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ANNUAL TECHNICAL REPORT
1971-72

IMPROVING CAPACITY OF CUSUSWASH UNIVERSITIES
FOR WATER MANAGEMENT
FOR AGRICULTURE

REPORT NUMBER III
COLORADO STATE UNIVERSITY



Contract No. AID/csd 2460
August 31, 1972

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Contract No. AID/csd 2460
August 31, 1972

COLORADO STATE UNIVERSITY 211(d) GRANT ANNUAL REPORT

Title: "Optimum Utilization of Water Resources: With Emphasis on Water Delivery and Removal Systems and Relevant Institutional Building"

Grantee: Colorado State University

Director: Dr. Maurice L. Albertson

A. STATISTICAL SUMMARY:

Period of Grant: 23 May 1969 to 23 May 1974

Amount of Grant: \$750,000

Expenditures for Report Year \$195,074 Accumulated \$436,056

Anticipated for next year \$171,444

B. NARRATIVE SUMMARY:

The area of research assigned to Colorado State University under the 211(d) Grant is entitled, "Optimum Utilization of Water Resources: With Emphasis on Water Delivery and Removal Systems and Relevant Institutional Development." The Colorado State University's activity in the 211(d) Grant program involves participation by six departments: Agricultural Engineering, Agronomy, Civil Engineering, Economics, Political Science, and Sociology. Traditionally, engineers and agriculturists working in the areas of water delivery and removal systems have little or no understanding of, or concern for, the related institutional structure which is required today for the successful operation of water systems. A primary purpose of the 211(d) Grant program is to overcome these shortcomings by recognizing the concomitant need to analyze prevailing social systems as they affect water delivery and removal systems including the kinds of institutional changes necessary, the sources of resistance to change, and effective ways of dealing with

social resistance. Thus, one of the chief characteristics of the University's participation in the 211(d) Grant program is its inclusion of social, economic and cultural factors along with engineering and technological considerations, thereby increasing the capabilities, dimensions of understanding, and competence of the University in this assigned area of research.

Because of the complex nature of the physical, financial, and technological constraints placed upon the optimal use of water delivery and removal systems including relevant institutional structures, the participating disciplines feel that solutions may best be found through a comprehensive interdisciplinary approach. Each of the participating departments has looked to the International Interdisciplinary Seminar for guidance in relating research activities to the Grant objectives. The Seminar reviews and discusses a related spectrum of technical, social, economic, political and cultural factors affecting developmental changes in order to bring about a better understanding of the processes involved with regard to optimum utilization of water resources including water delivery and removal systems and related institutional development. More specifically, the departments have strengthened and improved research activities with regard to and in support of the Grant objectives through: Adding faculty members who have expertise in water delivery and removal; teaching courses involving water delivery and removal systems and related institutional development to students in engineering, agriculture, economics, and the social sciences; guiding the research activities of faculty and research assistants in the area of optimum utilization of water resources including water delivery and removal systems and related institutional development; supporting graduate research assistants who are interested in optimum utilization of water resources; publication of technical reports; and developing linkages.

In general, the six participating departments are increasingly able to meet the requirements of the 211(d) Grant through close cooperation and coordination of their 211(d) activities with each other; by deeper understanding of the role of each department to the theme of the Grant program;

through establishment by each department of benchmark data and literature applicable to the Grant objectives; and by developing capabilities within each department to respond to water delivery and removal problems through orienting and training students and faculty to the issues of development and to the larger questions of utilizing water and other natural resources for the achievement of planned change. In the following pages, Colorado State University accomplishments are discussed, including the details of the impact of Grant-supported activities in developing institutional capabilities, utilization of institutional resources in development, other resources for Grant-related activities, and next year's plan of work.

C. DETAILED REPORT

I. General Background and Purpose of the Grant

Water management has been established as a critical and limiting factor in increasing agricultural productivity throughout the world. This is especially true in the case of developing countries. The need for more efficient use of water to increase agricultural productivity has not only been well stated in many reports and publications, but the necessity of introducing good water management systems is now widely accepted throughout the world. Attaining efficient water use in the United States, particularly in the west, occupies a high level of priority in specific U.S. Government organizations. The many national and international organizations and institutions in the world today dealing with water use for the purpose of increasing agricultural productivity is ample testimony to its importance. Recognition of the numerous urgent requests for technical assistance in this field provided the U.S. incentive for the establishment-- under United States Title II, Section 211(d) of the Foreign Assistance Act-- of the Council of United States Universities for Soil and Water Development in Arid and Sub-Humid Areas (CUSUSWASH) by four Land-Grant Universities, i.e. Colorado State University, University of Arizona, Utah State University, and the University of California. Accordingly, it can be expected that increasingly high priorities will be given by developing countries located in arid and sub-humid areas of the world to new and improved development of their own water resources.

Water management for agriculture is a complex subject embracing many individual arts and sciences involving such activities as protecting or reclaiming land from excess precipitation or flooding, husbanding or managing soil moisture, optimizing cropping practices to the moisture regime, impoundment of water, distribution and application of irrigation water supplies, coordinated management of watershed areas, and the development and maintenance of institutional capability necessary for support of water-related aspects of agricultural operations.

While all the CUSUSWASH universities have varying capabilities in the water management fields, extending the capacity for international service had to be coordinated, both for sharing research results and for optimum utilization of funding by the Agency for International Development. Based on these concepts and considering existing capabilities and interest of the several universities, Colorado State University was assigned the area of research on optimum utilization of water resources with special emphasis on water delivery and removal systems including relevant institutional development. The following pages depict research activities by Colorado State University during the reporting period related to the above assignment involving such topics as: Water supply development, structures for conveyance, delivery and drainage, impoundment and storage of water, control and measurement of water, control of erosion and sedimentation, use of wells, systems analysis for optimal utilization of water and economic allocation of water; also acquiring and/or developing a concomitant understanding of social systems, culture, and process of change to better accomplish a usually difficult and complex task of transferring technology and related institutional building to developing countries.

II. Objectives of the Grant

1. Objectives Restated

With the funds from the 211(d) Grant, Colorado State University is improving its level of excellence with respect to planning, development, management, and utilization of water resources with special emphasis on water delivery and removal systems and relevant institutional development related to the needs of the developing countries. Specifically, the objectives and scope of the CSU 211(d) Grant Project, as stipulated in the Grant Document, are as follows:

- a. Improving and expanding its professional staff in the various departments of the University which are now involved in water resource activities related to the needs of the less developed countries.
- b. Expanding its number of graduate students in the departments interested in the less developed countries.

c. Expanding its departmental research programs and activities related to the needs of the less developed countries.

d. Expanding its course offerings in these departments-- including interdisciplinary courses--which are related to the less developed countries.

e. Expanding special activities and initiating new ones in the United States and abroad which are related to research, teaching, and service, e.g. seminars, exchange programs, institutes, conferences, and publications which are concerned with the less developed countries.

f. Helping to alleviate the critical shortage of qualified professional personnel with international interests, experience, and expertise, and with cross-cultural insights.

g. Expanding its capability to serve in advisory and consulting capacities to various individuals, government agencies, industries, business, and other organizations having an interest in activities abroad.

h. Improving its understanding of the nature of the less developed societies, and finding ways and means of assisting them to resolve crucial problems relating to water resources development and management.

i. Developing an exchange of personnel and publications, and other programs of interaction, which will help to establish steady and effective lines of communication between Colorado State University and the less developed countries.

In addition, the CSU 211(d) Grant Document specifically lists the following area subjects:

a. Development of water supplies from various sources.

b. Conveyance, delivery, and drainage of water in open and closed conduits, including rivers, canals, irrigation ditches, tunnels, and pipelines.

c. Storage and use of water in reservoirs, both above and below ground.

d. Control and measurement of water in storage and water being conveyed either for delivery or for removal (drainage).

e. Control of erosion and sedimentation with respect to delivery, removal, and storage.

f. Use of wells as a source of water or for storage of water underground.

g. Use of systems engineering for development of optimum solutions to problems of water resources utilization.

h. Understanding social, economic, political, and cultural factors in technological change, and the processes of developmental change.

i. Analysis of prevailing social systems, their structural-functional characteristics within specific less developed countries to determine:

(1) The kinds of structural changes necessary for maximizing water resource development and management, including the use of necessary new inputs.

(2) The sources of resistance to these necessary changes.

(3) Effective ways of dealing with social resistance.

j. To analyze specific organizational and administrative structures for agricultural development in specific less developed countries to determine needed changes for better water utilization in maximizing agricultural production.

k. To conduct economic analyses, including input response studies and including the analysis of delivery and removal systems, to achieve efficient and economic allocation of water for agricultural purposes in selected areas of the less developed countries.

l. By use of systems analysis, develop case studies analyzing and documenting the above relationships in selected areas of the less developed countries for instructional research and training purposes in a multidisciplinary setting.

Also, the CSU 211(d) Grant **Document** spells out specifically the operational plan as follows:

a. Assemble and analyze existing information on water delivery and removal systems related to the less developed countries.

- b. Assemble and analyze existing information on development of institutions relevant to optimum utilization of water resources in the less developed countries.
- c. Prepare plans for additional research programs which will increase the knowledge of methods, techniques, and procedures for optimizing the utilization of water resources in the less developed countries.
- d. Increase the breadth and depth of teaching and educational materials for the subjects of this proposal and for the situations in various less developed countries.
- e. Solicit especially well qualified graduate research assistants, from both the United States and the less developed countries, who expect to work in some aspect of international development upon completion of their training.
- f. Expand the library collection, especially with respect to the problems of the less developed countries.
- g. Develop a program of student and faculty exchange with certain less developed countries.
- h. Plan, initiate, and expand an interdisciplinary seminar on development and the interrelationship of the many factors involved in development--especially in the less developed countries.
- i. Conduct short courses, institutes, seminars, and other activities to stimulate other personnel to become more deeply and actively involved, and to help in continuing education for those already involved in various aspects of international development.

2. Review of Objectives

After several years of experience, Colorado State University feels that these objectives serve effectively as guideposts and are indispensable with respect to planning, development, management, and utilization of water resources as applied to water delivery and removal systems, and relevant institutional building.

III. Colorado State University Accomplishments

The boundaries of research work carried on by the faculty and research assistants in the 211(d) Grant program during the reporting period has been determined by the 211(d) Grant objectives assigned to Colorado State University, i. e. Optimum Utilization of Water Resources: With Emphasis on Water Delivery and Removal Systems and Relevant Institutional Development. With this context in mind, the work of the faculty and research assistants in the six participating departments is described below in two parts as follows:

1. Relationship of Research to Objectives

Because of the complex nature of the physical, financial, and technological constraints placed upon the optimal use of water delivery and removal systems including relevant institutional structures, the participating disciplines feel that solutions may best be found through a comprehensive interdisciplinary approach. Each of the participating departments has looked to the International Interdisciplinary Seminar for guidance in relating research activities to the Grant objectives. The Seminar reviews and discusses a related spectrum of technical, social, economic, political and cultural factors affecting developmental changes in order to bring about a better understanding of the processes involved with regard to optimum utilization of water resources including water delivery and removal systems and related institutional development.

In addition, participating departments at CSU continue to look to the creative work performance of CUSUSWASH Committees such as IMP (Irrigation Management Program) which has made great progress working through the broad spectrum of interdisciplinary approach for finding solutions to the many facets of water management development including water delivery and removal systems and related institutional development. More specifically, the departments have strengthened and improved research activities with regard to and in support of the Grant objectives through:

- a. Adding faculty members who have expertise in water delivery and removal, have experience in developing countries and have a

strong interest in continued work with developing countries. Civil Engineering has hired two new, experienced faculty members and Agricultural Engineering is supporting one new staff member, two of whom have had extensive experience in developing countries.

b. Teaching courses involving water delivery and removal systems and related institutional structures to students in engineering, agriculture, economics, and the social sciences. Four courses have been developed and eight courses revised due to increased knowledge gained in part through the 211(d) Grant program at little or no cost to the Grant program. Such courses have and continue to greatly broaden the knowledge and interest of faculty and students in developing countries.

c. Guiding the research activities of faculty and research assistants to increased knowledge of and/or solutions to problems in the area of optimum utilization of water resources including water delivery and removal systems and related institutional development. For example, the Agricultural Engineering Department has concentrated this year on collecting and developing water measurement technology to be used in water delivery and removal studies. In most countries, including the U.S.A. in some cases, water measurement of delivery systems and drainage return flow is poorly done or nonexistent. To knowledgeably analyze, improve or modify delivery and removal systems, water measurement is absolutely necessary.

d. Supporting research assistants who are interested in optimum utilization of water resources; desire to work in water delivery and removal area; want to understand more thoroughly how to put into effect related institutional structures; and who have a deep interest in developing countries.

e. Publication of technical reports and papers, and developing design manuals on water delivery and removal systems and related institutional development considered to be of high priority by developing countries.

f. Developing linkages by faculty, staff, and research assistants at CSU with faculty and staff of other universities, government

officials, officials of private companies, institutions, and individuals in developing countries.

In general, the six participating departments are increasingly able to meet the requirements of the 211(d) Grant through close cooperation and coordination of their 211(d) activities with each other; by deeper understanding of the role of each department to the theme of the Grant program; through establishment by each department of benchmark data and literature applicable to the Grant objectives; and by developing capabilities within each department to respond to water delivery and removal problems through orienting and training students and faculty to the issues of development and to the larger questions of utilizing water and other natural resources for the achievement of planned change.

2. Accomplishments

a. Increased Teaching Competence

Dr. Wayne Clyma, Department of Agricultural Engineering, was supported by 211(d) Grant funds for six months. His primary interests are in water delivery and removal problems. He has had overseas experience in Ethiopia and is interested in further overseas activities. Dr. Clyma worked effectively on on-campus research in water delivery and removal systems, participated with the Department of Agronomy in the Interdisciplinary Seminar. Dr. Clyma has become fully integrated into the CSU faculty and program and has made plans to spend two years in Pakistan as part of the CSU team there. Following this tour, he will return to the CSU campus.

Two new faculty members joined the College of Engineering at Colorado State University. They are Dr. Willis W. Shaner and Dr. John W. Labadie, and are supported in part by 211(d) Grant funds. Dr. Shaner is teaching engineering courses directly related to water delivery and removal systems. Dr. Labadie is working on the development of methodology and models to improve water delivery and allocation. Both men have contributed much of their time to planning and supervising

graduate assistants performing research work related to water delivery and removal systems.

Two new courses have been developed and taught by the Department of Agricultural Engineering as a result of the 211(d) Grant. AE 555, Irrigation Structures, by Professor G. V. Skogerboe, which deals specifically with water delivery systems. This course was taken by 25 Agricultural and Civil Engineering students. AE 483, Irrigation Practices in Developing Countries, by Dr. Wayne Clyma, was taken by 15 faculty and staff from nonengineering fields who benefited from a better understanding of water delivery and removal problems in developing countries.

One new course was added to the University curriculum in the Department of Political Science, GS 797, International Interdisciplinary Seminar in Water Resources Management. The course includes studies in the area of water delivery and removal systems. This course is a direct result of the International Interdisciplinary Seminar conducted by Professor Henry P. Caulfield. The work involved in establishing this course was partially supported by 211(d) funds. No 211(d) funds are involved in support of the course itself. Four additional new courses were added in this department, at no cost to 211(d), which are indirectly related to the Grant objectives and were added due to increased knowledge and interest gained in part through the 211(d) Grant program.

Eight courses in the Department of Economics were revised, at no cost to the 211(d) Grant program, by Drs. H. H. Biggs, G. C. Wilken and J. S. Krebs of the department. The revisions were made based on information obtained from the International Interdisciplinary Seminar and on 211(d) Grant-related activities.

The Department of Agricultural Engineering has developed, published and distributed to numerous irrigation organizations throughout the world during 1971, the design manual, "Check-Drop-Energy Dissipator Structures in Irrigation Systems." Another design manual, "Installation and Field Use of Cutthroat Flumes for Water Management" was prepared this year, but has not yet been distributed. Preparation and publication of these design manuals were partially supported by 211(d) Grant funds.

b. Improved Training of Staff; Entrainment Effects

The 211(d) Grant funds have provided the following faculty members of the Department of Economics the opportunity for research, writing, participation in the International Interdisciplinary Seminar, and graduate student advising in the application of economics, law, and institutional development to optimum utilization of water resources with emphasis on water delivery and removal systems and related institutional development. Dr. George E. Radosevich has become quite extensively involved with the special legal and institutional constraints affecting water resource management practices not just in the U.S. where he has worked in the past, but also in many other countries of the world, particularly Pakistan. During 1972-73 Dr. Radosevich will be working at the United Nations in this problem area. Dr. Huntley H. Biggs has been concerned with the problems of technological change and institutional relationships in the context of small farm agriculture and its relationship to optimum utilization of water resources. He has published two articles on the subject and written a technical report on the Puebla Project in Mexico. These presentations dealing with the delivery and utilization of water for development of small farm agriculture may be published in an edited form as evidence of CSU's enhanced competence in this area. Dr. Ronald L. Tinnermeier has been able to participate in professional conferences dealing with the problems of credit institutions for small farmers to promote better utilization of water resources and to offer consulting services to international agencies engaged in these activities, such as the Agricultural Development Council, at no cost to the 211(d) program. Dr. Terutomo Ozawa has been studying institutions and the problem of transferring and introducing new technologies in water resources development. He also serves as a consultant to the United Nations and the World Bank at no cost to the 211(d) program. Dr. John Reuss and other staff members of the Department of Agronomy have assisted in introducing agronomic concepts

concerned with modeling supplies and delivery of irrigation water in the International Interdisciplinary Seminar and into other seminars and courses. Dr. Reuss, with foreign experience in Nigeria, and two post-doctoral fellows from Pakistan and Iran have been involved with considerable success in obtaining the interest of and training other staff and students in the optimum utilization of water resources and emphasizing water delivery and removal. In addition, the 211(d) Grant has stimulated the development of an undergraduate major entitled, "Foreign Service in Agronomy." Also, awareness of the need for foreign agricultural assistance has stimulated the College of Agricultural Sciences to have an annual undergraduate seminar entitled, "Seminar in Foreign Agriculture." Agronomy staff associated with the 211(d) project contribute each year to presentations and discussions at no cost to the Grant.

The Agronomy Department has a small group of foreign students from the developing countries. They are encouraged to participate in the International Interdisciplinary Seminar, in other seminars involving developing countries, and they serve as additional resource persons used in training CSU staff and students in the development of water resources, especially in optimum utilization of water resources and related water delivery and removal systems.

The same kind of improved staff and student training resulting in increased interest and capabilities, including entrainment effects, may be applied to each of the other participating departments.

c. Publication of Technical Reports

Six Colorado State University CUSUSWASH reports were prepared and published under the 211(d) Grant program. They were:

1. Width Constriction in Open Channels, by J. W. Hugh Barrett, Agricultural Engineering
2. Cutthroat Flume Discharge Relations, by Ray S. Bennett, Agricultural Engineering
3. Culverts as Flow Measuring Devices, by Va-son Boonkird, Agricultural Engineering

4. Installation and Field Use of Cutthroat Flumes for Water Management, by G. V. Skogerboe, Ray S. Bennett, and Wynn R. Walker, Agricultural Engineering

5. Dualism in Mexican Agricultural Development: Irrigation Development and the Puebla Project, by Huntley H. Biggs, Economics

6. The Puebla Project: Progress and Problems, by Huntley H. Biggs, Economics

The Appendix contains copies of these reports.

During the reporting year five M.S. research studies were completed. These studies were partially supported by 211(d) Grant funds and were directed toward research on some aspect of optimum utilization of water resources including water delivery and removal systems and related institutional development. The completed M.S. studies are:

1. Effect of Settlement on Flume Ratings, by Tsu-Yang Wu, Agricultural Engineering, page 49.

2. Width Constriction in Open Channels, by J. W. Hugh Barrett, Agricultural Engineering, page 50.

3. Culverts as Flow Measuring Devices, by Va-son Boonkird, Agricultural Engineering, page 51.

4. Cutthroat Flume Discharge Relations, by Ray S. Bennett, Agricultural Engineering, page 52.

5. A Systematic Approach to the Water Supply of a Large Area, by Alain Deredec, Civil Engineering.

Available abstracts, 1-4, are in Appendix A (page 48) of this report.

In process are the following theses:

1. An Analysis of the Helmand-Arghandab River Basin Development Program, by Philip A. Hosterman, Civil Engineering.

2. Water Resource Project Planning: A Conceptual Framework for Analyzing Social Action, Michael Schiefer, Civil Engineering.

3. Public Investments in Irrigated Agriculture:
Mexico, 1940-1960, by Larry Caswell, Economics.

d. Library Improvement

Dr. Garth N. Jones, Political Science Department, headed a special task force consisting of members of participating departments and university librarians to strengthen the present system of identification, acquisition, storage, and retrieval of information and data in the area of water resources, particularly on the water delivery and removal systems component. In addition, he worked with library personnel at Utah State University on ways and means of integrating water resources information on a more systematic and modern storage and retrieval basis between the two universities. As one of the first steps taken at CSU to improve the cataloging system directly and/or indirectly related to water resources development or management, the Project Office moved its library collection, approximately 1400 publications, to the CSU Morgan Library.

e. Seminars

The International Interdisciplinary Seminar is conducted under the leadership of Professor Henry P. Caulfield, Jr. He also served as Chairman of the Program Committee for the Seminar composed of seven faculty members, implements committee decisions, chairs the meetings, and guides discussion to meaningful conclusions. The Seminar serves as a catalyst for the fusion of ideas on water resource management and the central theme of optimum utilization of water delivery and removal systems and related institutional development. These Seminars have greatly stimulated the thinking and actions of the participating departments, particularly in regard to the relationship of research to objectives of the Grant. Twenty-eight presentations were made during the reporting period by the International Interdisciplinary Seminar on Water Resources Management using as a central theme, "Optimum utilization of water resources: with emphasis on water delivery and removal systems and relevant

institutional development." Most of the presentations were given by CSU faculty and graduate research assistants and the remainder from outside sources. One new development included acceptance of a plan for regularizing the Seminar into the academic structure of the University. The attendance at this Seminar for the year was approximately 840.

Many project 211(d) Grant personnel, stimulated in part by the Grant, attended other seminars on related water resources development and management topics both on and off campus at no cost to the Grant. Brief subject material descriptions including the names of the speakers and titles of the talks are given in the Annex.

f. Research Assistants (GRA's)

Seventeen research assistants received support from 211(d) Grant funds ranging from three to six months' support for each individual. The nature of studies supported by 211(d) Grant funds were directly related to some phase concerned with optimum utilization of water resources including water delivery and removal systems and related institutional development. All of these research assistants are required to attend the weekly sessions of the International Interdisciplinary Seminar. The research assistants are:

James Barrett, Agricultural Engineering
 Ray S. Bennett, Agricultural Engineering
 Jacob H. Dane, Agronomy
 Ghulam Ahmad, Civil Engineering
 Alain Deredec, Civil Engineering
 Philip A. Hosterman, Civil Engineering
 W. A. Lemma, Civil Engineering
 Rashid Makhdoom, Civil Engineering
 Helena Mbele-Mbong, Civil Engineering
 Michael C. Schiefer, Civil Engineering
 Christopher Dowswell, Economics
 Tiffin D. Harris, Economics
 John M. Fly, Political Science
 Everett Myers, Political Science
 William Neal, Political Science
 Calliope Boudara, Sociology
 Forrest Deseran, Sociology

As shown in Section c., Publications, J. W. Hugh Barrett completed a study on "Width Constriction in Open Channels, Ray S. Bennett completed a study on "Cutthroat Flume Discharge Relations," and Alain Deredec completed a study on the subject, "A Systematic Approach to the Water Supply of a Large Area." Near completion are a study, "Analysis of the Helmand-Arghandab River Basin Development," by Philip A. Hosterman, and a study, "Water Resource Project Planning: A Conceptual Framework for Analyzing Social Action," by Michael Schiefer. These studies not only include but emphasize water delivery and removal systems as contributions to general studies in the area of optimum utilization of water resources. In the area of graduate research assistant supervision, the pattern of economics' involvement has followed a similar pattern of beginning with a broad approach and narrowing focus onto the institutional structures related to water management problems of small farmers. Larry Caswell was concerned with institutions related to irrigation development in the northwest region of Mexico. Chris Dowsell is currently in Guatemala where he has been involved in analyzing specific organizational and administrative structures needed for better water delivery and removal systems in maximizing agricultural production. The remaining graduate research assistants are still in various stages of thesis development. For example: Calliope Boudara and Forrest Deseran of Sociology are continuing a bibliographic survey as to aspects of water and society, and developmental issues related to the general problem of water delivery and removal, collecting data on population problems to be used as case studies for demographic constraints and the understanding of areas affected by proposed projects on water delivery and removal systems, and continuing work on a theoretical scheme integrating demographic data requirements and the interrelationship between population growth and water resource utilization with emphasis on water delivery and removal systems.

g. Meetings and Travel

Two interuniversity (CUSUSWASH) meetings were held, one at the University of Arizona (Tucson) and the other at Colorado State University (Fort Collins). Since the subject material discussed at these meetings covered both 211(d) Grant and the CUSUSWASH overseas Contracts, the travel and meeting costs are appropriately divided.

Six CUSUSWASH Committee Meetings were held at one or another of the Consortia Universities. Grant funding was provided for CSU participants. Two international trips were supported by 211(d) Grant funds and one was partially supported.

3. Summary of Accumulated Accomplishments

a. Increased Teaching Competence

Two new faculty members joined the College of Engineering, Dr. Willis W. Shaner and Dr. John W. Labadie. Two new courses were developed in the Department of Agricultural Engineering and taught by Professor G. V. Skogerboe and Dr. Wayne Clyma. One new course was added to the University curriculum in the Department of Political Science, and four courses added at no cost to the 211(d) Grant. Eight courses in the Department were revised due to increased knowledge gained in part through the 211(d) Grant program at little or no cost to the Grant program. Developed and distributed throughout the world the design manual, "Check-Drop-Energy Dissipator Structures in Irrigation Systems". Another design manual published but not distributed, "Installation and Field Use of Cutthroat Flumes for Water Management". See abstracts in Appendix A.

b. Improved Training of Staff; Entrainment Effects

Greatly improved and more effective use of 211(d) Grant funds by all six participating departments providing time for research, writing, participation in the International Interdisciplinary Seminar, travel, developing linkages at and participation in professional conferences, graduate student advising, and promoting entrainment

affects in the field of optimum utilization of water resources: with emphasis on water delivery and removal system(s) and related institutional development.

c. Publication of Technical Reports

Six Colorado State University CUSUSWASH reports were prepared and published under the 211(d) Grant program; five M.S. research theses. Abstracts for most of these reports and studies may be found in Appendix A.

d. Library Improvement

Members of the six participating departments together with two university librarians strengthened the present library system particularly in the area of water delivery and removal systems. During the reporting year, 52 new publication purchases were made from non-211(d) Grant funds. At the end of the fiscal year, the project office moved its library collection, approximately 1400 publications, to the CSU Morgan Library as a first step in improving the availability of reference material on water delivery and removal systems.

e. Seminars

Twenty-eight presentations were made during the reporting period, greatly stimulating the thinking of the participating departments, particularly in relationship of research to objectives of the Grant.

f. Graduate Research Assistants (GRA's)

Seventeen research assistants received support from 211(d) Grant funding ranging from three months to six months support. Five of this number completed M.S. theses. The remainder are in the process of producing theses which may take from one to two years longer to complete, having just begun their studies. All studies are directed toward some aspect of the central theme of the 211(d) Grant program.

4. Proportion of Year's Expenditures Used for Each Area of Activity

The following table contains the same activity areas as appears in Table I, page 46.

	<u>Expenditure</u>	<u>Percent</u>
Salaries (Increased teaching competence)	\$ 84,594	43
Stipends (Graduate research assistants)	59,695	30
Travel	13,188	7
Library and Publications	13,060	7
*Other (Office expenses)	14,537	8
CUSUSWASH Executive Director's Office Support	10,000	5
Total	<u>\$195,074</u>	<u>100</u>

*Breakdown:

Clerical costs	\$ 9,073
Office expense	<u>\$ 5,464</u>
(telephone, Xeroxing, mailing, supplies, Western Union)	\$14,537

IV. Impact of Grant-Supported Activities in Developing Institutional Capabilities

As a direct result of increased faculty competence through 211(d) Grant funding in teaching, research, publications, seminars, conferences and consulting, the participating departments of CSU can now participate even more heavily in projects and programs with developing country governments and international institutions in the broad aspects of optimum utilization of water resources development with special emphasis on water delivery and removal systems as well as related institution development. Regarding these specific areas of increased capabilities, the participating faculty looks at the problem from a broad perspective by gaining a basic understanding of the process of technological change and the factors which critically affect the optimal use of water resources. The rationale governing this approach is the necessity of first understanding the basic institutional engineering, social, and economic constraints which influence individual decisions, then designing the appropriate water delivery and removal system(s) which will assure an optimal use of water resources for increasing agricultural productivity. Research efforts have indicated that the availability of technology and credit institutions, together with resource management practices, can have an important bearing on the optimal use of water.

The International Interdisciplinary Seminar, has had a major impact on the faculty members and graduate assistants representing the participating disciplines in bringing about a better understanding of optimal development of water resources, particularly in water delivery and removal systems and to related institutional development. The International Interdisciplinary Seminar has met for two hours each week throughout the academic year 1971-1972 under the direction of Professor Henry P. Caulfield, Jr., Department of Political Science. Though the terms of reference for the Seminar are quite broad, as indeed they should be, for encouragement of faculty-student intellectual development, Professor Caulfield has been increasingly successful in creating an

appreciation among faculty, graduate assistants, and others of the complex character and the diversity of factors involved -- including engineering, social and political, cultural, biological, and economic -- and thus, of the multidisciplinary and international nature of the problems inherent in increasing agricultural production in the world through optimal utilization of water resources. As a result, the participating individual acquires a broader background and a basis for better comprehension of the complicated processes involved in successfully establishing in developing countries water delivery and removal systems and related institutional structures. Thus, the Seminar has been useful in helping the participating departments to establish basic guidelines for interdisciplinary research activities related to the 211(d) Grant objectives.

The Grant has made the following specific impacts in developing the Department of Agricultural Engineering's capability in the areas of water delivery and removal: increased staff competency -- the department now has increased numbers of staff (Skogerboe, Walker, Clyma) who have developed linkages in the developing countries, are aware of problems in developing countries, have an interest in these problems and have significant capability to provide technical assistance for the solution of these problems. Graduate students have been trained who are interested in working in or with the developing countries and who have helped to establish linkages in these countries, who work in developing countries, who have significant contacts there and increase CSU's linkages. Courses directly and indirectly related to water delivery and removal and relevant institutional development have been developed and are being taught to students and staff from many parts of the campus. In addition, existing courses have been focused more toward the solutions of problems in developing countries. Various design manuals have been and are being prepared which can be used to provide needed technology to the developing countries in the field of water delivery and removal systems and relevant institutional development.

It is anticipated some of these will be translated into Spanish or other languages to increase their usability. Each of the areas described above have built upon CSU's existing capabilities and the staff and students have become more aware and responsive to the needs in developing countries.

The 211(d) Grant program has created a greater awareness of the needs of developing countries in the solution of problems in water resource management on the part of the Department of Agronomy. It has been responsible, in part, for developing courses designed to inform and train both undergraduate and graduate students for foreign assignments in water resource management especially in water delivery and removal systems. The program has improved staff capability for advising the increasing number of U.S. and foreign students coming to our Department to study in the various program areas such as delivery and removal systems, irrigation management, and related institutional development situations. The 211(d) program also has increased the competence of CSU staff actively involved as advisors for the CSU/USAID project in Pakistan. For example, three trips to Pakistan in 1971-72 were requested by the Mission for consulting and program planning on the water management project.

The 211(d) Grant program has made it possible for the Department of Civil Engineering to: improve faculty and staff capability for advising foreign students in the field of optimum utilization of water resources and more specifically, in water delivery and removal systems and related institutional structures; increase the competence of staff and faculty by adding to the staff Drs. Shaner and Labadie; developing a greater awareness of the priority needs of developing countries in the solution of water resource management problems, specifically in water delivery and removal systems and related institutional development; improving the design and content of courses for undergraduate and graduate students emphasizing water delivery and removal systems and related institutional structures; and increased number, capabilities and desire of faculty and staff to serve overseas.

The approach of and the impact on the Department of Economics in the 211(d) Grant program has been to involve as many young faculty members as possible in research and teaching in the problems of the developing countries, with special focus on understanding the constraints (technological, financial and legal) which influence the optimal use of water resources. Accomplishment of the Grant objectives by faculty members and research assistants have been increasingly realized through a number of activities, including teaching, research, publications, conferences and consulting. As a direct result of increased faculty competence in these areas through 211(d) Grant funding, the Department of Economics can now participate even more heavily in projects and programs with developing countries. Beginning several years ago, research efforts have gradually been focused more and more on the small farmer. This reflects the conviction that if developmental efforts are to have an impact on the majority of the world's impoverished peoples they must be focused on this group. Currently, it is the technical, financial and legal constraints confronting the small farmer that have largely limited the effectiveness of water removal and delivery systems in developing countries. It is anticipated that even greater attention will be given to this problem area in the future by the Economics Department.

The impact of the 211(d) Grant program on the Department of Sociology resulted in the creation of a group within the department entitled, "RDM" (Research in Demography and Modernization), which was established with the explicit purpose of providing a forum and a concrete means for the study of the general problems of the project. This group of faculty members and graduate students (four faculty members contributed time without 211(d) Grant funding) attempted to extend and understand problems of water delivery and removal in the context of a more systematic undertaking of the designing and establishment of a set of data banks related to demography and modernization with emphasis on water delivery and removal; instigation of original surveys and other field studies which may provide the training ground

for graduate students in problems of water and development; collection of an initial library and material reflecting aspects of water and the larger questions of both quantity and quality problems in water delivery and removal. Like the other disciplines involved in this 211(d) Grant program, it was early decided that as a first step in studying water delivery and removal systems it was necessary to gain an understanding of the larger parameters of problems of water management and organization.

V. Utilization of Institutional Resources in Development

Increasing agricultural productivity throughout the world to a major degree is dependent upon making the proper use of water--effectively and efficiently coordinating water use with other agricultural inputs. Since this is a tremendously large and complicated problem, Colorado State University is assigned, through the 211(d) Grant program, the improvement of its competency in optimum utilization of water resources; with emphasis on water delivery and removal systems and related institutional development. Six disciplines are actively involved and the International Interdisciplinary Seminar acts as a catalyst for a fusion of coordinated ideas leading to a better understanding of the CSU 211(d) Grant theme. The Seminar, under the leadership of Professor Henry P. Caulfield, has had and continues to exert a great deal of influence through its connections with all the departments of the University and their personnel participating in the program, and other faculty members and research assistants interested in the general subject, as well as outside institutions, both government and private concerned with various aspects of water resources development. The competence of Colorado State University in the above stated Grant theme has greatly improved its utilization of such institutional resources through the activities of the Seminar. Within the campus, the six participating departments (Agronomy, Agricultural Engineering, Civil Engineering, Economics, Political Science and Sociology) receiving Grant support have developed meaningful ties with each other. Elsewhere, ties were also continued with CUSUSWASH and during the year contacts, linkages, and communication were established or continued and strengthened with off campus institutions in the United States and abroad. Examples of the utilization of institutional resources in development appear below.

The following utilization of institutional resources in development was made by the Department of Agricultural Engineering: Dr. W. E. Hart made a trip to Nigeria to help give a seminar at the International Institute of Tropical Agriculture. He has spent considerable time

preparing the seminar dealing with irrigation development and problems in this region in the work. Dr. Hart is well able to focus on these topics because of his experience in irrigated agriculture in tropical and semi-arid regions. While in Nigeria, Dr. Hart visited with a number of African educators, researchers and Government officials, thereby gaining additional knowledge and experience in water delivery and removal systems. Professor G. V. Skogerboe and Dr. D. B. McWhorter, also of the Department of Agricultural Engineering, organized and taught the Irrigation Practices Short Course under the sponsorship of the USDA. Thirty participants from all over the world came to CSU to interact with our faculty and to obtain some intensive instruction and tour irrigation developments in the Rocky Mountain Region. This short course (60 days) was very supportive of the 211(d) Grant objectives and dovetailed into CSU's overall program (no 211(d) funds involved). A design manual prepared during fiscal year 1971 was distributed this fiscal year to numerous irrigation organizations throughout the world. The title of this manual is "Check-Drop-Energy Dissipator Structures in Irrigation Systems" (partially funded by 211(d), abstract page 53). Another design manual, "Installation and Field Use of Cutthroat Flumes for Water Measurement," was prepared this year, but has not yet been distributed (partially funded). Numerous letters have been received regarding the first design manual, with statements being made regarding the usefulness of such a report in the actual design of structures. After developing an awareness of specific design problems in any particular irrigated region, the possibility of presenting a short course on designing irrigation distribution systems, as well as the role of such systems in improved water management and consequent agricultural productivity, should be undertaken.

The increased utilization of institutional resources made possible by the 211(d) Grant has permitted the Agronomy Department to make a major contribution to the development of the CSU/AID/csd 2162 water management research project in Pakistan at no cost to the 211(d) Grant Program, also to permit one Agronomy staff member to serve as a

consultant for the USBR during the year on the Pamong Irrigation Project in Thailand, again at no cost to the 211(d) Grant.

Many members of the Civil Engineering faculty are asked each year to serve as advisors and consultants to various foreign governments, and various industries and organizations (such as the World Bank) on problems of water delivery and removal. Experience gained by faculty, staff, and research assistants through participation in the 211(d) Grant program has, over the past several years, noticeably increased this department's competence, ability, and willingness to respond to such requests. Utilization of the institutional resources of the Civil Engineering Department and of the University as a whole through 211(d) Grant participation has made it possible to provide competent personnel and persuade University officials to permit the use of University equipment, laboratory facilities, and library facilities for such overseas projects as the AID/csd 2162. Brief examples of the department's response to overseas requests are: Dr. Maurice L. Albertson's participation in a seminar sponsored by the International Institute of Tropical Agriculture (IITA) in Ibadan on Prospects for Irrigation in West Africa; and Dr. Albert G. Mercer's participation with the National Science Foundation (no 211(d) funds involved) regarding the new link-canal study in collaboration with the Mona project in Pakistan.

The participation of CSU in the 211(d) Grant program has heightened the visibility of the Department of Economics in the area of water resources management, especially in optimal utilization of water resources, water delivery and removal systems, and related institutional development. An increasing number of foreign students have selected CSU to pursue a graduate degree in water resources economics, related economic development as well as agricultural development including investigating through research, ways and means of increased food production through optimal utilization of water resources. Examples of the utilization of institutional resources by faculty members are: Dr. George Radosevich, an Assistant Professor of Economics, holds a Doctor of Jurisprudence as well as a Master of Agriculture in economics. His special area of

interest is in water law and the legal constraints which affect the optimal use of water resources. In part with the support of 211(d) funding, he responded to a request from AID to travel to Europe and Southeast Asia for the purpose of gathering information and material for the USAID/Pakistan Water Law Project. This trip was completed in the summer of 1971. In April, 1972, he was requested by USAID/Mission Pakistan and Afghanistan to travel to Pakistan, Afghanistan, Iran, Israel, and Italy to gain information regarding water management through legal controls. During the summer of 1972, Dr. Radosevich served as the legal and economics adviser to a special USAID three-man team to Nigeria, Africa, to assist in the preparation of a request for a feasibility study of the Do-Anambra River Basin. Dr. Huntley H. Biggs has worked on the problems of technological change with regard to small farm agriculture and its relation to optimum utilization of water resources institutional development, and published two articles on the subjects including a technical report on the Puebla Project in Mexico. Dr. Ronald L. Tinnermeier participated in many conferences during the year dealing with problems of credit institutions for small farmers to promote better utilization of water resources. Dr. Terutomo Ozawa continued his studies on institutions and the problem of transferring and introducing new technologies in water resources development. In addition, examples of the utilization of institutional resources by graduate students are: Larry Caswell concerned with institutions related to irrigation development in northwest Mexico; and Chris Dowswell involved in analyzing specific organization and administrative structures needed for better water delivery and removal systems in maximizing agricultural production.

The Department of Sociology, through the 211(d) Grant has been provided the opportunity to develop firm ties with the participating departments on campus in the area of optimum utilization of water resources including water delivery and removal systems and particularly in related institutional development activities. During the year

communication was also established with other social scientists working in the field of natural resources, especially water, in such places as Michigan State University and Brigham Young University. However, once again, it is imperative to re-emphasize that the general thrust of the utilization of the institutional resources has been one of increasing the general sensitivity for the presence of sociology in the area of water resources rather than of specific task accomplishment. The importance of continuing such sociological activities should not be underestimated.

As a direct result from the accumulated impact of the 211(d) Grant, a number of spin-off activities have been generated. For example:

1. A request by the World Bank as to the interest of CSU in providing expatriate consultants to aid in the preparation of Mexico's National Water Plan. Subsequently, CUSUSWASH became interested and the resources of the Consortia of Universities were offered to the Government of Mexico. As a result, a World Bank official and two highly placed Mexican officials came to the CSU campus and were met by 22 CSU scientists.

2. A letter of intent signed between the University of Coahuila, Saltillo, Mexico, and CUSUSWASH in a collaborative arid zone research and development proposal.

3. As a direct result of Dr. Maurice L. Albertson's trip to Nigeria, May 23-30, and through his contacts with personnel of the International Institute of Tropical Agriculture (IITA) in Ibadan, Colorado State University received an invitation to participate in a seminar sponsored by IITA on Prospects for Irrigation in West Africa to be held from the 23rd to the 27th of October, 1972. Colorado State University will respond by sending to Nigeria four scientists, Drs. Maurice L. Albertson, W. Doral Kemper, Evan C. Vlachos, and William E. Hart to Nigeria who will present papers at the seminar. Also, Dr. George Radosevich will be sent to Nigeria to help on the Do-Anambra River Basin study.

4. Development of an outline of principles as a result of a visit by Professor Emanuel Guggino, representing the Polytechnic Foundation of the Mediterranean, Italy, to Colorado State University in the area of water resources.

Dr. Garth N. Jones, Department of Political Science, has been engaged in many 211(d) Grant supported activities as well as generating many spin-off activities related to 211(d) Grant objectives. Some of these spin-off activities, not 211(d) funded, are:

1. Participation as a member of the water development workshop program of the Agricultural Development Council (ADC).
2. Presented a paper on December 23, 1970 to East-West Center senior scholars on "Emerging Conceptions and Patterns of Development Assistance".
3. Participated in sessions sponsored by AID on irrigation systems and development.
4. Assisted in course revision and development of new courses.

VI. Other Resources For Grant-Related Activities

All of the participating departments have reported that contributions in time to the training of students in the field of optimum utilization of water resources with emphasis on water delivery and removal systems and related institutional development are two to three times the 211(d) Grant funds for salaries. Also, all departments list the AID Research Contract AID/csd 2162 as a valuable resource for the 211(d) Grant.

Other resources for Grant-related activities allocated to the Department of Agricultural Engineering include: Irrigation Practices, Return Flow Salinity and Crop Yield -- Environmental Protection Agency; Improvements in Sprinkler Irrigation Systems -- Office of Water Resources Research; Consolidation of Irrigation Systems -- Office of Water Resources Research; Systems of Management for Optimal Water Use -- United States Bureau of Reclamation.

A dual effort research program under the Department of Agronomy is being developed through the combined funding from 211(d) and from OWRR to study the interactions of water and salt movement in soil profiles. The proposed research relates to the quality of water in return flows. This information will be useful in the design and management of irrigation water delivery and removal systems. Staff has been obtained and research will begin immediately.

The Department of Civil Engineering in cooperation with the Colorado State Experiment Station is presently doing water research work in the following projects: Irrigation Flow Measurement; Hydraulics; Water Resources Optimization; and Groundwater Resources. Cooperative studies are also undertaken with such organizations as: Bureau of Reclamation; Office of Water Resources Research; and U. S. Geological Survey. Dr. Albert G. Mercer, at no cost to the 211(d) Grant, submitted to the National Science Foundation a proposal for collaboration with WAPDA, Pakistan, to increase food production in waterlogged and saline areas.

Currently, the major source of funding for Grant-related activity in the Department of Economics is provided by the Agency for

International Development through CUSUSWASH in support of a water Management Program in Pakistan. The central focus of this program is "On-Farm Water Management." Dr. Gene Wilken, at no cost to the 211(d) Grant, is attempting to develop a research program through the National Science Foundation. This research program was to be concerned with "Resource Management and Native Farming Systems in East Africa." It is expected that a number of additional research programs will be submitted to funding agencies in the coming year dealing with problems of water resources and agricultural development in the developing countries.

One of the major resources utilized by the Department of Sociology (beyond the immediate funding of graduate students) has been the volunteered time of a number of faculty who were guided by the general interest and concern for the area of water management research. Also extensive use was made of the computer facilities of the University (also no cost to 211(d)) in the context of both training and research in order to develop the general capabilities of graduate students.

VII. Next Year's Plan of Work and Anticipated Expenditures

The Department of Agricultural Engineering will continue to utilize research results in preparing at least one design manual during fiscal year 1973. In addition, the total research effort to date will be assimilated into the compilation of information on irrigation structures which had been collected at an earlier date. This will allow another upgrading of the course material for AE 555, "Irrigation Structures."

Mr. Qurban Ali Khan, a graduate research assistant, attended the Irrigation Practices Training Course conducted by CSU during the summer of 1971. This course was sponsored by AID. He is presently on leave from the Directorate of Agricultural Engineering at Lyallpur, Pakistan. He will undertake a study on small irrigation structures for water delivery and control used in Pakistan, and the information being utilized in designing such structures. This information will be compared with the existing material collected by the department to determine: Which structures have adequate design information and which have inadequate design information. Also, CSU collected information will be used to improve design information or to obtain additional needed design information

The anticipated budget and expenditures are:

	<u>Man Months</u>	<u>Budget</u>
Staff and faculty	3	5, 244
Graduate research assistants	10	<u>5, 000</u>
		10, 244

The Department of Agronomy will activate a new research project, "Salt Transport in Soil Systems," under the direction of Dr. Arnold Klute and Dr. W. T. Franklin. It will emphasize the movement and accumulation of salt in the soil as a function of the quality of water delivered and the effectiveness of the removal systems. The staff will continue to attend and contribute to the International Interdisciplinary Seminar and Dr. John Reuss will serve on the Planning Committee for the Seminar. Other members of the Agronomy Department will continue to be active in research planning and student training in international water resource management with emphasis on water delivery and removal systems.

The anticipated budget and expenditures are:

	<u>Man Months</u>	<u>Budget</u>
Staff and faculty	2	2,365
Graduate research assistants	9	5,040
		7,405

211(d) funds this coming year will be used by the Department of Civil Engineering primarily to obtain new Civil Engineering personnel to increase staff resources in optimum utilization of water resources-- particularly in water delivery and removal systems and relevant institutional development. The department is supporting two new faculty, Drs. W. Shaner and J. Labadie. They are being supported six and four months, respectively, by 211(d) Grant funds.

Dr. Shaner has been hired by the College of Engineering to broaden its water management program to include water delivery and removal systems and related institutional development. He has had extensive foreign experience both in South America and in Africa. His experience and knowledge of these areas will strengthen the teaching of the water delivery and removal systems programs of the Engineering College and of the University. Dr. Shaner will take part in the Water Management Seminars, work with Dr. Albertson in developing optimum utilization of water resources programs in Africa, East Asia and South American, and will be available for short or long term assignments on specific water delivery and removal problems. Dr. Labadie was hired in the water resources program of the Civil Engineering Department. He is working on improvement of water delivery and removal systems courses, the development of methodology and models to improve water delivery and removal. In addition to the new staff, the 211(d) Grant monies will be used for support of Drs. M. L. Albertson (2 months), E. V. Richardson (1 month), H. J. Morel-Seytoux (1/2 month), and A. G. Mercer (1/2 month) in order that they might have time to guide and plan research and the work of graduate assistants on water delivery and removal studies, take part in the International Interdisciplinary Seminar, to correspond, advise and work with

CUSUSWASH officials, and other 211(d) Grant affairs involving the United Nations, World Bank, foreign governments and universities (foreign and U.S.). The 211(d) Grant to improve the competence of Colorado State University in optimum utilization of water resources, especially in the field of water delivery and removal systems including relevant institutional structures, will allow the following graduate research assistants to continue their studies: W. A. Lemma, Michael Schiefer, and Rashid A. Makhdoom.

The anticipated budget and expenditures are:

	<u>Man Months</u>	<u>Budget</u>
Staff and faculty	14	30,380
Graduate research assistants	36	<u>21,900</u>
		52,280

Dr. Huntley H. Biggs, Department of Economics, will continue to: take an active part in the International Interdisciplinary Seminar including service on the Planning Committee for the Seminar as representative from Economics; act as chairman of a seminar series on a selected topic concerned with constraints affecting optimum use of water resources with emphasis on water delivery and removal systems and relevant institutional development; continue research in the field of employment and technology that was initiated under 211(d) during 1971-72 related to water development and removal systems and essential institutional structures; advise graduate research assistants funded under 211(d), supervise theses of Larry Caswell and Chris Dowswell; continue interest in investigating the impact of increasing production of small farms on general economic development using the Puebla Project area of Mexico as a case study and tying these studies in with water delivery and removal systems. Dr. Terutomo Ozawa will participate regularly in the International Interdisciplinary Seminar and continue with his input on international transfer of technology in the field of optimum utilization of water resources, water delivery and removal systems and related institutional development.

Dr. Ronald Tinnermeier will continue to increase professional competence in water delivery and removal systems and to carry out research on the economics of agricultural development with special emphasis on subsistence agriculture as affected by water delivery and removal problems; continue looking at supervised agricultural credit institutions for small farmers. The introduction and use of new water management delivery and removal techniques along with other complementary inputs almost always requires additional capital. Few research results are available suggesting how credit institutions can best be extended to small farmers to acquire such inputs; and to seek additional resources to complement Grant-related activities. Dr. Gene C. Wilken will continue attendance and participation in the Seminar on optimum utilization of water resources emphasizing water delivery and removal systems and related institutional development; continue research and preparation of reports: Ecologic Aspects of Native Farming Systems, including perception, modification, and optimum utilization of water resources, use of water delivery and removal systems and related institutional development including the cultural aspects of underdeveloped areas. Dr. J. Stuart Krebs will continue attendance and participation in the 211(d) International Interdisciplinary Seminar on optimum utilization of water resources emphasizing water delivery and removal systems and related institutional development; and begin research on a modest scale on the effects of agrarian reform upon agricultural production, focused primarily on Chile including effect of reform on water delivery and removal and results upon agricultural production.

The anticipated budget and expenditures are:

	<u>Man Months</u>	<u>Budget</u>
Faculty and staff	7	10, 579
Graduate research assistants	6	<u>3, 300</u>
		13, 879

Professor Henry P. Caulfield, Department of Political Science, will continue his work in the development, direction and conduct of the Interdisciplinary Seminar. The Department will attempt to supplement

its support of four graduate research students whose course of studies will focus on the political science aspect of water delivery and removal systems including relevant institutional structures.

The anticipated man months and bduget are:

	<u>Man Months</u>	<u>Budget</u>
Faculty and staff	6	9,385
Graduate research assistants	18	<u>9,720</u>
		19,105

During the year the Department of Sociology completed a general cycle of sensitization to both problems of water delivery and removal systems and to the larger questions of the relationship between water and development. Intended for next year is a more specific writeup of activities reflecting the concern with irrigated agriculture, and especially the component reflecting water delivery and removal systems. As such, a major paper is prepared dealing with socio-economic aspects of irrigated agriculture in order to provide a background document as well as a training device for both faculty and graduate students participating in the program.

The major expenditure for next year involves essentially the time of a faculty member whose purpose will be to write the documents reflecting the general concern with the socio-economic aspects of irrigated agriculture as well as coordinate the nonfunded activities of other faculty members and supervise the work of two research assistants. The research assistants are expected to utilize the theme of relating population growth to problems of water delivery and removal systems. It is believed that this plan will help improve the competence of sociology with relationship to the requirements of the Grant and will also provide for the emergence of capabilities for applied research in this area.

The anticipated man months and budget are:

	<u>Man Months</u>	<u>Budget</u>
Faculty and staff	3	6,228
Graduate research assistants	12	<u>5,400</u>
		11,628

VIII. Other

The utilization of institutional resources not related directly to water delivery or removal systems and not supported by 211(d) Grant funds generated by participating department faculty members but showing the entrainment effect of the Grant includes the following examples:

1. During August, 1971, Dr. Ronald L. Tinnermeier presented a paper on supervised agricultural credit programs in developing countries for the Agricultural Policy Seminar in Washington, D. C. He also presented a second paper dealing with supervised agricultural credit for the Seminar on Development Strategies for Small Farmers sponsored by Ohio State University and the Research and Training Network of the Agricultural Development Council, Columbus, Ohio, in September, 1971. As a result of the Ohio seminar, Dr. Tinnermeier was also asked to organize a workshop to analyze specifically agricultural credit requirements for small farmers. This seminar was completed in April, 1972. Dr. Tinnermeier has been invited to participate in the USAID Annual Spring Review concerned with Agricultural Credit for Small Farmers in developing countries to be held in 1973. Beginning in June 1972, a resident economist from CSU, Dr. Jerry Eckert, has been assigned to participate in the project as a member of CSU's field party in Pakistan. The major thrust of the research effort will be to formulate a technical package which is relevant to the needs of the small farmers in that country. During 1971-72, there were a number of students from developing countries enrolled in a graduate program in economics. Typically, the major areas of interest are: water resources economics, agricultural economics, and development economics. The selection of CSU and these courses reflect the growing interest in the economic aspects of water resources management and in other areas supported by the 211(d) Grant. In addition, a number of non-economics students are now taking courses in these areas. Quite a few economics faculty members serve on graduate committees for CSU non-economics graduate students from developing countries. Below is a list of the graduate

students enrolled in the graduate program in economics. Each of these students is a candidate for the Masters of Science degree; however, some of them will continue into the Ph.D. program in the future.

<u>Name</u>	<u>Country</u>	<u>Specialization</u>	<u>Funding</u>
Acquah, Benjamin Kojo	Ghana	Ag Econ Nat Res Dev	USAID
AlTell, Tariq	Jordan	Ag Econ Statistics	FAO
Khan, Mohammad Jameel	Pakistan	Ag Econ Nat Res Dev	211(d)
Khan, Ahmad Saeed	Pakistan	Ag Econ Dev	211(d)
Lee, Sun-Jong	Korea	Ag Econ Nat Res	USAID
Mesfin, Mebrahtu	Ethiopia	Ag Econ Nat Res	USAID
Tekie, Million	Ethiopia	Ag Econ Dev Stat	USAID
Reyes, Pedro	Peru	Ag Econ Dev	
Sarwar, Mohammad	Afghanistan	Dev Nat Res	
Satiroglu, Kadir	Turkey	Dev International	
Sumali, Muttamara	Thailand	Ag Econ	USAID
Weng, Yueh-Shya	Taiwan	Ag Econ	

2. Graduate students of the Department of Agricultural Engineering who have chosen to come to CSU because of interest in institutional development work in the area of water delivery and removal systems are as follows: (no support from 211(d) excepting two as noted)

Zewdie Abate	Ethiopia
Chuntse Chang	China
Ken Tsai Huang	China
Jindasanguan Leck	Thailand
Qurban Ali Khan	Pakistan *
Mohamad Mahmoodian-Shoostari	Iran
Habte Neghassi	Ethiopia *
Mahmood Shariatmadar-Taleghani	Iran
James Taylor	USA

* Supported in part by the 211(d) Grant program.

3. The participating departments have provided faculty support for an ongoing institute at CSU called the International School of Water Resource-Environmental Management. This school is sponsored by CSU's Department of Civil Engineering to provide one-year training programs for persons from developing countries. Many of these students take engineering, economics, and sociology courses in water resources and faculty from the six participating departments serve in an advisory capacity for a number of these students at no cost to the 211(d) program.

IX. Report of Expenditures

1. The expenditures as shown in Table I and Table II state the expenditures for fiscal year July 1, 1971, through June 30, 1972, the period under review. The amount shown in Expenditures to Date represents the actual amounts spent in each line item since the beginning of the Grant, July 1, 1969. The projected budget for FY '73 represents the total funds allocated to the six departments involved in the 211(d) Grant Program. The projected budget for FY '74 is outlined in Section VII, Next Year's Plan of Work and Anticipated Expenditures.

The Report of Expenditures as shown in Table I is as follows:

Line Item I, Teaching, gives the salaries plus the CSU fringe benefits paid to faculty. In many cases a faculty is paid only one or two months salary for the purpose of initiating and teaching a new course or serving as an advisor for a graduate student. This has had the effect of stimulating other programs and research for Grant-related activities at minimal cost with an expanding or entrainment effect. Line Item I also includes the costs of consultants to support the programs of the Interdisciplinary Seminar. Some consultants served in this capacity at no expense to Grant funds.

Line Item II is the amount paid to graduate students for stipends. A student is required to work at least 20 hours per week in support of his research project, and to qualify for Grant funding. A list of Graduate Research Assistants supported by 211(d) funds for periods from three to six months is given on page 17.

The Line Item III on travel represents all international travel and also travel within the United States. See page 47 for foreign travel. Some travel support was provided for faculty to attend 211(d) seminars and Grant-related conferences for presentation of papers and increasing their knowledge and competence in the Grant area.

Library and publications expenses, Line Item IV, cover the cost of books purchased out of 211(d) Grant funds requested by the various faculty, staff and graduate research assistants connected with the

program in order to improve the CSU and CUSUSWASH library covering the areas of the research program as outlined in the Grant objectives. Also, covered in these expenditures is the cost of printing and publishing the theses and dissertations by graduate students on their research activities including papers and reports by CSU faculty and mailing expenses for these publications.

With regard to Line Item V, since the Grant funds have been responsible for spin-offs in other research, there was no need to purchase equipment as most of the equipment was provided by non-211(d) Grant funds.

Line Item VI, Other and Office Expenses, shows the amount spent for clerical assistance for the CSU contributed share of the CUSUSWASH Executive Director for administration of the Grant, and for the funds allocated to the various departments. Other office expenses cover items as telephone, miscellaneous office supplies, and Xeroxing.

The line items as listed in Table II conform with the budget in the Grant Document, while Table I shows a general distribution of funds in the area of activity.

2.

Table I

Expenditure Report
(Actual and Projected)

Under Institutional Grant AID/csd-2460

Review Period 1 July 1971 to 30 June 1972

(List all Grant-related activities)	Expenditures to Date		Projected expenditures		Non 211(d) Funding Amount
	Period under Review	1 July 69 - 30 June 72 Cumulative Total			
		FY '73	FY '74		
I Teaching	\$84,594	\$198,012	\$68,500	\$53,500	\$ 96,800
II Research	59,695	113,555	68,500	53,500	165,000
III Travel	13,188	43,083	17,500	18,500	20,000
IV Libraries and Publications	13,060	20,066	4,000	5,000	10,000
V Equipment	--	3,331	2,000	1,000	55,000
VI *Other	24,537	58,009	10,944	11,000	
TOTAL	\$195,074	\$436,056	171,444	142,500	\$346,800
*Breakdown on Other					
Direct Costs:					
Clerical expense	9,073				
Office expense	5,464				
(telephone, Xeroxing, mailing, supplies, Western Union)					
CUSUSWASH Executive Director's Office	10,000				
(CSU contribution)	\$24,537				
11 April 1973					

11 April 1973

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3.

Table II

**Expenditure Report
(Actual and Projected)**

Under Institutional Grant AID/csd-2460

Review Period 1 July 1971 to 30 June 1972

(List all Grant-related activities)	Expenditures to Date		Projected expenditures		Projected Five-Year Total
	Period under Review	1 July 69 - 30 June 72			
		Cumulative Total	FY '73	FY '74	
Salaries	\$84,594	\$198,012	\$68,500	\$53,500	\$320,012
Stipends	59,695	113,555	68,500	53,500	235,555
Travel	13,188	43,083	17,500	18,500	79,083
Equipment	--	3,331	2,000	1,000	6,331
*Other (Office Expenses)	24,537	58,009	10,944	11,000	83,498
Library and Publications	13,060	20,066	4,000	5,000	25,521
TOTAL	\$195,074	\$436,056	171,444	142,500	\$750,000
*Breakdown on Other Direct Costs:					
Clerical expense	9,073				
Office expense (telephone, Xeroxing, mailing, supplies, Western Union)	5,464				
CUSUSWASH Executive Director's Office (CSU contribution)	<u>10,000</u>				
	\$24,537				
11 April 1973					

11 April 1973
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FOREIGN TRAVELDESCRIPTIONDOLLAR AMOUNT PER TRIP

A BRIEF NARRATIVE STATEMENT LISTING THE NAME AND TITLE OF THE INDIVIDUAL, PURPOSE AND RESULTS OF THE TRIP, DURATION AND THE TOTAL AMOUNT CHARGED TO THE GRANT. IF PARTIAL FUNDING WAS CHARGED TO THE GRANT, THIS SHOULD BE INDICATED.

GRA	Philip A. Hostermann - Kabul, Afghanistan - 2 months	ticket	1,545.18	\$2,093.22
	To study the Helmand River Valley and other	actual		
	water resources in Afghanistan in relation to CSU Institutional Grant.	expenses	548.04	
Faculty	Dr. Maurice L. Albertson - Bulgaria, Nigeria - 1 month	ticket	802.40	\$1,384.40 (partial)
	To attend the ICID Executive Council	(partial)		
	To attend the Soils Consortium in Ibadan as a representative of CUSUSWASH.	expenses	582.00	
Faculty	Dr. Huntley H. Biggs - Mexico City - 10 days	Ticket	209.00	\$447.86
	To conduct research activities connected with	expenses	238.86	
	water resources that are related to the objectives of the 211(d) Institutional Grant	(actual)		

APPENDIX A

Appendix A contains the following abstracts:

1. Effect of Settlement on Flume Ratings
2. Width Constrictions in Open Channels
3. Culverts as Flow Measuring Devices
4. Cutthroat Flume Discharge Relations
5. Check-Drop-Energy Dissipator Structures in Irrigation Systems

ABSTRACT

EFFECT OF SETTLEMENT ON FLUME RATINGS

Frequently, flow measuring flumes placed in unlined channels settle at the flume exit because of the scouring action of the high velocity flow leaving the flume. Usually, this settlement condition goes uncorrected in the field. A more satisfactory solution to the problem would be in evaluating the effect of this settlement upon the discharge rating of the flume.

Four cutthroat flumes were selected for hydraulic testing in the laboratory. These flumes had been previously rated with the flume floor horizontal. In this study, hydraulic data were collected under both free flow and submerged flow conditions for each flume at various degrees of flume floor slope.

The experimental results show that there is a very definite effect upon the discharge rating of a flume due to settlement. The amount of correction increases as the tilt angle increases. Also, the amount of correction increases as the flume length is increased.

Tsu-Uang Wu
Agricultural Engineering Department
Colorado State University
Fort Collins, Colorado 80521
August, 1971

ABSTRACT

WIDTH CONSTRICTIONS IN OPEN CHANNELS

The purpose of this study is to compare the existing methods of calculating the backwater due to, or discharge through, a constriction in an open channel, and to show how these methods are but particular expressions of a more general submerged flow equation.

An extensive literature review has been made describing the analyses leading to the current methods of computation. The application of these methods of computation has been described. The derivation and application of the submerged flow equation to these methods has also been described.

The equations of Kindsvater, Carter and Tracy; Liu, Bradley and Plate; and the Bureau of Public Roads, have each been expressed in the form of a submerged flow equation, with data generated from the equations plotted in terms of the submerged flow parameters. The relation of the Froude number to the submerged flow analysis is then shown.

Application of the submerged flow equation, as presented in this work, is considerably simpler than previous methods. Also, more accurate results were obtained when the equation was applied to data collected from model studies. However, the submerged flow analysis has not been proven in prototype application.

J. W. Hugh Barrett
Agriculture Engineering Department
Colorado State University
Fort Collins, Colorado 80521
November, 1971

ABSTRACT

CULVERTS AS FLOW MEASURING DEVICES

Culverts are encountered throughout irrigation systems. Many of these culverts operate under free surface flow conditions. Usually, the flow depths in the culvert are governed by downstream flow conditions. This particular flow condition can be described as free surface outlet control. Only an approximate solution for determining discharge has been available for this situation.

A 12 inch diameter corrugated metal pipe has been used in the laboratory to test the validity of the submerged flow analysis employed with flow measuring flumes and weirs in describing free surface outlet control in culverts. Various slopes and culvert lengths were studied.

This study has shown that discharge ratings under free surface outlet control flow conditions can be developed. Such ratings can be related to the discharge relationships for inlet control and submerged outlet control. Thus, culverts can be used as flow measurement structures in irrigation systems.

Va-son Boonkird
Agricultural Engineering Department
Colorado State University
Fort Collins, Colorado 80521
February, 1972

ABSTRACT
CUTTHROAT FLUME DISCHARGE RELATIONS

The purpose of this study is to rate a group of cutthroat flumes which have the same geometric shape. Because of geometric similarity, the behavior of all flumes which are dimensionally similar to those tested should be capable of being predicted within a degree of accuracy suited for field use.

Twelve flumes were used in this study, all of which have the same shape. Three flume lengths were used, namely, 1.5 feet, 3 feet, and 4.5 feet, with four different throat widths for each length. In addition, the flume sizes were selected so as to permit correlation with the initial cutthroat flume studies (28), wherein a flume length of 9 feet, and throat widths varying from 1 foot to 6 feet, were studied.

The hydraulic data were collected under both free flow and submerged flow conditions. The method of submerged flow analysis reported by Skogerboe, Hyatt, and Eggleston (29) was utilized in developing the rating curves for the cutthroat flumes. This method of analysis was performed while the data were being collected.

An outstanding feature of the cutthroat flume is that generalized discharge rating curves can be easily developed.

ABSTRACT

CHECK-DROP-ENERGY DISSIPATOR STRUCTURES
IN IRRIGATION SYSTEMS

There is a large volume of available literature regarding small energy dissipator structures. Existing publications present basic information for particular types of structures. This information has been compiled in order to present present-day available design information. Also, research topics are delineated which would further assist the development of adequate design criteria.

Skogerboe, Gaylord V., Venus T. Somoray, and Wynn R. Walker. CHECK-DROP-ENERGY DISSIPATOR STRUCTURES IN IRRIGATION SYSTEMS. Report to United States Agency for International Development, Contract No. AID/csd-2460. Water Management Technical Report No. 9, AER 70-71GVS-VTS-WRW4, Agricultural Engineering Dept., College of Engineering, Colorado State University, Fort Collins, Colorado. May 1971.

KEYWORDS - baffles, drops (structures), hydraulic design, *hydraulic structures, *open channel flow, overfalls, riprap, stilling basins.

APPENDIX B

Further information on the 211(d) Grant supported program of the International Interdisciplinary Seminar is provided in Appendix B and is presented in two parts:

1. The Three Types of Presentations
2. Titles of Presentations

1971-1972 Report on the 211(d) Grant Supported Program of the International Interdisciplinary Seminar in Water Resources Management

The general plan for conduct of the Seminar in 1971-1972 called for three types of presentations:

1. Theories of Modernization and Development of Less Developed Countries. A multidisciplinary faculty-student group under the leadership of Dr. Huntley Biggs, Assistant Professor of Economics, developed a series of presentations under the general heading with particular emphasis upon the role of technology in developmental change related to institutional development affecting optimum utilization of water resources: with emphasis on water delivery and removal systems.
2. Review of the Comprehensive Framework Study of the Platte-Niobrara Subbasin. This study is a part of the larger "Comprehensive Framework Study of the Missouri River Basin" (one of eleven such large studies now underway or recently completed in the United States) that has been recently completed by the Missouri Basin Inter-Agency Committee which is composed of representatives of the several Federal departments and agencies and of the States that are concerned. A multidisciplinary faculty-student group under the leadership of Dr. Albert Mercer, Associate Professor of Civil Engineering, undertook review of the Platte-Niobrara reports and prepared papers for presentation to the seminar. Criteria used to guide the review related: (a) to the appropriateness of the study design, the professional competence exhibited in conduct of the study, and the usefulness of the results in terms of the abilities and needs of the United States; (b) to the usefulness of such an approach to planning water and related land resources use in less developed countries; and (c) from these reviews what conclusions or lessons might be drawn regarding water delivery and removal systems and related institutional development necessities.
3. Interdisciplinary Modeling of Water Management Problems. Emphasis in the development of papers presented to the seminar was placed on rigorous construction of interdisciplinary models. This approach,

which was undertaken under the leadership of Dr. John Reuss, Associate Professor of Agronomy, resulted in a series of presentations relating to optimal timing of the delivery of irrigation water and in one presentation on the conjunctive use of ground and surface water in irrigation.

In implementation of this general plan, the following presentations were made:

1. Theories of Modernization and Development of Less-Developed Countries
 - a. Perspectives on Development: Problems of Definitions and Concepts, Dr. Huntley Biggs, Assistant Professor of Economics; Dr. David M. Freeman, Assistant Professor of Sociology and Anthropology; Robert F. Schmidt, Classroom Assistant, Political Science.
 - b. Classical Models of Economic Development, Dr. Huntley Biggs, Assistant Professor of Economics.
 - c. A Sociological View of Technology in Development, Dr. David M. Freeman, Assistant Professor of Sociology and Anthropology.
 - d. Organizational Requirements for the Development and Application of Technology, Dr. Garth N. Jones, Professor of Political Science; Robert F. Schmidt, Classroom Assistant, Political Science.
 - e. Information and Misinformation on Models for Decision Making, Dr. David M. Freeman, Assistant Professor of Sociology and Anthropology.
 - f. Some Ecological Aspects of Technological Change, Dr. Gene Wilken, Associate Professor of Geography.
 - g. Factors Conducive to Transferring Technologies: The Viewpoint of Developed Countries, Dr. Terutomo Ozawa, Associate Professor of Economics.
 - h. The Appropriateness of Technological Transfers: The Viewpoint of the Developing Countries, Dr. Huntley Biggs, Assistant Professor of Economics.

2. Review of the Comprehensive Framework Study of the Platte-Niobrara Subbasin.
 - a. The High Policy of Comprehensive Multiple Purpose River Basin Planning in the United States, Professor Henry P. Caulfield, Jr., Department of Political Science.
 - b. The Framework Study of the Missouri River Basin with Special Reference to the Platte-Niobrara Subbasin.
 - (1) Overall Analysis Planning, Conduct and Results of Framework Study, Mr. Gus Karabotsus, Chief, Planning Division, Missouri River Basin Division, Army Corps of Engineers. Omaha, Nebraska.
 - (2) Fish, Wildlife and Outdoor Recreation Aspects, Emanuel Laucks, Bureau of Outdoor Recreation, Denver.
 - (3) Irrigation Aspects Plus State Role in Study, Mr. James Owen, Assistant Executive Secretary, Soil and Water Conservation Commission, State of Nebraska, Lincoln.
 - c. An Overall Appraisal of the Comprehensive Framework Study, Platte-Niobrara Subbasin, Michael C. Schiefer, Graduate Student, Department of Civil Engineering.
 - d. Framework Study, Platte-Niobrara Subbasin--Analysis of Surface and Groundwater Hydrology, Cathy Kraeger, Graduate Student, Department of Civil Engineering; and Dr. Albert G. Mercer, Associate Professor of Civil Engineering.
 - e. Framework Study, Platte-Niobrara Subbasin--Use of Economic and Population Projections, Dr. Robert A. Young, Associate Professor of Economics, Colorado State University.
 - f. Framework Study, Platte-Niobrara Subbasin--Analysis of Agricultural, Municipal, and Industrial Water Needs, Dr. Robert A. Young, Associate Professor of Economics, Colorado State University; and Dr. Raymond Anderson, Research Economist, Economics Research Service, USDA, Fort Collins.

- g. Framework Study, Platte-Niobrara Subbasin--Analysis of Fish, Wildlife and Recreation Aspects, Dr. Howard Alden, Department of Outdoor Recreation, College of Forestry and Natural Resources; and Dr. James Bailey, Department of Fishery and Wildlife Biology. College of Forestry and Natural Resources.
 - h. Framework Study, Platte-Niobrara Subbasin: Critique of Plan Formulation and Overall Plan in Terms of Professional Standards and Utility in United States and Less Developed Countries, Panel of faculty members and graduate students.
 - i. North Atlantic Framework Study (For Comparison to Platte-Niobrara Subbasin Study), Harry Schwarz, Senior Planner, North Atlantic Division, Army Corps of Engineers, New York City. Discussants: Dr. Albert G. Mercer, Associate Professor of Civil Engineering; Dr. Burnell Held, Professor of Recreation Resources and Economics; Dr. Robert A. Young, Associate Professor of Economics.
3. Interdisciplinary Modeling of Water Management Problems
- a. A Program for Water and Soil Management in Irrigated Regions, Dr. Wayne Clyma, Associate Professor of Agricultural Engineering; George L. Smith, Associate Professor of Civil Engineering. Discussants: Dr. David M. Freeman, Assistant Professor of Sociology and Anthropology.
 - b. The Effects of Varying Levels of Water Availability on Crop Response, Habte Mariam Neghassi, Graduate Student from Ethiopia in Agricultural Engineering; Dr. V. J. Bidwell, Research Associate from New Zealand, Department of Civil Engineering. Discussants: Dr. John O. Reuss, Associate Professor of Agronomy; Dr. Raymond L. Anderson, Economist, Economic Research Service, USDA; and Dr. H. J. Morel-Seytoux, Associate Professor of Civil Engineering.

- c. The Effects of Water Distribution Rules on the Economic Returns from Irrigation, Dr. Raymond L. Anderson, Economist, Economic Research Service, USDA. Discussants: Dr. Robert E. Danielson, Professor of Agronomy, Dr. Wayne Clyma, Associate Professor of Agricultural Engineering; and Dr. John O. Reuss, Associate Professor of Agronomy.
- d. Plant Responses to Water Stress and Possible Modeling Approaches, Dr. John O. Reuss, Associate Professor of Agronomy; Dr. Robert E. Danielson, Professor of Agronomy.
- e. An Improved Model for Optimal Timing of Irrigation, Habte Mariam Neghassi, Graduate Student in Agricultural Engineering. Discussants: Dr. Vincent Bidwell, Research Associate, Department of Civil Engineering; Dr. Robert Young, Associate Professor of Economics; Dr. John O. Reuss, Associate Professor of Agronomy.
- f. Criteria for Conjunctive Operation of Ground and Surface Waters, Dr. H. J. Morel-Seytoux, Associate Professor of Civil Engineering; and Dr. Robert A. Young, Associate Professor of Economics. Discussants: George E. Radosevich, Instructor, College of Business; and Research Associate, Legal Specialist, Department of Economics; and Henry P. Caulfield, Jr., Department of Political Science.

In addition to the foregoing seminar presentations in accord with the general plan for the year, the following five presentations were also made.

- 1. The Search for Social Goals in Natural Resource Development--From the Viewpoint of an Engineer¹, Dr. Dean F. Peterson, Dean, College of Engineering, Utah State University.
- 2. The Search for Social Goals in Natural Resources Development--From the Viewpoint of a Social Scientist¹, Henry P. Caulfield, Jr., Department of Political Science.

¹These presentations were to a joint session of the International Interdisciplinary Seminar on Water Resources Management and the Seminar on Fluid Mechanics, College of Engineering, Colorado State University.

3. Pakistan's Agricultural Growth--Its Lessons and Some Unanswered Questions, Dr. Jerry B. Eckert, former Agricultural Planning Advisor for The Ford Foundation, Pakistan.
4. Political Unrest and Economic Development in Latin America--A Personal Experience, Dr. Claude L. Fly, Soil Scientist from Fort Collins.
5. A Methodology For Evaluation of Soil Productivity Potential for Uruguay, Dr. Claude L. Fly.

No multidisciplinary field trip was undertaken like those of the previous two years to the Balsas River Basin, Mexico. It was tentatively decided that such trips if they involve return trips to the same location should probably be conducted every two years.

Seminar Program Planned for 1972-1973

The general plan developed by the Program Committee for conduct of the International Interdisciplinary Seminar on Water Resources Management in 1972-1973 calls for seminar presentations falling under the following three general headings:

1. Small Farming Problems in Less Developed Countries
Because much irrigated farming in less developed countries is on small farms and promises to remain so, attention will be focused upon the factors that are critical in making such small farms economically, socially and politically viable.
2. Major Constructed Water Development Projects Throughout the World--Evaluation of their Planning Procedures, Experience During Construction, and Operations and Effects to the Present.
Emphasis in this series will be placed upon learning from apparent past mistakes. Also, efforts will be made to discern whether there is any difference in "mistake-making" if the projects are planned by public agencies in a country, by private engineering firms of the country or foreign, or by university planning teams.
3. Interdisciplinary Modeling of Water Management Problems--This part of the program will continue the emphasis upon modeling in previous years. The topics to be covered during the coming year have not yet been selected.