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ANNUAL TECHNICAL REPORT
1974-1975

IMPROVING CAPACITY OF CID UNIVERSITIES
FOR WATER MANAGEMENT
FOR AGRICULTURE

REPORT NUMBER VI
COLORADO STATE UNIVERSITY



Grant No. AID/csd 2460
July, 1975

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FOR AGRICULTURE

REPORT NUMBER VI
COLORADO STATE UNIVERSITY

Grant No. AID/csd 2460
July, 1975

211(d) Annual Report
Date Due August 30, 1975
Date August 15, 1975

Grant Title: OPTIMUM UTILIZATION OF LAND AND WATER
RESOURCES FOR AGRICULTURE: WITH SPECIAL
EMPHASIS ON WATER DELIVERY AND REMOVAL
SYSTEMS OPERATED UNDER CONDITIONS CHARACTER-
ISTIC OF DEVELOPING COUNTRIES

Grantee: Colorado State University

Grant Program Director: E.V. Richardson

Sponsoring Technical Office: Technical Assistance Bureau
Office of Agriculture

Statistical Summary: Period of Grant: 23 May 1969 to 30 June 1977
Amount of Grant: \$1,050,000
Expenditures for Report Year: \$84,727
Accumulated: \$835,122

Anticipated For Next Year: \$105,000

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I. NARRATIVE SUMMARY

A. Principal Accomplishments

1. Reporting Year

The most significant development during the reporting year was the elimination of generalized studies and activities and focusing on specific problems of water delivery and removal systems as they affect the small farmer in developing countries. A brief summary of accomplishments attained during the reporting year, includes: a cooperative information storage and retrieval system drawing together into a network the varied library resources in the participating CID universities was started; fifteen individuals occupying important water resource management positions from eleven different countries enrolled in the International School for Water Resource which is self-supporting and utilizes the total competence of the university; twenty-one meetings of the International Interdisciplinary Seminar on Water Resources Management were held at no cost to the 211(d) grant; four courses in water resources management were revised and a new course formulated; nine studies directly related to water delivery and disposal problems were completed and the abstracts or report introduction or foreword placed in Appendix 3; ten members of the Colorado State University faculty were called upon, for a total of 15 times, to fill specific advisory requests from AID or other sources relating to some water resource development problem; completion of plans for an International Symposium on Global Water Law Systems to be held in Valencia, Spain, September 1-6, 1975; formal meetings with CID, Tropical Soil Consortium, and other institutions, many CID committee meetings; more frequent and meaningful contacts among the 211(d) grant directors; a formal paper presented before CIENTO by two members of CID and other contacts with FAO resulting in many meaningful linkages and an increase in the network of communications.

2. Life of Grant

Accumulated accomplishments include the development of institutional capabilities to work with AID, World Bank, United Nations, and other donors in assisting lesser developed nations to strengthen their economic and social conditions through increased agricultural production. In accomplishing these objectives Colorado State University increased the faculty by twenty-two (22) new members working in the area of water resources development. Thirteen (13) of these positions were fully or partially supported initially by the 211(d) grant funds. In addition, Colorado State University expanded its course offerings by improving eighteen (18) courses and adding eleven (11) new ones. These courses are now fully supported by university funds. Research on water delivery and removal systems was further expanded by a wide variety of new funding generated by the faculty as a result of the grant funds. Joint research programs have been established both at Colorado State University and with the other CID universities. Stimulated by 211(d) funds, Colorado State University developed an interdisciplinary team approach to research in the full dimension of water resources problems as it pertains to the economic, sociological, and technical fields. For added detail regarding the above, including achievement and benefit to LDCs, please refer to the summary of the 5-year accomplishments contained in the 1973-74 Annual Report.

II. DETAILED REPORT

A. General Background and Description of Problem

Water management has long been recognized as a problem in LDCs but only in the last decade have International Technical Assistance Agencies given serious attention to the problem through funding of water related programs. In 1969, Colorado State University, Utah State University, and the University of Arizona were all authorized, through the 211(d) Section of the Foreign Assistance Act of 1961, to receive funds to increase competence in their particular field of interest. The purpose of the grant funding was to enable each university to assist the LDCs in overcoming the problems of water management. Colorado State University's emphasis is in "water delivery and removal systems including relevant institutional development"; Utah State University is in "on-farm water management"; and the University of Arizona is in "watershed systems." In as much as these universities are recognized as among the most competent in the U.S. in the field of water management, they were selected to receive 211(d) grant funds.

As indicated above, the field of study, research, and concentration by Colorado State University, involves the optimum utilization of water resources for agriculture with special emphasis on water delivery and removal systems and relevant institutional development. The relevance of water delivery and removal systems and the need for expertise in this area to increase food production and benefit the small farmer is reflected in a statement extracted from the FAO/UNESCO International Source Book Irrigation and Drainage, to wit: "---it may also be assumed that, in typical earth channels under usual conditions, about one-third (1/3) of the total water diverted will be lost by seepage, operational waste and evaporation." Actually, in many lesser developed countries, the proportionate loss of water is even larger because seepage and waste are greater. Poorly constructed and managed conveyance systems, over-irrigation, and many other factors contribute to the loss of irrigation water, which must be considered a vital resource in those areas of the world sufficiently arid to require irrigation for the land to be productive. This wastage and seepage of water not only is nonproductive but waterlogs the soil and results in the deposition

of salts and minerals adverse to plant growth. Salinity, both as it affects the land and return flows, is a major factor in decreased food production through the loss of thousands of acres each year in the LDCs due to this problem alone.

Complicating the above is that too often, especially in developing countries, irrigation conveyance systems are only partially completed. For example, many dams, reservoirs, and large canals are skillfully engineered only to pass the water on to small farmers who must on their own, be responsible for the last few miles of a much lower standard and incomplete system. In addition, the terminal end of the irrigation system, the small laterals, and the on-the-farm distribution system all receive more sediment than they can transport. It is to this aspect of the problem that Colorado State University has and will continue to confine its studies for the improvement of these small conveyance channels so important to the small farmer and consequently to the resolution of the existing world food problem.

B. Purpose of Grant

The Annual Technical Report for the period 1973-74 was actually a 5-year report of the 211(d) grant activities conducted at Colorado State University. During this period Colorado State University significantly improved its level of competence with respect to planning, development, management, and utilization of water resource management. According to grant objectives, special emphasis was placed on water delivery and removal systems and relevant institutional development related to the needs of less developed countries. Progress was made in the area of grant objectives such as identifying the boundaries of the grant; improving and strengthening university competence; and building the base for adequate institutional response for global technical assistance in the grant approved specialized activities. However, at the end of the 5th year it was apparent that an additional period of time was needed to center in on water delivery and disposal systems using the full competence of the university. An extension of the grant was approved but only after the grant was redesigned to assure the final accomplishment of grant objectives through bringing about an even greater institutional response

capability in water delivery and disposal systems concentrating on helping the small farmer solve his problems at the lower portions of the irrigation system.

This report period covers the first year of the revised plan. The primary focus, as already indicated, was given to water delivery and removal problems as a means of improving the quality of life for farmers in the lowest income brackets. Secondary purposes were focused on problems of watershed management and on-farm water management to permit intelligent and efficient integration of planning in all phases of the water chain. Accomplishment in the secondary purposes, of course, has been and will continue to be done in full cooperation with the participating Consortium of International Development (CID) universities.

In summary, the project purpose is to maintain and sustain an institutional response capability in water delivery and removal practices and systems with special emphasis on improving the quality of life of the small farmer in the LDCs. Also to cooperate with CID to focus on problems of watershed management and on-farm water management.

C. Objectives of the Grant

The approved revision was put into effect during the reporting year and is briefly reviewed below:

1. Objectives Restated

The major objectives/outputs were designed to integrate quality research, teaching, training, and consulting technological programs into an effective means of information transfer to developing countries. The outputs were identified as:

- a. Information capacity
- b. Education and training
- c. Expanded knowledge base
- d. Advisory capacity
- e. Linkages and networks

These outputs were chosen to be interrelated and complementary. For example, a seminar on water-soil-crop interaction should be designed to have a functional capacity in all of the above outputs, i.e. it would serve to: (Output a) disseminate the results of adaptive research and determine areas of consideration for further such

research; (Output b) education and training for personnel of LDCs; (Output c) build and utilize the expanded knowledge base; (Output d) maintain the institutional advisory capability; (Output e) and, finally, establish and sustain valuable linkages.

2. Review of Critical Assumptions

A principle critical assumption is that AID will work closely with the university in carrying out the mutually agreed upon objectives of the grant. This cooperation will include, but not be limited to, supplementary funding from AID for AID approved-projects that utilize university competence, but do not fall within the funding scope and planning of the 211(d) grant. Such funding may be provided directly or through CIB by a Basic Ordering Agreement, purchase order or other appropriate mechanisms. The assumption is made that AID will respond in a timely manner in the funding of approved activities.

It is also assumed that AID will assist the university in making appropriate contacts in LDCs, international research centers and elsewhere concerning efforts involving advisory services, research projects, training programs, symposia and other appropriate activities.

Further critical assumptions (not necessarily in order of priority) include:

a. AID will assist the university in the funding and dissemination of agreed upon publications resulting from grant activities if not otherwise provided. Only limited funds are provided for publication of the budget of this extension.

b. The other universities involved in CID and the Tropical Soils Consortia will cooperate in providing personnel and other assistance in the development of the proposed comprehensive inter-university information network.

c. The university, cooperating with CID and the Tropical Soils Consortium, will plan, conduct and supervise state-of-the-art studies. After sufficient preliminary planning is completed, and the types of analyses needed are identified, additional funding will be forthcoming for completing those state-of-the-art analyses which are mutually recognized by AID and the universities as being of high priority.

d. Projects terminated or compromised in LDCs as a result of political or government action will not be considered as a university failure if the agreed upon project objectives have been met in a timely fashion prior to such action.

e. The university will be able to retain the staff programmed to participate in the grant program.

f. AID will provide coordinating and supporting roles and other functions that directly service the needs of the 211(d) grant at the university.

g. AID will work closely with the university in carrying out mutually agreed upon projects, and will help the university make the contacts in the LDCs that are needed to accomplish the objectives of the grant.

h. That additional capabilities by staff increases or improvement will result in a gradual increase in utilization.

i. Utilization will increase available funding and staff capabilities and that these in turn will increase utilization.

j. That meaningful problems will be identified in the LDCs and adequate adaptive research will be performed.

In the following section, III. ACCOMPLISHMENTS, the applicable critical assumptions for each objective/output category is discussed.

III. ACCOMPLISHMENTS

General or Introductory Statement

The Comprehensive Review Report of the Colorado State University 211(d) grant on Water Delivery and Removal Systems noted some weaknesses in the seven points mentioned in the AID issues paper but also expressed confidence that the new leadership, including the recently appointed grant program director and higher university officials, recognize the need to make considerable changes in the focus, approaches, and techniques that Colorado State University should use for eliminating these weaknesses and in developing adequate response capabilities in water activities on a worldwide basis.

During the reporting year decisive steps were taken by Colorado State University to refocus and concentrate on strengthening Colorado State University's ability to solve problems relating specifically to grant objectives. This sharpening of Colorado State University's focus has, for example, led to increased emphasis on the small farmer thus emphasizing better on-farm water management rather than concentrating on new large and complicated systems; more CII program director meetings and subject-oriented meetings at the technical level; increased attention to state-of-the-art studies in water removal as well as promoting institutional response capability particularly in water removal and in some aspects of water delivery; and increased emphasis on farmer acceptance of desirable practices as well as acceptance by LDC organizations.

It should be kept in mind that the "sharpening up" process and refocusing aspects could not be accomplished in full during the few months following acceptance of the new grant revisions. But nevertheless, the groundwork has been completed for a new framework of accomplishment relating specifically to the recent revisions of grant objectives. The next several years will bring full accomplishment of the new and revised targets.

Format Deviation

In the preparation of this section it is important to note the following: The accomplishments from the beginning of the grant award to the end of the reporting period is presented in two parts. The first part deals with the accomplishment and expenditures for each of

the objective/outputs for the reporting year in accordance to the Annual Report format. The second part deals with the accumulated accomplishments and expenditures as shown in the 1973-74 Annual Report shown in paragraph F. This deviation from the format appears to be a more accurate way of presenting the facts in as much as the recent revision changing the objective/outputs began at the outset of the reporting year 1974-75.

A. Objective/Output #1 Information Capacities

1. Narrative Description

This category, Information Capacities, is concerned with the collection, evaluation, and dissemination of information relating to water resource utilization. More specifically it relates to: (a) increasing the size of the library collection or water delivery and removal systems, (b) developing and adapting methods of data storage and retrieval of information regarding available water supplies for the LDCs, (c) exchanging printing and publication capabilities of Colorado State University, and (d) increasing the distribution of reports, documenting research results to appropriate sources. The Colorado State University library is one of the finest in the country. But it like many others is finding it increasingly difficult to keep pace with the multitude of scientific and educational books, papers, reports, and journals received everyday from all parts of the world and making it easily available to students, staff, and faculty. Thus this university, like many others, is having to resort to such major aids as microfiche and computerizing. This modernization process has been extended during recent years to increase the collection of information relating to water delivery and disposal systems and to make this information more easily and quickly attainable.

More specifically, Colorado State University in cooperation with CID has begun to reference and catalog into a computerized information storage and retrieval system very specific and appropriate items (relative to water resources and management information) so they can become additions to the information available to managers, students, and planners on a worldwide basis as well as to AID, FAO, other international donors and LDC institutions.

Upon request, Colorado State University has and will continue to disseminate publications to LDC researchers and libraries, to FAO, AID missions, and others. Throughout each year series of papers on such subjects as hydrology, hydraulics, water resources, economics, and agronomy are published by Colorado State University. These reports are published by the various colleges, the experiment station, and by private publishing firms. Funds from the grant are used to furnish these reports to participating CID universities, to LDC libraries, International Centers, and to AID. Some of these reports especially those produced by grant funds are sent to AID's office of publication and dissemination service in Washington, D.C.

2. Targets for Reporting Year

The targets for this objective/output are:

- a. Maintain specific and appropriate library acquisitions in field of water and removal systems.
- b. Absorption of Engineering Reading Room into the general library system.
- c. Cooperate with CID universities in perfecting a computerized information storage and retrieval system.
- d. Improve dissemination of water resources and management publications by Colorado State University to interested national and international institutions.

The degree to which the above targets can be satisfactorily reached is dependent on whether:

- AID will assist the university in funding and dissemination of agreed upon publications resulting from grant activities if not otherwise provided. Only limited funds are provided for publication in the budget of this extension.

- The other universities involved in CID and the Tropical Soils Consortia will cooperate in providing personnel and other assistance in the development of the proposed comprehensive inter-university information network.

The means of verifying progress made in the information capacity category might include on site visitation, receipt of publications, actual data storage and retrieval documentation and, of course the Annual Report.

3. Accomplishments

a. Accumulative

The accumulated accomplishments are stated under paragraph F.

b. Reporting year

Marjorie Rhoades, Engineering Sciences Librarian, and Barbara Burke, Engineering Sciences Branch Librarian participate in the Information Capacities aspect of the 211(d) grant. They, together with Linda White of Arizona University, will work towards the development of a computerized information storage and retrieval system drawing together into a network the varied library resources in the participating CID universities which are relevant to the concerns of the grant. This work was initiated towards the end of this reporting year.

From June 8-12 Barbara Burke attended the Special Libraries Association Annual Conference in Chicago which had as a theme "Systems and Networks: A Synergistic Imperative." The entire meeting was devoted to systems and networks and many of the papers described the existence and development of systems joining several institutions with common interests into an information network similar to that desired for the 211(d) grant. This background information is certain to enhance her contribution to the network planning workshop in Tucson next September. With the assistance of Marjorie Rhoades, Barbara Burke, and other librarians the Engineering Research Center reading room collection containing some rare works on Water Resources, such as Emory Lane's collection of sedimentation, was absorbed into the general library system. This means that this collection and subsequent acquisitions will henceforth be catalogued and maintained by general library appropriations and can be more easily stored and retrieved through computerized processes.

c. Total expenditures

The accumulative expenditure for this item, Information Capacities, as shown in paragraph F, Table IV (5-year period) is \$112,770. The expenditures for the reporting year is \$1975. The university and other sources expenditures is estimated to be \$100,000 for staff salaries, book purchase, periodicals, printing of publications, etc.

B. Objective/Output #2 Education and Training

1. Narrative Description

The objective/output here is to strengthen education and training programs for technicians and policy makers in developing countries. The emphasis beginning with the reporting year has decisively changed to direct support of campus programs designed to strengthen, improve, and maintain this objective.

2. Targets for Reporting Year

a. Maintain and strengthen the International School of Water Resources. The school, which advances a multidisciplinary approach to water resource planning and management, is primarily utilized by technicians and prospective scientists from developing countries.

b. Develop in cooperation with the University of Arizona and with Utah State University a short course in watershed management for use by technicians in developing countries.

c. Continue the International Interdisciplinary Seminar in Water Resources Management but at no cost to the 211(d) grant.

d. Revision of Dr. Shaner's course, "Planning Engineering Projects in the Developing Countries."

3. Accomplishments

a. Accumulative

For accumulative accomplishment see paragraph F.

b. Reporting year

The International School for Water Resources continued its excellent program throughout the year. This is an interdisciplinary nondegree school for short- or long-term (2 weeks to 2 years) training of IDCs people in all phases of water resources. From 5 to 25 people are normally in the school at any one time. For example on January 7, 1975 there were 15 individuals enrolled from 11 different countries all of whom occupied important positions in their home country. That the school is reaching a relatively high technical and capable class of people around the world is evident from a sample of titles from among the above group as follows:

Regional Manager, National Water Resources Commission, Ethiopia
 Highway Department, Material Testing and Research Division, Thailand
 Manager for Operations and Logistics, Water Resources Division,
 Indonesia

Deputy Leader Institute of Planning Works, Hungary

Executive Engineer, Irrigation/Power Department, Pakistan

Deputy Conservator, Ministry of Agriculture, Port of Spain

Associate Engineer, Land Resources Division, Taiwan

For added detail please turn to Appendix 1.

The major sponsoring agencies are: UN, FAO, AID, LDCs, and private foundations. The school is self-supporting and utilizes the total competence of the university.

Dr. E.V. Richardson and Dr. K.G. Brengle presented a series of lectures on small dam construction and prevention of erosion including dryland farming at "Antonio Narro" Center in Saltillo, Mexico, March 1-10.

Dr. Willis Shaner, Mechanical Engineering Department, in 1975 developed a new course on "Planning Engineering Projects in the Developing Countries." Eleven out of nineteen students who took the course were from developing countries. During 1974 Dr. Shaner revised the course and entitled it "Engineering and Economic Planning for Development." Twenty-four students took the course and of these twenty-one were from developing countries. The course was jointly listed with and assisted by the Economics Department. In the linkage aspect, Dr. Shaner went to Washington, D.C. in September 1974 to interest USAID and the World Bank in sending students to Colorado State University to participate in a program of instruction in project analysis for the LDCs.

Twenty-one (21) meetings of the International Interdisciplinary Seminar in Water Resources Management were held during the reporting year. For those registering, credit was received. Approximately twenty-five to thirty individuals attended each session conducted by local professors, graduate students, and outside speakers on subjects related to water resources management. Professor Gaylord V. Skogerboe was program committee chairman. This was one of the university's contributions to the grant as no 211(d) funds were utilized.

Professor E.F. Schulz, who spent 4½ years teaching at the Asian Institute of Technology, Bangkok, Thailand, developed a course in Applied Tropical Hydrology. After returning to Colorado State and during the reporting year Professor Schulz laid the groundwork for writing a book on tropical hydrology. He is now exploring the possibility of taking a one-year overseas post for the purpose of improving the course and bringing the book into manuscript form.

During the Asian Studies Week last year, a film concerning the problems of water diversion in the Indus Valley of Pakistan was shown at the university's student center. Also, the week's feature program was presented by Dr. Maurice L. Albertson on, "An Engineer's View of Maoist China." An important element of his presentation concerned the excellent dams, reservoirs, irrigation systems, and flood control work observed.

During the course of the year, Professor Robert A. Longenbaugh, Civil Engineering Department, updated two important courses of instruction. One was Groundwater Systems which is basic for such studies as determining aquifer parameters or optimal allocation of resources for groundwater investigation. The other course involved performance characteristics of pumps. Foreign students taking these courses find a direct relationship to their concerns in LDCs.

c. Total expenditures

The accumulative expenditures as indicated in paragraph F, Table IV amounted to \$139,925. Expenditure for the reporting year was \$10,123. University and other expenditures are estimated to be \$50,000. The university completely supports such activities as the International School of Water Resources, the International Interdisciplinary Seminar, and so forth.

C. Objective/Output #3 Expanded Knowledge Base

1. Narrative Description

In order to effectively solve old and new problems of the very poor farmers in developing countries, more emphasis and concentration was placed on the state-of-the-art reports and applicable research. Revision of the grant objectives applicable to the reporting and subsequent years clearly defined the areas of concentration and leadership responsibility. More specifically, the knowledge base during the reporting year was expanded by the following means:

To identify areas where existing as well as new technology and principles can be brought to bear on improving on-farm water management, state-of-the-art studies were initiated for both humid and arid environments. These studies involved an analytical review of the knowledge accumulated by research and practice, setting forth the established principles, how and where they could be used, and identifying the gaps in knowledge needing research for establishment of better principles and practices.

Colorado State University provided leadership for CID in developing state-of-the-art reports on (1) waterlogging and salinity, (2) sediment control in delivery systems, (3) water delivery - rules and procedures, and (4) pumping method. The results of these analyses now in varying degrees of completion will provide information for LDCs and will help define gaps in knowledge and the appropriate associated research and training needs. These topics were selected because of their importance to LDCs and opportunities for progress. Although these analyses have and will continue to utilize faculty resources of CID universities, where appropriate, the primary time and effort contribution has and will continue to be from Colorado State University.

While the leadership responsibility is elsewhere in CID, Colorado State continued also to participate in the state-of-the-art effort on (1) soil erosion, (2) water harvesting, (3) irrigation methods, and (4) water-oriented food production technology.

These state-of-the-art studies are being conducted by literature reviews, by consultations with appropriate LDCs, AID, Washington, and field personnel, international organizations, and in cooperation with sister universities, resulting in a thorough review of all available sources of information and experience. Some results of the state-of-the-art studies have already been forwarded to LDCs and these will help define gaps in knowledge and provide guidance for future research and training needs. The documents, as completed, are being widely distributed, and have effectively involved senior faculty and graduate students in work relevant to the grant purpose and, in the process, produced products useful to them, AID, other donors, and the LDCs.

The grant also provided staff time for the planning and writing of these analyses, for the associated travel requirements, and for graduate student assistance.

2. Targets for Reporting Year

- a. A state-of-the-art report on water delivery and removal systems in the LDCs.
- b. Development and improvement of methods to reduce seepage from earthen channels. Research will be conducted on the design of impervious low cost sealing of canals.
- c. Research into the state-of-the-art on saline water control and conjunctive use of ground and surface water to facilitate drainage and increase available water supply.
- d. Development of a mathematical model for determining the movement and exchange of water between groundwater and surface water.
- e. A study on the design of sediment excluders and ejectors for the control of sediment input into canals and to the farm.
- f. A study in the design of small water storage and erosion control dams.
- g. Planning for an International Conference on Global Water Law Systems.

The means of verifying both the accomplishment and effective results of the above targets would most certainly include such factors as the number of requests for reports, the extent of utilization of both research results and staff doing the research, on site observation, and, of course, the object of it all - increase in food production. In the preparation of the Annual Report and in reviewing all of the factors involved it is felt that the reporting year indicated a distinct measure of success in accomplishing the set of goals. A critical assumption, however for continued success would be that Colorado State University in cooperation with CID and the Tropical Soils Consortium will continue to plan, conduct, and supervise state-of-the-art studies and that after sufficient preliminary planning is completed, and the types of analyses needed are identified, additional funding will be forthcoming for completion of those state-of-the-art analyses which are mutually recognized by AID and the universities as being of high priority.

3. Accomplishments

a. Accumulative

Accumulative accomplishments for the first 5-year period is given in paragraph F.

b. Reporting year

Water management for small irrigation reservoirs is a subject of great interest to many small farmers around the world. Recently, a study was made which evaluated in detail the design and operation of a small irrigation water reservoir in Northeast Thailand. This reservoir was one of over 100 irrigation projects each operating with small tanks or reservoirs. Consequently, the analyses and conclusions drawn should be applicable to other locations in the northeast region and perhaps in other areas of the world having similar conditions. The study was made by Dr. Robert C. Ward, Agricultural Engineering Department and Mongkol Chotisatorn of the Royal Irrigation Department, Ministry of Agriculture, Bangkok, Thailand. The title of the report is, "Water Management for Small Irrigation Reservoirs in Northeast Thailand." An abstract of this report may be found in Appendix 3. Colorado State University scientists who reviewed this report were Professor Gaylord V. Skogerboe and Dr. Willis W. Shaner. The report is presently waiting review and approval by appropriate Thailand Government officials.

Construction of small earth dams is also of great interest to the small farmer or group of farmers which the dam may serve. Oftentimes such dams are poorly designed and constructed, any one of which may become a potential cause of loss of life or economic loss. During the reporting year, a study was published by Dr. E.V. Richardson, Civil Engineering Department, and his graduate research assistant, A.D. Wood entitled, "Design of Small Water Storage and Erosion Control Dams." The study indicates that if earth dams are designed and constructed properly they can be extremely safe and points out five critical areas that need careful consideration. An abstract of this publication may be found in Appendix 3.

Procedures and methods for more accurate measurement and improved management of water are continually being sought to make better use of water resources. Measuring devices are important for

water conservation, equitable distribution of water, determining the amount of available water, meeting legal requirements and, successfully managing the available supply. One water measuring device is called the cutthroat flume. A bulletin on this subject was prepared by Professor Gaylord V. Skogerboe, Colorado State University, Agricultural Engineering Department and published as No. 11 of the Series of Technical Bulletins by the Office of Agriculture, Technical Assistance Bureau, AID/W. This bulletin is an outgrowth of research efforts of Colorado State University for strengthening research and training capacity in irrigation water delivery in order to assist developing nations in agricultural production problems on small farms. See Appendix 3.

Efficient water utilization and its proper management on the farm is one of the important elements in the new strategy for agricultural development in Pakistan. While new improved varieties of seed and increased agricultural inputs are important to crop yield increases, irrigation watercourses are, in general inadequate for proper division and distribution of water on small farms. The above problems are discussed in a report, "Improving Water Management to Alleviate Waterlogging and Salinity Problems in Pakistan" by Gaylord V. Skogerboe, Agriculture Engineering Department. See Appendix 3.

A three-dimensional, finite difference model was developed for simulating steady and unsteady, saturated and unsaturated flow in a stream-aquifer system by Catherine E. Kraeger Rovey in partial fulfillment of the requirements for the degree of Doctor of Philosophy. An abstract of the dissertation entitled, "Numerical Model of Flow in a Stream-Aquifer System" may be found in Appendix 3.

In most countries of the world, earth channels are extensively used for water delivery and seepage from them is often substantial. In Pakistan, water losses from earth channels due to seepage, wastage through channel breaks, and evapotranspiration by nonbeneficial plants frequently range from 30 to 50 percent of the available flow and thus, in Pakistan, water supplies are often insufficient for maximum agricultural output. What can be done in a practical way to help the farmer reduce his seepage water losses? The farmer of

a developing country might be greatly aided by changes in established techniques or new methods if they could easily be understood and implemented by using available tools, labor, and materials. A thesis study by Stephen W. Smith entitled "Soil Puddling For Reducing Seepage" offers a way within the reach of small farmers. Results of the research shows that while mechanical puddling produces greater seepage reductions with less labor input, hand puddling can be accomplished with tools already available to most agriculturists of the developing countries. An abstract of this thesis may be found in Appendix 3. Guidance in the preparation of this thesis was given by Dr. William E. Hart, Dr. Wyrn R. Walker, Dr. Robert C. Ward - all in the Department of Agricultural Engineering, and Dr. Willis W. Shaner, Department of Mechanical Engineering

The economical design of the side slopes in water storage structures and conveyance channels is often dependent on knowledge of the shear strength which develops along the contact between a buried, flexible, membrane lining and its overlying cover material. A study was made under both dry and submerged conditions to determine the shear strength which could develop between a polyvinyl chloride (PVC) lining and five different soil cover materials. The results of this study are contained in a thesis entitled "Stability of Earth Cover Overlying PVC Membranes" by Roger Drury. Guidance for this thesis was given by Dr. E.V. Richardson and Dr. J.D. Nelson of the Civil Engineering Department, and W.R. Walker of the Agriculture Engineering Department. An abstract of the above thesis may be found in Appendix 3.

Due to expansion of cities and the increase demand for food throughout the world, there is a growing need to divert more water from alluvial rivers for municipal uses and for irrigation. The removal of sediment from canals has become a major economic problem and, to a lesser extent, removal of sediment from rivers. In general canals have a greatly reduced capacity to transport sediment compared to the transport capacity of the river. An M.S. thesis entitled "Exclusion and Ejection of Sediment From Canals," by A.M. Melone, graduate research assistant, offers some specific sediment control methods. An abstract may be found in Appendix 3.

A state-of-the-art review paper on "Salinity Problems in Agriculture" was started by Jim Riley (graduate research assistant). A wide range of topics was covered giving people with a limited background in salinity a greater appreciation of the problem and the many disciplines that must be involved in solving salinity problems in agriculture. Guidance for this paper was provided by Dr. M.L. Albertson, Dr. G.V. Skogerboe, and Dr. F.V. Richardson. This report should be completed next reporting year. A draft of the abstract may be found in Appendix 3.

A multiple crop irrigation planning model was developed to determine crop acreages and irrigation timing and amounts with two objectives in mind (1) maximization of expected return and (2) minimization of variance due to random precipitation. This study was undertaken as a Ph.D. dissertation by Herbert G. Blank and is entitled "Optimal Irrigation Decisions With Limited Water." It is believed that the methods revealed in this dissertation can be readily applied to irrigation sites with limited water supplies in many developing countries. See Appendix 3 for an abstract of this study. The dissertation will be completed next year.

Professors George Radosevich, Evan Vlachos, and Gaylord Skogerboe working with Professor David Daines, Utah State University, made all the necessary arrangements for a Global Water Law Conference to be held at Valencia, Spain, September 1-9, 1975. Sponsors are AID, CID, Colorado State University, Utah State University, NSF, Rocketteller Foundation, City of Valencia, and Community of Irrigators of Valencia. The host will be the Spanish Government. The expected outputs are a dialogue on the various laws and codes for administering water delivery and removal and a publication describing them.

A short paper was presented to the 211(d) Review Team from AID/W in July, 1974 entitled "Role of Water Law in Informing the Water Delivery and Removabilities of the Farmer" by George E. Radosevich, Economics Department. See Appendix 3 for this paper.

c. Total expenditures

The accumulated total for the first 5-year period is shown as \$166,167 (See Table IV, paragraph F). For the reporting year the amount is \$49,554. University expenditures in the field

of water for agriculture exceeds \$1,000,000. Most of the funding comes from the Colorado Experiment Station although some comes from OWRT.

D. Objective/Output #4 Advisory Capacity

1. Narrative Description

The emphasis here is to acquire sufficient flexibility, to respond quickly and adequately to requests for technical assistance to LDCs. Colorado State University has made significant progress toward attainment of this flexibility as well as making available faculty members from a variety of disciplines. The grant has funded a small amount of consulting time to be provided in emergency situations where individuals are needed on a very short notice and when other means cannot be found or utilized without causing unacceptable delay.

During the reporting year faculty members taught, performed application-oriented research with special consideration to problems in developing nations, and participated in state-of-the-art studies.

Release time was provided for faculty members for advisory and consulting work in LDCs. Faculty were paid to substitute in the classroom and laboratory for other faculty members who accepted LDC assignments. This provision afforded users of faculty resources a wide range of talent which could not otherwise be available for LDC programs.

Advisory capacity was maintained for the whole water chain in addition to capability in water delivery and removal systems. This secondary capacity provided an expanded range of talent for cooperative efforts implemented by CID and other appropriate organizations. Personnel from other universities and organizations including CID members were also called upon when needed.

The University worked with CID by means of advisory and other services in developing and providing expertise in problem identification and analysis and project design and evaluation, functions which AID anticipates will become increasingly important. For these functions and those related to operations and implementation, Colorado State University has identified faculty members and their specialties

for inclusion in a CID talent bank. The grant program director became the CID "systems manager" for that portion of the talent bank dealing with irrigation water delivery and removal systems.

Grant funds were used for short-term consulting, for release time of faculty members, for staff training, and for the development, improvement, and organization of the talent bank.

2. Targets for Reporting Year

a. Increase advisory and consultant capability for AID, LDCs, consulting firms, World Bank, and others.

b. Provide release time making it possible for any professor to get away for a short period of time.

c. Train faculty to respond quickly to a consulting request.

The following statements which attempt to document the reporting year's request for advisors or consultants are testimonials to the university's capacity to respond to such requests. Other verification factors would be found in trip and project reports, peer evaluation, and donor recommendations.

Colorado State University's ability to increase advisory and consultant capacity quickly, depends on (1) funding for release time, (2) that there is a real need for such consulting services, and (3) that the availability and talent at Colorado State University is known by the potential user.

3. Accomplishments

a. Accumulative

Accumulated accomplishments for the first 5-year period may be found under paragraph F.

b. Reporting year

Tippett-Abbott, McCarthy and Stratton (TAMS) Consulting firm in New York requested Dr. S. Karaki, Civil Engineering Department, to visit Tarbela Dam site in Pakistan to advise them on valve problems that arose during the first season of operation. His trip took place August 31-September 18, 1974. As a result additional model studies will be conducted on the Tarbela outlet works.

Dr. George E. Radosevich has been called upon a number of times in an advisory or consulting capacity with regard to water law systems and the effect of such laws, rules and regulations, irrigation practices. Primarily due to his efforts a Global Water Law Systems Conference will be held from September 1-6 this year at Valencia, Spain.

Dr. W.W. Shaner was called in an advisory capacity and sent to Peru for the period November 21, 1974 through January 11, 1975 to assist in the analysis of small scale irrigation in the Andes.

Dr. W.W. Shaner in an advisory capacity was again called upon to assist the USAID Mission in Peru on completing a loan paper from May 24 to June 14, 1975.

Dr. W.W. Shaner was requested to give a 50-hour course in Project Planning to members of upper management in the Department of Water Resources within the Ministry of Agriculture, Government of Peru.

At the request of CENTO, Dr. Shaner gave a paper on "Planning Integrated Rural Development" at Islamabad, Pakistan.

Dr. William E. Hart, Agricultural Engineering Department, visited Pakistan in an advisory capacity to assist the Colorado State University Water Management Team in developing a more efficient and less expensive water turn-off gate for irrigation purposes.

Dr. William E. Hart later visited Peru as an irrigation engineer to advise on irrigation scheduling. Dr. Hart could not have performed this activity had it not been for release time for Dr. James F. Ruff, Civil Engineering Department, paid for by 211(d) grant funds. Dr. Hart used George Hargraves, USO, evaporation equations very successfully. These were provided immediately and George Olsen, also of USO, was very cooperative. This provides a good example of inter-university (CID) cooperation.

Dr. Donald R. Wood, Department of Agronomy, participant in a seven man mission assembled by CID for USAID to review agricultural research in Kenya and Tanzania, January 29-February 17, 1975.

Dr. E.V. Richardson, Civil Engineering Department, director of the 211(d) grant project at Colorado State University, took part in the NAS, "U.S.-Egyptian Workshop on Research Planning and Management" in Cairo, May 3-8. He also spent two days in Rome consulting with

officials at FAO on soil and water problems affecting the small farmer and in developing linkages, May 3-8, 1975.

Dr. E.V. Richardson also visited the Mexican National Center for Arid Zones "Antonio Narro", Saltillo, in an advisory capacity, March 2-8, 1975 and gave a number of lectures on small dam construction and prevention of erosion.

Dr. Kenneth G. Brengle presented a series of lectures on dryland farming at "Antonio Narro" Center in Saltillo, Mexico, March 1-10, 1975.

Dr. Robert C. Ward, in an advisory capacity, completed a study and coauthored a report with Mongkol Chotisasitorn on Water Management For Small Irrigation Reservoirs in Northeast Thailand in April 1975.

Dr. H.J. Morel-Seytoux went to Les Cayes, Haiti in May 1975 under a consulting contract with Engineering Consultants Inc. of Denver to help with work on an AID contract. Dr. Morel-Seytoux advised the chief engineer with an assessment of the hydrology of the area but most particularly with investigating the potential of the alluvial aquifer for domestic and irrigation water supply. In December 1975 Dr. Morel-Seytoux will lecture for two weeks at the Centro Interamericanos de Desarrollo Integral de Aguas y Tierras, Merida, Venezuela for a post graduate course on Land and Water Resources Development. In the summer of 1976 he has an offer from the Ford Foundation to develop a course in the area of "Systems Planning with Reference to Ground Water Resources" at the University of Roorkee, Roorkee, India.

Dr. Daryl B. Simons, Associate Dean, College of Engineering, at the request of the State Department conducted a brief study of the Iquitos area of the Amazon River. He is also a consultant for Engineering Consultants, Inc., Karachi, Pakistan, a member of the Mekong River Commission, Bangkok, Thailand. Recently he was appointed to the Advisory Board for the Kalabaugh Dam on the Indus River. This dam is to be used for additional water supply to improve crop production in Pakistan.

Dr. Cleon V. Kimberling is presently the coordinator of the Kenya Veterinary Program which started in 1963 and is due to phase out in 1978. The total program involved the step by step process of establishing a College of Veterinary Medicine within the University of Nairobi

capable of high level accomplishments. Many Colorado State University veterinary personnel have served and are serving in Kenya and many participants have come to Colorado State University, as well as to other institutions, for formal degrees in Veterinary Medicine.

E.V. Richardson, G.V. Skogerboe, M.K. Lowdermilk, and S.A. Bowers, took part in AID's Soil and Water Management Workshop, February 17-21, 1975 in Washington, D.C.. Professor Skogerboe and Dr. Bowers presented discussion papers.

Dr. Wendell H. Bragonier, Dean of the Graduate School, visited Korea from September 1 through October 6, 1974 where he served as coordinator of an American team of an educators' advisory mission to the Seoul National University. The group evaluated the university's graduate programs in physics, chemistry, mathematics, biology, and earth science. The evaluation was to determine for AID the eligibility of the institution for a seven million dollar loan. The university will be moving soon to a new one-hundred million dollar campus 15 miles south of Seoul.

Dr. Donal D. Johnson, Dean of the Colleges of Agricultural Sciences, upon request from AID/W went to Bolivia, May 16-23, 1975 to negotiate a contract in agricultural and water resources development between CID and Bolivia.

Drs. J.M. Cheney, Department of Veterinary Medicine, and W.D. Bonham, Jr., Department of Range Science, took part in an AID design team for a livestock program in Senegal Africa. Dr. Cheney served as team leader.

Dr. Vearl N. Smith, Professor of Animal Science, is a member of a continuing Rural Development project in Iran for CID.

c. Total expenditures

The accumulative expenditures are estimated to be \$282,063. See Table IV, paragraph F. For the reporting year the amount is \$7,975 and for the university and other sources \$20,000.

E. Objective/Output #5 Linkages and Networks

1. Narrative Description

The recent revision of the 211(d) reporting guidelines emphasizes stronger relationship with a network of existing domestic

and multilateral organizations for the purpose of collaborating in a joint problem-solving approach developing cooperative research and becoming more effectively involved in information exchange and dissemination.

2. Targets For Reporting Year

a. Maintain a close collaborative and professional relationship with AID Missions and the Regional and Technical Assistance Bureaus in achieving the purposes of this grant.

b. Strengthen linkages with the other members of CID. Principal domestic linkages include CID and the Tropical Soils Consortium. Establish very close relations with the other 211(d) directors in the water chain. The Colorado State University Grant Program Director will become the systems leader within CID for irrigation water delivery and removal/drainage systems and linkages between that and dryland farming, watershed management, and on-farm water management. The grant will provide some funding for support of the newly assigned leadership and coordination role of CID.

c. Maintain close linkage with the Tropical Soils Consortium and its constituent organizations to carry out the state-of-the-art reports which will be produced on the subject of soil and water management for erosion control, water management for heavy soils and waterlogging and salinity.

d. Strengthen linkages with institutions working in water for food production in Africa, Near East, Pakistan, and Latin America. Establish linkages with several worldwide and regional organizations. Of these, the primary organization will be FAO.

e. Linkages supporting Colorado State University's state-of-the-art studies on water delivery and removal systems will be sought with regional agricultural organizations, LDCs, etc. to assure that the studies are relevant to LDC problems, particularly to water related problems for food production to help the small farmer, and to provide data and information for such studies.

During the reporting year many joint programs were developed with other institutions including seminars and training sessions particularly with the CID universities. But linkages with the other institutions such as the Tropical Soils Consortium were also strengthened. , dance

by Colorado State University personnel at International Conferences sponsored by such organizations as FAO, CENTO, AID placed Colorado State University scientists in contact with scientists in the same field of activity from other areas of the world thus broadening linkages and the network system. These linkages are mentioned below. However, if these linkages are to be maintained AID assistance and support is quite essential for universities by themselves cannot support that type of grant outreach. Cooperation by participating universities with AID is also necessary.

3. Accomplishments

a. Accumulative

A summary of accumulative accomplishments may be found in paragraph F. For a detailed account see the 1973-74 Annual Report.

b. Reporting year

A very important linkage in direct support of grant purpose was the completion of plans for an International Symposium on Global Water Law Systems to be held in Valencia, Spain, September 1-6, 1975. The planning effort took more than a year and will result in the first International Conference on Water Law Systems ever held. The originator and main instigator of the international conference idea is Dr. George E. Radosevich of Colorado State University's Department of Economics. Dr. Radosevich's interest in international water law systems was aroused when he was exposed to various water law systems in foreign countries through funding provided by the 211(d) grant and other university grants and contracts. During the latter important stages in formalizing the conference, Dr. Radosevich was ably assisted by Professor David Daines of Utah State University, also an expert in international water law particularly in South America. Working closely with Dr. Radosevich at Colorado State University in certain aspects of water law systems during the reporting year were Dr. Evan Vlachos, Social Science Department, and Professor Gaylord V. Skogerboe, Agricultural Engineer. The total planning activities for the conference was a joint effort of Colorado State University, Arizona University, and Utah State University. The purpose of the conference is

to produce a reference document on water laws as existing in the LDCs. It is anticipated, of course, that many important and meaningful linkages will accrue from the conference. Some linkages that already have been established may be found in Appendix 4.

Dr. Willis W. Shaner was one of four official U.S. delegates requested by USAID to attend a CENTO (Central Treaty Organization) Seminar (January 24-February 5, 1975) and present a paper together with Dr. John L. Fisher of Arizona University on "Problems in Planning Integrated Rural Development (IRD)." Also present were delegates from Pakistan, Iran, Turkey, and England. IRD is the comprehensive and coordinated development of economic, social, and political conditions in the rural sector of CENTO countries. Dr. Shaner established and remains in contact with a number of the high ranking attendees. In addition to the above, Dr. Shaner performed valuable services in Peru with expressed commendation from USAID and AID/W thus enlarging and cementing linkages with host country and AID.

At the request of USAID working through CID, Colorado State University provided the services of Dr. Donald R. Wood to participate in a 7-man mission to review agricultural research in Kenya and Tanzania. Dr. Wood established and maintains a number of meaningful contacts with important officials in both countries.

As a direct result of taking part in the NAS, U.S.-Egyptian Workshop on Research Planning and Management in Cairo, May 3-8, 1975 several very important linkages were developed by Dr. E.V. Richardson which may lead to requests for assistance in the water management field.

Dr. E.V. Richardson's and Dr. Kenneth G. Brengle's visits to the Mexican National Center for Arid Zones, University of Agriculture, "Antonio Narro" at Saltillo to present lectures and in an advisory capacity were accomplished in full coordination with CID. Agreements for an interchange of information and technical assistance are in effect. Not only have Colorado State University and CID scientists actively participated at Saltillo but the University officials from Saltillo have visited the CID campuses to further strengthen relationships.

Dr. Robert C. Ward strengthened linkages that Colorado State University already has in Thailand through his ties with the Royal Irrigation Department, Ministry of Agriculture, Thailand and production of a report coauthored with his counterpart in Thailand.

Dr. William E. Hart also strengthened ties and linkages that exist in Pakistan with Colorado State University through his work with Dr. Doral Kemper, Chief of Party, in Pakistan. In addition, Dr. Hart made a valuable contribution in Peru thus strengthening linkages there too.

The dissemination of information is very important if meaningful linkages are to be maintained and prevent network linkages from falling apart. In order to receive information from outside sources vital to, let us say, state-of-the-art studies and to positively identify problems it is essential for Colorado State University to communicate freely through meetings, correspondence, telephone calls, personal contact and dissemination of reports and literature with all interested outside institutions and organizations. This is being accomplished at an increasing rate.

In general, Colorado State University recognizes that linkages and networks mean little unless some action or response is stimulated. Since revision of the grant (beginning of reporting year) and under new leadership, great progress has been made in focusing down on the primary issues and setting into motion state-of-the-art studies and appropriately using existing university talent to bring into full play Colorado State University's competence in helping solve LDC problems with water delivery and removal for the purpose of increasing food supply and helping the small farmer. Factors contributing to this progress include the close relationship between directors of the 211(d) grants to CID universities, renewed and revitalized ties with USAID Missions and with AID, and these in turn have stimulated ties and linkages with outside agencies and organizations concerned with water management and food production.

The attendance and participation of 211(d) grant personnel at CID "in-house" meetings are, of course, important from the standpoint of coordinating research activities and cooperating in carrying out such activities. Such meetings are a major source for strengthening

linkages among CID universities, other universities, and between CID and AID/W the sponsoring agency. The meetings held were:

1. The CID meeting at Fort Collins, Colorado, July 9, 10, and 11, 1974.
2. The CID meeting with AID/W participation held at the TWA Ambassador's Club Conference room at Stapleton International Airport, July 17-18, 1974.
3. Special meeting of CID Board of Trustees and 211(d) grant Directors in Tuscon, September 12 and 13, 1974.
4. The CID meeting at Riverside, California, January 13 and 14, 1975.
5. The CID-CALI meeting with the African Bureau in Washington, D.C. on February 4, 1975.
6. CID-Southwestern Universities Meeting, June 29-July 2, 1975.

Other meetings attended by Colorado State University personnel relating to grant objectives are:

1. Soils Consortium Meeting at Cornell University, Ithaca, New York and at the University of Hawaii, Honolulu, Hawaii, attended by Dr. E.V. Richardson.
2. Soil and Water Management Workshop held in Washington, D.C., February 18-20, 1975, attended by Dr. E.V. Richardson, S. Bowers, M. Lowdermilk, and Professor G.V. Skogerboe.

c. Total expenditures

The accumulated expenditure as given in paragraph F, Table IV amounts to \$50,370. For the reporting year the expenditure was \$15,100 and for non-211(d) grant expenditure or university or other support the amount is estimated to be \$30,000.

F. Accumulative Accomplishments

Excerpts from 1973-74 Annual Report

"A. Principal Accomplishments

1. Summary of accumulated accomplishments

During the initial five-year period of the 211(d) institutional grant, CSU has, within the major objectives, studied the optimum utilization of water resources with emphasis on water delivery

and removal systems and relevant institutional development. The 1973-74 Annual Report gives a detailed report on the initial 5-year period. A brief description of what has been accomplished is as follows:

a. Increased the competence of the CSU faculty in research, and teaching it has developed institutional capabilities to work with AID, World Bank, United Nations, and others in helping to develop LDCs to increase their economic and social conditions through increased agricultural production. In accomplishing these objectives CSU has increased the faculty by twenty-two (22) new members who are all working in the area of water resources development. Thirteen (13) of these positions were fully or partially supported initially by the 211(d) grant funds which enabled the departments to employ these faculty and thereby increase the competence and capabilities of CSU.

b. CSU in the past five years has expanded its course offerings by improving eighteen (18) courses and adding eleven (11) new ones. These courses are now being fully supported by University funds. These course offerings have established an interdisciplinary program for students interested in water resources to receive a cross section of courses from both the engineering and social sciences aspects of this field. Prior to the grant the existing courses were taken primarily by students in the department in which courses were taught. As a result of the grant, however, many of these courses have been revised and new ones added. Furthermore, engineering and agricultural students are taking social science courses and vice versa.

c. Research on water delivery and removal systems has been further expanded by the wide variety of new funding which has been generated by the faculty as a result of the grant funds. The 211(d) grant funds have stimulated an interest to develop an approach to research in the full dimension of water resources problems as it pertains to the economic, sociological, and technical fields. Joint research programs have been established both at CSU and with the other CUSUSWASH universities. Through the results of this type of research, assistance is being furnished to the LDCs to help eliminate problems encountered in water delivery and removal systems. The total expression of the research program at CSU was outlined in Appendix B of the 5-year report.

d. The competence of the CSU Staff, to serve the needs of LDCs was increased. This competence was utilized in the LDCs. The details are given in Chapter III and Appendix II of the 5-year report.

e. By the use of the 211(d) funds over the past five years, CSU has been able to develop and interdisciplinary team approach which is showing significant payoff. One major factor in developing this interest and activity is the interdisciplinary seminar which was established from 211(d) grant funds. The seminar is now being offered as a course for credit for graduate students by the university and is supported by three colleges and six departments. CSU also has research contracts which involve four or five colleges and many departments.

f. The potential operational significance and benefit to the LDCs has been demonstrated by (1) the request for use of the services of the CSU faculty; (2) the added courses for the benefit of foreign graduate students; (3) the increase in research funding which has worldwide application; and (4) the publications on research projects which will benefit both the economy and the agricultural production of LDCs.

g. Joint and cooperative activities were carried out with the other CID universities. Details of these activities are given in Chapter III and VI of the 5-year report."

Table IV--Supplementary Table I
 Distribution of 211(d) Grant Funds and Contributions From Other Sources of Funding*
 Reporting Period 23 May 1973 to 22 May 1974

| Grant Objectives/Outputs | 211(d) Expenditures | | | | Non 211(d) Funding** Amount |
|---|------------------------|---------------------|------------------------|------------------------------|--------------------------------|
| | Period Under Review | Cumulative Total | Projected Next Year | Projected to end of Grant | |
| 1. Center for collecting, evaluating and dissemi- nation of knowledge | 20,274 | 112,770 | 24,000 | 136,770 | |
| 2. Education and training | 24,116 | 139,025 | 17,605 | 156,630 | |
| 3. Adaptive Research | 29,000 | 166,167 | 38,000 | 204,167 | |
| 4. Consulting Capacity | 48,954 | 282,063 | 7,000 | 289,063 | |
| 5. Linkage and Utilizing | 12,680 | 50,370 | 13,000 | 63,370 | |
| Total | 135,024 | 750,395 | 99,605 | 850,000 | 1,750,000 |

TOTAL

*These figures are best estimates
 **Other AID projects are included

IV. IMPACT OF GRANT SUPPORTED ACTIVITIES IN ACHIEVING GRANT PURPOSE:

The various water resources programs of research and education at Colorado State University constitute one of the largest such graduate programs in the world, and of this a significantly large number of specific graduate programs are committed to foreign research activities. The university has continued to expand its international activities during the grant period and has a continuing commitment to do so in the future. The impact of the 211(d) grant program on stimulating university involvement in foreign research activities has been very significant and is continuing to grow. Course offerings have been expanded through improvement of 22 courses and adding 12 new ones. These courses are now being fully supported by university funds. An interdisciplinary program for students interested in water resources and international development has been established. Research on water delivery and removal systems has been expanded by new funding generated by faculty partially as a result of the grant. 211(d) grant funds were also used to stimulate the development of an approach to research in the full spectrum of water resources problems pertaining to economic, sociological, and technical fields, both in the U.S. and in developing countries. In accomplishing the 211(d) grant objectives, Colorado State University has increased the faculty working in the area of water resources development by 23 new members. Fourteen of these positions were fully or partially supported initially by the grant, enabling the departments to employ these faculty and thereby increase the competence and capability of Colorado State University. The activities supported by the grant were widely spread not only through the engineering sciences but also through such divergent disciplines as economics, anthropology, water law, and sociology. Research competency, teaching capability, and institutional capacity and capability have all been significantly increased.

While the operant knowledge base of the university has been tremendously broadened, what needs to be done is to bring this operant base of knowledge into precise focus on particular problems. The basis has now been laid for a critical focus on the problems of

water delivery and removal systems as they affect the small farmer. Recent grant revisions, and under new grant leadership put into effect during the reporting year, have resulted in a significant increase in the impact of 211(d) grant funding both as to accomplishment of specific grant objectives and as to grant management and program effectiveness.

An important spin-off is the contact provided to participating university departments between the formal courses on one hand and the on-going field research in the developing countries on the other. These contacts have provided the necessary impact for a continual revision of course material relating to developing countries. Not only has the impact of 211(d) grant funding led to strengthening the university's competence in water delivery and removal but has had a domino effect in making it possible for the university to respond relatively quickly to international requests for long- and short-term assignments.

Colorado State University has succeeded in refocusing on many specific aspects of water delivery and removal and thus has increased the total overall impact. However, to successfully find research solutions to many remaining problems in this area, the university looks with great seriousness to AID/W for assurances that the competence built up at considerable effort and cost will not be left hanging just at the point of greatest return both to the developing nation and to the United States Government.

V. OTHER RESOURCES FOR GRANT-RELATED ACTIVITIES

Through the support of AID and other organizations, Colorado State University conducts an International School for Water Resources. The school was established to provide a structure to meet the need for improving professional personnel in water resources engineering to learn new techniques, to encompass up-to-date knowledge, and to broaden outlooks.

The school provides a tailored-made program to meet the needs of each individual and agency. The International School has no faculty of its own but utilizes existing faculty in the various departments of the eight colleges at Colorado State University. The flexibility of the program and the time periods allowed by the International School permits, participants to conform to the stipulations of many different sponsoring agencies.

A list of participants as of January 1975 is attached in Appendix I. A bulletin giving more detailed information on the International School is available upon request to Professor Victor A. Koelzer, Director, International School for Water Resources and Associated Programs, Colorado State University.

The Colorado State University College of Agricultural Sciences offers an International Agricultural Program. The program is designed to assist in coordinating and supporting programs involving foreign students, trainees, and visitors sponsored by AID/W, USAID/Missions, FAO, IIE, and other organizations in accordance with formal or informal agreements on a case by case basis. The program also provides for coordination and support of programs of training and orientation for Colorado State University students preparing to go overseas. The average length of study of each student is approximately two (2) years and about 90 percent of the students are in the Graduate School.

The program has also been expanded to provide agriculture seniors and post-graduate agriculture students to participate in a work-study program in Latin America and an Agriculture Intern Program in Francophone, West Africa.

James R. Graham, Associate Director and Foreign Student Advisor of the Office of International Education, assists foreign students in their housing, registration, social, and economic aspects and in general

helps out in many of the foreign student needs at Colorado State University.

Research under Colorado Project 125 and AID Water Management Research Contract was continued under the direction of Dr. W.T. Franklin to evaluate the effect of water quality and methods of irrigation on the salt content of return flows used in the irrigation system.

Major water related projects which have grant related activities are as follows:

| <u>Project</u> | <u>Funding Agency</u> |
|---|-----------------------|
| Grand Valley Salinity Control Demonstration Project | EPA |
| Irrigation Practices, Return Flow Salinity, and Crop Yields | EPA |
| Irrigation Return Flow Quality Literature Abstracting | EPA |
| Water Quality Control in Mine Spoils | EPA |
| Water Data Bank | Colorado State Eng. |
| Transport of Salts in Irrigation Return Flow | OWRR |
| Consolidation of Irrigation Systems | OWRR |
| Quality of Water Literature Abstraction | EPA |
| Recycle and Utilization of Livestock Manure through Subsurface Injection | EPA |
| Animal Wastes and Runoff Affects by Manual Harvesting | EPA |
| Salinity Control Technology in Grand Valley | EPA |
| Irrigation Practices | EPA |
| Irrigation Return Flow | EPA |
| Agricultural Salinity Control | EPA |
| Technical Services | AID |
| Water Resource Optimization | Colo. Exp. Sta. |
| Water Resources Hydraulics | Colo. Exp. Sta. |
| Groundwater Management | Colo. Exp. Sta. |
| Hydrometeorology | Colo. Exp. Sta. |
| Soil Salinity and Irrigation Water Quality | Colo. Exp. Sta. |
| Economic and Institutional Analysis of Water Quality Standards and Management | Colo. Exp. Sta. |
| Farm Investigation Water Management | Colo. Exp. Sta. |

| <u>Project</u> | <u>Funding Agency</u> |
|---|-----------------------|
| Optimal Operation of Sprinkler Irrigation Systems | Colo. Exp. Sta. |
| Quantification of Water-Soil-Plant Relation for Efficient Use | Colo. Exp. Sta. |
| Solubility of Heavy Metals in Soils | Colo. Exp. Sta. |
| Irrigation Practices, Return Flow Salinity | Colo. Exp. Sta. |
| Energy Production from Agriculture Products | Colo. Exp. Sta. |
| Design Criteria for Interceptor Drains | Colo. Exp. Sta. |
| Irrigation Flow Metering | Colo. Exp. Sta. |
| Mathematical Modeling of Small Watersheds | Colo. Exp. Sta. |
| Experimental Investigation of Small Watershed Floods | Colo. Exp. Sta. |
| Subsurface Hydrologic Models | NOAA |
| Sediment Yield From Watersheds | USFS |
| Asian Institute of Technology | AID |
| Salts in Irrigation | OWRT |
| Role of Water Reuse | OWRT |
| Study of Salt Control in California River Basin | OWRT |
| Feeding Programs in Developing Countries | ERS |
| Solar Energy | NSF |
| Alluvial Channel Mechanics in Pakistan | NSF |

Because of the heterogeneous--social, political, agricultural, systems engineering--make-up of the Irrigation Management Program as a subcommittee of the Integrated Approaches Committee of CID, each member institution has been able to develop broader as well as deeper insight into the various components, and their interrelationships, of an irrigation water management system as related to irrigation water delivered to, or retrieved from a farm field. The delivery of irrigation water to a field, for example, might satisfy the soil moisture requirement of the crop, but failure to recognize the need for drainage--water retrieval--will usually lead to the subsequent establishment of undesirably high water table and/or salinity conditions within the soil profile as evidenced in the Indus Basin of the Pakistan-Indian subcontinent.

VI. UTILIZATION OF INSTITUTIONAL RESPONSE CAPABILITIES IN DEVELOPMENT PROGRAMS

A. Requests for Assistance (Tables III-A and III-B)

The utilization of institutional response capabilities as shown in Table III-A and III-B includes mainly grant-supported activities and the technical services of individuals supported in part by 211(d) grant funds. All AID requests are reported and all non-AID requests for assistance in LDC development programs.

B. Specific Information

1. Number of Foreign Graduate Students from LDCs

During the spring quarter of 1975 there were 329 foreign students registered at Colorado State University. The total number of countries represented was 67. Ph.D. candidates numbered 112 and M.S. 168. Nearly one-third (31%) of the total number of students were enrolled in the College of Engineering. A list of the countries and the number of students from each country is given at the end of this section.

2. Number of On-Campus Visitors or Consultations

The number of visitors or on-campus consultations with regard to matter specifically relating to water management or research ranges from 500 to 750 half of whom are from foreign countries. Some of these are directed to the university by U.S. federal agencies having water management responsibilities.

3. Known Use of Research, etc. Developed Under Grant

Dr. Willis W. Shaner, specialist in engineering-economic planning developed a special 50-hour course in project planning related to the water resources field. The request for such a course came directly through Dr. Cornejo, Director of the Department of Agriculture, Lima, Peru to be given to members of upper management. In addition, Dr. Shaner helped initiate and later helped to finalize an agricultural loan paper for the USAID Mission in Peru. Dr. Shaner could not have been available to perform either of these two activities without 211(d) grant support funding.

Dr. William E. Hart, specialist in design of field irrigation systems, hydrology, hydraulics, irrigation engineering, and related fields, used his specialized knowledge to assist Dr. William D. Kemper

in Pakistan for a short period of time to develop a stronger, more durable, and far cheaper irrigation gate for the Pakistani farmer. Later, Dr. Hart's services were requested in Peru as an Irrigation Engineer for assistance in irrigation scheduling. The response capability of the university could not have been met in these two instances if it had not been for 211(d) grant support.

The same can be said for Dr. George L. Radosevich, specialist in international water law, who has succeeded in establishing an International Conference on Global Water Law Systems scheduled for 1-6 September 1975 at Valencia, Spain. He was assisted in part by Dr. Evan Vlachos, specialist in methodology, demography, and comparative social structure; also by Professor Gaylord V. Skogerboe, Agricultural Engineer.

4. Significant Graduate Roles

It is a little early yet to outline the significant roles played by university graduates who were benefited by 211(d) grant funds. Undoubtedly, most of them will assume positions of leadership either in government, in the educational field, or private sector. Recent graduates are:

Dr. Larry Caswell
 Dr. Mohammad T. Chaudhry
 Dr. Alfred J. Tambur
 Dr. Lemma Wendim-Agegnehu
 Mr. Qurban Ali Khan
 Mr. Alta Mohammad Nazar
 Mr. Bailey F. Wharton
 Mr. Anthony M. Melone

5. Personnel Working on Development Programs

a. Reporting year personnel

Dr. Everett V. Richardson
 Dr. Maurice L. Albertson
 Dr. Kenneth G. Brengle
 Dr. William E. Hart
 Dr. Khalid Mahmood
 Dr. George E. Radosevich
 Dr. James F. Ruff
 Dr. Willis Shaner
 Prof. Gaylord Skogerboe
 Dr. Evan C. Vlachos
 Dr. Robert C. Ward

The above and other faculty members working on development programs and eligible for advisory service are listed in section VII including, for each, a brief statement of his field of expertise.

b. Utilization of Colorado State University's competence

The Board of the Colorado Association for International Education (CAIE) is made up of participants from eighteen (18) universities, colleges, and institutions, seventeen (17) of which are in Colorado. The association is organized for the purpose of enabling the institutions of higher education to develop cooperative programs in the field of international education. One of the five (5) seminars held during 1974-75 was hosted at Colorado State University on International Development. One of the guest speakers was from AID/W.

At the present time CAIE is developing a computerized information retrieval system for the purpose of compiling an information bank of the international experiences, talents, and interests of faculty members in the member institutions. This will identify to those faculty who are interested in activities and assignments of an international nature. It also identifies the competence and expertise available for international activities.

This illustrates one of the many ways that the competence of the faculty is being utilized as a result of grant funds.

6. Progress in Establishing and Maintaining Linkages

This activity is described in section III E.

7. Utilization of Institutional Response Capacities During and After Grant Expiration

The utilization aspects of response capacities on solutions of LDC problems during the remainder of the grant term are implied in the Work Plan for the next two years.

Table III-A

Requests For Assistance Received During Reporting Period May 23, 1974 to June 30, 1975

A. Requests Attended

| Description of Request for Assistance | Whom did you Assist? | Who Requested Assistance | Who Funded Assistance | Size of Effort | | Results of Assistance |
|--|---|--------------------------|-----------------------|----------------|----------|--|
| | | | | Dollars | Man Days | |
| Irrigation engineer to develop irrigation scheduling | governments, USFA, farmers | Peru | 211(d) | 5500 | 60 | Scheduling system greatly improved |
| Increase efficiency and costs of irrigation gates | governments, USFA, farmers | Pakistan | USAID | 5500 | 60 | New type of gate costing far less will soon be produced |
| Confer with FAO in Rome on soil and water problems affecting small farmers | 211(d) | AID | 211(d) | 200 | 2 | Help decision making process in allocating 211(d) grant assistance |
| Evaluate efficiency of small irrigation reservoirs in Northeast Thailand | governments, USFA, farmers | Thailand | 211(d) USAID | 4500 | 68 | Increase government assistance to farmers |
| Valve problems at Tarbela Dam | Pakistan | TAMS | TAMS | 4000 | 19 | Additional model studies on Tarbela Dam Outlet works. Increase linkages |
| Problems in planning integrated rural development. Paper given at Istanbul, Pakistan | CENTO | CENTO | CENTO | 2500 | 16 | Broaden scope of IRD. Increase knowledge, dissemination of information, and cooperation with an international organization |
| Develop an international conference on Global Water Law Systems | governments, U.S. foreign assistance, farmers | AID | 211(d) | 9262 | 90 | Conference schedule for 1-6 September 1975 at Valencia, Spain |

Table III-A (continued)

| Description of Request for Assistance | Whom did you Assist? | Who Requested Assistance | Who Funded Assistance | Size of Effort | | Results of Assistance |
|---|---|--------------------------|-----------------------|----------------|----------|---|
| | | | | Dollars | Man Days | |
| Present course on dryland farming at Mexican National Center for Arid Zones, Saltillo, Mexico | governments U.S. foreign assistance, farmers | Mexico | 211(d) | 5000 | 45 | Course gave vital boost to strengthening educational program. Hopefully course can be given to other LDCs in future |
| Review agriculture in Kenya and Tanzania Seven man mission One man from CSU | governments, U.S. foreign assistance, farmers | Kenya Tanzania | 211(d) USAID | 2227 4000 | 27 | Identification of problems and recommendations for problem solving |
| Analysis of small scale irrigation in Peru | governments, USFA, farmers | Peru | 211(d) | 5000 | 51 | Strengthening emphasis on helping the small farmer |
| Finalize USAID agricultural loan paper in Peru | governments, USFA, farmers | Peru | 211(d) | 2500 | 21 | Loan to help eliminate lack of credit to small farmer and others |
| Problem of erosion on banks of Amazon River | governments, USFA, farmers | Peru | AID | 4000 | 7 | Vital information to Peruvian Government |
| Short tour with CSU field team in Pakistan on on-farm water management (Reuss and Johnson) | GOP USAID | USAID | AID/W USAID | 7175 | 52 | Probably 2-year assignments for each of 2 men |
| U.S./Egyptian workshop on research planning and management | NAS AID | NAS | NAS Aid | 3000 | 15 | Meaningful linkages for possible use of CSU competence in water research and management |

Table III-B

Requests For Assistance Received During Reporting Period May 23, 1974 to June 30, 1975

B. Requests Not Fulfilled

| Description of Request for Assistance | Whom did you Assist? | Who Requested Assistance | Who Funded Assistance | Size of Effort | | Why not met? |
|--|-------------------------|-----------------------------|--------------------------|----------------|-------------|-----------------------------------|
| | | | | Dollars | Man Days | |
| Water resources economist Bill Shaner Robert Young Ronald Tinermeier Ken Nobe | Nicaragua | AID | | | | Fulfilled from other resources |
| Technical advisor for Bolivia | Bolivia | CID | | | | Still under negotiation |

Foreign Students Attending Colorado State University

| Country | Number of Students | Country | Number of Students | Country | Number of Students |
|------------------------------|--------------------|-------------------------|--------------------|------------------------------|--------------------|
| Afghanistan. | 6 | Hungary | 2 | Pakistan | 17 |
| Algeria. | 1 | Iceland | 1 | Panama | 1 |
| Argentina. | 3 | India | 14 | Paraguay | 1 |
| Australia. | 6 | Indonesia | 13 | Peru | 2 |
| Austria. | 2 | Iran. | 25 | Philippines. | 1 |
| Bangladesh | 1 | Iraq. | 10 | Saudi Arabia | 4 |
| Brazil | 13 | Israel. | 5 | Senegal. | 1 |
| Canada | 15 | Ivory Coast | 1 | South Africa | 1 |
| China, Republic of | 28 | Jamaica | 1 | Sri Lanka. | 2 |
| Columbia | 7 | Japan | 10 | Sudan. | 5 |
| Costa Rica | 1 | Jordan. | 2 | Tanzania | 2 |
| Czechoslovakia | 1 | Kenya | 3 | Thailand | 20 |
| Dominican Republic | 1 | Khmer Republic. | 2 | Trinidad & Tobago. | 1 |
| Egypt. | 1 | Korea | 5 | Tunisia. | 3 |
| Ethiopia | 10 | Kuwait. | 3 | Turkey | 5 |
| El Salvador. | 1 | Libya | 15 | United Kingdom | 2 |
| Fiji | 1 | Malaysia. | 2 | Uruguay. | 1 |
| Finland. | 1 | Mexico. | 8 | Vietnam. | 5 |
| France | 3 | Nepal | 1 | Venezuela. | 14 |
| German, Fed. Rep. | 2 | Netherlands | 7 | Yugoslavia | 1 |
| Guatemala. | 1 | New Zealand | 1 | Stateless. | 1 |
| Honduras | 2 | Nigeria | 5 | Total number of students | 329 |
| Hong Kong. | 6 | Norway. | 1 | Total number of countries | 67 |
| | | | | Total number of new students | 19 |
| | | | | PhD candidates | 112 |
| | | | | Masters candidates | 168 |
| | | | | Non-Degree | 17 |
| | | | | Undergraduates | 32 |

VII. NEXT YEAR'S PLAN OF WORK AND ANTICIPATED EXPENDITURES

Work Plan 211(d)--May 23, 1975 to June 30, 1977

The work plan to obtain the outputs indicated in the proposal for continuing support under AID's 211(d) program is given in this report and in Table 2. Estimated man power and dollar inputs for each output are given in Table 3.

1. Information Capacity

A. Library Acquisitions

Library acquisitions in the field of water delivery and removal systems to improve food production and the living conditions for the small farmer will be maintained by Colorado State University. However, some books and periodicals will be purchased as requested by staff working on the grant in order to get a quick response to his needs.

The purpose of all acquisitions will be to maintain CSU's excellent library in this field and to serve staff working on the grant in a timely manner.

B. Information Storage and Retrieval Systems

Working with the other CID universities, some of the library materials on water delivery and removal systems will be incorporated into a computerized information storage and retrieval system. Money will be provided for travel of library staff to member institutions to interact with their staff and attend workshops. A workshop is scheduled in the early Fall of 1975 at Arizona University.

C. Publications Dissemination

Several series of papers on hydrology, hydraulics, water resources, economics, agronomy, etc. are published by the University. These reports are published by the various colleges, the experiment station and by private publishing firms. Upon request, publications

will be disseminated to LDC researchers and libraries, FAO, AID missions, the other members of CID, etc. with funds from the grant. Some of these reports, especially those produced by grant funds, will be furnished to AID's publication dissemination service.

2. Education and Training

A. International School for Water Resources

The International School for Water Resources is supported by Colorado State University with a half-time director who spends his time interfacing with the officials from AID missions, FAO, LDCs, UNDP, donor agencies, etc. making them aware of the course contents and availability of this school. The director designs course programs for the students; and interacts with various government bureaus and consulting firms such as Bureau of Reclamation, Corps of Engineers, Agriculture Research Service, Geological Survey to obtain specialized training for the students. The Director of the 211(d) Program helps with the advisory and with contact with the LDCs, donor agencies, and potential training centers. No man months from the grant are budgeted for this activity but some travel of the director may be paid for.

B. Watershed Short Course

A watershed short course to train the middle manager and top level policy maker on the importance and need of watershed management to prevent erosion and increase food production will be prepared by Arizona University in cooperation with the other CID Universities. The pilot short course will be developed by 1977.

C. Short Course on Irrigation Water Delivery and Removal Systems

A short course involving practical aspects of irrigation water delivery and removal systems will be developed for presentation in LDCs.

This will involve faculty resources from CID institutions and LDC representatives. Colorado State will assume the primary responsibility for organizing the course on behalf of CID but the other member Universities of CID will contribute faculty resources. The course will be for decision makers and technicians responsible for resource planning, development and application. The purpose is to help the participants understand the importance of and problems associated with delivery of water to and removal from the farm. The course will be developed on a pilot basis for testing and refinement with the ultimate goal being widespread LDC use subject with local modification in approach as the needs indicate.

A manual will be written for use in conjunction with the short course. The course syllabus, manual, and necessary materials will be completed by Fall 1976.

D. On-Farm Water Management Short Course

A short course in practical aspects of on-farm water management will be developed by Utah State University. Colorado State University will participate by reviewing the syllabus and by assisting in the presentation as required.

3. Expanded Knowledge Base

A. Waterlogging and Salinity Control

A state-of-the-art report will be prepared on the present status of research and knowledge on the problems of waterlogging and salinity and methodology to prevent or control them. Part of the report will describe state-of-knowledge on the duty of water under various irrigation systems, cropping patterns and climatic conditions. Utah State University will actively contribute to this report.

B. Sediment Control

A state-of-the-art paper describing the sediment problem at the lower end of the irrigation system and on the farm will be produced. The paper will use sediment transport equations to illustrate why sediment is such a problem at the lower end of the system and will describe methods to alleviate the sediment problem on the small farms.

A draft report will be completed by Spring of 1976 with final reports by January of 1977.

C. Water Delivery--Rules and Procedure

Working with Utah State state-of-the-art papers delineating various legal and administrative systems and pointing out the constraints, advantages and disadvantages of each system will be prepared. One paper will be a follow-up of the Global Water Law Conference that CSU is presenting this year in collaboration with USU and the University of Valencia, Spain. Also specific papers will be prepared describing how water delivery is administered in specific countries or regions. The first paper will be prepared by Spring of 1976 and the follow-up paper or papers the following year.

D. Pumping Systems

A state-of-the-art report will be prepared on irrigation pumping plants. This study will be accomplished by literature review, by consultations with appropriate LDC's AID personnel and in cooperation with sister universities, and in consultation with pump manufacturers. Emphasis will be placed on the simplest means of water lifts such as the wind mill, hand pump, Persian wheel, etc. and will consider the efficiency and energy aspects as related to the small farmer. The resulting document will be a thorough review of all available sources

of information and will delineate problem areas, potential solutions and recommend research areas. The report will be completed by the end of 1976.

E. Erosion Control

Colorado State University will cooperate in the preparation of the state-of-the-art paper described in Arizona's Work Plan. To wit

"The University of Arizona will develop a state-of-the-art paper on the present status of research and knowledge, a review of present management practices and a consideration of the problems associated with erosion control technology in the small watershed often found in LDCs. This document will be an outgrowth of the planned 1976 Erosion Symposium and will be completed by April 1977."

F. On-Farm Water Management

Colorado State University will participate in the preparation of state-of-the-art reports on water management in heavy soils and water oriented food production technology for which USU will provide the leadership.

4. Advisory Capacity

A. Consulting Service

During the two year period of the grant \$9,300 is budgeted to provide consulting services in emergency situations where individuals are needed on very short notice and when other instruments cannot be used without causing unacceptable delay.

B. Release Time

Five (5) man-months during the two year period of the grant are budgeted to provide release time for a faculty member so that he can respond to AID's request for consulting service. This method was done in 1974-75 whereby Professor James Ruff was paid to take Dr. Hart's course on the design of farm irrigation systems, and prepare himself

to teach a similar course the following quarter. He was thus able to release Hart to go to Peru to serve as an advisor on an irrigation system design project. The training Ruff obtained has expanded our advising capabilities.

C. Improving Advisory Capacity

It is anticipated that top AID or other personnel will be available to present one week short courses to be attended by CID university personnel. These short courses would be designed to improve the competence of the university personnel in the areas such as project planning and design. It is expected that several members from each CID University would attend such short courses. Presently, no funds are allocated for this activity. A supplemental appropriation may be requested for this activity once the courses and sites at which the course is to be taught are identified. The first course is expected to be presented in April, 1976.

5. Linkages and Networks

A. CID Support

CID will promote meetings where CID engineers and scientists will meet and exchange views, the results of their scientific work, and discuss LDC problems.

This will be a working symposium, where people working on mutual problems will get together. State-of-the-art problems will be discussed. Items of discussion will include present objectives, future objectives and present status of programs with regard to the LDC. It is expected that the soils consortium will also take part in these meetings.

B. Establishing Linkages

Money is budgeted for salary and travel of faculty members to establish viable linkages with CID, LDC's Tropical Soils Consortium, research and service organizations, FAO, and other regional agricultural organizations. Faculty members will be expected to develop linkages with regional agricultural organizations and LDC institutions for use in developing data for state-of-the-art statements and will contribute data generated through these contacts to such studies in which CSU is involved. Where possible CSU's sabbatical leave policy will be utilized in the development of these linkages.

WORK PLAN

APPENDIX

Table 1. CSU Staff Consultants

| <u>Name</u> | <u>Field of Interest</u> | <u>Function*</u> |
|-----------------------|--|---------------------|
| William T. Franklin | Diagnosis and reclamation of salt-affected soils; water management related to water quality and soil fertility; soil mineralogy | 1, 2, 3, 4, 5, 6 |
| Neil S. Grigg | Water resources, water supply, urban drainage, flood control, water management, hydrology | 1, 2, 3, 5, 6 |
| William E. Hart | Irrigation systems, drainage, waterlogging, field machinery | 1, 2, 3, 5, 6 |
| Robert A. Longenbaugh | Groundwater hydrology, hydrology, water resources, operations research or systems engineering | 1, 2, 3, 5, 6 |
| Max K. Lowdermilk | Extension work, irrigation systems planning, water management, adaptive crop research | 1, 2, 3, 4, 5, 6 |
| Kalid Mahmood | Alluvial channel mechanics, river control, hydraulic structures on alluvial channels, model studies | 1, 2, 3, 5, 6 |
| David B. McWhorter | Theoretical and practical aspects of flow in porous media and groundwater hydraulics and hydrology | 1, 2, 3, 5, 6 |
| H. J. Morel-Seytoux | Hydrology, water resources planning | 1, 2, 3, 5, 6 |
| G. E. Radosevich | Water law and administration, agricultural law, environmental law, economics of natural resources | 1, 3, 5, 6, 7 |
| E. V. Richardson | Experimental fluid mechanics, turbulence and diffusion, open channel flow, fluvial hydraulics, fluid measurement, stream morphology and water management | 1, 2, 3, 5, 6, 7 |
| James F. Ruff | Hydraulics, hydrodynamics, hydraulic structures, remote sensing, open channel flow, closed conduit flow | 1, 2, 3, 5, 6 |
| Willard R. Schmehl | Soil fertility, clay mineralogy, soil management | 1, 2, 3, 4, 5, 6, 7 |
| Edmund F. Schulz | Hydrology, flood runoff, small watershed hydrology, water resources, and flood plain planning | 1, 2, 3, 5, 6 |
| Willis Shaner | Water resource planning, engineering economics | 1, 2, 3, 5 |

Table 1 cont'

| <u>Name</u> | <u>Field of Interest</u> | Function* |
|----------------------|---|-------------|
| Gaylord V. Skogerboe | Waterlogging, salinity, irrigation systems, water measurement, drainage | 1, 2, 3, 5, |
| Daryl B. Simons | Erosion and sedimentation, river mechanics, hydraulics, stable channel design, open channel flow, flood control and navigation, water resources development, stream gaging, hydraulic structures. | 1, 2, 3, 5, |

*Numbers under the heading Function refer to the following:

- 1 - Problem identification and analysis
- 2 - Program or project design
- 3- Education and training
- 4- Extension
- 5- Advisory capacity and professional backstopping
- 6 - Research
- 7 - Evaluation of mission program

Table 2. Project purpose, objectives (outputs and means of verification).

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumption |
|--|---|---|--|
| <p>Project Purpose</p> <p>To maintain and sustain an institutional response capability in water delivery and removal practices and systems with special emphasis on improving the quality of life of the small farmer in the LDCs. In cooperation with CID to focus on problems of watershed management and on-farm water management.</p> | <p>a) Colorado State University is recognized as a center of excellence for information, personnel, adaptive research and knowledge on water delivery and removal systems, watershed management and</p> <p>b) Continuous and significant involvement and linkages with LDC institutions.</p> <p>c) Linkages and networks with other significant institutions working on food production problems in the LDCs.</p> | <p>a) Peer evaluation</p> <p>b) Record of utilization</p> <p>c) Annual report</p> | <p>a) That additional capabilities by staff increases or improvements will result in a gradual increase in utilization.</p> <p>b) Utilization will increase available funding and staff capabilities. These in turn will increase utilization.</p> <p>c) That meaningful problems will be identified in the LDCs and adequate adaptive research will be performed.</p> |

Table 2. Project purpose, objectives (outputs and means of verification).

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumption |
|---|---|---|--|
| <p>Project Output 1</p> <p>Information Capacity. Collection evaluation and dissemination of information related to water resource utilization</p> | <p>a) Distribution of reports documenting research results.</p> <p>b) Expand printing and publication capabilities of CSU.</p> <p>c) Increase the size of the library collection on water delivery and removal systems.</p> <p>d) A developed information storage and retrieval system.</p> | <p>a) Annual report and on site visitation.</p> <p>b) Receipt of publications</p> <p>c) Documentation of data storage and retrieval programs.</p> | <p>a) LDCs, CID and donor agencies will provide inputs and utilize the information system.</p> |

Table 2. Project purpose, objectives (outputs and means of verification).

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumption |
|---|--|---|--|
| <p>Project Output 2 Education and Training</p> <p>Several short courses will be developed and use will be made of on going activities such as SURGE and the International School for Water Resources.</p> | <p>a) Development and revision of courses</p> <p>b) Increase of students from LDCs in both conventional graduate training and International School for Water Resources.</p> <p>c) Development and presentation of short courses and training sessions on drainage and delivery of water to the small farmer.</p> <p>d) Development of contracts to improve training in LDCs research institutions and universities.</p> <p>e) Seminar in a LDC on soil and water management for erosion control</p> <p>f) Global Water Law Conference in 1975 to develop an understanding of legal and administrative constraints on water delivery and removal.</p> | <p>a) Annual report with specific numbers and examples of accomplishments.</p> <p>b) Number of students and countries using International School</p> <p>c) Final reports on seminars or conferences.</p> <p>d) Symposium proceedings</p> <p>e) Manuals developed for short courses.</p> | <p>a) There is a need and demand in the LDCs for the training and education so that funds will be provided for students to participate in the training.</p> <p>b) Cooperation by LDC institutions for training and education programs.</p> |

Table 2. Project purpose, objectives (outputs and means of verification).

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumption |
|--|--|--|--|
| <p>Project Output 3 Expanded Knowledge Base</p> <p>Emphasis will be placed on state-of-the-art and problem identification relating to small farms in LDCs.</p> | <p>a) Identification and evaluation of practices utilized by LDCs in water removal and delivery systems.</p> <p>b) Design and adapting new techniques for water removal that have low energy demand, can be utilized by small farmers and existing irrigation projects.</p> <p>c) Adaptive research on water delivery to small farmers that decrease water loss and improve crop production.</p> <p>d) State-of-the-art reports on water delivery and removal systems and relevant institutional development.</p> <p>e) Studies on salinity control to increase crop production and decrease loss of land from production.</p> <p>f) Low cost and energy demand pumping methods for both drainage and water supply. State-of-the-art reports on pumping systems.</p> <p>g) Handbooks on the design of drainage systems, salinity control, sediment handling methods, operation of irrigation systems, etc.</p> <p>h) State-of-the-art report on sediment problems at lower end of the irrigation system.</p> | <p>a) State-of-the-art-reports</p> <p>b) Annual report.</p> <p>c) On site observations.</p> <p>d) Utilization of both research results and staff doing the research.</p> <p>e) Requests for reports.</p> <p>f) Increase in food production.</p> <p>g) Peer review.</p> | <p>a) Effective help from AID, Research projects, and LDCs in identifying problems or needs and conducting the research, etc.</p> <p>b) Continue interaction by 211(d) directors with AID, LDCs and CID to identify research priorities.</p> |

Table 2. Project purpose, objectives (outputs and means of verification).

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumption |
|--|--|--|--|
| <p>Project Output 4 Advisory Capacity Advisory and consultant capability for AID, LDCs, consulting firms, World Bank and other donors. Provide release time, allow faculty to respond quickly to a consulting request.</p> | <p>a) Over 36 faculty are available for consulting on optimum water management for improved crop production. These are in the fields of civil engineering, irrigation engineering, watershed sciences, on-farm water management, agronomy and dryland farming.</p> | <p>a) Annual report documenting requests for consultants. b) Trip reports c) Final project reports d) Peer evaluation e) Donor recommendations</p> | <p>a) There is a need for these consulting services. b) That the availability and talent at Colorado State University is known by the potential user.</p> |

Table 2. Project purpose, objectives (outputs and means of verification).

| Narrative Summary | Objectively Verifiable Indicators | Means of Verification | Important Assumption |
|---|---|---|--|
| <p>Project Output 5 Linkages and Networks</p> <p>Linkages and networks with institutions concerned with water resource utilization for food production. Emphasis on water removal and delivery.</p> | <p>a) Establish or strengthen our linkages with institutions working in water for food production in Africa, Near East, Pakistan and Latin America.</p> <p>b) Strengthen our linkage with the other members of CID.</p> <p>c) Establish very close relations with the other 211(d) directors in the water chain.</p> <p>d) Establish a network of institutions working on water and water related problems for food production in the LDCs.</p> <p>e) Establish linkages with the centers and consortiums working to increase food production to help the small farmer.</p> | <p>a) Annual report</p> <p>b) Number of joint programs seminars and training programs that have been developed with other institutions.</p> | <p>a) AID assistance and support.</p> <p>b) The cooperation of the other institutions.</p> <p>c) Linkages and networks provide an effective basis for utilization of institutional capacity.</p> |

Table 3. Estimated Man Power and Dollar Inputs by Outputs.

| OUTPUTS | INPUTS | | Dollars |
|------------------------------------|------------|-----------|----------------|
| | Man Months | | |
| | Faculty | GRAs | |
| <u>1. Information Capacity</u> | | | |
| A. Library Acquisitions | - | - | 2,000 |
| B. Information Storage & Revetment | - | 12 | 13,000 |
| C. Publication Dissemination | - | - | 2,000 |
| TOTAL | - | 12 | 17,100 |
| <u>2. Education and Training</u> | | | |
| A. International School | - | - | 600 |
| B. Watershed Short Course (S.C.) | 1 | - | 5,600 |
| C. Water Delivery & Removal (S.C.) | 6 | 12 | 27,100 |
| D. On-Farm Water Management (S.C.) | 2 | - | 7,000 |
| TOTAL | 9 | 12 | 40,300 |
| <u>3. Expanded Knowledge Base</u> | | | |
| A. Salinity Control | 4 | 12 | 24,300 |
| B. Sediment Control | 4 | 6 | 21,300 |
| C. Water Delivery Rules | 5 | - | 14,300 |
| D. Pumping Systems | 6 | 6 | 23,300 |
| E. Erosion Control | 1 | - | 4,000 |
| F. On-Farm Water Management | 1 | - | 4,000 |
| TOTAL | 21 | 24 | 91,200 |
| <u>4. Advisory Capacity</u> | | | |
| A. Consulting Service | 2 | - | 9,300 |
| B. Release Time | 5 | - | 14,100 |
| C. Improving Advisory Capacity | - | - | - |
| TOTAL | 7 | - | 23,400 |
| <u>5. Linkage and Network</u> | | | |
| A. CID Support | 2 | - | 25,000 |
| B. Establishing Linkages | 4 | - | 13,000 |
| TOTAL | 6 | - | 38,000 |
| <u>TOTAL</u> | <u>43</u> | <u>46</u> | <u>210,000</u> |

VIII. INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

In adding faculty and graduate students to the University, a conscious effort has been made to add minorities and women. We have been more successful with students than faculty because there are so few technically trained minorities and women. Unfortunately, it has been difficult to convince minorities and women that there are opportunities in a technical career.

The College of Engineering sends out faculty to area high schools with predominantly minority students (Blacks and Spanish Americans). Several of these schools are in the Denver area. The university has a summer intern program for Blacks. These programs have not been attracting a significant increase in minorities. We think, however, that in time this will change.

We have increased the number of women enrolled in engineering with a significant increase each year in freshman women engineering students. This year two women engineers received their Ph.D. degrees in Water Management. These ladies were Drs. Catherine E. Kraeger Rovey and Della Laura Bennett. They were partially supported by the 211(d) grant. Dr. Rovey is now an Assistant Professor of Civil Engineering at Oregon State University. Dr. Bennett is a housewife.

The following U.S. minorities have been involved in the program.

| | <u>Faculty</u> | <u>Graduate Students</u> |
|--------------------|----------------|--------------------------|
| Women | 2 | 2 |
| Blacks | | |
| Spanish Americans | 1 | |
| American Orientals | 4 | 2 |

IX. TABLES I, II-A and II-B

Table I shows the distribution of 211(d) grant funds and contributions from other sources of funding for the reporting period 23 May 1974 to 30 June 1975.

Table II-A shows the 211(d) actual and projected expenditure for the reporting year.

Table II-B shows the detail expenditures for the reporting year.

Table I
 Distribution of 211(d) Grant Funds and Contributions From Other Sources of Funding*
 Reporting Period 23 May 1974 to 30 June 1975

| 211(d) Expenditures | | | | | |
|--------------------------|---------------------|------------------|---------------------|---------------------------|-----------------------------|
| Grant Objectives/Outputs | Period Under Review | Cumulative Total | Projected Next Year | Projected to end of Grant | Non-211(d) Funding** Amount |
| Information Capacity | 1,975 | 114,745 | 8,550 | 8,550 | 100,000 |
| Education and Training | 10,123 | 149,148 | 20,150 | 20,150 | 50,000 |
| Expanding Knowledge Base | 49,554 | 215,721 | 45,600 | 45,600 | 1,000,000 |
| Advisory Capacity | 7,975 | 290,038 | 11,700 | 11,700 | 20,000 |
| Linkages and Networks | 15,100 | 65,470 | 19,000 | 19,000 | 30,000 |
| Total | 84,727 | 835,122 | 105,000 | 105,000 | 1,200,000 |

* These figures are best estimates

**Includes other relevant AID projects

Table II-A
 211(d) Expenditure Report
 Actual and Projected Summary
 Under Institutional Grant AID/csd-2460
 Reporting Period 23 May 1974 to 30 June 1975

| | Expenditures to date | | Projected Expenditures | | | | |
|--------------------------------|-------------------------|---------------------|---------------------------|--------------|--------------|--------------|--------------|
| | Reporting Period | Cumulative Total | Year | | | | |
| | 6 | | 1 | 2 | 3 | 4 | 5 |
| | 1974-75 | | 1969-70 | 1970-71 | 1971-72 | 1972-73 | 1973-74 |
| Salaries | 48,412 | 388,125 | 55,460 | 53,587 | 84,594 | 79,566 | 66,506 |
| GRA | 18,850 | 219,366 | 21,977 | 37,044 | 59,695 | 52,426 | 29,374 |
| Travel | 6,916 | 63,491 | 4,351 | 19,470 | 13,188 | 16,232 | 3,334 |
| Equipment | 826 | 4,253 | 213 | 3,118 | - | 96 | - |
| Office Expense and Computer | - | 124,262 | 13,132 | 19,291 | 28,082 | 33,465 | 30,292 |
| Library and Publications | <u>1,487</u> | <u>27,389</u> | <u>6,077</u> | <u>1,188</u> | <u>9,515</u> | <u>3,604</u> | <u>5,518</u> |
| | 84,727 ^{1/} | 835,122 | 101,210 | 133,698 | 195,084 | 185,389 | 135,024 |

^{1/} Includes CID Support

Table II-B
211(d) Expenditure Report
Reporting Year Detail
Und. Institutional Grant AID/csd-2460
Reporting Period 23 May 1974 to 30 June 1975

| I. A. <u>Professional</u> | <u>% of Time</u> | <u>Salaries</u> |
|--|--------------------|--------------------|
| M.L. Albertson | 11 | 3,311.10 |
| K.G. Brengle | 4 | 1,791.82 |
| W.E. Hart | 22 | 3,711.16 |
| K. Mahmood | 22 | 4,000.00 |
| A.M. Melone | 14 | 1,225.00 |
| G.E. Radosevich | 12 | 1,722.92 |
| E.V. Richardson | 32 | 7,944.69 |
| J.F. Ruff | 22 | 3,618.00 |
| W.W. Shaner | 22 | 4,377.79 |
| G.V. Skogerboe | 22 | 4,545.06 |
| E.C. Vlachos | 11 | 2,044.44 |
| R.C. Ward | 25 | 4,255.02 |
| | Total Professional | 42,547.00 |
| B. Clerical | | 1,526.23 |
| Library | | 0 |
| Other nonprofessional | | 0 |
| C. Fringe Benefits-Retirement only 9.5% of Gross Salary | | 4,338.75 |
| | | <u>\$48,411.98</u> |
| II. <u>Student Support</u> | <u>Country</u> | <u>Amount</u> |
| H.G. Blank | USA | 4,650.04 |
| A.M. Melone | USA | 300.00 |
| J.A. Riley | USA | 3,150.00 |
| S.W. Smith | USA | 2,700.00 |
| M. Svendsen | USA | 2,400.00 |
| D.M. Temple | USA | 2,700.00 |
| A.D. Wood | USA | 2,400.00 |
| | | 18,300.04 |

Table II-B (continued)

| | |
|---|--------------------------------|
| III. A. Consultants | 0 |
| B. Guest Lecturers | 0 |
| IV. Travel | |
| A. Domestic (14) | 2,449.73 |
| B. Foreign (8) | 4,465.90 |
| | Total 6,915.63 |
| V. Equipment | 826.25 |
| VI. Library Acquisitions | |
| Thesis & Dissertations, Reports, Papers, etc. | 1,224.80 |
| VII. Other | |
| Telephone | } 262.80 |
| Postage | |
| Computer | |
| Miscellaneous | |
| CID support | 8,235.00 |
| | Grand Total \$84,726.50 |

Table III-A

Table III-B

These tables are shown in section VI of the report

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Appendix 1

Students in International School
for Water Resources & Associated Programs
January 7, 1975

Abraha, Berhane, Regional Manager-Co-Manager on Water Supply Project,
National Water Resources Commission, Addis Ababa, Ethiopia.
Sponsored by: United Nations-Oleg Kalashnikov
Dates here: 9/74-6/75
Local Address: 612 Durward Hall
Phone: 491-4576

Brayhon, Henry, Senior Hydrologist, UPRP-NIA, Quezon City, Philippines.
Sponsored by: Engineering Consultants, Inc., Denver
Dates here: 1/75-3/75
Local Address: International Center, 614 Mathews
Phone: 493-9820

Bhorntus, Chavalit, Highway Department, Material Testing & Research Div.,
Bangkok, Thailand.
Sponsored by: Royal Thai Embassy
Dates here: 9/74-6/75
Local Address: 519 S. Meldrum, #320
Phone: 484-4151

Campos, Jose Humberto, Hydrologist Engineer, Direccion General de Recs. Nat
Renov., San Salvador, El Matasano Soyapango, El Salvador, Central
America.
Sponsored by: World Meteorological Organization
Dates here: 1/75-6/75
Local Address: College Inn, 601 S. Howes
Phone: 484-3704

Duarsa, Putra, Manager for Operations & Logistics, Brantas Multi-purpose
Project, Director General of Water Resources Division, J.L. Surabaya 2/
Malang, Indonesia.
Sponsored by: Aid through Bureau of Reclamation, Denver
Dates here: 1/75-3/75
Local Address: 645 Remington
Phone:

Hample, Karoly Ferenc, Deputy Leader of the Department of Planning
Works Institute for Hydraulic Planning, Budapest, Munnich F.-u.26.
Hungary.
Sponsored by: FAO, R. Doan
Dates here: 1/30/75-6/75
Local Address:
Phone:

Jafar, Ata Mohammad, Executive Engineer, Irrigation/Power Department,
Government of Baluchistan, Quetta, West Pakistan.
Sponsored by: AID, George Armstrong
Dates here: 1/74-3/75
Local Address: 705 S. Washington, Apt. 308
Phone: 482-1462

Lackhan, Narine Praim, Deputy Conservator, Ministry of Agriculture, St. Clair, Port of Spain.

Sponsored by: FAO, Gary Fleming for R. Doan

Dates here: 10/74-10/75

Local Address: 1600 West Plum, Apt. 28A

Phone: 493-6849

Liao, Tsung-shen, Associate Engineer, Taiwan Land Resources Development Committee, 182, Nan-King Road, Taichung, Taiwan.

Sponsored by: AID-Chinese Embassy pays

Dates here: 1/75-12/75

Local Address: 1301 Remington

Phone: 484-0774

Palteng, Serafin A., Chief, Plan Formulation Section, National Irrigation Administration, Quezon, Phillippines.

Sponsored by: Engineering Consultants, Inc., Denver

Dates here: 1/75-3/75

Local Address: International Center, 614 Mathews

Phone: 493-9820

Soriano, Bernardo, Senior Meteorologist, Pagasa, Quezon City, Phillippines.

Sponsored by: World Meteorological Organization.

Dates here: 1/75-3/75

Local Address:

Phone:

Tharatabhand, Chalood, Soil Fertility Officer, Kalasin Project, Dept. of Agriculture, Ministry of Agriculture, Bangkok, Thailand.

Sponsored by FAO-Doan

Dates here: 6/74-5/76

Local Address: University Manor, Apt. 6, 109 West Myrtle

Phone: 493-8858

Thunya-Udom, Boripat, Field Crop Researcher (Rice), Office of the Under-Secretary of State, Ministry of Agriculture, Bangkok, Thailand.

Sponsored by: FAO-Doan

Dates here: 6/74-5/76

Local Address: University Manor, Apt. 5, 109 West Myrtle

Phone: Can be reached through Tharatabhand

Udomsiang, Prayoon, Extension Officer, Kalasin Project, Dept. of Extension, Ministry of Agriculture, Bangkok, Thailand.

Sponsored by: FAO-Doan

Dates here: 6/74-5/76

Local Address: University Manor, Apt. 5, 109 W. Myrtle

Phone: Can be reached through Tharatabhand

Vivero, Julio E., AID Engineering, IRHE, Panama, Panama.

Sponsored by: World Meteorological Organization

Dates here: 1/75-6/75

Local Address: College Inn, 601 S. Howes

Phone: 484-3704

Appendix 2

TITLE: International Conference on Global Water Law Systems

SUBJECT: Summary of action and conclusions of 8-12 September meeting in Spain

On 8 September, Dr. George E. Radosevich left Fort Collins for Valencia and Madrid, Spain to confer with Senor Vicente Giner and others regarding various topics essential at this stage of the pre-conference activities. Dr. D. Daines accompanied Dr. Radosevich during this period of time, and remained in Valencia a few days more to wrap up several details while Dr. Radosevich went to London to confer with the Director of the Water Resources Board of England.

The following issues were acted upon:

1. Time of Conference: 1-6 September 1975

It was concluded that this was the most ideal time for the conference. Water uses for agricultural and other purposes are still in process, the time just precedes harvests, the weather is still warm, and this date immediately precedes another major conference in Valencia, and thus hotel accommodations remain available.

2. Place of Conference:

Originally the conference was to be held at the beautiful Hotel Monte Picayo overlooking the Valley of Valencia. However, rates during September are far in excess of per diem allowances and believed beyond ability to pay by persons attending from developing countries (\$25 per night per person without food).

Senor Giner suggested the excellent facilities of the Faculty of Law in Valencia and we discussed this proposition with the Dean of Law, Senor Cobo. No obstacle appears; however, a formal request for use of the facilities will be sent from Colorado State University to Dr. Cobo.

3. Format:

The general format included in the proposal is acceptable. Changes will have to be made as follows in order to reflect local customs and allow for tours around the local area. Sessions will run as follows:

| | | |
|------------|------------------------|--|
| Sunday: | Registration and tours | 1200 - |
| Monday: | 0900 - 1300 | 1500 - 1800 |
| Tuesday: | 0900 - 1300 | 1500 - 1800 2000 Reception and Social Hour |
| Wednesday: | 0900 - 1700 | Tour of Huerta of Valencia |
| Thursday: | 0900 - 1130 | 1200 Tribunal of Waters 1500 - 1800 |
| Friday: | 0900 - 1300 | 1500 - 1800 |
| Saturday: | 0900 - 1300 | 1500 - 1700 |

4. Outline of Topics:

Remains the same except for a few additions. In Part I a discussion of the water law in the Canary Islands will be added to the presentation on Spanish water law system. In Part II, A.2.i. specific cases, four minor water law systems will be discussed. They are: Hindu-Bali; Hispano-Latin American; Israeli; Australian-Asiatic.

In Part IV B.1 on Human Environment and Water Law, g and i will be merged and consist of major presentation with panel of water law experts assisting the key speaker field questions. A new topic will be added on transmountain diversions.

5. Speakers:

There was no objection to the tentative list of speakers. Senior Giner provided the suggestions for Spanish speakers for several positions; i.e., Spanish Water Law Systems; Conjunctive Use of Ground and Surface Water; Chairman for Part IV and addition of one paper covering transmountain diversions. Cable contact has been made with all speakers on Appendix I, except for those contacted by telephone (Part IV B.1, 3, 5, 7, 9, 10) and those who will be contacted by Senor Giner (Part II 2.).

6. Registration:

A fee of \$10 pre-paid for all pre-registrants will be charged.

7. Conference Languages:

The conference will be carried out in two languages--Spanish and English. This is a retraction of the previous position of Spanish-English-French. Primary reason is cost involved; secondary reason is the conference complications and facilities. In this manner, only two interpreters (oral translators) will be required and only one set of microphones and earphones necessary.

8. Local Public Relations Work:

Senor Vicente Giner has agreed to take charge of all local arrangements; i.e., tours, transportation, local public relations, hostess services for wives and family of conferrees, banquets, coffee hours, entertainment, etc. Communications between co-directors will cover this topic more frequently as the conference date draws near.

9. Conference announcements, pamphlets, etc.:

Professor G.V. Skogerboe is in charge of this topic. A draft pamphlet will be taken to Madrid by Professor Skogerboe on 5 November for discussion/approval by Senor Giner and Commissioner of Water Resources.

10. Spanish Contribution:

Meetings in Valencia were held with the Governor of the Province, Lord-Mayor of Valencia, President of the Tribunal of Waters, Administrative Chief of the National Water Resources Branch for Province of Valencia, and Dean of College of Law, Valencia. In Madrid meetings were held with the Commissioner for Water Resources Bureau, Ministry of Public Works and his chief advocate.

In terms of contributions: The Ministry of Public Works is enthusiastic about the conference, has agreed to co-sponsor and provide financial assistance. The amount is not yet determined; it will depend upon the new estimates to be obtained of translations equipment, tape recorders, interpreters, small secretariat in Valencia and other costs. George E. Radosevich will formulate revised budget and transmit to Senor Giner. Approximately \$10,000 is anticipated.

A banquet has been pledged by the City and Provincial Council in the amount of 300,000 Pts. (\$5,000) approximately. It is estimated the Community of Irrigators will provide \$3,000 - 5,000.

11. Local Attendance:

Senor Giner estimated approximately 100 persons may attend from Spain.

12. U.N. Association with Conference:

Discussions with the Associate Director of Resources and Transport Division, U.N. and the Associate Chief of Water Resources Section RTD concluded that the U.N. should be listed as a participant in the International Conference and that results of this Conference will serve as an input into the U.N. World Water Conference to be convened in Buenos Aires, Argentina, in mid-1977.

In summary, the Conference is now launched. Providing USAID funding comes through within the very near future as Mr. Plucknett has stated many times, then no real financial problems appear on the horizon.

The next step is to immediately contact all identified speakers and secure their commitments.

GLOBAL WATER LAW SYSTEMS: REPORT FORMAT

II. Spectrum of Alternatives: Existing Water Law Systems

A. Proceedings

1. Background of systems formulation through custom, religion, and/or legislation
2. Elaboration of major identified water law systems or variations (as descriptively outlined in Figure 1)
 - a. Roman and Modern Italian
 - b. Spanish
 - c. Moslem
 - d. Chinese
 - e. English Common Law (Riparian Doctrine)
 - f. French (Continental System)
 - g. Russian
 - h. North American (Appropriation and Riparian Doctrines)
 - i. Specific cases illustrating unique features, i.e., Israel, Bali, etc.

B. Procedures

The specific format of summary presentations for each legal system or sub-system (to be followed in both the written report and the oral presentation) will include:

- a. Brief introductions into the legal philosophy and framework of the water law system (national or federated)
- b. Delineation of the policies of the law
- c. Status of the substantive laws regarding:
 - (1) Classification of waters
 - (2) Concept of ownership
 - (3) Manner of allocation and control, i.e., permit, water right, etc.
 - (4) Preference of uses and status of preferred use
 - (5) Meaning and application of efficiency criteria, i.e., concept of beneficial use
 - (6) Treatment of ground, surface, and other classes of water
 - (7) Relevance to both quantitative and qualitative problems
 - (8) Implementation provisions
 - (9) Types and extent of enforcement provisions and procedures
 - (10) Impact of law on the environment
 - (11) Constraints to rational water allocation and management, i.e., appurtenancy doctrine, prevention of investment opportunity
 - (12) Other particulars of the system: relation of water law to taxes, subsidies, public project implementation and financing, and land use

d. Trans-national water dependencies (problems of multi-national water systems)

- (1) Legal doctrine
- (2) Jurisdictional aspects

III. Spectrum of Alternatives: Water Institutions and Organizational Arrangements

A. Proceedings

1. For each major legal system described in Part II, specific organizations and procedures for carrying out water allocation, use, and control will be discussed
2. Analysis will concentrate around two dimensions:
 - a. Description and operation of the organizational arrangement designed or developed to carry out the water laws (including specific administrative forms of public, quasi-public, or private systems)
 - b. Problems of management (Personnel, facilities, and procedures)

B. Procedures

1. The specific format for the written paper and summary presentations will include:
 - a. Introduction into organizational philosophy and framework (i.e., national or federated system of management)
 - b. Defining the levels of administration
 - (1) Public or governmental water organizations
 - (a) National, provincial/state, sectoral, or local water levels with their functions, manners of administration, and degrees of authority, specifically elaborating on those charged with enforcement of substantive laws--administrative agencies, judicial bodies, etc.
 - (b) Identifying facilitators and/or organizational constraints in structures for rational water allocation and management
 - (2) Private and quasi-public use and management entities
 - (a) Operation, scope of involvement, fundamental purpose of each with particular reference to:

- Types of water demands (agricultural, municipal, industrial)
 - Types of water uses (consumptive, stream flow, on-site)
- (b) Constraints and/or facilitators in structure to rational water allocation and management

Appendix 3-A

ABSTRACT OF DISSERTATION
NUMERICAL MODEL OF FLOW IN A STREAM-AQUIFER SYSTEM

A three-dimensional, finite difference model was developed for simulating steady and unsteady, saturated and unsaturated flow in a stream-aquifer system. The basis of the model is the finite difference form of Richard's equation for unsaturated and saturated subsurface flow. Effects of streamflow on groundwater movement are treated by applying the appropriate boundary conditions to Richard's equation. Contributions of groundwater to river flow are quantified by including seepage rates in the computation of river discharge. The three-dimensional model was developed for use in this study to interact with two-dimensional model segments, which were interfaced with the three-dimensional model on its upstream and downstream ends.

The model produced results which match observed data for the study area, which consisted of a 40 mile reach of the Arkansas Valley of Southeastern Colorado. Computed estimates of river discharge at each end of the study area and water table elevations throughout the region agreed reasonably well with observed data. An analysis of the sensitivity of results produced by the model to variation in the values of several input parameters was included as part of the study.

Catherine E. Kraeger Rovey
Civil Engineering Department
Colorado State University
Fort Collins, Colorado 80523
Fall, 1974

Appendix 3-B
ABSTRACT OF THESIS
STABILITY OF EARTH COVER OVERLYING PVC MEMBRANES

Knowledge of the shear strength which develops along the contact between a buried, flexible, membrane lining and its overlying cover material is of importance in the economical design of the side slopes in water storage structures and conveyance channels where such linings are used.

Tests were done under both dry and submerged conditions to determine the shear strength which could develop between a polyvinyl chloride (PVC) lining and five different soil cover materials. Four of these were freely draining sands and gravels while the fifth was sandy with silt and clay fines. Seepage was considered qualitatively but drawdown and wave action were not investigated.

The friction angle along the soil-lining contact, ϕ_1 , was essentially the same under both dry and submerged conditions for the materials tested. The value of ϕ_1 varied from around 18 to 28 degrees for soils whose angle of internal friction, ϕ , ranged from about 32 to 50 degrees. Coarser cover material sizes and higher densities increased the values of ϕ_1 .

Roger Drury
Department of Civil Engineering
Colorado State University
Fort Collins, Colorado
Spring, 1975

Appendix 3-C
ABSTRACT OF THESIS
SOIL PUDDLING FOR REDUCING SEEPAGE

This thesis is a report of laboratory and field studies designed to determine the potential of soil puddling for reducing seepage in irrigation distribution systems.

Laboratory studies were conducted under ideal conditions of thorough puddling, a screened soil, constant head, and nearly constant temperature. Field studies were conducted under less controlled but more realistic conditions. A 26-foot, polyethylene covered, rectangular channel was constructed at three field sites, and seepage was monitored before and after puddling the channel invert. Hand and mechanical puddling methods were employed. Labor input is less and the effectiveness of the puddled layer greater with mechanical puddling.

Results indicate that soil puddling has potential for reducing seepage, particularly when the entire channel perimeter can be puddled. This method can be labor intensive and adaptable to the situation found in many developing countries.

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Spring 1975

Appendix 3-D
ABSTRACT OF DISSERTATION
METHODOLOGY FOR THE SELECTION AND TIMING OF WATER RESOURCES PROJECTS
To Promote National Economic Development

The methodology developed in this dissertation is designed to facilitate the selection and timing of water resources projects to optimally achieve "a priori" specified national economic development through desired strategies. The methodology is composed of several analytical procedures.

The input-output model is used to simulate the national economy thus further facilitating consistent projections of the elements of final demands in accordance with the national economic development objectives and strategies, and assessing the total and incremental requirements for sectoral outputs of goods and services at designated future time periods. A mathematical model for the selection and timing of water resources projects for their implementation, in other words for the formulation of an optimal national water resources development program, has been developed and its application demonstrated on an example problem. The model incorporates important factors such as economic efficiency of projects, demand targets for project outputs of goods and services necessary to achieve desired national economic growth, resources capabilities and limitations, and project interrelationships. Incorporation of these and other related factors makes the model reflective of the real world problem it is intended to aid in solving.

The application on an example problem convincingly indicates it to be a very useful tool indeed in the national economic planning process. This exercise also reveals the avenues for further research improvement.

Lemma Wendim-Agognchu
Civil Engineering Department
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Fort Collins, Colorado 80523
July, 1974

Appendix 3-E
EXCLUSION AND EJECTION OF SEDIMENT FROM CANALS
BY
A.M. Melone, E.V. Richardson, and D.B. Simons

ABSTRACT

The various exclusion and ejection techniques for sediment control are discussed. The utilization of these methods relies on a knowledge of river mechanics concepts and on the proper analysis of the field conditions.

Because each river system is unique, a sediment control structure must be specially designed for each individual field situation. Although the various methods discussed have been widely used, quantitative design criteria, in general, does not exist. Only guidelines and design cautions can be presented.

The successful design of a sediment control structure requires that the engineer consider not only the local effects of the structure, but also the river system and its upstream and downstream response to changes. The key to successful design lies in the application of both sediment and river mechanics concepts.

The specific sediment control methods discussed are 1) settling basins, 2) guide walls and channel curvature, 3) guide walls and still ponds, 4) vortex tube, 5) guide vanes, 6) tunnel excluders, 7) combination tunnel-settling basin excluder, 8) combined relieving weir and silt ejector, 9) drop inlet diversion structure, and 10) combination tunnel-guide vane ejector.

Appendices are included to aid in the collection of pertinent river basin data, and in the event sediment discharge data is not available, approximation techniques are presented.

Appendix 3-F
DESIGN OF SMALL WATER STORAGE AND EROSION CONTROL DAMS

by
A.D. Wood and E.V. Richardson

ABSTRACT

The design criteria and construction methods for small earth and rock-filled dams are presented. The materials and methods to be used are considered for both mechanical and manual labor.

Several types of ponds, foundation conditions, and water uses are discussed as design considerations. Special attention is given to the selection of appropriate outlet works and spillways. The construction of earth embankments is quite dependent on available materials, however placement of water barriers and drains allows some flexibility in the cross section design. An appendix is included to address the problem of seepage and its influence on design.

KEY WORDS: Earth-filled dams, water storage, erosion control, seepage

Appendix 3-G

ABSTRACT

WATER MANAGEMENT FOR SMALL IRRIGATION RESERVOIRS IN NORTHEAST THAILAND

by

Mongkol Chotisasitorn

The primary aim of this report is to evaluate the water use efficiency of small irrigation reservoirs in Northeast Thailand. These reservoirs are necessary for consistent agricultural production in this region. Reservoir capacities are restricted by topography and rainfall runoff is their source of water. Water management of these reservoirs has to take into consideration the risk of a varying rainfall distribution.

The method of evaluation used in this report is to synchronize the cropping time with the probability of rainfall in order to minimize the risk of wet-season cropping and to maximize utilization of the reservoir storage for dry-season cropping.

The Huey Si Thon Project is used as a study area in this report. An analysis of the data indicates that the wet-season cropping schedule should depend on the amount of rainfall during May to June. Generally, the suitable cropping schedule of the wet-season crop (rice) should begin in early July. During the wet-season cropping, the reservoir storage should remain full. The full reservoir storage can then be used for dry-season cropping. If this remaining reservoir storage is not used for dry-season cropping, much of the water will be lost by evaporation and seepage. The relationship between the irrigable area for the wet-season cropping and the optimal capacity should be determined by the mean rainfall during the cropping period. Increasing reservoir capacity to reduce the risk of wet-season cropping will increase the service area for dry-season cropping. The irrigable area for wet-season cropping may be increased in the future if further research indicates that watershed runoff can be successfully diverted and stored in the rice paddies.

Appendix 3-H
CUTTHROAT FLUMES FOR WATER MEASUREMENT

Gaylord V. Skogerboe

This bulletin describes a simple yet accurate method of measuring water. It is especially suited for open irrigation channels on flat terrain. The device is relatively easy and inexpensive to construct and is self-cleaning. It should have application over a wide range of conditions where irrigated agriculture is practiced.

The Office of Agriculture, Technical Assistance Bureau (TA/AGR) is issuing a series of technical papers on subjects of primary importance to the developing countries. As is the case with previous issues in this series, this one treats its subject in a general sense and it does not attempt to deal with the particular problems of a specific country. This bulletin is the outgrowth of research efforts of Colorado State University, who has received an AID 211(d) institutional grant for strengthening research and training capacity in irrigation water delivery in order to assist developing nations in agricultural production problems on small farms.

Additional copies of this Bulletin may be obtained from TA/AGR, through the U.S. Agency for International Development Missions (USAIDs) or through Regional Offices of AID overseas. Requests for more information regarding this publication may be directed to the authors or to this office.

Leon F. Hesser
Acting Director
Office of Agriculture
Technical Assistance Bureau
Agency for International
Development
Washington, D.C. 20523

Appendix 3-I

IMPROVING WATER MANAGEMENT TO ALLEVIATE WATERLOGGING AND
SALINITY PROBLEMS IN PAKISTAN

Gaylord V. Skogerboe

Practical means for alleviating and/or controlling waterlogging and salinity problems resulting from irrigated agriculture must be developed. Where control measures are not readily apparent, research is needed to develop criteria for effective solutions. A unified research and development program requires careful planning, which includes defining specific research activities necessary for the successful implementation of control problems.

Appendix 4

Linkages and Network

COLORADO
STATE
UNIVERSITY

department of economics

FORT COLLINS
COLORADO
80521

November 22, 1974

MEMORANDUM

TO: E. V. Richardson, Director
211d Program

FROM: G. E. Radosevich, *WR*

SUBJECT: Developing U. N. Linkages

Regarding our recent telephone conversation concerning the establishment of stronger ties with the United Nations, and in particular, the UN experts in the Water Resources field, I have hereafter set out the key individuals located in New York. If you are interested in setting up an appointment with any of them, a call could be placed to Mr. Fano's number and his secretary can make the arrangements.

Dr. Vladimir Baum, Director
Resources and Transport Division
United Nations
New York, New York
(212) 754-1234 Ext. 5555

Dr. Baum is Director of the Division in charge of Water, Energy, Geology, Mining, Cartography, and Transportation. He was previously the Director of the Ocean Science and Technology Division of the UN. A very reasonable individual to work with. You should attempt to meet with him whenever possible.

Mr. Pierre Najlis
Assistant to the Director
RTD/UN
New York, NY
(212) 754-1234 Ext. 5553

Pierre Najlis was previously with the Water Resources Section, RTD/UN. He is an economist currently serving as Baum's right-hand man. If you should like an appointment with Baum, it might be best to get in touch with Pierre.

Karl-Erik Hannsen
Associate Director
Resources and Transport Division
United Nations
New York, NY

Mr. Hannsen is the individual primarily responsible for conferences and reports emanating from the Resources and Transport Division.

Mr. Alagappa Alagappan, Chief
Water Resources Section
RTD/UN
New York, NY

Mr. Alagappan is the actual Chief of the Section, however, he has been assigned to other details and is not directly in charge of the Section at this time. See Mr. Fano



E. V. Richardson
November 22, 1974
Page 2

Mr. Enzo Fano
Associate Chief
Water Resources Section
Resources and Transport Division
United Nations
New York, NY
(212) 754-1234 Ext. 5529

Mr. Fano is directly in charge of the Water Resources Section. He is an Italian agricultural economist on secondment from FAO. By contacting him he can put you in touch with the Water Resources Experts in the Water Resources Section.

You are probably familiar with the fact that there are two types of personnel at the United Nations. One is the UN staff which is responsible for all of the UN programs at UN Headquarters including much of the administrative details. The second class of personnel is the technical advisor, and here is where you will find your most competent water resources personnel, the ones who operate out in the field and are in charge of the UNDP programs in the developing nations. The following is a list of these people in the Water Resources Section.

Mr. Andre Bouchardeau
Technical Advisor

Andre is in charge of the River Basin Management Projects of the UN that are primarily located in Africa. A very key individual to contact.

Mr. G. A. N. Rao
Technical Advisor

Mr. Rao is by far the most competent expert from the Indian sub-continent that I have ever met. He is in charge of the River Basin and Surface Management schemes in Asia and the Middle East. He was previously the Chief Engineer of the Irrigation and Power Department of India. Humble and extremely knowledgeable.

Robert Dijon
Technical Advisor

Mr. Dijon is a ground water hydrologist whose primary work has been in Africa. Again, extremely competent particularly with respect to development of ground water for meeting needs of rural population.

Karoly Szepty
Economic Affairs Officer
Staff

Mr. Szepty is formerly the Director of the Water Resources Institute of Hungary. He is an engineer, extremely competent, has worked very closely with Lucien Duckstein.

I believe that is about all of the people at the UN in the RTD who are experts or could be considered competent in the fields we are dealing in. The UN hired a young attorney, Dominique Alhertiere, who I interviewed, to take my place when I left. They also have several other people who are almost primarily involved with the administrative aspects of the UN/RTD program.

Appendix 5

ROLE OF WATER LAW IN IMPROVING THE WATER DELIVERY AND REMOVAL ABILITIES OF THE FARMER

Gaylord V. Skogerboe

Abilities of the Farmer

One of the major constraints which farmers of today operate under is water codes, laws, regulations and systems of administration that were developed decades and in some cases, centuries ago. In modern societies with dynamic process of change an integral part of legal system, the water laws which originally evolved from custom and tradition, have been revised to at least permit implementation of new and improved technology and irrigation practices.

However, to the farmer in many LDC's his method of receiving water and removing excesses are constrained to the tradition and custom of his forefather. Even though the laws and regulations are adopted at the national and/or regional/provincial levels, the impact is ultimately upon the water user. Issues such as flexibility in transferring water to neighbors when not required, incentive to realign and maintain conveyance system and structures, irrigation practices and water pricing are all affected by water laws. One of the major concerns of small farmers today is costs associated with construction and maintenance of delivery and removal works. Yet many water codes are void of any provisions which encourage formation of water users associations.

To identify and understand the system of water allocation and control is imperative to any assistance program to farmers. Laws and regulations in most every country can be changed where the constraints imposed are unduly preventing the water user from receiving the amount of water when and where he needs it. Many systems, even in and around semiarid areas, have an adequate supply of water if proper distribution practices are employed.

The program Colorado State University is undertaking under the direction of Dr. George E. Radosevich is to obtain as much data on the major system of water allocation, distribution, utilization and removal and to make this information available in analytical form to nations requiring information and assistance in this field.