<br>(21)                        | 100%<br>(128)  |
| b. In how you sell your product.  | 20%<br>(25)             | 20%<br>(25)                         | 28%<br>(36)                | 24%<br>(31)                            | 9%<br>(11)                         | 101%*<br>(128) |
| c. In how you manufacture your product.                                       | 17%<br>(22)             | 15%<br>(19)                         | 27%<br>(35)                | 32%<br>(41)                            | 9%<br>(11)                         | 100%<br>(128)  |
| d. In the qualifications, training, and technical skills of your employees.   | 14%<br>(18)             | 12%<br>(15)                         | 34%<br>(44)                | 35%<br>(45)                            | 5%<br>(6)                          | 100%<br>(128)  |
| e. In dealing with the solid and/or liquid wastes of your production process. | 23%<br>(30)             | 20%<br>(25)                         | 21%<br>(27)                | 23%<br>(30)                            | 13%<br>(16)                        | 100%<br>(128)  |

\*The percentage does not equal 100% because of rounding.

Table II shows the extent of change experienced by these companies in the last ten years. We asked the question in the way in which it was worded in the heading of the table. As can be seen, there has been less change in company handling of solid and liquid wastes than in any other area of company operation. It is possibly true, however, that more changes in waste control have occurred in the last five years or less as ten years ago waste control and the general level of pollution was not considered as serious a problem as it is today. Also, the function of pollution control agencies was not as sharply delineated nor were they as powerful. Again, the reader must be reminded that we have selected only a small portion of the overall data and we are dealing with it in a descriptive rather than an explanatory manner.

The implications of the above data are (1) Minnesota companies legitimize the regulatory function of state pollution control agencies and (2) change is extensive in the Minnesota companies we studied but change in dealing with waste lags behind change in other areas of the firms' operations. Although we found that companies generally legitimated the function of state pollution control agencies, there was a clear distinction made by the companies between state and federal control. This was particularly true with the large companies. Company reaction to local, state, and federal control is one aspect of the analysis for the following year but a few tentative conclusions can be made at this point. Several executives from the larger companies clearly preferred federal to state control. Large companies were concerned that state agencies could put them at a competitive disadvantage with companies in other states who were not subject to such stringent requirements. There was, however, no diminution of the extent of control. Companies felt that extensive control was necessary and should be carried out. If there was any resistance, it was resistance to the way that programs are currently being administered and not to the need for public management of industrial and community water use. The critical point (which will be studied more thoroughly in the second data gathering period) from our preliminary analysis is that large companies do not object to control if all companies are subject to the same degree of control and especially if competitors are subject to the same degree of control.

#### (B) Publications.

"Pollution and Self Interest," Journal of Environmental Education (to be published in the next volume.)

"Factors Related to Industrial Change in Pollution Control," paper to be read at the session on Environment and Society, Rural Sociological Association annual meeting, August 29, 1972.

"The Role of Scientists in Environmental Policy-Making," 1972 (Mineographed paper to be submitted for publication.)

#### (C) Project Status.

The project will continue in progress in fiscal year 1973.

#### (D) Application of Research Results.

In the above section, we discussed the rather prevalent support for agency regulation by companies in our sample. It was also found that there had been less change in development of waste control facilities than in other aspects of company operation. Of course, this data needs considerably more analysis, which we are in the process of undertaking, but some tentative conclusions and suggestions can be outlined. Our main conclusion at this point is that the problem of water pollution or the solutions to water management are not to be found in the simple addition of new technology but in the relationship of industries to regulatory agencies at all levels of government. The problem is, therefore, somewhat larger in scope than has been anticipated by scholars and practical planners working in this area. It is not the technological solution that is so hard to come by, but the organization of effort or the coordination of effort to correct certain pollution problems. The core of the problem is the institutional framework of water management.

Other students of water management have reached the same conclusion. However, too often the subject is left at such a level of abstraction that little re-organization of effort is stimulated. We found some very specific aspects in the first stage of our analysis that will be more explicitly studied in the second phase. Generally, we have focused on the relationship between industrial firms and regulatory agencies. Specifically, we studied the problems of uncertainty by companies of the details of pollution control standards. Production managers, for example, often mentioned that "if we only knew what to do (or what they want, meaning the regulatory agencies) we would do it." Secondly, we dealt with conflicting standards of agencies. Many different agencies representing state and federal levels are responsible for the same bodies of water. When agencies do not agree on standards, the company is put into the position of determining which set of standards will be enforced and which will not be. Therefore, the company must judge the relative power of each to determine what policy to follow. Indeed, this variable differs from uncertainty because companies know what different agencies expect of them but the expectations are conflicting. The cliché "more communication is needed" is not applicable as agencies and companies are communicating and companies know what each agency wants. Change will be delayed in companies until there is a consistent set of standards. Conflict between agencies may well be the seat of the problem rather than conflict between industries and pollution control agencies.

A number of companies have requested specific reports. Each company that participated in the study will receive a small preliminary report this summer with a fuller report at the end of the data analysis period.

#### (E) Work Remaining, and Progress Contemplated During Next Year.

During the summer and fall, 1972, the companies included in the first analysis will be subject to re-study. In the second analysis, we will concern ourselves with the relationship that companies have with the regulatory agencies to which they are responsible at the city, regional, state and federal level. The final data will be collected and analyzed by February, 1973.

During next winter and spring a final report will be written covering the research during the last three-year period. Research papers will also be presented for publication.

OWRR Project No. B-049-Minn.

Agreement No. 14-31-3295

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

FCST - COWRR Research Category: 06-B

Name and Location of University Where Project is Being Carried Out:

Bemidji State College, Bemidji, Minnesota 56601

Project Began - July 1, 1970 To Be Completed - September 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| J.P. Ludwig                   | Ph.D.              | Ecology                                  |
| <u>Students Assistants</u>    | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| Allen Batterman               | B.S.               | Biology                                  |
| David Ostenso                 | B.S.               | Geography                                |
| Larry Daby                    | Undergrad.         | Chemistry                                |
| Hans Christensen              | Undergrad.         | Geography                                |
| Donald Crosby                 | Undergrad.         | Political Science                        |
| David Hirte                   | Undergrad.         | Geography                                |
| Davis Koffron                 | Undergrad.         | Geography                                |
| William Kunisher              | Undergrad.         | Geography                                |
| Carolyn Williams              | Undergrad.         | Biology                                  |

Narrative Statements

(A) Research Project Accomplishments.

A. By Dr. Tideman of St. Cloud State College - My own research activity has been related to gathering data, analyzing and mapping riparian land use in the study universe. I am also analyzing returns from the High School questionnaires administered in February 1971.

B. By Norman Baron of Winona State College - Interviews were conducted with a variety of special interest users and non-users of the Mississippi River from Anoka south to the Iowa border. Interviewers were categorized as riparian home owners, recreationalists, commercial users, agriculturalists, and nearby home owners. These comparative data were analyzed on a first order basis this year, and additional analysis is proceeding now.

C. By E. James Cecil of Bemidji State College - Interviews with special interest groups (as indicated in B. above with the addition of sewage plant operators) above Anoka, Minnesota to the headwaters at Itasca State Park. The general mail questionnaire sent to a sample of persons living in the twenty-three county universe was returned and analyzed. Several specialty questionnaires were also analyzed. Data analysis is continuing.

D. By the entire project staff - A series of three public seminars were hosted by the three cooperating schools, April 10 at Bemidji State, April 11 at St. Cloud State, and April 13, at Winona State. Each conference publicized the major findings of the research project plus providing a forum for persons performing research on river-related problems in immediate proximity to the location of the program. Each program thus possessed a common theme of the B-049-Minn. project findings including topics of local interest. Between 300 and 400 persons attended one of these seminars. Part of the Bemidji Conference was aired on campus radio KBSB-FM, and Mr. Cecil was interviewed by KSPT Television at St. Cloud relative to the results of the general mail questionnaire.

(B) Publications.

An article appeared in CURA Reporter, March-April 1972: "The Mississippi River...How Do Minnesotans Feel About It?" CURA Reporter, Center for Urban and Regional Affairs, University of Minnesota, Vol. II, #3, March-April 1972.

(C) Project Status.

The project will continue in progress in the next fiscal year.

(D) Application of Research Results.

A wide variety of people including politicians, the League of Women Voters, and more than 100 non-state-college persons at large have already requested copies of the final report when published. The planning sections of several power companies, the cities of Minneapolis and St. Cloud, and faculty from eleven colleges of Minnesota and Wisconsin have requested copies of the final report as well. It is difficult to assess how the project results will be used by all these diverse interests. Since a major portion of the study has assessed current attitudes toward river development and use, it seems clear that this study will be exceptionally valuable to estimate public response to development programs and hence valuable for all levels of planners.

(E) Work Remaining, and Progress Contemplated During Next Year.

Between July 1 and September 30, 1972 the project staff will complete the analysis of the collected data and will prepare a final edited report by September 30. A minimum of new data will be collected.



OWRR Project No. B-053-Minn.

Agreement No. 14-31-0001-3600

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

FCST-COWRR Research Category: 06-G

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, St. Paul, Minnesota 55101

Project Began - July 1, 1971 To Be Completed - June 30, 1974

| <u>Principal Investigators</u> | <u>Degree</u> | <u>Discipline</u> |
|--------------------------------|---------------|-------------------|
| A.C. Mace                      | Ph.D.         | Forestry          |
| J.M. Hughes                    | Ph.D.         | Forestry          |

  

| <u>Student Assistants</u> | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
|---------------------------|--------------------|--|
| John C. Clausen           | M.S.               | Forest Hydrology                         |
| Frank M. McCorrison       | M.S.               | Forest Hydrology                         |
| Mark Boche                | M.S.               | Forest Hydrology                         |
| Virginia Busch            | Undergrad          | Forestry                                 |

Narrative Statements

(A) Research Project Accomplishments.

The first phase of the study related to determination of water use coefficients has been completed. Direct water use coefficient (ratio of water requirements for a given sector to the gross dollar output of that sector) were derived for all 34 of the economic sectors used in the original input-output analysis for Itasca County. (Table 1) These coefficients were ranked by decreasing water use per dollar of output which provides an implied value of the water for the different economic sectors of the county.

A water content matrix was formulated by using the original direct-plus-indirect coefficient matrix and the direct water use coefficients to determine direct-plus-indirect water use coefficients. These coefficients provide a measure of the direct water use per dollar output of the sector plus the associated and indirect water use related to the economic activity by a sector. Comparison of the ranking of direct and direct-plus-indirect water use coefficients in Table 1, indicate that some sectors generate a large indirect water use. These sectors include: automobile and truck sales, wholesale and distributing, grocery and drug sales and households.

(B) Publications.

None

(C) Project Status.

The project will continue in progress in the next fiscal year.

Table 1: Water Use Coefficients by Sector for Itasca County (1966, economic data)

| Sector Number | Sector Title                    | Rank | Water Use Coefficients (Gallons/Dollar of Output) |                                      |
|---------------|---------------------------------|------|---|--------------------------------------|
|               |                                 |      | Direct Gallon/Dollar                              | Direct & Indirect Rank Gallon/Dollar |
| 1             | Timber production               | 1    | 17,727.890  | 2                                    |
| 2             | Timber operators                | 33   | 0.109   | 30                                   |
| 3             | Sawmills                        | 20   | 2.127   | 24                                   |
| 4             | Agriculture                     | 2    | 8,394.542   | 3                                    |
| 5             | Food processing                 | 15   | 2.863   | 25                                   |
| 6             | Stone, clay, glass, cement      | 14   | 5.722   | 27                                   |
| 7             | Other industry n.e.c.*          | 3    | 205.554   | 11                                   |
| 8             | Construction and contracting    | 34   | 0.005   | 12                                   |
| 9             | Transportation and warehousing  | 27   | 0.652   | 22                                   |
| 10            | Lumber and hardware             | 28   | 0.384   | 15                                   |
| 11            | Automobile and truck sales      | 32   | 0.112   | 6                                    |
| 12            | Gasoline and service station    | 22   | 1.925   | 14                                   |
| 13            | Automobile repair               | 26   | 0.720   | 17                                   |
| 14            | Grocery and drug sales          | 24   | 1.033   | 5                                    |
| 15            | Dry goods and appliances        | 25   | 1.001   | 10                                   |
| 16            | Food and beverage service       | 10   | 11.114  | 18                                   |
| 17            | Other retail n.e.c.*            | 12   | 5.803   | 28                                   |
| 18            | Professional services           | 17   | 2.499   | 16                                   |
| 19            | Skilled and semi-skilled trades | 7    | 29.806  | 21                                   |
| 20            | Finance and real estate         | 18   | 2.451   | 7                                    |
| 21            | Hotel, motel and rental         | 4    | 61.031  | 29                                   |
| 22            | Electric utilities              | 29   | 0.332   | 19                                   |
| 23            | Communications                  | 30   | 0.319   | 20                                   |
| 24            | Wholesale and distributing      | 31   | 0.197   | 9                                    |
| 25            | Resorts                         | 5    | 45.122  | 31                                   |
| 26            | Recreation and entertainment    | 23   | 1.874   | 23                                   |
| 27            | Education                       | 6    | 41.379  | 32                                   |
| 28            | Non-profit organization         | 11   | 6.336   | 26                                   |
| 29            | Public schools                  | 16   | 2.737   | 8                                    |
| 30            | Local governments               | 8    | 28.752  | 13                                   |
| 31            | County government               | 19   | 2.334   | 4                                    |
| 32            | State government                | 9    | 12.562  | 33                                   |
| 33            | Federal government              | 21   | 2.071   | 34                                   |
| 34            | Households                      | 13   | 5.789   | 1                                    |

\*n.e.c. means not elsewhere classified.

(D) Application of Research Results.

Results of this project will provide city, county, and state planning agencies with information pertaining to the water use requirements per dollar output of various economic sectors and/or industries. In addition, state and federal land management agencies will be provided with an additional input, water quality effects and associated economic changes, with which alternative land management decision can be evaluated.

These results may be useful to the following organizations: Itasca County Advisory Commission, Itasca County Board, Itasca County Development Association, Minnesota State Planning Agency, Department of Natural Resources, Minnesota Pollution Control Agency and the U.S. Forest Service.

(E) Work Remaining, and Progress Contemplated During Next Year.

Effects of alternative forest management systems on water quality parameters will be completed next year. These residual outputs will be combined with the assimilative capacity of the water and applied to the modified input-output model.

Direct and indirect water use coefficients will be adjusted for each alternative forest management system and a resulting water content matrix derived. Comparisons will be made concerning the effects of each alternative forest management system on the economy of the area.

OWRR Project No. B-054-Minn.

Agreement No. 14-31-0001-3601

Project Title: Socio-Economic Implications of Alternative Water resources policies in Minnesota

FCST-COWWR Research Category: 06-E

Name and Location of University Where Project is Being Carried Out:

University of Minnesota, St. Paul, Minnesota 55101

Project Began - July 1, 1971 To Be Completed - June 30, 1974

| <u>Principle Investigator</u> | <u>Degree</u> | <u>Discipline</u>                |
|-------------------------------|---------------|----------------------------------|
| John J. Waelti                | Ph.D.         | Agricultural & Applied Economics |

| <u>Student Assistants</u> | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
|---------------------------|--------------------|--|
| Alan Hopeman              | B.S.               | Agricultural & Applied Economics         |
| Cheryl Coyle              | Undergrad          | Sociology                                |

Narrative Statements

(A) Research Project Accomplishments.

A study of flood control policy has begun, focusing on structural and non-structural alternatives in the Minnesota River Valley. The structures which are feasible from a technical standpoint have been identified along with their estimated costs. Contacts have been made with relevant State and Federal agencies and some work completed in an attempt to identify the social costs of flooding in Minnesota. This analysis is being planned as a thesis by a graduate student working for the M.S. degree in agricultural economics. In addition, a rough draft has been completed for a manuscript in which an examination is made of environmental alternatives, their relationship to democratic capitalism, and our social decision-making processes.

(B) Publications.

None.

(C) Project Status.

The project will continue in progress in fiscal year 1973.

(D) Application of Research Results.

The Minnesota State Planning Agency and the Department of Natural Resources in addition to offering cooperation necessary for the projects completion have expressed an interest in the flood control analysis. Insofar as major policy decisions will be made in Minnesota in the near future it is anticipated that the State Legislature will be interested in

the results of the research. While the manuscript on environmental alternatives will be of interest to water resource professionals and public agencies, it will be geared to aid public understanding of the implications of public policy alternatives.

(E) Work Remaining, and Progress Contemplated During Next Year.

- (1) The data on costs of flooding needs to be assembled and analyzed.
- (2) The non-structural alternatives for flood control need to be more precisely identified.
- (3) The costs and benefits of alternatives along with their incidence on private individuals, State, local, and Federal government need to be identified along with the policy implications.
- (4) The manuscript on environmental alternatives will be revised in accordance with recent development and current information. During fiscal year 1973 items 1, 2 and 4 will be completed.

OWRR Project No. B-057-Minn.

Agreement No. 14-31-0001-3602

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

FCST-COWRR Research Category: 04-B

Name and Location of University Where Project is Being Conducted:

University of Minnesota, St. Paul, Minnesota 55101

Project Began - July 1, 1972 To Be Completed - June 30, 1974

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| E.R. Allred                   | M.S.               | Agricultural and Civil Engineering       |
| <u>Staff Cooperators</u>      | <u>Degree</u>      | <u>Discipline</u>                        |
| Paul E. Read                  | Ph.D.              | Horticultural Science                    |
| L.L. Boyd                     | Ph.D.              | Agricultural Engineering                 |
| J.R. Gilley                   | Ph.D.              | Agricultural Engineering                 |
| <u>Student Assistants</u>     | <u>Degree Held</u> | <u>Discipline or Academic Background</u> |
| Peter F. Frenzel              | B.S.               | Agricultural Engineering                 |
| Jean M. LeBarbier             | B.S.               | Agricultural Engineering                 |
| Gary Johnson                  | Undergrad.         | Agricultural Engineering                 |

Narrative Statements

(A) Research Project Accomplishments.

Field plots were established during the fall of 1971 at the University of Minnesota Sand Plains Experimental Station, at Elk River, Minnesota. A 4-inch diameter well was drilled to a depth of 35 feet to provide a dependable source of water supply. A submersible pump was installed in the well and a small building constructed to house pumping equipment. The latter also serves as an operation control center for the project. Water is applied to the crops via plastic tubes, placed in each crop row and at an approximate depth of 2 inches beneath the soil surface. During the current season the principal crop being investigated is potatoes. Trial work is also being done with selected other crops to determine their feasibility for study another year. In addition to the plots where heated water is used for irrigation, check plots using unheated water have also been established.

Since this is the first year of the study and the growing season only partially completed, no conclusive data regarding the effects of using heated water are available. Early emergence and growth of potatoes in the warm-water plots was observed during the early part of the season. Because of unavoidable delays in the installation of the water heated, however, no attempt was made to extend the growing season into the very early weeks of spring. Such studies are contemplated in the future. Much of the work

thus far has been exploratory in nature since there is little work of precedence. It has been found, for example, that the original plastic tubing design, being used in the distribution lines collapse as the result of external soil pressures. Such condition has resulted in unsatisfactory and nonuniform distribution of water within the lines. A completely new design of subsurface piping has now been acquired and will be installed immediately following removal of present crops. Work is nearing completion on the installation of a modern electronic data acquisition system at the field site. Such a system will be capable of recording various temperature and climatological data, at specified time intervals, on both printed and on magnetic tape.

(B) Publications.

None.

(C) Project Status.

The project will continue in progress during fiscal year 1973.

(D) Application of Research Results.

The principal object of the research is to determine the feasibility of using the heat energy contained in water discharges from electrical generating plants, and from other industry, for the growing of agricultural crops. The discharge of heated water into natural streams often causes undesirable ecological imbalances to occur. Such occurrences are especially critical during the summer months of the year. Irrigation of agricultural crops appears to offer one means of alleviating such conditions during the growing season, while at the same time providing revenue through increased crop production. It may be found that the use of excess heat energy will make it possible to extend the growing season in Minnesota, and in other northern areas, through earlier planting of the crop.

(E) Work Remaining, and Contemplated During Coming Year.

The new subsurface irrigation system, using non-collapsible plastic pipe with spaced emitters, will be installed during the fall of 1972. Such a system should permit the circulation of warm water during late winter periods as a means of obtaining above normal soil temperatures. Crops will be planted in the heated soil mantle as early in the spring as possible. The benefits, if any, resulting from such early planting will be determined for various crops. Also, benefits to be realized from the use of heated water for irrigation during the later parts of the growing season will also be appraised.

OWRR Project No. B-060-Minn.

Agreement No. 14-31-0001-3603

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

FCST-COWRR Research Category: O2-E

Name and Location of University where Project is Being Conducted.

University of Minnesota, Minneapolis, Minnesota 55455

Project Began - July 1, 1971 To Be Completed - June 30, 1972

| <u>Principal Investigator</u> | <u>Degree</u>      | <u>Discipline</u>                        |
|-------------------------------|--------------------|--|
| C.E. Bowers                   | M.S.               | Civil Engineering                        |
| <u>Student Assistants</u>     | <u>Degree held</u> | <u>Discipline or Academic Background</u> |
| A.F. Pabst                    | M.S.               | Civil Engineering                        |
| K. Kim                        | M.S.               | Civil Engineering                        |
| Gary Lake                     | B.S.               | Civil Engineering                        |
| James Pennaz                  | B.S.               | Civil Engineering                        |

Narrative Statements(A) Research Project Accomplishments.

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) has involved (1) the assembly of meteorological and hydrologic data concerning past spring floods and new data pertaining to floods during the contract period; and (2) procurement and preliminary evaluation of selected mathematical models of watersheds. In future work under Phases II and III the data will be subjected to further analysis using available mathematical models, modifications of such models and new models to assist in synthesizing continuous runoff records.

The Upper Midwest is a relatively flat area compared to the mountainous regions of the country; studies of the contribution of snowmelt to spring floods and the critical combination of hydrologic conditions that are characteristic of major floods in this area are of major importance. Of special interest are 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. As the objective is to assist in flood forecasting it is necessary to work with large watersheds or basins and the associated meteorological and hydrological data available over large areas from present data collection agencies rather than specialized collections over one or more small research watersheds. Also, the problem involves large amounts of data due to both the physical size of the basins but also because the problem requires continuous analysis over several months to a year in any one run.

Most of the data needed are available on magnetic tape, Fosdic film, or cards as well as printed tables.

For these studies it is desirable to have data available on magnetic tape. Of special interest are National Weather Service and U.S. Geological Survey Data. The following data have been obtained on magnetic tape from the U.S. Geological Survey:

1. Daily discharge data for 27 gaging stations in the Minnesota River Basin for the complete period of record available.
2. Daily discharge data for 74 other gaging stations in Minnesota in addition to item (1).
3. Daily discharge data for 54 gaging stations in North and South Dakota, and Wisconsin in the Red River of the North and Upper Mississippi River Basin.

The following data have been received or are on order from the National Weather Service:

1. Daily Observations (Card Deck 486) on magnetic tape for the State of Minnesota for the period October 1963 through December 1971.
2. Hourly Precipitation Data (Card Deck 488) on magnetic tape for the State of Minnesota for the period January 1960 through June 1971.
3. Daily solar radiation data (Card Deck 480) for St. Cloud, Minnesota for the period 7/54 - 4/62, 6/62 - 12/70 (on tapes).
4. Surface 3 hourly data on tape in TDF 14 Format for Minneapolis, Rochester, St. Cloud, Fargo, Sioux Falls, Duluth, and LaCrosse for the period 01/59 to 12/71.
5. Summary of Day (Card Deck 345) for Alexandria, Duluth, Hibbing, Minneapolis, Redwood Falls, Rochester, St. Cloud, and Willmar (periods available vary but generally from about 1948 to 1971).

The preceding USGS and NWS data have been obtained on 1/2 inch wide, 7 track, BCD, 556 BPI magnetic tape to be compatible with the CDC 6600 computing system.

Maps showing the water content of snow at selected times during late winter and early spring have been obtained from the St. Paul District U.S. Army Corps of Engineers and from the National Weather Service, Minneapolis-St. Paul International Airport. The years for which these are available cover the period from 1950 to 1972, but in years with very little snow maps are not available. Thirty-five maps were obtained from the Corps of Engineers and about 60 from the National Weather Service. To use these data in a mathematical model it is necessary to digitize the desired data. As the spring melt usually starts in March, one map for each of 13 years was selected for initial processing. The map selected was usually dated March 10 to 20. Snow or rain after the date selected could be used from the taped data noted above. A grid 10 minutes by 15 minutes was laid over the map and the water content of snow shown on the map was punched in card form for each grid point. This was then transferred to magnetic tape.

As these data were procured with State and Federal funds, they are considered to be available to other users. Some expense will be involved in discussion, retrieving and copying the tapes, and other users would be expected to cover this cost.

The data on magnetic tape are in good form for storage purposes but not convenient to use. For operation with a mathematical model selected stations and years were transferred to random access disk storage.

Procurement of mathematical models that are of interest in this area was initiated in an earlier study and has continued in the present project. Discussions were held with engineers, hydrologists, and meteorologists from various organizations relative to the modeling problem.

Several models such as the SSARR (Streamflow Synthesis and Reservoir Regulation) and the Stanford Model (IV) were operated with inputs of up to one year's data in a single run. The results of this phase were very encouraging and are covered in more detail in a technical report.

#### (B) Publications.

"Flood Forecasting -- Data Assembly and Preliminary Analysis," by C. Edward Bowers, and A.F. Pabst, St. Anthony Falls Hydraulic Laboratory, Project Report No. 137, June 1972.

#### (C) Project Status.

The project has been completed.

#### (D) Application of Research Results.

The project has resulted in the assembly, in readily useable form, of meteorological and hydrological data that can be used in mathematical models to compute daily flows on large watersheds for the period 1963 to the present. Output can be for a single flood or with some models continuous periods up to a year or more.

#### (E) Work Remaining, and Progress Contemplated During Next Year.

None.

New Courses Developed

University of Minnesota

FBio 1-101 - Introduction to Air and Water Quality (4 cr): Presents an overall view and an appreciation of air and water quality problems. Basic processes which govern the acration, depletion, and cycles of specific types and sources of pollution. Methods of pollution abatement and assessment of the influence of political, social and economic pressures on the maintenance of a "quality environment".

AgEn 5-082 Design-Soil and Water: (4 cr.; prerep. senior status, 1 lecture and 6 lab hours per week). An individual engineering design project in sediment control, irrigation, drainage, water development or utilization, flood control, and/or water quality control, integrating previous work and covering the whole range of the design process from conceptualization through preparation of the project report.

New Courses Replacing Discontinued Courses

AgEn 5-540 Erosion Control, Watershed Engineering: (4 cr; prereq 3-050, 3-060, CE 5-401; 3 lect and 3 lab hrs per wk) Measurement and mechanics of watershed runoff and soil erosion. Estimating peak runoff, soil losses and sediment yeilds. Environmental effects. Principles of small watershed planning for flood control, water storage and sediment control. Hydraulic design of graded and storage type terraces, grass waterways, diversions and erosion control structures.

AgEn 5-550 Drainage and Irrigation Engineering: (4 cr; prereq 3-050, 3-060, CE 5-401; 3 lect and 3 lab hrs per wk) Flow of water through agricultural soils. Irrigation and drainage requirements, salinity control, evapo-transpiration, water supply development and control. Conveyance of drainage and irrigation waters. Considerations for design, layout, and construction of irrigation and drainage systems. Institutional, environmental, and economic aspects of soil moisture control.

Additional Water Resources Related  
Staff Members Added

None.

New Research and Training Facilities  
Other than Research Equipment Items

The Freshwater Biological Research Foundation was organized several years ago for the purpose of building and staffing a major aquatic research institute at Lake Minnetonka. Construction of the Institute has not yet begun, but the foundation allocated funds to build a mobile laboratory. The mobile laboratory is a specially-designed 27-ft. self-propelled motor coach. The design includes laboratory benches, sinks, compressed air and vacuum, a refrigerator-freezer, and storage cabinets for equipment, instruments, and chemicals. It is equipped with the usual assortment of water

samplers and other field equipment, a fluorometer, a spectrophotometer, a large centrifuge, a pyroheliometer, and colorimeters. This mobile laboratory has been used since July, 1971, for the research at Lake Minnetonka, so that the small mobile laboratory can be used exclusively for the study of the lakes at Fairmont. The mobile laboratories are indispensible because they provide lake-side facilities for studying rates of photosynthesis by phytoplankton in its natural environment. They also make it possible to perform chemical analyses on fresh samples before the chemistry of the samples has been altered by biological activity.

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

| <u>Category of Students</u>  | <u>No. by Scientific Discipline or Major Field of Study (Engineering, Biology, Economics, etc.) 2/</u> |               |
|------------------------------|--|---------------|
|                              | <u>Scientific Discipline of Student</u>  | <u>Number</u> |
| (1) <u>Undergraduates</u>    | Agricultural Engineering   | 2             |
|                              | Biology  | 2             |
|                              | Botany   | 1             |
|                              | Business Administration  | 1             |
|                              | Civil Engineering  | 2             |
|                              | Chemistry  | 1             |
|                              | Forestry   | 1             |
|                              | Geography  | 4             |
|                              | Horticulture   | 2             |
|                              | Nursing  | 1             |
|                              | Political Science  | 2             |
|                              | Pre-Medicine   | 1             |
|                              | Public Health  | 2             |
|                              | Sociology  | 3             |
|                              | Soil Science   | 1             |
| (2) <u>Master's Students</u> | Agricultural & Applied Economics   | 2             |
|                              | Agricultural Engineering   | 3             |
|                              | Animal Nutrition   | 1             |
|                              | Biology  | 6             |
|                              | Chemistry  | 1             |
|                              | Civil Engineering  | 5             |
|                              | Ecology  | 1             |
|                              | Geography  | 1             |
|                              | Hydrogeology   | 1             |
|                              | Medical School   | 1             |
|                              | Public Health  | 1             |
|                              | Sociology  | 4             |

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.

| <u>Category of Students</u>      | <u>No. by Scientific Discipline or Major Field of Study (Engineering, Biology, Economics, Etc.)</u> |               |
|----------------------------------|---|---------------|
|                                  | <u>Scientific Discipline of Student</u>   | <u>Number</u> |
| (3) <u>Doctoral Students</u>     | Anthropology  | 1             |
|                                  | Agricultural Engineering  | 1             |
|                                  | Chemistry   | 1             |
|                                  | Civil Engineering   | 2             |
|                                  | Ecology   | 1             |
|                                  | Forestry  | 3             |
|                                  | Horticulture  | 1             |
|                                  | Hydrogeology  | 1             |
|                                  | Public Health   | 2             |
|                                  | Soil Science  | 2             |
| (4) <u>Postdoctoral Students</u> | Horticulture  | 1             |
|                                  | Soil Science  | 1             |

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.

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

| EMPLOYMENT STATUS   | Bachelor's Degree | Master's Degree | Doctoral Degree | Total |
|---|-------------------|-----------------|-----------------|-------|
| 1. No. employed in water-related positions in:                |                   |                 |                 |       |
| Total-----  | 0                 | 4               | 5               | 9     |
| Federal Agencies-----   | 0                 | 1               | 1               | 2     |
| State & Local Agencies---                                     | 0                 | 1               | 0               | 1     |
| University or College----                                     | 0                 | 0               | 3               | 3     |
| Other - Including private enterprise-----                     | 0                 | 1               | 1               | 2     |
| 2. No. graduates returning to school for advanced degree----- | 1                 | 1               | 0               | 2     |
| 3. No. going into military service-----                       | 0                 | 0               | 0               | 0     |
| 4. No. unemployed or working in other fields-----             | 0                 | 0               | 0               | 0     |
| 5. No. status unknown-----                                    | 2                 | 0               | 0               | 2     |
| 6. Totals-----  | 3                 | 4               | 5               | 12    |

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 |
|---|-------------------|-----------------|-----------------|-------|
| 1A. Federal Agencies:                                 |                   | 1               | 1               | 2     |
| a. Primarily Research -----                           | 0                 | 0               | 1               | 1     |
| 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               | 0               | 1     |
| f. Other or not known -----                           | 0                 | 0               | 0               | 0     |
| 1B. State & Local Agencies:                           | 1                 | 0               | 0               | 1     |
| 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               | 0               | 1     |
| f. Other or not known -----                           | 0                 | 0               | 0               | 0     |
| 1C. University or College:                            | 0                 | 0               | 3               | 3     |
| a. Primarily Teaching -----                           | 0                 | 0               | 0               | 0     |
| b. Primarily Research -----                           | 0                 | 0               | 0               | 0     |
| c. Primarily Research & Teaching -                    | 0                 | 0               | 3               | 3     |
| d. Other or not known -----                           | 0                 | 0               | 0               | 0     |
| 1D. Other - Including Private Enterprise:             | 1                 | 1               | 0               | 2     |
| a. Primarily Research -----                           | 0                 | 0               | 0               | 0     |
| b. Primarily Planning -----                           | 1                 | 0               | 0               | 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                 | 0               | 1               | 1     |
| Totals -----  |                   | 3               | 5               | 8     |

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)-----        | 0 |
| Operations (1Ad, 1Bd & 1Dd)-----         | 0 |
| Management (1Ae, 1Be, & 1De)-----        | 2 |



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