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9. ABSTRACT

The primary focus of the Colorado State University grant during the reporting year has been on delivery and removal components of the water chain with emphasis on practices applicable to the small farmer and on drain-systems. A secondary focus also was maintained on other elements of the water chain in cooperation with the CID universities. Response capabilities have been augmented resulting in notable increases in the utilization of water resource information, education and training, expanded knowledge base, advisory capacity, and linkages and networks. More specifically, the utilization activities included training at lower levels, i.e., on-site in LDCs, distribution of publications on practices applicable to LDCs, faculty and student exchange, joint advisory and research teams, building and maintaining a nationwide talent banking function for water delivery and removal, and maintaining linkages with selected international agricultural institutes and LDCs. This year major progress was made in state-of-the-art studies in water delivery and removal systems and practices concentrating on identification of simple systems easy to operate and maintain and best adapted to the varied conditions of LDCs. With regard to the above, special attention was given to cost/benefit analyses and social and political constraints as well as energy saving practices.

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**ANNUAL TECHNICAL REPORT  
1975-1976**

**IMPROVING CAPACITY OF CID UNIVERSITIES  
FOR WATER MANAGEMENT  
FOR AGRICULTURE**

**REPORT NUMBER VII  
COLORADO STATE UNIVERSITY**



**Grant No. AID/csd 2460**

**June 30, 1976**

**ANNUAL TECHNICAL REPORT  
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**IMPROVING CAPACITY OF CID UNIVERSITIES  
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**REPORT NUMBER VII  
COLORADO STATE UNIVERSITY**

**Grant No. AID/csd 2460**

**June 30, 1976**

211(d) Annual Report  
Date Due: June 30, 1976  
Date: July 15, 1976

Grant Title: OPTIMUM UTILIZATION OF LAND AND WATER  
RESOURCES FOR AGRICULTURE: WITH SPECIAL  
EMPHASIS ON WATER DELIVERY AND REMOVAL  
SYSTEMS OPERATED UNDER CONDITIONS  
CHARACTERISTIC 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: \$84,086  
Accumulated: \$919,208

Anticipated for Next Year: \$130,792

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## I. NARRATIVE SUMMARY

### A. Principal Accomplishments

#### 1. Reporting Year

The primary focus of the Colorado State University grant during the reporting year has been on delivery and removal components of the water chain with emphasis on practices applicable to the small farmer and on drain-systems. A secondary focus was also maintained on other elements of the water chain in cooperation with the CID universities. Response capabilities have been augmented which has resulted in notable increases in the utilization aspects of water resource information, education and training, expanded knowledge base, advisory capacity, and linkages and networks. More specifically, the utilization activities included 1) training at lower levels, i.e., on-site in LDCs, distribution of publications on practices applicable in LDCs, faculty and student exchange, joint advisory and research teams, building and maintaining a nationwide talent banking function for water delivery and removal, and maintaining meaningful linkages with selected international agricultural institutes and LDCs. This year major progress was made in state-of-the-art studies in water delivery and removal systems and practices concentrating on identification of simple systems easy to operate and maintain and best adapted to the varied conditions of LDCs. With regard to the above, special attention was given to cost/benefit analyses and social and political constraints as well as energy saving practices.

#### 2. Life of Grant

A brief summary of the life of the grant might be contained in the statement that the first five (5) years of the grant was spent in improving the competence of the University in water delivery and removal systems while the last two (2) years has been spent in utilizing this competence. During the period of competence development, Colorado State University increased its faculty by twenty-two (22) new professional personnel working in the area of water resources development. Thirteen (13) of these positions were fully or partially supported by university funds. A characteristic of the first five (5) year period was the development of a strong interdisciplinary team approach to research in the full dimension of water resources problems as it pertained to the economic, sociological, and engineering fields.

The comprehensive review of July 1974, drastically changed the former thrust of the grant program at CSU resulting in the elimination of generalized studies and activities in the field of water resources development, management and research. Instead, activities were concentrated on specific problems of water delivery and removal systems - particularly on the latter - as they affected the small farmer in developing countries. Research on water delivery and removal systems was expanded by a wide variety of new funding generated by the faculty as a result of the extended grant funds and joint research programs were established between CSU and with the other CID universities. During the reporting year several new courses were developed but no additions to the faculty membership were made.





## II. DETAILED REPORT

### A. General Background and Description of Problem

Improved water management is an essential element for increasing agricultural productivity throughout the world. Reports show that 60 percent of the world's arable lands are deficient in soil moisture during all or some part of the growing season and that much of the remainder suffer from floods and lack of drainage. 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. Colorado State University's emphases was in "water delivery and removal systems including relevant institutional development"; Utah State University was in "on-farm water management"; and the University of Arizona was in "watershed systems." In as much as these universities were 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.

To enlarge the scope of expertise, the University of California joined CID. The consortium is now incorporated as a non-profit organization directed by an executive director selected by a board composed of representatives from each member university. The most recent additions to CID are the Universities of Oregon State and Texas State.

As indicated above, the field of study, research and concentration by Colorado State University, seeks to find 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 recently published in an International Source Book on Irrigation and Drainage to the effect 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 incompleted 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.

Another problem is a lack of trained people for adequate transfer of water management knowledge. This lack of technology and information continues to be a deterrent to expanded food production.

#### B. Purpose of Grant

The overall purpose of the institutional grant program is to develop confidence and expertise within U. S. research and educational institutions to help solve critical water problems of less developed countries. The specific purpose of the CSU grant was, and continues to be, to develop competence and expertise in water delivery and removal systems. However, after the initial five (5) year period of the grant, the purpose was modified by AID and the grant period extended for three (3) years in order to focus and sustain, within a utilization framework, an institutional response capability in water delivery and removal systems with emphasis on small farms.

This report period covers the second year of the revised plan. The primary focus, as already indicated, is 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 are 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, through a process of system analysis, with special emphasis on improving the quality of life of the small farmer in the LDCs. Also, to cooperate with the CID universities to focus on problems of watershed management and on-farm water management.

In support of the above program, it is expected that the consortium (CID) will cooperate by helping to prevent duplication of efforts among the six universities and that AID will continue to strengthen the long-range resources of the educational and research institutions for effective institutional response to the continually expanding needs of the LDCs.

### C. Objectives of the Grant

#### 1. Objectives Restated

With regard to the objectives restated, it should be kept in mind that the AID grant review of July 1974-75 rearranged the original objectives into five (5) specific objective outputs which are outlined in paragraph (i) following.

The initial grant program had as its main objective a broad scale plan to increase and expand the existing competence of Colorado State University in the science and technology concerned with water delivery and drainage systems. Increased competence in teaching and in research activities were to be developed as follows:

Specific objectives (as stated in grant document)

a. Expand its professional staff in the various departments of the University which are now involved, or which would like to be involved,

in water resources activities related to the needs of the less developed countries.

b. Expand its number of graduate students in these departments from or interested in, the less developed countries.

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

d. Expand its course offerings in these department – including interdisciplinary courses – which are related to the less developed countries.

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

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

g. Expand its capability to serve in advisory and consulting capacity to various individuals, government agencies, industries, business, and other organizations who have an interest in activities abroad. It would be understood, however, that substantial specific services in this area will be funded by AID and any other sponsoring agencies under separate contractual arrangements.

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

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

During the past year, a review by AID of this grant program resulted in identifying for the future the following specific objective/outputs:

1. Information capacity
2. Education and training
3. Expanded knowledge base (state-of-the-art (SOTA) studies)
4. Advisory capacity

### 5. Linkages and networks

It was felt that by organizing research, teaching, and training to provide the above outputs, the response capabilities would be greater and information transfer to developing countries would be more effective. During the reporting year, personnel of CSU receiving some support from grant funds, and others, have given special attention to the utilization aspect of their research work. An example of the more practical research accomplished useful to the small farmer is the SOTA study on "Water Lifters and Pumps for the Developing World."

### 3. 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 CID 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. CID 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.

### III. ACCOMPLISHMENTS

#### Introductory Statement

As a direct result of the comprehensive review of the Colorado State University grant and of the general review of all grants in the CID university group in July 1974, the emphasis for each university has been changed from one of increasing University competence to one of utilization of the developed competence.

As a result of decisive steps taken by Colorado State University last year to refocus and concentrate on strengthening the University's ability to solve problems relating specifically to grant objective/outputs, perhaps the most significant step was the channeling of institutional response capability away from large and complicated water delivery and removal systems and practices to smaller and simpler systems more likely to win popular acceptance and make a major contribution to the improvement of the quality of life of the small farmer in the LDCs.

The presentation of accomplishments for the initial 5-year period of the grant in terms of the five (5) outputs approved last year will obviously have to be estimated. But an attempt will be made in the body of the report as well as in Table 1 in the summary of accumulated accomplishments for the life of the grant.

#### A. Objective/Output #1 Information Capacities

##### 1. Narrative Description

Information capacities is concerned with the collection, evaluation, and dissemination of information relating to water resource utilization. At CSU it relates specifically to: (a) increasing the size of the library collection on 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 CSU, and (d) increasing the distribution of reports documenting research results to appropriate sources.

In order to keep pace with the multitude of scientific and educational books, papers, reports, and journals received every day from all parts of the world, this University, like many others, is having to resort to such major aids as microfiche and computerizing to make the desired information more easily available to students, staff, and faculty.



This modernization process has been extended in recent years to increase the collection of information relating to water delivery and disposal systems on a worldwide basis.

## 2. Targets for Reporting Year

The targets for this objective/output are:

- a. Cooperate with CID universities in perfecting a computerized information storage and retrieval system.
- b. Acquire specific and appropriate library acquisitions in fields of water delivery and removal systems helpful in improving food production and living conditions for the small farmers.
- c. 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:

— 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.

## 3. Accomplishments

### a. Reporting Year

— Marjorie Rhoades, Engineering Sciences Librarian, Barbara Burke, Engineering Sciences Branch Librarian, and Dr. Max Lowdermilk of the CSU/AID Water Management Research Project in Pakistan attended a workshop for the development of a CID information network system, held at Tucson, Arizona, September 22-25, 1975. As a result of this meeting it was agreed, after a discussion of problems, opportunities, and goals, that an information network named CIDNET would be established. The first steps were taken immediately by an exchange of journal lists among the member universities including computerized indexing of pertinent articles in selected journals, technical reports and book holdings. This index has been designed to be compatible with the MUSAT index now being compiled at the University of California, Riverside.

It soon became evident that subject parameters had to be established. Accordingly, Everett Wallace of the Libraries at the University of

California, Riverside visited CSU on October 29-31 to meet with the Advisory Committee. It was decided that the computerized index would limit its coverage to the fields of hydrology and irrigation including items on food, resources, and agriculture deemed useful to developing countries. To make the above information available to the CID network, a special training session attended by three (3) librarians from CSU and three (3) CIDNET persons from the other universities was held at the CSU Engineering Research Center. Machine readable data is now available, or soon will be, at most of the CID libraries.

As a result of the above training two (2) CSU librarians, part time, and a half-time indexer-typist, have made more than 1000 index entries which print out into separate indexes by author, title subject and geographical area. While still in the developmental stage, this index promises to be a powerful tool maximizing, and making available to the CIDNET community, the strong collections at Colorado State University. Thus, the first steps have been taken of making the collection known and available to the CIDNET participants.

— Colorado State University in cooperation with CID universities 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. A sample of the distributing of reports documenting research results may be found in Appendix A.

There remains, however, a real problem of how to fulfill requests for such library services from foreign countries. Assignment of responsibility and adequate funding are needed if this aspect of library service is to become viable.

b. Accumulative

From the beginning of the 211(d) program, CSU has recognized the necessity of developing a computerized information storage and

retrieval system, especially for the items relevant to the concerns of the grant. During the past several years a number of significant steps have been taken to improve the library system at CSU. 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. Librarians have been trained in different skills required to implement the computer processes. All of this had led to the training of library personnel, collection - and subsequent acquisitions of library material - under the centralized control and funding of the general library system. These improvements have resulted in CSU's ability to enter effectively into the CIDNET computerized information center making more easily available in much less time and cost, valuable information formerly virtually unobtainable.

c. Total Expenditures

i. Reporting Year

This amounts to \$6,826

ii. Accumulative

For the last seven (7) year period, this amounts to \$115,506

iii. University and Other Sources

The total expenditure for this category is estimated to be \$110,000 for such items as staff salaries, book purchase, periodicals and printing of publications.

B. Objective/Output #2 Education and Training

1. Narrative Description

The objective/output for this classification is to design, develop and strengthen education and training programs in the field of drainage and delivery of water to the small farmer. The primary purpose is to help meet the need and demand in the LDCs for such training.

During the reporting year excellent progress has been made in reaching this objective.

2. Targets for the Reporting Year

a. Maintain and strengthen the International School for Water Resources and Associated Programs to provide training to professional personnel from developing countries who seek improvement of their capabilities.

b. Continue two-hour seminars on issues in International Agricultural Development.

c. Colorado State University to assume primary responsibility for developing a short course involving practical aspects of irrigation water delivery and removal systems geared to the small farmer in LDCs.

d. Develop a CSU course on Project Planning for the LDCs with emphasis on techniques for identifying, preparing, evaluating, and implementing projects.

e. Colorado State University will assist Utah State University by reviewing a syllabus of a short course in practical aspects of on-farm water management prepared by USU; and CSU will also assist, along with other CID universities, the University of Arizona to prepare a short course in Watershed Management.

### 3. Accomplishments

#### a. Reporting Year

— The International School for Water Resources and associated programs, administered by the College of Engineering and the Department of Civil Engineering, continued its excellent performance in providing, on a flexible basis, needed additional education for many professional personnel from around the world seeking improvement of their knowledge in order to return to their organization and perform their role in a more effective manner. The school is an interdisciplinary nondegree school for short or long term (2 weeks to 2 years) training of LDC people in all phases of water resource including other phases of engineering and the applied sciences. Courses chosen for participants are selected because of their practical or applied nature. The International School has no faculty of its own, but utilizes the regular faculty in the various departments of the nine colleges on campus. The School is entirely state funded and no 211(d) grant funds are utilized.

Perhaps the most outstanding development in the School's program of continuing education is the departure from a relatively narrow field of instruction to a much broader base including the following academic fields:

Water Resources and Development  
 Hydraulic and Fluid Mechanics  
 Hydrologic and Hydraulic Modeling  
 Hydrology  
 River Mechanics  
 Water Resources Systems  
 Groundwater  
 Environmental Engineering  
 Control of Air and Water Pollution  
 Agricultural Engineering  
 Agronomy  
 Soil Science (Agricultural Soils)  
 Urban Water Management  
 Water Law and Related Administrative Aspects

Since initiation of the International School, students from thirty-five (35) countries have participated in various school programs. Some of the programs were only for several weeks, others were for several years. Still others who so desired and had the requirements, were absorbed into the University system and went on to obtain a Masters or Ph. D. degree. Over the past several years, 79 students have enrolled at the International School for Water Resources and Associated Programs. For such details as the particular names, highest degrees attained, home country, who provided financial assistance, length of time in school, dates, their special interests, and the award granted upon termination of the school program, may be found by turning to Appendix B.

— Open seminars, at no cost to the 211(d) program, were held on issues in International Agricultural Development. The following subjects are typical of the issues discussed:

"The World Food Situation and the U. S. Role in Production" conducted by Professor Victor Koelzer.

"Development Strategies in the Low Income Nations" led by Mark T. Svendsen

"Rural Employment Dynamics in Developing Countries" conducted by Dr. Jerry Eckert.

"Field Methods and Problems in Watercourse Surveys in Pakistan" led by Dr. Max Lowdermilk

"International Conference on Global Water Law Systems in Perspective" conducted by Dr. George Radosevich.

"Technology Transfer and the Low Income Nations" led by Mr. Janakiram Subramaniam.

"Agriculture in the Mekong Delta" led by Dr. Sidney Bowers.

"Socio-Economic Aspects of Water Management" led by Dr. Evan Vlachos.

"Improving Irrigation Water Management" conducted by Professor Gaylord Skogerboe.

"Contribution of International Agricultural Research Centers to Increase Food Production" led by Dr. Gurdev S. Khush

— Dr. William E. Hart, Agricultural Engineering, conducted a two-week summer course in August 1975 on irrigation water delivery and removal systems. The purpose was to observe many of the irrigation and drainage systems now in use in Colorado and to show how they are adapted to local conditions. The field trips covered commercial and experimental installations in Grand Junction, the San Luis Valley, the Arkansas Valley, eastern Colorado, the Platte River, and the Grant Range. Dr. Arthur T. Corey, Agricultural Engineering, assisted Dr. Hart. This course will be given again next year in August of 1976.

— Dr. Willis W. Shaner, Mechanical Engineering Department, created a short course on Development Planning for Developing Countries, including instructions in project evaluation. This course has been integrated into the regular University curriculum. Preliminary discussions have been held with USAID officials about offering a similar course to USAID staff and foreign students during summer sessions. Also a follow-up course to the one noted above is being planned for this fall. If approved, this would be given to a small group of graduate students specializing in economic development. Case studies would be analyzed and the techniques of analysis proposed by UNIDO, OEDC, and the World Bank would be studied.

Dr. Shaner is also studying, analyzing and determining through optimization processes the improvements to the methodology used in evaluating the small-scale irrigation project, "Water Resources Projects to Aid Peasant Farmers in the Peruvian Sierra..." in Peru last year. This study is in the formative stages and will most likely be the dissertation topic of Axel Dourojeanni of the Direccion General de Aguas in the Peruvian Ministry of Agriculture who is now a Ph. D. candidate under Dr. Shaner's direction.

In conjunction with the above activities, Dr. Shaner developed a computer program for carrying out financial and economic analyses of investments in small-scale irrigation projects, based on a USAID computer program and work done in Peru. Tom Sheng, a Ph. D. candidate under Dr. Shaner, is working on this program and plans to write his dissertation on computer assisted optimization techniques in project analysis of less developed economies.

In addition to the above activities, Dr. Shaner also participated in the planning of an on-site course in Lima, Peru on the transfer of modern methods of systems analysis in water resources planning. Discussions were held with Peruvians during a one-week visit to the CSU campus. Course activities will include preparation of material, a two-week course participation in Lima, and assistance to the Direccion General de Irrigaciones concerning the proposed Tacna project in southern Peru. CSU's presentation in Lima is scheduled for June 28 to July 23, 1976.

b. Accumulative

Due to persistent refocusing on the real needs of developing countries, more effective and greater utilization of research results has taken place, particularly during the last several years, in CSU's education and training activities.

c. Total Expenditures

i. Reporting Year

The expenditures for this year was \$16,100.

ii. Accumulative

The accumulative expenditures amounted to \$157,730.

iii. University and Other Sources

These are estimated to be \$55,000. The University completely supports such activities as the International School of Water Resources, Seminars and new courses developed originally to carry out the objectives of the 211(d) grant.

C. Objective/Output #3 Expanded Knowledge Base

1. Narrative Description

With regard to this category, emphasis during the reporting year has been placed on state-of-the-art studies as well as problem identification relating particularly to small farms in the LDCs. More

specifically, emphasis has been placed on such factors as identification and evaluation of practices utilized by LDCs in water removal and delivery systems; the design and adaptation of new techniques for water removal having low energy demand; adaptive research on water delivery to small farmers resulting in the decrease in water loss and increase in crop production; salinity control to increase crop production and decrease loss of productive land; and on state-of-the-art reports on water delivery and removal systems.

Thus Colorado State University continues to provide leadership for CID in developing state-of-the-art reports on (1) low cost water removal and low energy demand pumps, (2) sediment control in delivery systems, (3) water delivery-rules and procedures, (4) waterlogging and salinity, (5) project planning.

From these studies, handbooks are in varying stages of development covering design and recommended procedures. The above topics are of great concern to LDCs and the practical application of research results are bringing major benefits to developing countries.

CSU continues 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, though the leadership responsibility lies elsewhere in CID.

The 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. Many results of the state-of-the-art studies have been forwarded during the last several years to LDCs and these will help fill gaps in existing knowledge and provide guidance for future research and training needs. The studies, as completed, are being widely distributed in the states and abroad, 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 the Reporting Year

- a. A SOTA study on "Water Lifter and Pumps for the Developing World."
- b. A SOTA study on "Sediment Stable Canal Systems."
- c. A SOTA study on "Global Water Law Systems."
- d. SOTA studies on:
  - "Optimal Irrigation Decisions."
  - "Investigating Agricultural Waterlogging and Salinity Problems."
- e. A SOTA study on Methodology for the Selection and Timing of Water Resources Projects to Promote National Economic Development."
- f. Study on "Optimizing Crop Production through Control of Water and Salinity Levels in the Soils."
- g. Water Resources Project Planning
- h. Other Cooperative Studies

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 - increased 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 establishing an adequate foundation for accomplishing this set of goals. A critical assumption, however, for continued success would be that Colorado State University in cooperation with CID, can 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 these state-of-the-art analyses which are mutually recognized by AID and the CID universities as being of high priority.

## 3. Accomplishments

### a. Reporting Year

#### Low Energy Demand Pumps

— Raising water for irrigation and drainage were among man's first motives for developing water lifting devices. Without such water lifters, many areas of the world would not be fit for agricultural

use; too arid to grow food or forage crops, or too wet to allow cultivation. Over some five millenniums, water lifting has grown into a major industry, producing thousands of types and sizes of devices both to lift water and to serve as prime movers. The thesis on "Water Lifters and Pumps for the Developing World" was prepared by Alan D. Wood as a state-of-the-art study presenting a review of how water lifting has developed throughout the world, where it stands today, and provides some insight into its future needs. Guidance and assistance in the preparation of this thesis were provided by Dr. E. V. Richardson, Dr. J. F. Ruff and Professor G. V. Skogerboe. An abstract of this thesis may be found in Appendix C-1 of this report.

— With regard to the above SOTA report, CSU cooperated with USU to define the division of labor in the SOTA report on low head irrigation and drainage water lifting. At a meeting held in December 1975, it was decided that Alan Wood go ahead with a Masters thesis on low head water lifting methods for irrigation and drainage. It was also decided that Charles Burt of USU proceed on his SOTA work of improving the lifting efficiency of windmill power pumps. At this meeting other information and references were exchanged which were very useful to both universities, not only in the preparation of each SOTA report, but also from the standpoint of the future utilization of the SOTA reports in workshops and seminars.

#### Sediment Control

— The problem of sediment routing within a canal system becomes a design consideration whenever material of a size capable of being transported by the flow is available to the flow field. The purpose of this SOTA study, "Sediment Stable Canal Systems," by Darrel Martin Temple, is to review the various approaches available to the engineer faced with the problem of canal system design and to relate these to the problem of sediment routing within the system. For an abstract of this study please see Appendix C-2.

— Not hitherto reported, was a dissertation on the Geology and the Water Resource System of the Indus Plains by Alfred J. Tamburi. Geologic investigations have revealed new resource potential as well as potential geologic hazards. For example, study of sediment source areas in the Indus Basin reveals that geology is an important influence on sediment

production in the fluvial system. Reinterpretation of the classical geologic history of Pakistan in the continental drift context has also had important consequence for the water resource system. These consist of new energy sources for groundwater pumping and location of regions of tectonic instability in the canal command areas. The author's advisor was Dr. Maurice L. Albertson, Civil Engineering Department. An abstract of the dissertation may be found in Appendix C-3.

#### Water Rules and Regulations

— The International Conference on Global Water Law Systems was convened in Valencia, Spain from September 1-6, 1975. The purpose was to focus upon particular basic issues to analyze and improve water laws in the light of the role and function of the law and its relationship to other disciplines and sectors of socioeconomic activity. Among the water law systems reviewed were the Spanish, French, British, Italian, Soviet, Hindu-Bali, Moslem, Latin American, Israeli, and the variations found in the United States and selected Asiatic countries. Three key issues or problems identified as an impediment to water resources optimization were discussed in light of needed changes in the law - allocation and reallocation of water supplies; integration of water quantity and water quality control; and, management and conjunctive use of ground and surface waters. The proceedings in four volumes (1451 pages) contain the reports of some 35 specialists in water resources areas. Dr. George E. Radosevich, Department of Economics was the Conference Director. Others assisting from CSU were, Professor Gaylord V. Skogerboe, Agricultural Engineer and Dr. Evan Vlachos, Sociologist. An abstract of the completion report on the Conference proceedings is included in Appendix C-4.

— Dr. George E. Radosevich, during the reporting year, also prepared a proposal to the Government of Baluchistan on a water code for the country which is still under consideration. A preface to the proposal is contained in Appendix C-5.

— In addition to the above, Dr. Radosevich has a paper ready for publication entitled, "Moslem Water Law and Its Influence on Spanish Water Law and the Irrigation System of Valencia." An abstract of this report will be included in next year's Annual Report.

### Water Logging and Salinity Control

— Irrigation is an agricultural practice followed by man for centuries, its purpose being to increase the productivity of land resources and to reduce the uncertainty associated with crop production. This early attempt by man to control his environment for his own benefit has evolved over time to the present irrigation systems upon which the world depends for much of its food supply. A goal of modern research is to provide information to farmers regarding increased productivity through more efficient use of the land and water resources available to the farmer. This study attempts to continue this line of research. It is entitled, Optimal Irrigation Decisions with Limited Water, prepared by Herbert G. Blank and submitted as a dissertation. An abstract is shown in Appendix C-6. Guidance for this study was provided by Drs. Maurice L. Albertson, Everett V. Richardson, Robert Young, Warren Hall, John Labadie and others.

— Now nearly completed is another SOTA study which also considers waterlogging and salinity problems. This study indicates that waterlogging and salinization of agricultural land is a primary impediment to achieving the goal of doubling the production of food and fiber during the next thirty years. The title of this thesis is Investigating Agricultural Waterlogging and Salinity Problems, and is being prepared by Mark T. Svendsen. An abstract of this report will be submitted in next year's Annual Report.

— Dr. Robert Danielson and Dr. William T. Franklin of CSU are among CID investigators on a crop production function research conducted under the auspices of the Consortium for International Development. The study involves optimizing crop production through control of water and salinity levels in the soils.

Sizeable investments have been made and continue to be made throughout the world to develop irrigation potentials but only if returns to irrigation are increased through improved water management and use, results in greater food production. A knowledge of how plant growth cycles relate to moisture and salinity levels in the root zone is prerequisite to developing practical ways of maintaining optimum conditions for maximum production per unit of water concerned. The research further defines how irrigation timing and salinity management affect crop production. An ultimate objective is to develop practical techniques for predicting crop response to management measures.

### Project Planning in LDC's

Despite the fact that more and more countries are exercising some form of economic planning, and despite the fact that the literature on planning and project evaluation for developing countries is literally mushrooming, work concerning the extremely vital subject of project selection and timing for implementation to enhance national economic development is disappointingly meager and incomplete. A recent study by Dr. Wendim-Agegnehu Lemma on a Methodology for the Selection and Timing of Water Resources Projects to Promote National Economic Development addresses itself directly to this aspect. The paper develops a methodology composed of rigorous analytical procedures based on sound optimization techniques for the selection and timing of the implementation of water resources projects to enhance national economic development. For added detail please turn to the abstract in Appendix C-7.

— The following document recently published is perhaps an atypical by-product of the far-reaching consequences of the 211(d) grant. The publication, A Bibliography of Selected Periodicals for Social Scientists, by Forrest A. Deseran is a compilation of material from the perusal of literature in connection with the broad topic of social aspects of water resources development and modernization. It is in this context that one can view this particular monograph as an expression of the larger commitment of social scientists at CSU to the area of natural resources and development. See Appendix C-8 for an abstract of this publication.

— Dr. W. W. Shaner's course Development Planning for the Developing Countries has been integrated into the regular University curriculum. Due to this course and to other of his 211(d) grant related activities, the following people have been attracted to the program because of its emphasis on project planning in LDCs.

\* Ms. Lee Ann Ross, now with AID as an International Development intern.

\* Janakiram Subramaniam, Ph. D. candidate working on SOTA paper regarding project analysis of small-scale water resources projects for agricultural development.

\* Tom Sheng, Ph. D. candidate working on computer assisted optimization techniques in project analysis for the less developed economics.

\* Axel Dourojeanni, Ph. D. candidate working on analytical and optimization improvements to the methodology used in evaluating a small-scale irrigation project in the Andean highlands of Peru.

— The rapid expansion of population, industry and agriculture in arid regions of the world has brought about a substantial increase in usage of groundwater resources to supplement surface water supplies. Needed by water regulatory agencies is a planning tool for analyzing the movement of groundwater, the flow of surface water and the interaction between them. The paper by Dr. Catherine E. Kraeger Rovey titled Numerical Model of Flow in a Stream-Aquifer System describes a groundwater - surface water flow simulation model useful to water regulatory agencies. An abstract of this paper may be found in Appendix C-9.

#### Other Cooperative Studies

— While the study Water Management for Small Irrigation Reservoirs by Mongkol Chotisasitorn and Dr. Robert C. Ward, was mentioned in last year's Annual Report, it was not published until January 1976. For an abstract of this study please see Appendix C-10.

— As a result of Dr. William E. Hart's visit to Peru, a paper was prepared entitled, Irrigation Scheduling for Peru. Dr. Hart points out that irrigation scheduling has as its objective the management of water so that it is applied only at the time and in the amount needed. Under this principle, he made recommendations suitable to various areas and conditions existing in Peru. For additional detail, see the summary and recommendations in Appendix C-11.

— A paper on Water Conservation Practices for Dryland Farming was prepared by Dr. Kenneth G. Brengle, Associate Professor of Agronomy. The paper describes the practices used in dryland agriculture. The best known method, however, is summer fallow, utilizing good stubble mulch practices where wheat is produced on large acreages using large farming equipment. A summary of this report may be found in Appendix C-12 of the Annual Report.

#### b. Accumulative

Lessons of the past have taught, if nothing else, the futility of a general approach or application of the processes involved in the transfer of knowledge. Indeed, the present concentration on requirements of, and benefits to, the poor farmer in regard to irrigation and drainage has begun to take real affect. This development is probably due to the total accumulation of experience and knowledge gained in past years' efforts.

c. Total Expenditures

i. Reporting Year

The expenditures for this year amounts to \$36,505.

ii. Accumulated Total

For the first 7-year period, the amount expended is \$262,866.

iii. University and Others

In this category, it is estimated the University expenditure in the field of water for agriculture exceeds \$1,100,000.

D. Objective/Output #4 Advisory Capacity

1. Narrative Description

The grant has funded a small amount of consulting time to be provided in emergency situations when individuals are needed on a very short notice and when other means cannot be found or utilized without causing unacceptable delay for advisory and consulting work in LDCs. Through availability of this fund, CSU has made excellent progress towards responding quickly to requests for technical assistance to LDCs. This flexibility now extends to faculty members from a variety of disciplines. Faculty were paid to substitute in the classroom and laboratory for other faculty members who accepted LDC assignments. Thus, grant provision provided users of faculty resources a wide range of talent which could not otherwise be available for LDC programs. In fact, an advisory capacity was maintained for the whole water chain in addition to capability in water delivery and removal systems. This secondary capacity provided an even greater expanded range of talent than last year for cooperative efforts implemented by CID and other appropriate organizations.

As indicated above, CSU worked more closely than ever with CID by means of advisory and other services in developing and providing expertise in problem identification and analysis and in project design and evaluation, functions which AID and the University realize are most significant to future success. For these functions and those related to operations and implementation, Colorado State University has identified faculty members and their specialties for inclusion in the CID talent bank. The

CSU grant program director, in effect, acts for that portion of the talent bank dealing with irrigation water delivery and removal systems. Over thirty-six (36) faculty members are now available for consulting on optimum water management for improved crop production in the fields of civil engineering, irrigation engineering, watershed sciences, on-farm water management, agronomy and dryland farming.

During the reporting year, grant funds were used for short-term consulting, for release time of faculty members, for staff training; and for 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.

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. Reporting Year

— Dr. E. V. Richardson, Civil Engineering Department, Director of the 211(d) grant project at CSU was the Team Leader for a group of scientists sent to Egypt, March 25 to April 24, by AID to determine the feasibility of initiating an On-Farm Water Management Program. The team members, other than Dr. Richardson were: Drs. W. Clyma, W. R. Schmehl and W. W. Shaner - all from CSU. Mr. R. S. McCandliss was also a member of the team representing AID/W. A feasibility report was prepared which indicated that existing on-farm water and agronomic technologies are available for farm application in Egypt. Also, a project paper for a project titled "On-Farm Water Management" was drafted. While this project was funded from other than 211(d) AID grant funds, it may be considered typical of one of the beneficial off-shoots (utilization) of the basic 211(d) grant program.



— Dr. Richardson also took part in a National Academy of Science sponsored "U. S. - Egyptian Workshop on Research Planning and Management" in Cairo.

— In addition, Dr. Richardson did some consulting work for Engineering Consultants, Inc. (ECI) on reservoir sedimentation in the Philippines. This complemented his 211(d) work as it enabled him to also observe some of the problems of erosion and irrigated agriculture in the Phillipine Islands.

— Dr. Willis W. Shaner, Mechanical Engineering and Economics Departments, provided consultant services to USAID and the Government of Peru for a loan proposed for investments in small-scale irrigation in the Andean highlands from July 29 through August 29, 1975. His report is entitled, Water Resources Projects to Aid Peasant Farmers in the Peruvian Sierra: Technical, Economic and Financial Analysis and was prepared for the USAID Mission, Lima, Peru. Ms. Lee Ann Ross was a contributor to the report. She attended Dr. Shaner's course on Project Planning for Developing Countries at CSU and was particularly well qualified to assist in the project analysis aspects of the project paper. Upon termination of the above project, she joined USAID as an international development intern.

— From February 2 to March 5, 1976, Dr. Shaner was a consultant to USAID and the Government of Honduras for a loan proposal for institutional development in water resources planning. Preliminary discussions with USAID/W indicates he will return to Honduras the latter part of the year to assist in setting the scope of work and analytical procedures of a feasibility study of alternative investments in water resources projects.

— Dr. Shaner continued his consulting services by joining a CSU team member on assignment to Egypt from March 25 to April 24, 1976 to develop a research project paper on the topic of On-Farm Water Management. As a result, Dr. Shaner became one of the contributors to the preparation of a feasibility report, On-Farm Water Management Project for Egypt, submitted to AID/W last April.

— Other miscellaneous activities, mostly in an advisory capacity, engaged in during the past fiscal year by Dr. Shaner include: (a) talk to the Latin American Student Organization at CSU on development activities in Peru, (b) presentation to the International Interdisciplinary Seminar at CSU on project planning processes, (c) participation in a workshop

meeting with Everett Wallace from the University of California at Riverside regarding CIDNET - an information storage and retrieval library system, (d) membership in a small interdisciplinary group on campus exploring the possibilities of establishing a program on the comparative study of India and China, (e) participation in a group discussion on the topic of information transfer and diffusion presented by Douglas Canton, AID/W (f) a meeting with ROCAP and AID (Guatemala officials in Guatemala City, (g) appointed to the planning committee for the Second International Conference on Transfer of Water Resources Information to be held at CSU in 1977, (h) preliminary discussions with Ron Timmermeier (USAID TAB/DA) and Rollo Ehrich (AID/Peru) on the possibilities of a research project in Peru to study small-scale irrigation activities, (i) exploration, on a preliminary basis, of the possibility of holding a workshop at CSU on methods of teaching project analysis techniques to those interested in economic development, (j) discussions with Bechtel Corporation on a technical assistance and training program for the Algerian government, (k) assignment as one of the CSU contacts for the UNDP Project Manager of Ethiopian Water Resources Authority who is responsible for sending Ethiopians abroad for advanced training and degrees in water resources planning, and (l) assigned as an advisor to various foreign students working on advanced degrees.

— Dr. Hubert J. Morel-Seytoux, Civil Engineering, lectured for two weeks (December 1975) at the Centro Interamericano de Desarrollo Integral de Aguas y Tierras (C.I.D.I.A.T.), Merida, Venezuela for a post-graduate course on Land and Water Resources Development.

— In June of 1976, Dr. Morel-Seytoux, under the sponsorship of the Ford Foundation, went to the University of Roorkee, Roorkee, India to develop a course in "Systems Planning with Reference to Ground Water Resources." He will return to CSU early in October.

— Dr. William E. Hart, went to Peru on a TDY assignment to develop an irrigation scheduling procedure. He developed a small computer program which used Hargreave's method for estimating potential evapotranspiration, some data from Hawaii for determining crop coefficients and a procedure reported by Kincaid and Heermann for estimating stress coefficients. The project was quite successful and easily adaptable to LDCs where applicable. Dr. Hart's report Irrigation Scheduling for

Peru was later presented to the Rocky Mountain regional meetings of the American Society of Agricultural Engineers in April 1976.

— Late in June, the first two of four professors of Colorado State University left for Lima, Peru to give a four-week in-country intensive water resource course for thirty (30) engineers. The course titled, Water Resources Planning in Peru, which is in progress at this writing, will cover six professional areas: (1) Hydraulics and hydraulic structures; (2) Mathematical modeling; (3) Technology of sedimentation and river mechanics; (4) Advanced hydrology, systems engineering of water resources; and (5) Project planning. The CSU professors involved are: Dr. Vujica Yevjevich, (Project Director), Professor of Civil Engineering and the Professor in Charge of the Graduate and Research Program in Hydrology and Water Resources; Dr. Daryl Simons, Professor of Civil Engineering, Professor in Charge of the Graduate and Research Program in Hydraulics and Hydraulic Engineering, and Associate Dean for Research of the College of Engineering; Dr. Warren Hall, Professor of Civil Engineering, and Professor in Charge of the Graduate and Research Program for Water Resources System Engineering, and; Dr. W. W. Shaner, Associate Professor of Mechanical Engineering and Economics for Water Resources Planning and Development.

— Dr. Daryl B. Simons, Associate Dean of the College of Engineering made a number of trips during the reporting year in an advisory or consultant capacity. These included a trip to the Dominican Republic with regard to the development of the natural resources of the eastern provinces and utilization of the Rio Chavon and its tributaries for the irrigation of arable lands. On the same trip he went to Sao Paulo, Brazil to be session chairman at the IAHR conference and from there he went to Iquitos, Peru where he met a group of engineers to discuss channel and embankment stability problems on the Amazon River. In October he visited Porto Alegre, Brazil with Dr. Neil Grigg to discuss coordination of a CSU subcontract with UNESCO/UNDP and the Center for Applied Hydrology. A month later he was called to Quito, Ecuador for a preliminary analysis of River Mechanics and Sediment Transport problems related to the development of the Guoyas Watershed in Ecuador. In December he went to Montreal, Canada as a consultant on the James Bay project involving a review of the hydrology of the La Grande River, general properties of the soils

forming the bed, and banks and stability conditions. In January and February he was in Madrid, Spain, making an analysis of the Guadacquivier River.

— Professor E. F. Schulz, Civil Engineering accepted a one (1) year assignment with FAO and is now in Iran working as a Hydrologist Advisor.

— Dr. Cleon V. Kinberling 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 program of establishing a College of Veterinary Medicine within the University of Nairobi capable of high level accomplishments. Many Colorado State University veterinarian personnel have served and are serving in Kenya and many participants have come to CSU, as well as to other institutions for formal degrees in veterinary medicine.

— Dr. Wendell H. Bragonier, Dean of the Graduate School, served as coordinator of an American team of educators advisory mission to Seoul National University in the fall of 1974. Upon request from the World Bank, Dr. Bragonier returned to Korea in the fall of 1975 to evaluate a five million dollar loan request from the Seoul National University submitted to the World Bank.

— At the request of Tippet-Abbott, McCarthy and Stratton (TAMS) consulting firm in New York, Dr. S. Karaki, Civil Engineering Department, visited the Tarbela Dam work in Pakistan in 1974 to advise on some valve problems. As a result, additional model studies during the past year were conducted at CSU by Dr. Karaki and during 1975 he returned to Pakistan to give additional advice on the Tarbela outlet works.

— Professional personnel from CSU are actively involved in the following CID/AID contracts:

1. CID/Bolivia
2. CID/Iran

CID activities in Africa alone presently involves nine (9) short-term consultant contracts and two (2) pending short-term contracts, and one (1) long-term contract which has been signed but not manned. Colorado State University is constantly reviewing available personnel for the specific positions desired and maintains constant contact with the CID executive office, through CID meetings, correspondence and telephone,

concerning the availability of personnel and provides the services of individuals for preparation of or for evaluation of proposals from LDCs, private firms or private organizations, and national and world technical assistance organizations. An example of project evaluation is the visit of Donal D. Johnson, Dean of the Office of Agricultural Sciences, to Pakistan to evaluate the proposal for a program in rain-fed agriculture. In addition, he contributed in evaluating the Sudan proposal. Mention also should be made of Dr. W. W. Shaner's contributed time and effort to provide the Bechtel Corporation with information indicating the technical competence of CID to provide a technical assistance and training program for the Algerian government.

### 3. Accomplishments

#### b. Accumulative

— At the beginning of the 211(d) grant program, relatively few professors were willing to leave the confines of the campus for even a short period of time due mainly to uncertainties of what their absence might do to their future, i.e., promotion, tenure, and so forth. Today, largely due to such Federal Assistance Programs as 211(d) grant, the Water Management Program, CID and so on, the general attitude of the University from the President on down, is one of encouragement through rendering of substantial backing to the participating individuals. Thus, over 36 faculty members are now available for consulting on optimum water management for improved crop production.

#### c. Total Expenditures

##### i. Reporting Year

For the reporting year the amount is \$9,342.

##### ii. Accumulative

These are estimated to be \$294,831 for the last six (6) year period.

##### iii. For the University and other source, the amount is estimated to be \$21,000.

### E. Objective/Output #5 Linkages and Networks

#### 1. Narrative Description

Stronger and more meaningful relationships have been developed during the reporting year with networks of existing domestic and multilateral organizations for the purpose of collaborating in a

joint problem-solving approach through cooperative research and information exchange and dissemination. More specifically, the University has made notable progress in strengthening linkages with institutions working in the field of water resources and management for increased food production in Africa, Near East, Pakistan and Latin America; in establishing institutions working on water and water related problems for increased food production in the LDCs; in establishing linkages with Centers and Consortiums working to increase food production through helping the small farmer; and in closer and more effective relationships with the other grant directors in the water chain including strengthening the University's linkage with the other members of CID.

## 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 211(d) directors in the water chain. The Colorado State University Grant Program Director is the systems leader within CID for irrigation water delivery and removal/drainage systems and establishes linkages between that and the Program Directors for dryland farming, watershed management, and on-farm water management. The grant provides some funding for support of the above assigned leadership and coordination role of CID.

c. Strengthen linkages with institutions working in water for food production in Africa, Near East, Pakistan, and Latin America. Establish linkages with several world wide and regional organizations. Of these, the primary organization is FAO.

d. 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. Attendance by Colorado State University personnel at International Conferences sponsored by such organizations as FAO, OECD, CENTO and 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 because universities by themselves cannot continue to support this type of grant outreach. Cooperation by participating universities with AID is also necessary.

### 3. Accomplishments

#### a. Reporting Year

##### General

Not often reported in a formal way is the volume of correspondence that takes place between responsible parties interested in getting specific projects underway. Normally, there is a 3-way flow, forward and return, among the key personnel representing (1) AID/W, (2) CSU, and (3) the host country involved. Adequate preparation, timely planning, thoughtful action and follow-through are some of the ingredients necessary and expected on the part of committed individuals. In this respect, CSU as an institution, has begun to acquire a world vision and responsibility in developing International Education through Technical Assistance activities.

Much of the credit for expanding the boundaries of educational outreach at CSU and other like institutions across the nation, must be given to the federal government, who in the Foreign Assistance Act, and other acts, have laid the groundwork and provided essential funds over the past several decades.

However, as exemplary as this development may be, the supporting structure of technical assistance to foreign countries could easily collapse if funding for international activities is not available in some form. At present, most state governments are having a hard time

internally in funding their own institutions, and private sources fall far short of the need.

#### Synergistic Relationship

Linkages and contacts with other institutions or organizations are virtually meaningless unless they are intelligently and sincerely utilized to bring about a synergistic relationship helpful to both parties involved. Activities which have an entrainment effect of this nature at CSU are:

— On April 8 of this year, CSU's President A. R. Chamberlain was decorated by the Mexican Government in a ceremony at the Mexican Embassy in Washington, D. C. President Chamberlain was presented the Order of the Aztec Eagle, Commander Degree, the highest honor Mexico can give to individuals in recognition of service to that country and to humanity. The award, signed by the President of Mexico, was presented in recognition of CSU's cooperation with Mexican education officials, specifically in the areas of water resources, agriculture and veterinary medicine. In making the presentation, the Mexican Ambassador to the United States stated that the CSU President "has played a key role in the development of educational and scientific cooperation between his university and various Mexican academic and research institutions which are basic conditions to reach not only economic and social betterment, but also to attain a higher cultural level through which human society may function in a more harmonious way." He went on to say that "international cooperation based on mutual understanding and equity is without doubt the best means within our reach to solve the world problems of today." In answer to the above, President Chamberlain said, "countries such as Mexico, by virtue of their great investment in education, research and social development have advanced to the point that we learn as much as we share from interactions among our intellectual and public policy makers." He urged all present to "work to increase the economic and social well-being of the peoples of the world as well as of our two neighboring nations."

#### International Education

Largely as the result of outstanding, forward looking educators in the Department of Civil Engineering, College of Engineering, in extending their field of competence - beginning in earnest about a decade ago - in both domestic and international realms, present day activities related



to international education have grown to the extent that they are underway in practically every unit of the CSU institution. Most of the activities in progress are directed by individual faculty members who have taken the initiative to develop programs. Educational programs currently underway are: the Asian and Latin American area studies; the Russian/East-Central group; the China Studies Committee; World Interdependence. The main classifications include, international education, international programs, study abroad and exchange and foreign student affairs.

Because of CSU's obvious interest and development in the international educational aspect, and because facilities and qualified personnel are now available, Dr. James Ragin, Acting Dean of the Graduate School, was asked by the U. S. State Department to meet with educational officials in Ethiopia, the Sudan, Kenya, Zambia, Malawi, South Africa, Botswana, Tanzania and Uganda, to plan and coordinate programs for African students intending to study in American universities. As a result of his trip a number of African students are taking advanced degrees in this and other institutions in the United States.

#### CSU Water Scientists

A sample of Colorado State University scientists in the field of water management, research, and development in contact with scientists in the same field of activity - thus broadening important linkages and the world network system, is as follows:

— Dr. Vujica Yevjevich, Professor of Civil Engineering and Professor-in-charge of the Civil Engineering Department's Hydrology and Water Resources Program, was made the U. S. Coordinator for the establishment of a cooperative U. S. - Yugoslav project begun in 1972, now called the Karst Hydrology and Water Resources Projects. The coordinator for the Yugoslavian research was Aleksander Trumic, Professor of Civil Engineering and Director of the Institute of Hydraulic Engineering at the University of Sarajevo. The First Bilateral U. S. - Yugoslavia Symposium in Hydrology and Water Resources of Karst Regions was held last year and covered the first three (3) years of the project. Papers delivered at the symposium will be distributed to various countries providing them with ideas, experiences and knowledge for use in their work on hydrology problems.

— Victor A. Koelzer, Professor of Civil Engineering, recently received the first American Society of Civil Engineers (ASCE) Julian Hinds Award in recognition for his contributions to water resources development and more specifically, for his uniquely varied and outstanding career in planning, development and management of water resources, both domestic and foreign, in both private and public practice of civil engineering. Professor Koelzer currently serves part-time as a Professor of Civil Engineering and as Director of the International School for Water Resources and Associated Programs.

— Henry P. Caulfield Jr., Professor of Political Science, recently received the Iben Award of the American Water Resources Association (AWRA) for his "outstanding contributions in promoting communications among disciplines on water resource problems."

Professor Caulfield was the first director of the U. S. Water Resources Council in Washington, D. C., served in numerous executive and staff positions in the U. S. Department of the Interior, several other U. S. Agencies, as well as the International Statistical Institute in London. Since joining the CSU faculty extra curricula activities included leadership in conducting the International Interdisciplinary Seminar in Water Resources Management. He also has lectured in India, Yugoslavia, and other countries in the field of governmental aspects of water resources management.

— Maxwell E. Becker, Civil Engineering, was invited to visit Yonsei University in Seoul, Korea and at the same time invited to attend the 90th Anniversary of Ewha Woman's University, said to be the largest in the world, having 10 colleges and 60 departments, also located in Seoul. The occasion was to honor his father, Dr. Arthur L. Becker who was one of the founders of Yonsei University and known as the Father of Science in Korea, and who also served many years on the advisory board of Ewha. In an assembly meeting attended by the President of Ewha Haktang, the President of Yonsei University, the former President of Seoul National University, the former Minister of Education and about fifty (50) faculty and staff of both Universities, Max addressed the group about his past connections with Yonsei and Ewha Universities and in his speech also mentioned the high caliber work being carried on by the Colorado State University in the field of water development, management and research both at home and abroad.

— Dr. George E. Radosevich attended the 2nd International Conference on Water Law Administration held in Caracas, Venezuela, 8-14 February 1976 and presented a report on the Resume of the 1975 Valencia Global Water Law Systems Conference. He also served as rapporteur to the first Conference session on Water Resources Law: An Examination of Current Status and Recent Tendencies.

— Dr. E. V. Richardson and Dr. Evan C. Vlachos attended an Organization for Economic Cooperation and Development (OECD) meeting in Paris last March on Water Resources Utilization and Management. Three broad social science problems within water resources development were discussed:

- \*National water resources policy, institutional capacity, macro-planning and investment criteria;

- \*Management, administration and training, and

- \*Micro-economics of project design and implementation

Because of the obvious professional linkages of the OECD meeting and the forthcoming UN Water Conference (March 1977, Mar del Plata, Argentina) the fifty two (52) participants were briefed on the UN preparations for the conference.

Dr. Richardson personally met with many of the world's experts on water resources. Linkages were established with seventeen (17) participants not only through contacts at the meeting but by sending copies of Alan Wood's report on "Water Lifters and Pumps for the Developing World" to those who expressed interest in receiving the publication. The replies were very favorable. Several samples are included in Appendix D. Many of the participants were also advised about the role of CID in water resources development, water management, and water research. The CID brochure was also distributed.

— Dr. Richardson participated in a National Science Foundation sponsored meeting on the CSU campus in July 1975 on an assessment of the present and potential role of weather modification in agricultural production. There were forty two (42) participants from across the nation.

— A continuing source of linkages is CSU's team stationed in Pakistan working on Water Management Research. Through their highly successful scientific activities in Pakistan, important linkages are maintained and new ones constantly added.

— Dr. Judson M. Harper, Head, Agricultural Engineering Department, who has played an important part in providing personnel for the AID/CSU Water Management Research project in Pakistan as well as providing support for the 211(d) grant program on campus, made four (4) trips abroad during the reporting year in an advisory capacity in nutrition. The countries requesting his services were: (1) Kenya and Tanzania, (2) Syrlanka, (3) Costa Rica, and (4) Bolivia. The trips were sponsored by USDA.

— Dr. Maurice L. Albertson, Civil Engineering Department, a prominent figure on the CSU campus in International affairs, became Co-Driector, July 1975, along with his counterpart, Co-Director Mohammad Athaullah of the Institutional Development Program involving the Faculty of Engineering University of Peshawar and the College of Engineering, Colorado State University. This program is to continue for the next three (3) years and will cover such activities as faculty exchange, short-term consultants, graduate student exchange, in-service study, instrument center, and the like.

A sample of the attention given by Colorado State University to International visitors of prominence to the CSU campus as a result of contacts established through meetings or other forms of communication, is as follows:

#### International Visitors

High level group visit from Egypt on May 20, 1976 by the following people:

Dr. Abdel Aboul ATTA, Minister of Agriculture and Minister of Irrigation

Dr. Salah El-Abd, Senior Under Secretary, Ministry of Agriculture

Eng. Mahmoud Saad Eldin El Gindi, President, Drainage Projects Authority

Eng. Abdel Ghani Hassan, Director-General, High Dam and Aswan Authority

Dr. Mahmoud Abou Zeid, Director, Water Distribution Research Institute

Dr. M. M. Gaser, Director, Hydraulic Research Institute

Mr. R. J. Edwarus, US/AID Mission, Cairo

The schedule of activities included: a. A visit to a small one-family farm which has some irrigation. b. A visit to the CSU Experiment Station. c. A luncheon in the Long's Peak Room. d. A visit to the CSU Engineering Research Center. e. A brief drive through an area with sprinkler and other irrigation.

Following is a list of local guests invited to luncheon at the Long's Peak Room who participated in discussions, explanations, and host responsibilities on the campus at the Experiment Station, ARS, the Engineering Research Center, Extension Service and so forth:

- Dr. George G. Olson, Associate Vice-President for Research, CSU
- Mr. Lowell H. Watts, Director of Extension Service, CSU
- Dr. William R. Thomas, Associate Dean, College of Agriculture, CSU
- Dr. Wayne F. Keim, Department Head, Department of Agronomy, CSU
- Dr. Willard R. Schmehl, Professor, Agronomy Department, CSU
- Dr. Willis Shaner, Associate Professor, Mechanical Engineering Department, CSU
- Dr. E. V. Richardson, 211(d) Director, Civil Engineering Department, CSU
- Dr. D. B. Simons, Associate Dean for Research, College of Engineering, CSU
- Mr. Robert E. Whedbee, College of Agriculture, Director of International Programs
- Dr. Norman A. Evans, Director, Environmental Resources Center, CSU
- Dr. Arnold Klute, Soil Scientist and Research Leader, Agriculture Research Service, Fort Collins
- Dr. Max Lowdermilk, Assistant Professor, Sociology Department, CSU
- Dr. Neil Grigg, Director of International Education, CSU
- Dr. Robert E. Moreng, Director of Research, Agricultural Sciences and Assistant Director of Experiment Station
- Mr. Harvey Johnson, President of Water Supply and Storage Company
- Mr. Gayle Knott, County Extension Agent, Colorado Cooperative Extension Service
- Dr. Robert E. Danielson, Professor, Department of Agronomy, CSU
- Dr. L. V. Baldwin, Dean of Engineering, College of Engineering, CSU

A sample of the care and follow-through by members of the CSU faculty for the many International visitors on campus is as follows:

— Dr. Willis Shaner acted as host to three (3) Peruvians from the Direccion General de Aguas for a month during their visit to CSU in September 1975. One of these three, Julio Lostao, is the director of a small-scale irrigation project in the Andean highlands called "Water Resources Projects to Aid Peasant Farmers in the Peruvian Sierra."

### CID Meetings

The participation of CSU personnel in CID meetings is, of course, important particularly from the standpoint of coordination and cooperation in carrying out research activities. The meetings are a major source for strengthening linkages among CID universities, other universities and organizations, and between the CID universities and AID/W, the sponsoring agency. This one for all and all for one spirit that has developed has resulted in the ability of CID universities to respond positively more quickly to more overseas requests for technical assistance. The CID meetings held during the reporting year were:

1. CID semi-annual meeting, June 30 - July 1, 1975 on the USU campus, Logan, Utah. CSU attendees were: Drs. Donal D. Johnson, E. V. Richardson, and M. W. Felton, Professors George Smith and Wayne Cook. A brief format of the meeting included:

- a. A business session for the Board of Trustees Monday a.m.
- b. Special reports Monday afternoon consisting of -
  - i. Discussion of Africa
  - ii. Viewing of a special film on Sahel and an update on AID/TAB/Agric.
- c. All day Tuesday was devoted to technical committees reporting their progress and activities. These committees are:
  - i. 211(d) Technical Committee (meet January, April, July, October)
  - ii. 1 AC Committee        } Meet month before annual  
       1 MP Committee        } and semi-annual meetings
  - iii. OWRT Committee (meet August, October and December)

2. A CID technical meeting between CSU and USU on December 2, 1975 was held at USU to define the cooperative effort in the SOTA report on low head irrigation and drainage water lifting, as well as on the report on improving the lifting efficiency of windmill power pumps. Information and references were exchanged which will assist both Universities in developing their sections of the SOTA reports.

3. CID Annual Meeting, January 5-6, 1976 held at the Arizona Inn in Tucson. This was mainly a business meeting for the Board of Trustees. † The main CID activities discussed were contracts with the following: Iran, OWRT, Bolivia and Africa. Participating from CSU were Donal D. Johnson, E. V. Richardson and James Meiman.

4. CID 211(d) Directors meeting held February 2-3, 1976 at Washington, D. C. to discuss on-going and new SOTA projects needing funding in the future.

5. Board of Trustees members invited to a West Africa Conference scheduled at UA, Tucson for April 11-14, 1976.

6. CID University presidents and members of the Board of Trustees Meeting June 14, 1976 at the Royal Inn, Salt Lake City, Utah.

b. Accumulative

Colorado State University has long recognized that linkages mean little unless some action or response is stimulated. During the early years of the grant, CSU was aware that its personnel were making most of the advances in establishing linkages with little or nor response from the other party. Looking back on the task of establishing linkages from the past six (6) years, it is almost incredible the progress made over the last few years in this relationship. Firm linkages are in evidence at the highest levels of LDC governments and strong efforts are now being made by many LDCs to maintain or strengthen their linkages with CSU.

c. Total Expenditures

- i. Reporting Year . . . . . \$15,313
- ii. Accumulative . . . . . \$80,040
- iii. University and other sources . \$35,000

#### 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. Past and present utilization of 211(d) grant funds have played an important part in the development of capabilities in technical assistance to foreign countries in water research and management. The influx of foreign students during the past decade, attracted by the excellent water resources programs in research and education, has produced many beneficial results such as: improvement of the libraries by the addition of water resources literature from other countries of the world; establishment of CIDNET making it possible to quickly obtain information from any of the CID universities; successful operation of the International School for Water Resources for a number of years; improvement of language instruction at the University through the teaching of English as a second language, and; utilization of grant funds has had a beneficial effect on recruiting and holding highly scientists available for teaching, directing research and responding to overseas requests for technical assistance.

As indicated above, the activities supported by the grant were widely spread not only through the engineering sciences but also through such divergent disciplines as economics, and anthropology, water law, and sociology resulting in increased competency, teaching capability, and better utilization of research finding.

While the operant knowledge base of the university is quite broad perhaps the most significant impact the grant has made, is the utilization of the operant base of knowledge to bring into focus specific problems which then can be more quickly solved. For example, one such critical focus is on the problems of water delivery and removal systems as they affect the small farmer. Part of this flexibility has been brought about by opportunities provided by the grant for CSU faculty to visit foreign countries and participate directly with host country individuals on specific problems. As a result, there has been a great increase in the interest of faculty on world affairs as well as greater competence on the part of individual faculty members in



directing advance degree programs of foreign and domestic students based on solving some aspect of water resources development or management problem in their respective countries.

Not only has the impact of the grant funding led to strengthening the university's competence in water delivery and removal systems but it also has had an entrainment effect in making it possible for the university to respond relatively quickly to international requests for long- and short-term assignments.

There is little doubt but that the 211(d) grant funds have had a major effect on turning some of the attention of a large university to assisting foreign countries in solving technical problems. Hopefully, this broadening of the University's horizons may be continued and the momentum gained so far may be maintained. To keep the momentum going however, will cost the federal government only a fraction of the amount it took to get the whole 211(d) grant program started. Ways and means should be found, through Title XII for example, to keep the desirable aspects of the present and future technical assistance needs of developing countries available. While state and private funding are continually being sought, experience indicates such would fall far short of the required amount resulting, it is feared, in the lessening of the University's capabilities and competence in the International aspects of water resources development, management and research as well as the ability to respond promptly to AID/W requests for technically competent scientists for specific overseas tasks.

## V. OTHER RESOURCES FOR GRANT-RELATED ACTIVITIES

Some of the other resources for carrying out grant-related activities would include many of the departments and units of the University, including the Engineering Research Center, Colorado Experiment Station, and other units such as the following:

1. One of CSU's educational facilities is the International School for Water Resources and Associated Programs, in existence since 1967. This school is administered by the College of Engineering and the Department of Civil Engineering. It provides training in other phases of engineering and applied sciences, although an emphasis is still maintained on water resources. The School can adapt its educational program to fit the needs of the individual, though to begin with, a first degree is a requirement. A diploma is usually granted to those who successfully complete one or more years and a certificate to those studying less than a year. The School does not award degrees. A few qualified individuals sometimes transfer from the School to a regular degree program. Enclosed is a Bulletin, Appendix B-1, which describes in greater detail the scope of teaching and training activities of the School. Appendix B-2 gives a complete list of School participants since 1967 including the following information for each enrollee; highest degree, home country, financial assistance provided by, length of time in school, dates, special interest, remarks, and award. About 50 percent of the school's participants to date have been supported through one of several UN agencies.
2. Another CSU educational facility is offered by the College of Agricultural Sciences known as the International Agricultural Program. AID/W is familiar with this facility and, through an agreement with the training division of USDA, sends most of its AID participants, seeking formal or informal training in agricultural related subjects to USDA for formal preparation of individual or group programs agreed to by the various educational institutions in the country. The agricultural program is designed to assist in coordinating and supporting programs involving foreign students, trainees, and visitors sponsored by AID/W, USAID/Missions, UN agencies such as FAO, UNDP, etc., IIE, and other organizations in accordance with formal or informal agreements on a case by case basis. Most of the foreign students enrolled in the International

Agriculture Program are seeking degrees. Occasionally, a short summer course such as in Range Management, is offered, permitting both degree and non-degree enrollment. Some of the 23 AID enrollees listed in a subsequent paragraph are included in the International Agricultural Program such as those taking Agronomy and Animal Science.

3. Another educational facility at CSU, not used before by foreign students, but which might be useful in the future to help meet the needs of foreign students, is the University Center for Continuing Education. The Center offers a wide range of educational opportunities both on and off campus to those continuing their education on a part-time or interruptable basis. The Center's flexible program is designed to meet specifications of individuals, groups, or industries as well as to provide traditional academic, degree-oriented courses.

4. Yet another educational facility is CSU's SURGE (Colorado State University Resources in Graduate Education). Here, videotape brings CSU's educational resources to business, industry, and research organizations.

5. The University also has an Office of International Education. Though this office is primarily concerned in teaching the American student in the general areas of international and intercultural relations, the size and scope of teaching, and research activities, aids greatly the growing educational program for the foreign student. Among the approximately 1,600 faculty members at CSU, more than 55 foreign universities in 26 countries are represented. In addition, numerous faculty members are continually returning to foreign countries for advanced study and research. Also, a number of CSU faculty members whose specialized training has been in areas of international concern, have distinguished themselves nationally and internationally. The Office of International Education of CSU supports a Foreign Student Advisor who provides very valuable services to the foreign student. While the OIE is not primarily concerned with the foreign student, the program has had a favorable impact in making the campus a genial and helpful host to foreign students as well as to fulfil an important element of the International Education Program at Colorado State University.

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

| <u>Project</u>                                     | <u>Funding Agency</u>   |
|--|-------------------------|
| Water Data   | CERI                    |
| Water Availability for the White River Basin       | CERI                    |
| Water Rights Tabulation                            | CERI                    |
| Hiways in the River Environment                    | Dept. of Transportation |
| Animal Wastes and Runoff...                        | EPA                     |
| Irrigation Return Flow                             | EPA                     |
| Agricultural Salinity Control                      | EPA                     |
| Water Quality and Oil Shale                        | EPA                     |
| Hydrology in Mine Spoins                           | EPA                     |
| Salinity Control Technology                        | EPA                     |
| Water Resources Management in Sub-Humid Areas      | AID                     |
| Utilization of Water Resources                     | AID                     |
| Automated Control for Sewer Systems                | OWRT                    |
| Water Quality Problems in the Upper Colorado Basin | OWRT                    |
| Sub-Surface Hydrologic Model                       | OWRT                    |
| Water Recreation on High Country Reservoirs        | OWRT                    |
| Development and Expanding Stream Aquifers          | OWRT                    |
| Improved Water and Land Use                        | OWRT                    |
| Role of Water Reuse                                | OWRT                    |
| Snow Moisture Equivalent                           | OWRT                    |
| Strata to Store Water                              | OWRT                    |
| Salt Content/River Basin, California               | OWRT                    |
| Coordinating Water and Energy Strategies           | OWRT                    |
| Channel-Characterizations                          | ARS                     |
| Sediment from Small Watersheds                     | RMF/RES                 |
| Orographic Snowfall                                | USFS                    |
| Water Supply Analysis                              | ACE                     |
| Entrapment of Air in Ground Water                  | NSF                     |
| Stochastic Water Resources Processes               | NSF                     |
| Channel Observation                                | NSF                     |
| Water Resources in Karst                           | NSF                     |
| Large Scale Combined Sewer Systems                 | NSF                     |

| <u>Project</u>              | <u>Funding Agency</u> |
|-----------------------------|-----------------------|
| Water Resources Engineering | NSF                   |
| Pipeline                    | J. M. Corporation     |
| Cooling Pond                | Bechtel Corporation   |
| Hydraulic Gradient Test     | G. E.                 |
| Evaluation of Recharge      | FEC                   |
| San Luis River Basin        | SLW                   |
| Instream Flows              | University of Wyoming |

7. 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.

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 those faculty members who are interested in activities and assignments of an international nature. It also identifies the competence and expertise available for international activities.

8. Major water related projects undertaken by Colorado State University sponsored by the State Experiment Station are as follows:

- Water Resource Optimization
- Experimental Practices, Return Flow, Salinity and Crop Yields
- Systems of Management for Optimum Water Utilization
- Drainage Design Criteria
- Salinity Control Irrigation

The total State Experiment Station budget for sponsored research work carried on by CSU amounted to about \$494,000.

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. See pages 54 and 56.

B. Specific Information

1. Following are several classifications of full-time foreign students registered at CSU as of the Spring Semester of 1976:

a. Alphabetical listing and number of foreign students -

| <u>Country</u>                              | <u>Number of Students</u> | <u>Country</u>        | <u>Number of Students</u> |
|---|---------------------------|-----------------------|---------------------------|
| Alphabetical listing<br>of Foreign Students |                           |                       |                           |
| AF/Afghanistan                              | 7                         | IZ/Iraq               | 12                        |
| AG/Algeria                                  | 2                         | FI/Ireland            | 1                         |
| AS/Australia                                | 5                         | IS/Israel             | 7                         |
| BG/Bangladesh                               | 1                         | IV/Ivory Coast        | 1                         |
| BR/Brazil                                   | 13                        | JA/Japan              | 9                         |
| CM/Cameroon                                 | 1                         | JO/Jordan             | 4                         |
| CA/Canada                                   | 13                        | KE/Kenya              | 2                         |
| TW/Rep. of China                            | 35                        | CB/Khmer Republic     | 1                         |
| CO/Colombia                                 | 3                         | KS/South Korea        | 5                         |
| CS/Costa Rica                               | 1                         | KU/Kuwait             | 4                         |
| DA/Denmark                                  | 2                         | LY/Libya              | 33                        |
| DR/Dominican Republic                       | 1                         | MY/Malaysia           | 1                         |
| EC/Ecuador                                  | 1                         | MX/Mexico             | 10                        |
| EG/Egypt                                    | 3                         | MS/Micronesia         | 1                         |
| ET/Ethiopia                                 | 9                         | MO/Morocco            | 2                         |
| FJ/Fiji                                     | 1                         | NL/Netherlands        | 9                         |
| FI/Finland                                  | 1                         | NU/Nicaragua          | 1                         |
| FR/France                                   |                           | NI/Nigeria            | 7                         |
| GW/West Germany                             | 2                         | NO/Norway             | 2                         |
| GH/Ghana                                    | 2                         | PE/Peru               | 3                         |
| GT/Guatemala                                | 1                         | RP/Philippines        | 1                         |
| HO/Honduras                                 | 1                         | PK/Pakistan           | 19                        |
| HK/Hong Kong                                | 10                        | PR/Puerto Rico        | 1                         |
| HU/Hungary                                  | 1                         | SA/Saudi Arabia       | 10                        |
| IC/Iceland                                  | 1                         | SF/South Africa       | 1                         |
| IN/India                                    | 10                        | SP/Spain              | 1                         |
| IR/Iran                                     | 28                        | CE/Sri Lanka (Ceylon) | 3                         |

| <u>Country</u>    | <u>Number of</u><br><u>Students</u> |   |     |
|-------------------|-------------------------------------|---|-----|
| SU/Sudan          | 9                                   | Total number of students  | 371 |
| TZ/Tanzania       | 2                                   | Total number of countries   | 65  |
| TH/Thailand       | 18                                  | Total number of new students  | 52  |
| TS/Tunisia        | 2                                   |   |     |
| TU/Turkey         | 6                                   | Ph.D. Candidates  | 120 |
| UG/Uganda         | 1                                   | Master Candidates   | 186 |
| UK/United Kingdom | 2                                   | Non-degree  | 26  |
| VE/Venezuela      | 19                                  | Undergraduates  | 39  |
| VS/South Vietnam  | 4                                   |   |     |
| YE/Yemen          |                                     | Post-Doctoral, Researchers,<br>Visiting Faculty & Practical<br>Trainees (46, included in above<br>listings) |     |

b. Breakdown of student enrollment by academic classification, sources of support, and by College and Department:

Academic Classification

|                                 |            |            |
|---------------------------------|------------|------------|
| Undergraduates                  |            | 39         |
| Graduates                       |            | 332        |
| Masters candidates              | 186        |            |
| Ph. D. candidates               | 120        |            |
| Non-degree                      | 26         |            |
|                                 | <u>332</u> |            |
| TOTAL (full-time students only) |            | <u>371</u> |

Sources of Support

|  |    |     |
|--|----|-----|
| Full scholarships from Home Governments of institutions      |    | 124 |
| Full scholarships from United States agencies                |    | 14  |
| Full scholarships from U. S. Government (All AID)            |    | 23  |
| Full scholarships from private foundations and organizations |    | 8   |
| Rockefeller  | 3  |     |
| Ford   | 2  |     |
| Rotary International   | 2  |     |
| Other  | 1  |     |
| CSU Graduate Assistantships                                  |    | 84  |
| GRA's  | 75 |     |
| GTA's  | 9  |     |

|  |       |
|--|-------|
| CSU Athletic Scholarships  | 4     |
| CSU Tuition Waivers  | 10    |
| Tuition Waiver   | 1     |
| Joint programs involving<br>CSU tuition waivers                              |       |
| CSU-US Govt/Home Govt  |       |
| LASPAU   | 3     |
| AFGRAD   | 4     |
| IIE  | 2     |
| Students who are self-supported (family<br>support or other private sources) | 104   |
|  | <hr/> |
|  | 371   |

C. Breakdown by College and Department:

|             |                                    |       |
|-------------|------------------------------------|-------|
| By College: | Agricultural Sciences              | 42    |
|             | Business                           | 17    |
|             | Engineering                        | 143   |
|             | Forestry and Natural Resources     | 37    |
|             | Home Economics                     | 10    |
|             | Humanities and Social Sciences     | 39    |
|             | Natural Sciences                   | 32    |
|             | Vet Medicine & Biomedical Sciences | 29    |
|             | Professional Studies               | 11    |
|             | Intensive English Program          | 11    |
|             |                                    | <hr/> |
|             |                                    | 371   |

|                |                                  |    |
|----------------|----------------------------------|----|
| By Department: | Civil Engineering                | 73 |
|                | Agronomy                         | 26 |
|                | Economics(incl Agric. Economics) | 22 |
|                | Agricultural Engineering         | 19 |
|                | Business                         | 17 |
|                | Electrical Engineering           | 17 |
|                | Mechanical Engineering           | 15 |
|                | Range Science                    | 14 |
|                | Intensive English                | 11 |
|                | Animal Sciences                  | 10 |
|                | Clinical Sciences                | 10 |
|                | International School             | 10 |
|                | Atmospheric Science              | 8  |
|                | English                          | 8  |
|                | Fishery and Wildlife Biology     | 8  |
|                | Chemistry                        | 6  |
|                | Horticulture                     | 6  |
|                | Microbiology                     | 6  |
|                | Education                        | 5  |
|                | Forest and Wood Sciences         | 5  |
|                | Mathematics                      | 5  |



|                            |   |
|----------------------------|---|
| Pathology                  | 5 |
| Physics                    | 5 |
| Sociology                  | 5 |
| Statistics                 | 5 |
| Biochemistry               | 4 |
| Earth Resources            | 4 |
| Food Science and Nutrition | 4 |
| Physical Education         | 4 |
| Physiology and Biophysics  | 4 |

By far, the greatest student enrollment, 30 percent is in the College of Engineering, and of this, 20 percent are in the Department of Civil Engineering.

## 2. Number of On-Campus Visitors or Consultations

No accurate statistics are available regarding on-campus visitors or consultations specifically related to water research, development or management. In many cases of individuals or groups visiting the campus or attending conferences sponsored by CSU, water is a vital component of topics discussed. Nor has it been possible to separate, accurately, the number of domestic from the number of foreign visitors. In one conference alone, an Engineering Education Conference where a number of topics were discussed including water and energy development, two thousand (2,000) people attended of which it is estimated ten percent (10%) came from foreign countries. Other small conferences on campus sometimes were attended by a few foreign visitors interested in some phase of water management. A smaller number of foreign individuals or groups (less than 6) from such countries as Russia, Italy, Japan, Korea, India, Pakistan and from various countries in Central and South America visiting the campus primarily for water information might amount to one hundred (100) or thereabouts. Some of the above foreign visitors have been directed to the University by CSU contacts or linkages with foreign personnel interested in water research or development or by U. S. federal Agencies having water management responsibilities.

## 3. Known Use of Research Developed Under Grant

Since October of 1975, two (2) CSU librarians have made more than 1,000 index entries which print out into separate indexes by author, title, subject and geographical area. This index promises to be a powerful tool maximizing and making available to the CIDNET

community, the strong literary collections at Colorado State University. Further, the librarians were trained in different skills required to implement the computer processes which resulted in CSU's ability to enter effectively into CIDNET computerized information center making more easily available, in much less time and cost, valuable information formerly virtually unobtainable.

Grant funding was originally utilized to obtain the services of Victor Koelzer, a highly qualified water management scientist, as a member of the CSU faculty and Director of the International School for Water Resources and Associated Programs. Subsequently, the entrainment effect of the 211(d) grant on the CSU campus helped to obtain the technical support needed by the International School for its continuing educational services. The International School has no faculty of its own, but utilizes the regular faculty in the various departments of the nine colleges on campus. The school is entirely state funded and no 211(d) grant funds are utilized.

While formerly financially supported, open seminars, now at no cost to the 211(d) grant program, are held on issues in International Agricultural Development.

Dr. Willis W. Shaner, Mechanical Engineering Department, developed a computer program for carrying out financial and economic analyses of investments in small-scale irrigation projects in Peru. Two Ph. D. candidates are presently studying, analyzing, and determining through optimization processes improvements to the methodology used in evaluating small-scale irrigation projects last year in Peru.

Dr. Shaner initiated a course on "Development Planning for Development Countries" including instructions in project evaluation. This course has been integrated into the regular University curriculum. In addition to the above, a follow-up course, if approved, would be given this fall to a small group of graduate students specializing in economic development. Case studies would be analyzed and the techniques of analysis proposed by UNIDO, OECD, and the World Bank would be studied.

Dr. Shaner also participated in the planning of an on-site training course in Lima, Peru on the transfer of modern methods of systems analysis in water resources development.

In addition to being the main instigator of the first world conference ever held on Global Water Law Systems last year in Valencia, Spain, Dr. George E. Radosevich was also the prime mover in arranging for the 2nd International Water Law Conference in Caracas, Venezuela, February 8-14, 1976.

The recommendations made by Dr. Robert C. Ward and Mongkol Chotisatorn in their study "Water Management for Small Irrigation Reservoirs in Northeast Thailand" have been accepted and utilized by the Thailand Government.

Dr. William E. Hart, Agricultural Engineer devised an irrigation schedule for Peru. Dr. Hart pointed out that irrigation scheduling has as its objective the management of water so that it is applied only at the time and in the amount needed. Under this principle he made recommendations suitable to various areas and conditions existing in Peru.

Dr. Everett V. Richardson, Civil Engineering, was the team leader for a group of CSU scientists sent to Egypt by AID to determine the necessity of initiating an On-Farm Water Management Program. The team members other than Dr. Richardson were Drs. W. Clyma, W. R. Schmehl and W. W. Shaner.

Dr. Hubert J. Morel-Seytoux, Civil Engineering developed the following courses:

\*Land and Water Resources Development.

Given as a post graduate course at the Centro Interamericano de Desarrollo Integral de Aguas y Tierras, Merida, Venezuela.

\*Systems Planning with Reference to Ground Water Resources

Given as a graduate course at the University of Roorkee, Roorkee, India.

The following state-of-the-art studies have been completed and disseminated. Many of these SOTA studies are now being utilized by LDCs.

\*Water Lifters and Pumps for the Developing World

\*Optimal Irrigation Decisions with Limited Water

\*Water Conservation Practices for Dryland Farming

\*Geology and Water Resource System of the Indus Plains

\*Methodology for the Selection and Timing of Water Resources

Projects to Promote National Economic Development.

\*Numerical Model of Flow in a Stream-Aquifer System

\*Sediment Stable Canal Systems

#### 4. Significant Graduate Roles

The following is a sample of recent graduates who have assumed positions of leadership and responsibility in government, the educational field, or in the private sector:

Dr. Larry Caswell --- University Professor

Dr. Herbert G. Blank --- AID

Dr. Mohammad T. Chaudhry --- Engineer, WAPDA, Pakistan

Dr. Alfred J. Tamburi --- University Professor

Dr. Catherine E. Kraeger Rovey --- University Professor

Dr. Wendim-Agegnehu Lemma --- Engineer, Private Sector

#### 5. Professors Working on Development Programs

##### a. Reporting Year

Dr. Everett V. Richardson

Dr. William E. Hart

Dr. George E. Radosevich

Dr. Willard R. Schmehl

Dr. Willis W. Shaner

The above and other faculty members working on development programs and eligible for advisory or consultant service are listed in Section VII, Page 62, including for each, a brief statement of his field of expertise.

##### b. Utilization of Colorado State University's Competence

Very briefly, the utilization aspect of the University's competence would include such activities as:

\*Use of specialized services of Dr. E. V. Richardson, Dr. Max Lowdermilk, Marjorie Rhoades and Barbara Burke to help develop a CID information network system.

\* Continuation of the International School for Water Resources and Associated Programs with Professor Victor Koelzer as its Director, supported entirely by CSU and utilizing the regular faculty from the nine (9) colleges on campus.

\*Open seminars, conducted by professors and graduate students on issues in International Agricultural Development.

\*Release of Dr. Willis W. Shaner's time to develop a computer program for small-scale irrigation projects in Peru, consulting projects in Honduras and Egypt as well as initiating a graduate course on "Development Planning for Developing Countries."

\*Dr. George E. Radosevich, initiated the first World Conference ever held on "Global Water Law Systems" last year at Valencia, Spain, and followed through this year by a 2nd International Conference at Caracas, Venezuela.

\*Utilization of experienced faculty, i.e., those having lived and worked in foreign countries, to prepare or guide SOTA studies on water resources development, management and research useful to the small farmer.

\*The University has made excellent progress towards responding quickly to requests for technical assistance to LDCs, either directly from AID/W or through CID. Over thirty six (36) faculty members are now available.

\*Colorado State University's success in the International Education program, stimulated in part by the 211(d) grant, can be measured by the highest award the Mexican government can give to individuals in recognition of service to that country and to humanity - the Order of the Aztec Eagle, Commander Degree - bestowed upon the President of Colorado State University, Dr. A. R. Chamberlain in recognition of CSU's cooperation with Mexican education officials in the areas of water resources, agriculture and veterinary medicine.

TABLE III-A

Requests for Assistance Received During Reporting Period July 1, 1975 to June 30, 1976

## 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 |  |
| Investments in Small-scale Irrigation Proj.              | governments<br>USFA, farmers  | Peru                     | AID                   | \$ 5,000       | 45       | Developed computer program for carrying out financial and economic analysis of small-scale irrigation projects |
| Systems Analysis in Water Resources Planning             | governments<br>USFA, farmers  | Peru                     | AID                   | \$15,000       | 30       | Training of 30 Peruvian Engineers in six professional areas.   |
| Second Int'l Conf on Water Law Admin.                    | governments<br>USFA, farmers  | Venezuela, etc.          | UN, AID, others       | \$2,000        | 7        | Transfer of knowledge on Global Water Law Systems  |
| Water Code for the Gov't of Baluchistan                  | governments<br>farmers        | Baluchistan              | AID                   | \$3,000        | 30       | The Water Code is still under consideration by Government of Baluchistan.                                      |
| Irrigation Scheduling for Peru                           | governments<br>farmers        | Peru                     | AID                   | \$5,000        | 45       | Irrigation scheduling now improved resulting in better water management practices                              |
| Water Management for Small Irrigation Res.               | governments<br>farmers        | Thailand                 | AID                   | \$6,000        | 70       | Encourage government assistance to small farmers   |
| Institutional Development in Small Irrigation Reservoirs | governments<br>farmers        | Honduras                 | AID                   | \$5,000        | 45       | Loan proposal and scope still under discussion   |
| On-Farm Water Management Project for Egypt               | governments<br>farmers<br>AID | AID &<br>Egypt           | AID                   | \$30,000       | 120      | In process of activation   |

Table III-A (continued)

A. Requests Attended (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 |  |
| Reservoir Sedimentation in the Philippines               | governments farmers  | Philippines              | ECI                   | \$ 2,500       | 15       | Consultation and linkages  |
| Land & Water Resources Development                       | governments farmers  | Venezuela                | Venezuela             | \$ 1,500       | 15       | Lectured post graduate students  |
| Systems Planning with Reference to Groundwater Resources | governments farmers  | India                    | Ford Foundation       | \$10,000       | 90       | Developed and taught course in Systems Planning with reference to ground water resources |
| Expansion of CID/AID Bolivia Team                        | governments farmers  | AID/CID Bolivia          | AID                   | -              | -        | Too early for results  |
| Niger Cereals  | governments farmers  | AID/CID Niger            | AID                   | -              | -        | Being activated  |
| Consultation in Field of Polmology                       | governments farmers  | AID/CID Bolivia          | AID                   | -              | -        | Planning, evaluating and implementing program  |
| Iran Team  | governments farmers  | AID/CID Iran             | AID                   | -              | -        | Economic evaluation  |

TABLE III-B

Requests for Assistance Received During Reporting Period 1 July 1975 to 30 June 1976

## 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 |   |
| Director, Hydraulic Research Station, Wad Medani, Sudan                         | -                    | Sudan Gov't thru UNESCO                    | -                     | -              | -        | Original Director decided to stay on                              |
| Proposal on Water Efficiency-Coop. Project with Pakistan                        | -                    | Government of Pakistan                     | -                     | -              | -        | Under conderation by NSF  |
| Positions Available in College of Petroleum & Minerals in Dhahran, Saudi Arabia | -                    | College of Petroleum & Minerals, S.A.      | -                     | -              | -        | No response to this type of job opportunity.                      |
| Algerian Training Program for Extension Agents in Agric. and Irrigation         | -                    | Bechtel Corp. thru Algerian Government     | -                     | -              | -        | Under consideration   |
| Range and Water Management Team to the Cameroons                                | -                    | African Bureau AID thru Gov't of Cameroons | -                     | -              | -        | Notice received too late. Interested faculty already committed.   |
| Roorkee University Water Resources Training                                     | governments farmers  | 11E/UN                                     | Ford Foundation       | \$10,000       | 60       | Roorkee University cancelled because grant terms could not be met |





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

### General

The extended 211(d) Grant Work Plan covered slightly more than a two (2) year period, i.e., from May 23, 1975 to June 30, 1977. Next year's Plan of Work discussed below, therefore, covers the second or the last year of the grant.

In the following pages, Table 1 shows the CSU Staff Consultants and Fields of Interest. Table 2 gives a description of each of the five (5) outputs and the means of verification.

Next year's Plan of Work is based upon the desired outputs and is discussed below as follows:

#### 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 continue to be made by Colorado State University. However, some books and periodicals will be purchased for staff personnel working on the grant in order to get a relatively quick response to their needs.

##### B. Information Storage and Retrieval Systems

About 1000 citations were incorporated into the computerized information storage and retrieval system last year. This next year it is planned to add 2000 or more citations to the computerized system. Special attention will be given to the CIDNET System with our librarians working very closely with the other CID universities.

##### C. Dissemination of Publications

Each year many, many reports are published by the nine colleges, the experiment station, and by private publishing firms. Last year several hundred of these reports were disseminated to LDC researchers and libraries, FAO, AID missions, CID members and others using funds from the grant. This activity will be continued this next year.

#### 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, LDC's, 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, Agricultural Research Service, and 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 LDC's, donor agencies, and potential training centers. No 211(d) funds were utilized last year for the International School and no man months from the grant are budgeted for next year for this activity but some consulting services and travel of the director may be paid for if necessary.

#### B. Watershed Short Course

The primary responsibility for preparing a watershed short course to train the middle manager and tax level policy maker on the importance and need of watershed management to prevent erosion and increase food production has been taken by Arizona University in cooperation with the other CID universities. CSU maintained contact with AU during the reporting year by telephone bimonthly, 211(d) director's meetings and at the CID meetings. CSU will continue to cooperate with AU in the development of this short course.

#### C. Irrigation Water Delivery and Removal Systems

Work will continue on the development of a short course on the practical aspects of irrigation water delivery and removal systems. Emphasis will be to training middle management and top level policy makers on the importance and role of proper management of water delivery systems to increase crop production and to decrease drainage requirements. Arizona University and Utah State University will continue to cooperate in the development of this course.

#### D. On-Farm Water Management Short Course

A short course in the practical aspects of on-farm water management is nearing completion by Utah State University. CSU will continue to work with USU on the development of this course.

#### E. Project Planning Short Course

In response to several requests by students from LDC's, W. W. Shaner developed a course entitled "Planning for Development."

Subsequently, he presented a shortened version of the course in Peru. The course in Peru was sponsored by the Peruvian Ministry of Agriculture and USAID/Peru. This next year Shaner will develop a syllabus or manual for the course for presentation in LDC's. The title will be "Project Planning for Developing Economics."

### 3. Expanded Knowledge Base

#### A. Waterlogging and Salinity Control

During the past year several state-of-the-science reports were completed. Also, a draft state-of-the-art report on methodology for investigating waterlogging and salinity problems was completed in July of this year. However, with the resources available it will not be possible to adequately prepare a definitive SOTA on this important subject in the remaining time of the grant. Therefore, this next year will be spent on finalizing the SOTA on "Investigating Agriculture Waterlogging and Salinity Problems." Additional funds will be requested to finish the SOTA on Waterlogging and Salinity Control.

#### B. Sediment Control

A state-of-the-science 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 was completed in June 1976. The final reports will be prepared by May 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 the proceedings of the Global Water Law Conference that CSU presented in Spain in collaboration with USU and the University of Valencia, Spain. A specific paper was prepared describing the influence of Moslem Water Law and its influence on Spanish Water Law and the irrigation system of Spain. An additional SOTA on this important subject will be prepared this year.

#### D. Pumping Systems

The state-of-the-art report on waterlifters for irrigation will be completed this year. The literature review has been completed

and a report furnished to AID. Emphasis in the SOTA will be placed on the simplest means of waterlifts such as the windmill, 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. A preliminary report was finished by Allen Wood in June 1976. The final 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.

F. On-Farm Water Management

Colorado State University will participate in the preparation of state-of-the-art reports on on-farm management.

4. Advisory Capacity

A. Consulting Service

Grant funds will be utilized 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. Table 1 lists CSU Staff Consultants.

B. Release Time

Funds are budgeted in the grant to provide release time for a faculty member to respond to AID's request for consulting service.

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.

TABLE I. Colorado State University 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          |
| Gaylord V. Skogerboe  | Waterlogging, salinity, irrigation systems, water measurement, drainage  | 1,2,3,5,6        |
| 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 | 1,2,3,5,6,7      |

\*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 II. Project Purpose, Objectives (Outputs and Means of Verification)

| Narrative Summary  | Objectively Verifiable Indicators  | Means of Verification   | Important Assumption  |
|--|--|---|---|
| <b>Project Purpose</b>   | <ul style="list-style-type: none"> <li>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</li> <li>b) Continuous and significant involvement and linkages with LDC institutions</li> <li>c) Linkages and networks with other significant institutions working on food production problems in the LDC's</li> </ul>  | <ul style="list-style-type: none"> <li>a) Peer evaluation</li> <li>b) Record of utilization</li> <li>c) Annual report</li> </ul>  | <ul style="list-style-type: none"> <li>a) That additional capabilities by staff increases or improvements will result in a gradual increase in utilization.</li> <li>b) Utilization will increase available funding and staff capabilities. These in turn will increase utilization..</li> <li>c) That meaningful problems will be identified in the LDC's and adequate adaptive research will be performed.</li> </ul> |
| <p><b>Project Output 1</b><br/>Information Capacity.<br/>Collection evaluation and dissemination of information related to water resource utilization</p>  | <ul style="list-style-type: none"> <li>a) Distribution of reports documenting research results</li> <li>b) Expand printing and publication capabilities of CSU</li> <li>c) Increase the size of the library collection on water delivery and removal systems.</li> <li>d) A developed information storage and retrieval system</li> </ul>  | <ul style="list-style-type: none"> <li>a) Annual report and on-site visitation.</li> <li>b) Receipt of publications</li> <li>c) Documentation of data storage and retrieval programs.</li> </ul>  | <ul style="list-style-type: none"> <li>a) LDC's, CID and donor agencies will provide inputs and utilize the information system</li> </ul>   |
| <p><b>Project Output 2</b><br/>Education and Training<br/>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> | <ul style="list-style-type: none"> <li>a) Development and revision of courses</li> <li>b) Increase of students from LDC's in both conventional graduate training and International School for Water Resources.</li> <li>c) Development and presentation of short courses and training sessions on drainage and delivery of water to the small farmer.</li> <li>d) Development of contracts to improve training in LDC's research institutions and universities.</li> <li>e) Seminar in a LDC on soil and water management for erosion control</li> <li>f) Global Water Law Conference in 1975 to develop an understanding of legal and administrative constraints on water delivery and removal</li> </ul> | <ul style="list-style-type: none"> <li>a) Annual report with specific numbers and examples of accomplishments.</li> <li>b) Number of students and countries using International School</li> <li>c) Final reports on seminars or conferences.</li> <li>d) Symposium proceedings</li> <li>e) Manuals developed for short courses</li> </ul> | <ul style="list-style-type: none"> <li>a) There is a need and demand in the LDC's for the training and education so that funds will be provided for students to participate in the training.</li> <li>b) Cooperation by LDC institutions for training and education programs.</li> </ul>  |



TABLE II. (Cont'd)

| Narrative Summary   | Objectively Verifiable Indicators  | Means of Verification  | Important Assumption   |
|---|--|--|--|
| <p><b>Project Output 3</b><br/> <b>Expanded Knowledge Base</b><br/>                     Emphasis will be placed on state-of-the-art and problem identification relating to small farms in LDC's.</p>  | <p>a) Identification and evaluation of practices utilized by LDC's 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 LDC's in identifying problems or needs and conducting the research, etc.</p> <p>b) Continue interaction by 211(d) directors with AID, LDC's and CID to identify research priorities.</p> |
| <p><b>Project Output 4</b><br/> <b>Advisory Capacity</b><br/>                     Advisory and consultant capability for AID, LDC's, 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.</p> <p>b) Trip reports</p> <p>c) Final project reports</p> <p>d) Peer evaluation</p> <p>e) Donor recommendations</p>   | <p>a) There is a need for these consulting services.</p> <p>b) That the availability and talent at Colorado State University is known by the potential user.</p>   |

TABLE II. (Cont'd)

| Narrative Summary  | Objectively Verifiable Indicators  | Means of Verification  | Important Assumption   |
|--|--|--|--|
| <p>Project Output 5<br/>                     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 LDC's.</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> |



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. Last year two women engineers received their Ph. D. degrees in Water Management.

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

|                    | <u>Faculty</u> | <u>Graduate Students</u> | <u>Undergraduate</u> |
|--------------------|----------------|--------------------------|----------------------|
| Women              | 4              | 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 July 1, 1975 to June 30, 1976.

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 1 July 1975 to 30 June 1976

| Grant Objectives/Outputs   | 211(d) Expenditures |                   |                                  | Non 211(d) Funding**<br>Amount |
|----------------------------|---------------------|-------------------|----------------------------------|--------------------------------|
|                            | Period Under Review | Cumulative Total  | Projected Next Year End of Grant |                                |
| 1. Information Capacity    | 6,826               | 115,506           | 10,085                           | 100,000                        |
| 2. Education and Training  | 16,100              | 157,730           | 23,949                           | 50,000                         |
| 3. Expanded Knowledge Base | 36,505              | 262,866           | 55,459                           | 1,000,000                      |
| 4. Advisory Capacity       | 9,342               | 294,831           | 13,865                           | 20,000                         |
| 5. Linkage and Networks    | 15,183              | 79,910            | 22,686                           | 30,000                         |
| <b>Total</b>               | <b>83,956</b>       | <b>919,078***</b> | <b>126,044</b>                   | <b>1,200,000</b>               |

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TOTAL

\*These figures are best estimates

\*\*Other AID projects are included

\*\*\*Includes CID Support

TABLE II-A  
 211(d) Expenditure Report  
 Actual and Projected Summary  
 Under Institutional Grant AID/csd-2460  
 Reporting Period 1 July 1975 to 30 June 1976

|                             | Expenditures to date |                   | Projected Expenditures |         |         |         |         |         |
|-----------------------------|----------------------|-------------------|------------------------|---------|---------|---------|---------|---------|
|                             | Reporting Period     | Cumulative Total  | Year                   |         |         |         |         |         |
|                             |                      |                   | 1                      | 2       | 3       | 4       | 5       | 6       |
|                             | 1975-76              |                   | 1969-70                | 1970-71 | 1971-72 | 1972-73 | 1973-74 | 1974-75 |
| Salaries                    | 29,418               | 417,544           | 55,460                 | 53,587  | 84,594  | 79,566  | 66,506  | 48,413  |
| GRA                         | 25,817               | 245,183           | 21,977                 | 37,044  | 59,695  | 52,426  | 29,374  | 18,850  |
| Travel                      | 5,731                | 69,222            | 4,351                  | 19,470  | 13,188  | 16,232  | 3,334   | 6,916   |
| Equipment                   | 725                  | 4,978             | 213                    | 3,118   | -       | 96      | -       | 826     |
| Office Expense and Computer | 1,066                | 125,328           | 13,132                 | 19,291  | 28,082  | 33,465  | 30,292  | -       |
| Library and Publications    | 11,199               | 38,588            | 6,077                  | 1,188   | 9,515   | 3,604   | 5,518   | 1,487   |
| Subcontract                 | 10,000               |                   | -                      | -       | -       | -       | -       | 8,235   |
| Totals                      | 83,956               | 919,078 <u>1/</u> | 101,210                | 133,698 | 195,074 | 185,389 | 135,024 | 84,727  |

1/ Includes CID Support for 1975 and 1976

TABLE II-B  
 211(d) Expenditure Report  
 Reporting Year Detail  
 Under Institutional Grant AID/csd-2460  
 Reporting Period 1 July, 1975, to 30 June, 1976

| I.  | <u>A. Professional</u>                           | <u>% of Time</u> | <u>Salaries</u> |
|-----|--|------------------|-----------------|
|     | M. E. Becker                                     | 14               | 2,691.78        |
|     | W. E. Hart                                       | 22               | 4,152.62        |
|     | G. E. Radosevich                                 | 22               | 3,933.03        |
|     | E. V. Richardson                                 | 17               | 4,790.27        |
|     | L. A. Ross                                       | 16               | 1,600.00        |
|     | W. R. Schmehl                                    | 8                | 2,640.53        |
|     | W. W. Shaner                                     | 17               | 4,533.90        |
|     | Total Professional                               |                  | 24,342.13       |
|     | B. Clerical                                      |                  | 2,477.12        |
|     | Library  |                  | -0-             |
|     | Other nonprofessional                            |                  | -0-             |
|     | C. Fringe Benefits-Retirement only               |                  | 2,598.87        |
|     | 9.5% of Gross Salary                             |                  | -0-             |
|     |  |                  | 29,418.12       |
| II. | <u>Student Support</u>                           | <u>Country</u>   | <u>Amount</u>   |
|     | H. G. Blank                                      | USA              | 1,200.00        |
|     | C. S. Chen                                       | Taiwan           | 3,000.00        |
|     | A. C. Dourojeanni                                | Peru             | 3,000.00        |
|     | C. S. James                                      | So. Africa       | 800.00          |
|     | J. A. Riley                                      | USA              | 3,600.00        |
|     | J. Subramaniam                                   | India            | 3,716.70        |
|     | M. Svendsen                                      | USA              | 3,450.00        |
|     | D. M. Temple                                     | USA              | 3,600.03        |
|     | A. D. Wood                                       | USA              | 3,450.00        |
|     |  |                  | 25,816.73       |
|     | Grand Total: Professional<br>and Student Support |                  | 55,234.85       |



TABLE II-B (continued)

|      |   |                  |
|------|---|------------------|
| III. | A. Consultants  | -0-              |
|      | B. Guest Lecturers  | -0-              |
| IV.  | Travel  |                  |
|      | A. Domestic (7)   | 5,731.45         |
|      | B. Foreign (4)  | -0-              |
|      | Total   | <u>5,731.45</u>  |
| V.   | Equipment   | 725.00           |
| VI.  | Library Acquisitions, Training & Publications, i.e.,<br>Thesis & Dissertations, Reports, Papers, etc. | 11,199.00        |
| VII. | Other   |                  |
|      | Telephone   |                  |
|      | Postage   |                  |
|      | Computer  | 1,066.18         |
|      | Miscellaneous   |                  |
|      | CID Support   | <u>10,000.00</u> |
|      | Grand Total   | <u>83,956.48</u> |

APPENDIX A

DISTRIBUTION OF REPORTS DOCUMENTING RESEARCH RESULTS

1. To: Mrs. Katherine M. Roberts  
TAMS Agricultural Development Group  
Tippetts-Abbett-McCarthy-Stratton  
345 Park Avenue  
New York, New York 10022
- From: Dr. E. V. Richardson
  - a. Three (3) publications listing reports of Colorado State University, College of Engineering
  - b. One (1) brochure describing the Consortium for International Development (CIDNET)
  
2. To: H. M. A. Bakr  
Department of Soil and Water Science  
College of Agriculture  
University of Alexandria  
Shatby, Alexandria, A. R. E.
- From: Dr. E. V. Richardson  
Sent publications on Cutthroat flumes for water management, drip irrigation, and puddling method of canal lining.
  
3. To: M. Talib Chaudry  
National Engineering Services  
Wapda House  
Lahore, Pakistan
- From: E. B. Richardson  
Miscellaneous Water Management material
  
4. To: H. Fransen  
WHO International Reference Centre for Community Water Supply  
The Hague, Netherlands
- From: E. V. Richardson
  - a. "Small Farm Agricultural Development Problems," publication
  - b. "Exclusion and Ejection of Sediment for Canals," publication
  
5. To: Jean T. Burke  
Los Altos, Calif. 94022
- From: E. V. Richardson  
Sent publications on "Village Organizational Factors in Pakistan."

6. To: Dr. J. A. Ekpere  
Department of Agricultural Economics  
University of Ibadon  
Ibadon, Nigeria
- From: Dr. Huntley Biggs - CSU  
Sent publications on "Small Farm Agricultural Development Problems"
7. To: M. Said Abdallah, Professor of Hydraulics  
Head of Hydraulics and Irrigation Department  
Faculty of Engineering  
Cairo University, Giza, Egypt
- From: E. V. Richardson  
Sent complete set of Hydrology Papers and other publications
8. To: Eng. Herbert Farrer  
Professor Applied Hydraulics 2  
University of Costa Rica  
San Jose, Costa Rica
- From: E. V. Richardson  
Mailed five (5) CSU/211(d) grant publications
9. To: Lucien Duckstern and Marten Fogel  
School of Renewable Resources  
Univeristy of Arizona  
Tucson, Arizona 85717
- From: E. V. Richardson  
Sent 17 publications
10. To: P. H. Jones, Project Manager  
Control of Waterlogging and Salinity  
Food and Agriculture Organization of the U. N.  
Alexandria, Egypt
- From: E. V. Richardson  
Sent a number of publications
11. To: Ing. Ana Radu  
Bucarest, Romania
- From: Dr. James F. Ruff - CSU  
Mailed several articles and reports

12. To: R. Kalnert  
Head of Research, OECD  
Paris, France

From: E. V. Richardson  
Sent complete Water Management Series and National Water  
Commission Reports

13. To: R. C. Ballance  
Sanitary Engineer  
Community Water Supply and Sanitation  
Division of Environmental Health  
Geneva, Switzerland

From: E. V. Richardson  
Mailed copy of A. D. Wood's "Water Lifters and Pumps for  
the Developing World" and other publications

14. To: Dr. Richard Feochem  
University of Birmingham  
Birmingham, England

Dr. J. M. G. Van Duane  
WHO International Ref. Centre for Community Water Supply  
Hague, Netherlands

Dr. F. E. McJunkin  
P. O. Box 2427  
Chapel Hill, N. C. 27514

Dr. Philip F. Palmedo (head  
Energy Policy Analysis Division  
Brookhaven National Laboratory  
Associated Universities, Inc.  
Upton, Long Island, N. Y. 11973

From: E. V. Richardson  
Sent to the above listed personnel and to others on the CSU  
campus, a copy of Alan Wood's thesis on Pumps plus other  
information and publications.

15. To: Chery P. Wise, Special Assistant to International Program  
Standard Manufacturing and Analysis Section, U. S. Department  
of Commerce, National Bureau of Standards, Washington, D. C.  
20234, requested information about existing national and  
international engineering information systems.

From: E. V. Richardson  
Mailed copies of CIDNET brochure plus other information.

16. To: Dr. Lawrence R. Conklin, Department Agricultural Economics,  
University of Idaho, Moscow, Idaho

From: E. V. Richardson  
Mailed copy of "Optimal Irrigation Decisions with Limited  
Water" by Herbert Blank.

The above is not a complete distribution list. Many documents were sent to the CID universities, to other universities and individuals, to AID/W as well as provided to students. Perhaps in all, several hundred pieces of literature were distributed during the reporting year.



APPENDIX B

B-1 Through B-14 . . . The International School

B-15 Through B-25 . . . Information Regarding each Participant



## THE INTERNATIONAL SCHOOL

### Purpose

There are many professional personnel who seek improvement of their capabilities by training in new techniques, by updating their knowledge, or by obtaining additional education to broaden their outlooks. The essential need in these cases is to provide training that will allow individuals to return to their organization and perform their role in a more effective manner.

The International School for Water Resources and Associated Programs was established to provide a structure through which these needs could be met in water resources and associated fields. The International School is essentially a programming facility which can respond to individual needs or to those of a sponsoring agency or country. Thus, it is not a degree-granting program and specific curricula are not prescribed.

The School provides an opportunity for a program to be tailored to a certain individual's or agency's needs in a specified--often limited--time span. There is no formal listing of academic requirements. The Director of the School can arrange to meet leaders outside the University in a chosen field; highly qualified teachers can be selected at Colorado State University for certain topics; and travel can be directed to projects or governmental agencies where new techniques are used or where useful expertise can be garnered to take back to an individual job or area of the world.

The most common situation where sponsors may find enrollment of one of their fellows to be of distinct advantage is that in which applied training is considered desirable. This may occur because of a limitation in funds or because of a desire to combine academic training with on-the-job training in conjunction with a United States Government agency. It may occur because of a desire on the part of a participant of a sponsoring agency to learn certain techniques or attain certain knowledge, with no further academic degree goals in mind.

### History

The International School was established in 1967 on the campus of Colorado State University, Fort Collins, Colorado, for the specific purpose of providing training for individuals who already hold their first degree or title. The University has many areas of expertise and offers broad fields of endeavor which may be utilized in the various individual programs. Administered by the College of Engineering and the Department of Civil Engineering, the program originally was focused on the water resources area exclusively. Through the years, the program has broadened to include other phases of engineering and the applied sciences, although an emphasis is still maintained on water resources.

Academic fields in which students in the International School have focused include:

Water Resources and Development  
 Hydraulic and Fluid Mechanics  
 Hydrologic and Hydraulic Modeling  
 Hydrology  
 River Mechanics  
 Water Resources Systems  
 Power Systems  
 Groundwater  
 Environmental Engineering  
 Control of Air and Water Pollution  
 Agricultural Engineering  
 Agronomy  
 Soil Science (Agricultural Soils)  
 Urban Water Management  
 Water Law and Related Administrative Aspects

Additional fields of interest available for participants in the International School are given on pages 12, 13, and 14.

Since initiation of the International School, students from the following countries have participated in various programs:

|             |               |
|-------------|---------------|
| Afghanistan | Philippines   |
| Argentina   | Poland        |
| Brazil      | Panama        |
| Bulgaria    | Romania       |
| Colombia    | Saudia Arabia |
| El Salvador | Sierra Leone  |
| Ethiopia    | Sudan         |
| Fiji        | Taiwan        |
| Guatemala   | Thailand      |
| Hungary     | Trinidad      |
| India       | Turkey        |
| Jordan      | USA           |
| Korea       | Venezuela     |
| Lesotho     | West Cameroon |
| Libya       | West Germany  |
| Nepal       | Yemen         |
| Pakistan    |               |

#### Varied Non-Degree Programs

"Practical know-how" and its application is stressed in non-degree programs. Courses chosen for participants are selected because of their practical or applied nature.

The International School has no faculty of its own, but utilizes the regular faculty in the various departments of the nine colleges on campus.

The nine colleges are: College of Agricultural Sciences, College of Business, College of Engineering, College of Forestry and Natural Resources, College of Home Economics, College of Humanities and Social Sciences, College of Natural Sciences, College of Professional Studies, and the College of Veterinary Medicine and Biomedical Sciences. There are 56 departments of instruction within these colleges.

The School provides many approaches through which the participant may accomplish stated goals.

1. Formal classroom work.
2. Special projects of interest to the participant.
3. Participation in investigations and research projects.
4. Special assignments, lectures, and seminars.
5. Contact with local or national organizations which relate to the participant's area of interest.
6. Visits to university, state, national, and other laboratories; research centers; and operating projects which relate to the area of interest.

The flexibility in program and time periods allowed by the International School permit participants to conform to the stipulations of the fellowships granted by sponsoring agencies or organizations. If the terms of the fellowship include observational or practical training periods, the study program can be adjusted to fulfill these requirements.

The courses offered by the nine colleges of the University which are available to participants in the International School are exemplified by a separate pamphlet, Selected Courses Offered by Colorado State University in Water Resources and Associated Programs. This pamphlet demonstrates the courses which might be taken in an interdisciplinary program associated with the water resources area. The general catalog of Colorado State University should be consulted for a complete listing of courses offered. (A copy of the University General Catalog can be obtained by writing to the Director of the International School.)

#### Time of Admission

Colorado State University operates on the early semester plan. The academic year consists of the fall semester (late August to mid-December), the spring semester (mid-January to mid-May), and the summer session (mid-June to early August). There are two interim sessions of three weeks (one in late May to early June and one in late December to mid-January).

The average academic course load is considered to be 15 semester credits. Some participants have chosen to take an average of only about 12 credits so that there is time to assimilate more of the peripheral academic opportunities provided. Others will find it desirable to reduce their first semester enrollment to less than 10 credits because of the necessity of becoming acquainted with American academic procedures or because of difficulties in understanding the language. However, there is

no reduction in the charges per semester for the School if the participant elects to carry less than 15 semester credits. The normal course load for the eight-week summer school session is considered to be eight semester credits.

Following are examples of typical programs which have been pursued by students during the lifetime of the School:

- (a) One student, a deputy director for water and power in his ministry, operated under a program arranged by the U.S. Bureau of Reclamation (USBR) for the United Nations Development Fund. He first spent six months of on-the-job training with the USBR in design of dams and related hydraulic structures. This was followed by two quarters in the International School in courses in hydrology, hydraulics, soil mechanics, hydraulic structures, economics, and a special study in water resources planning. This was followed by a two-month field trip, arranged by the USBR, to view construction practices at a number of USBR projects in the western United States.
- (b) A second student, in a 25-week program sponsored by the United Nations Food and Agricultural Organization, took only academic work in preparation for the development of an irrigation project in the student's home country. His training was in irrigation agronomy and included a combination of theoretical, practical, and field work. The course work included soil physics, mathematical methods in the biological sciences, saline and sodic soils, irrigation practice, soil chemistry, crop ecology, and an interdisciplinary water seminar.
- (c) Another student, in a 25-week program arranged by the U.S. Geological Survey (USGS), combined courses for one quarter at Colorado State University with visits to different centers in several states operated by the USGS. He worked for 12 weeks with that agency obtaining training in hydrologic techniques for the systematic collection, compilation, and evaluation of data relating to the chemical quality of water. In the academic portion of his program, the student was introduced to fundamental studies of the occurrence and significance of dissolved and suspended substances and to laboratory techniques currently in use for analysis of the common chemical constituents in water.
- (d) Another student, at the request of the U.S. Agency for International Development (USAID), received training in water pollution control during a period that lasted only six weeks. The principal activity was in individualized laboratory sessions at Colorado State University. The training also included exposure to the legal and social, as well as the technical, aspects of formulating and administering government

environmental controls. This was accomplished through visits to two law schools, the Air Pollution Variance Board of Colorado, the Attorney General of Colorado, and a court proceeding on air pollution violation. This training supplemented arrangements by USAID for training at other universities in the United States.

Throughout the year, special lectures, seminars, and institutes are presented at Colorado State University by outstanding individuals working in practically all aspects of environmental management. These are available to enrollees in the International School. There are also many professional and industrial organizations which hold local, regional, and national meetings and conferences on the campus. These often are open to the interested student.

### Planning the Student's Program

The administrators of the International School welcome the opportunity of working with a sponsoring agency or company in the development of a general course of study or work program for a potential participant. There is no obligation for this service. The potential sponsor should outline the specific training needs requested and the approximate time span in which these are desired.

To accomplish the objective of attaining improvement in their present positions as professionals, the background and goals of each individual are carefully considered. When the student arrives at the University, an in-depth interview is held with the Director of the School, who acts as his or her adviser. The purpose is to probe the background of each individual, the position they have held and the one they will return to, and their goals in entering the program. A detailed program of participation is planned in this consultation with the participant. If the student's objectives include work outside of civil engineering, supervisors in other departments of the University are consulted, usually as an additional participant in the interview.

The program in the International School can be for any time period that the sponsor desires. If the student plans to attend for a full year, there is some advantage to begin attendance in the fall semester. However, this is by no means universal, and useful course work or other useful aspects of their programs usually can be planned for individuals starting later in the year.

### Diplomas and Certificates

Diplomas are granted by the School to those participants who successfully complete all requirements of the School and two full semesters, which are not necessarily consecutive. A certificate is given to those participants who attend the School for less than that period or who do not satisfy the requirements for the diploma. The diploma and the certificate are

evidence only of successful participation in the International School and do not constitute an academic degree.

A participant taking a course for credit usually does so under the traditional grading system. Occasionally, at the discretion of the Director of the International School, the student can take the pass/fail option if applicable to a specified course. It is also possible to audit a course.

#### RELATED EDUCATIONAL AND RECREATIONAL OPPORTUNITIES

Colorado State University is nestled in the foothills of the Rocky Mountains in one of the most important centers for water resource activities in the United States. The University faces west to the snow-capped peaks of the Rocky Mountains and east to the high plains region. This unique setting provides the advantage of many recreational and educational opportunities.

##### Off Campus

Within a short distance from the University are the Rocky Mountain National Park, the Fort Laramie National Historic Site, Shadow Mountain National Recreation Area, Pawnee National Grasslands (which is also the location for the Grassland Biome Study of the United States International Biological Program), and the Roosevelt and Arapahoe National Forests. In addition, there are various facilities nearby of technical interest such as a number of Research Centers of the University's Experiment Station, the U.S. Bureau of Reclamation's headquarters and research center, the National Center for Atmospheric Research, the Colorado-Big Thompson multipurpose project, and the Fort St. Vrain Nuclear Generating Station.

##### On Campus

The University has approximately 16,800 regular on-campus students. Over 2,100 of these are graduate students. Graduate programs are offered in more than 54 fields of study. This variety provides a dynamic academic setting for many organizations as well as formal classroom activity. Many federal and state agencies have established research or activity centers in cooperation with Colorado State University. Members of the professional staff of these organizations are available for consultation to participants in the School.

Among the U.S. Government organizations on the campus are: Fish and Wildlife Service (United States Department of the Interior), the Agricultural Research Service, Economic Research Service, Farmers Home Administration, Soil Conservation Service, and the Rocky Mountain Forest and Range Experiment Station of the Forest Service (United States Department of Agriculture), and the Center for Disease Control (United States Department of Health, Education and Welfare). The State of Colorado Division of Game, Fish and Parks and the Colorado State Forest Service are also located in

Fort Collins and share University facilities.

The William E. Morgan Library on the main campus houses nearly one million volumes, including a vast array of periodicals, journals, newspapers, manuscripts, films, phonorecords, microfiche, and other reference items. A few departments have separate assemblies of reference material provided by the University on various technical and scientific subjects.

The University Computer Center has a third-generation CDC 6400 Computer available with access through remote terminals and with availability for a large amount of disc storage, together with capability for graphical output. There are also smaller computers available at the Computer Center and in various departments on the campus, as well as facilities for analog-to-digital conversion and processing.

## FINANCIAL INFORMATION

### Sponsorship and Support of Participants

There are no scholarships or fellowships established by the University to support a student financially for this program. Usually participants are sponsored by an international organization, by their country, or by their employer.

Participants in the International School are required to spend full time on their program. Because of this, it is required that applicants arrange for their financial support prior to enrollment.

A sponsoring agency usually is one of the established international agencies. These may include agencies such as the United Nations or one of its specialized agencies, the Agency for International Development (United States Department of State), the International Development Association, or the Institute of International Education. (Applicants should refer to UNESCO's annual publications of the Institute of International Education, particularly the excellent "Handbook on International Study: For Foreign Nationals.")

A local, state, or federal agency of the United States or parallel organizations in other countries also may sponsor students. The sponsor may be a private firm--some students have been sponsored by consulting engineers under contract to foreign governments for water resources investigations, while another student has been financed by a consulting firm from a South American country. Sponsors also could be a legally recognized district, an institute, an educational organization, or a professional or industrial organization or association.

Although the usual approach to enter the International School is through a sponsoring agency or organization, it is possible for an individual to arrange for a program of study in engineering or applied science if the applicant can demonstrate the financial ability to provide personal

support for the duration of the proposed program. All communication about an individual program without agency sponsorship should be made directly to the Director of the International School.

### Attendance Fee

For the 1975-76 academic year, the charge for attendance at the School will be \$1200 for each semester. Charges currently planned for the 8-week summer session are \$650, and for the two 3-week interim sessions, when utilized, \$250 each. These fees include the School's expense for staffing and administration, basic health services, hospitalization and accident insurance (for applicant only), and costs for necessary field trips of short duration within the state of Colorado, as well as educational costs incurred by the University. These charges, as well as semester charges for subsequent years, may be changed by the State of Colorado as economic conditions change.

Foreign students who are not sponsored by an agency may, if they wish, prepay the attendance fee in advance of attendance. This would mitigate the problem of carrying large sums of money with them in traveling to the United States.

### Living Expenses

Lodging expenses shall be paid by the participant or the sponsoring agency. The participants in the International School have the privilege of obtaining board and room in a residence hall, as regular degree students do, if the participants are single and the rooms are available. They may also rent University-owned apartments if they are available. Assistance in finding adequate lodging will be given by the Office of Housing and Residence Education or the Office of Renters' Information (Student Center). The participants who plan to bring families should inform the Director of the School as soon as possible and no later than two months prior to their arrival in Fort Collins.

The University has an Adviser to Foreign Students and Faculty whose office also will assist a participant from another country in many ways so that a rapid adjustment can be made in relation to the move to Colorado State University. Participants should report to the foreign student adviser's office as their first contact immediately upon arrival at the campus.

The following are current (1975) examples of typical rental expenses. These almost certainly will vary from time to time. Past history has shown a constant escalation of prices.

#### 1. Single participant

##### University Housing

- a. Shared bedroom in two bedroom apartment  
(without meals) - \$65/month



- b. Private bedroom in one bedroom apartment  
(without meals) - \$118/month
- c. Private bedroom in three bedroom apartment  
(without meals) - \$75/month
- d. Private bedroom in four bedroom apartment  
(without meals) - \$65/month

Meals are available at Durrell Center with the above apartments for \$390/semester.

- e. Room and board in residence halls starts at \$630/semester and runs to \$680/semester, depending on residence hall assignment

#### Privately Owned Housing

- a. Large facility near campus  
Standard single room with 15 meals per week - \$792/semester, \$1549/two semesters  
Standard double room with 15 meals per week - \$596/semester, \$1161/two semesters
- b. Motor hotel near campus  
Single room without bath - \$25/week  
Single room with bath - \$11.55/day or \$43/week

## 2. Participant and family

#### University Housing

- a. Two bedroom furnished apartment (all utilities included except telephone service) - \$125 or \$130 or \$140/month
- b. Three bedroom furnished apartment (all utilities included except telephone service) - \$155/month

#### Privately Owned Housing

Apartments in town vary greatly in price but are generally more expensive than University-owned housing of comparable quality.

### Other Projected Expenses

These expenses are to be borne by the sponsor or participant and are not included in the attendance fee:

1. Transportation and other travel expenses of participants from their homes to Fort Collins, Colorado, and return.
2. Books, slide rules, pocket computers, drafting equipment, and materials necessary for course work.
3. Computer time exceeding that available for formal class work.

4. Expenses for extensive field trips to be taken as a part of the requirements of a specific program.
5. All other living costs of participants.
6. Insurance. Dependents of applicants must also have life and hospitalization insurance if accompanying applicant.

#### Application

The application for admission to the International School is included as a tear-out in this bulletin. The application and the additional information requested should be sent to the following address, unless another individual has been designated to receive applications as a result of contractual relationships between Colorado State University and a sponsor (i.e., between Colorado State University and AID).

Director, International School for Water Resources  
and Associated Programs  
212 Old Chemistry  
Colorado State University  
Fort Collins, Colorado, USA, 80523

It is preferred that sponsors of international students should submit their applications for admission at least two months prior to the opening of the semester to which admission is requested. If sponsored, the applicant should have an application sent to the Director by the sponsoring agency. Applications from within the United States also should be submitted two months before admission is requested.

#### Material to be Submitted with Application

The following information should accompany the completed application:

1. A photo-duplication copy of the credential or degree certificate which shows that the applicant has obtained a first academic degree or title. This should be accompanied by an English translation of the credential and the grading system should be explained.
2. A certified copy in the language of the country and a certified English translation of credit for any course work or degree received at the graduate level.
3. A photo-duplication copy of the complete post secondary record showing courses completed, grades received, or examinations passed. The grading system shown in the credentials should also be explained.

4. A statement by an appropriate representative in American embassies or consulates located in the applicant's country showing that the applicant has sufficient knowledge of the English language to follow the School's curriculum in English. Scores above 550 on the Test of English as a Foreign Language (TOEFL) or above 280 on the test of American Language Institute, Georgetown University (ALIGU), are acceptable and may be submitted for the statement.
5. Recommendation by the sponsoring agency (i.e., United States Department of Agriculture, the United Nations, the Agency for International Development of the United States Department of State, etc.) of the specific program which the applicant should pursue and under which he is being sponsored.
6. A brief autobiographical sketch showing all educational and professional experience.
7. Proof of financial support for the applicant and for his family if they are to accompany him. (If the applicant is sponsored, the letter from the sponsor will fill this need.)
8. All other pertinent information which the candidate or the sponsoring agency feels would improve an understanding of the program objectives.

#### Emphasis on Proficiency in English

Administrators of the School stress that applicants must have proficiency in English so that participants may receive maximum benefit from their educational experience. The most common reason for failure to attain program proficiency is lack of adequate English capability. Lack of English proficiency can greatly slow up the rate of progress in attaining credits or, more seriously, result in inadequate perception of course content or failure in grades.

Information about TOEFL or ALIGU is available in many locations outside the United States. It is usually available at American embassies and consulates, offices of the United States Information Service (USIS), United States educational commissions and foundations, binational centers, and many private organizations such as the Institute of International Education (IIE), African American Institute (AAI), American Friends of the Middle East (AFME), and the American-Korean Foundation (AKF). Information on TOEFL is also available from TOEFL, Box 899, Princeton, New Jersey, USA, 08540. TOEFL tests are given four times yearly in testing centers located throughout the world.

The acceptance scores on TOEFL and ALIGU represent guidelines. TOEFL scores of 500 and ALIGU scores of 250 can be accepted providing the student is willing to take additional English training upon arrival at the University by enrolling in a class entitled "English as a Foreign Language."

If language proficiency is at or below the above indicated margins for acceptance, attendance at special language schools in the United States, in advance of enrollment in the International School, is recommended. Sponsoring agencies will ordinarily have information concerning such schools; if not, information can be obtained by writing to the Director of the International School.

#### ADMINISTRATION OF THE SCHOOL

Dr. Lionel V. Baldwin, Dean, College of Engineering  
 Dr. Daryl B. Simons, Associate Dean for Research, College of Engineering  
 Dr. J.W.N. Fead, Head, Department of Civil Engineering, College of Engineering  
 Victor A. Koelzer, Director, International School for Water Resources and Associated Programs  
 James R. Graham, University Adviser to Foreign Students and Faculty  
 Dr. Donal D. Johnson, Dean, College of Agricultural Sciences

#### EXPERTISE OF THE INSTITUTION

Colorado State University was established in 1870 by the Council and House of Representatives of Colorado Territory. Since that time, the faculty and staff of the Institution have brought the University to a place of national and international eminence in certain areas of research and to a place of recognition as a leading university in the United States. The College of Engineering has added to this stature with preeminence in the fields of water resources, fluid dynamics, and atmospheric science.

The University is a member of CID (Consortium for International Development). This consortium of five leading universities was created to provide expertise in the foreign assistance programs of the United States, particularly in the development and technical assistance phases of those programs. (The universities in the consortium are Colorado State University, Utah State University, Arizona State University, University of California at Davis, and the University of California at Riverside.)

Students in the International School will be able to associate with professors recognized in their fields both nationally and internationally.

The following list will serve to illustrate some of the more specific fields of interest available to participants in the School.

Agricultural Engineering

Agronomy

Agricultural Extension

Air Pollution Control

|   |                                       |
|---|---------------------------------------|
| Animal Ecology, Wildlife Resources                        | Forestry                              |
| Atmospheric Chemistry                                     | Geomorphology                         |
| Atmospheric Sciences                                      | Groundwater                           |
| Atmospheric Water Resources                               | Hydraulic Modeling                    |
| Baking Technology and Protein<br>Supplementation          | Hydraulic Structures                  |
| Bio-Engineering   | Hydrologic Modeling                   |
| Cloud Physics, Weather Modification                       | Hydrology                             |
| Computer Sciences   | Hydropower                            |
| Cooperative Extension Service<br>and Continuing Education | Information Storage and Retrieval     |
| Dams  | Irrigation Agronomy                   |
| Domestic Water Supply                                     | Irrigation Engineering                |
| Drainage of Agricultural Lands                            | Irrigation Practices                  |
| Drainage (Urban)  | Mathematics                           |
| Ecological Simulation and Modeling                        | Nutrition Education                   |
| Economics   | Plant Ecology and Botany              |
| Environmental and Structural<br>Aerodynamics              | Political Science                     |
| Environmental Climatology                                 | Range Management                      |
| Environmental Health                                      | Recreation Resources                  |
| Environmental Law and Economics                           | Remote Sensing                        |
| Environmental Resources                                   | River Mechanics                       |
| Environmental Sensor Systems                              | Snow Hydrology and Snow Physics       |
| Evapotranspiration and Revegetation                       | Sociology and Developmental<br>Change |
| Flood Control   | Soil Fertility                        |
| Food Processing   | Soil Management                       |
| Forest Hydrology  | Soil Mechanics                        |
|   | Soil Physics                          |

Soil-Plant-Water Relations

Soil Science

Statistics and Stochastic  
Processes

Wastewater Treatment

Water Law

Water Microbiology

Water Pollution Control

Water Resources Planning and  
Management

Water Resource Systems Engi-  
neering

Watershed Management

| Participant       | Highest Degree | Home Country           | Financial Assistance Provided by | Length of Time in School | Dates      | Special Interest                        | Attachment A  |             |
|-------------------|----------------|------------------------|----------------------------------|--------------------------|------------|---|---|-------------|
|                   |                |                        |                                  |                          |            |   | Remarks   | Award       |
| Agbor, J. B.      | B.S.,C.E.      | West Cameroon (Africa) | AID                              | 1 yr.                    | 6/67-6/68  | Domestic Water Supply                   |   |             |
| Mellema, W. J.    | B.S.,C.E.      | USA                    | Corps of Engineers               | 1 yr.                    | 6/67-6/68  | River Behavior                          | Obtained M.S., C.E.   | Diploma     |
| Stensatter, G. A. | M.S.,C.E.      | USA                    | U.S. Forest Service              | 9 mo.                    | 9/67-6/68  | Water Quality, Economics & Water Supply |   |             |
| Krukowicz, A.     | M.S.(Hyd.)     | Poland                 | UNDP                             | 3 mo.                    | 9/68-12/68 | Computer Application to Hydrology       | Vistula River Project-UNDP  | Diploma     |
| Rutowski, M.      | M.S.(Hyd.)     | Poland                 | UNDP                             | 6 mo.                    | 9/68-3/69  | Computer Application to Hydrology       | Vistula River Project-UNDP  | Diploma     |
| Mathe, Zoltan     | B.S.(Hyd.)     | Hungary                | UNESCO                           | 6 mo.                    | 1/69-6/69  | Planning Flood Control                  | Limited Funds-UNESCO fellowship admin. by Inst. Internat'l. Ed.             | Diploma     |
| Kozak, Miklos     | D. Sc.         | Hungary                | Ford Foundation thru IIE         | 4 mo.                    | 2/69-5/69  | Hydraulics of Open Channels             | Actually visiting Prof.-handled by Sch. for admin. of \$1100 computer chgs. |             |
| Kindler, Januz    | M.Sc.          | Poland                 | UNDP                             | 1 mo.                    | 6/69       | River Basin Planning                    | Dir., Vistula Proj. Assigned Water Res. Inst. 2 wk.-trip arranged           |             |
| Stachy, J. J.     | D. Sc.         | Poland                 | UNDP                             | 3 mo.                    | 1/70-3/70  | Planning-Hydrology                      | Vistula River Project-UNDP  | Diploma     |
| Lee, Keun-Hoo     | B.S.,A.E.      | Korea                  | AID                              | 3 mo.                    | 3/70-6/70  | Groundwater                             | AID Funding admin. USGS, returned Same funding                              | Certificate |
| Zielinska, Maria  | D.Sc.          | Poland                 | UNDP                             | 4 mo.                    | 3/70-7/70  | Planning Hydrology Systems              | Vistula River Project-UNDP  | Diploma     |

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| Participant         | Highest Degree                | Home Country | Financial Assistance Provided by | Length of Time in School | Dates      | Special Interest  | Remarks  | Award       |
|---------------------|-------------------------------|--------------|----------------------------------|--------------------------|------------|---|--|-------------|
| Bennett, R. B.      | B.S.,<br>C.E.                 | USA          | Self                             |                          |            | Planning, River Flows<br>Programmed Storage<br>Releases | Entered 9/69 but<br>left Sch. 2nd day<br>for personal reasons  |             |
| Lara, R. F.         | B.S.,<br>C.E.                 | Colombia     | Colombia Govt.                   |                          |            | Hydrology   | Entered 9/69 but<br>trans. to Grad. Sch.<br>after orientation.<br>No degree                                  |             |
| Lawson, E. F.       | B.S.,<br>CE                   | Sierra Leone | WHO                              | 3 mo.                    | 9/70-12/70 | Water Resources<br>Development                          | WHO Fellowship for<br>1 yr. beginning 9/70,<br>trans. to Grad. Sch.<br>Jan. 71. Received<br>M.S.(B), Spr. 72 | Certificate |
| Tripathi, M. S.     | B.E.,<br>Civil                | India        | WHO                              | 9 mo.                    | 9/70-6/71  | Domestic Water Supply                                   | WHO Fellowship for<br>10 mo.-9 mo. CSU &<br>1 mo. inspection<br>trip planned by<br>CSU. Admin. by USPHS      | Diploma     |
| Martinez A., Hector | B.S.                          | El Salvador  | Self                             | 14 mo.                   | 1/71-4/72  | Civil Engineering                                       | Failed Grad. Sch.  | Diploma     |
| Borges, C. A.       | M.S.,<br>Water Re-<br>sources | Venezuela    | MOP                              | 6 mo.                    | 1/71-6/71  | Remote Sensing<br>(Water Resources)                     | Funded by Govt.<br>of Venezuela  | Diploma     |
| Narvaez, J. M.      | M.S.<br>Water Re-<br>sources  | Venezuela    | MOP                              | 6 mo.                    | 1/71-6/71  | Remote Sensing<br>(Water Resources)                     | Funded by Govt.<br>of Venezuela  | Diploma     |
| Singh, B. R.        | B.E.,<br>Civil                | India        | Self                             | 3 mo.                    | 3/71-6/71  | Drainage  | Withdrew from Int.<br>Sch. 6/71  |             |
| Trujillo, H. A.     | B.S.,<br>C.E.                 | Venezuela    | Univ. of the<br>Andes            | 3 mo.                    | 9/71-12/71 | Water Resources<br>Planning                             | Univ. of the Andes<br>Engineer   | Diploma     |
| Zuberi, F. A.       | B.E.,<br>C.E.                 | Pakistan     | UN                               | 9 mo.                    | 9/71-6/72  | Drainage & Groundwater                                  | Site Engr., West<br>Pakistan Water &<br>Power Development,<br>Received M.S.(B),<br>C.E., Wtr. '73            | Diploma     |



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| Participant     | Highest Degree                   | Home Country | Financial Assistance Provided by | Length of Time in School | Dates             | Special Interest                       | Remarks  | Award       |
|-----------------|----------------------------------|--------------|----------------------------------|--------------------------|-------------------|--|--|-------------|
| Duma, Didi      | Ph.D.                            | Romania      | Nat'l. Academy of Science        | 3 mo.                    | 1/72-3/72         | Fluvial Hydraulics & Physical Modeling | Academy of Sci. exchange fellow  |             |
| Chen, Jyh-ching | no info.                         | Taiwan       | UN thru Bur. of Rec.             | 3 mo.                    | 4/72-6/72         | Hydraulics                             |  | Certificate |
| Goktay, Behan   | B.Sc., Ag.                       | Turkey       | USDA-ERS                         | 6 mo.                    | 9/72-3/73         | Mgmt. of Irrigation Systems            | Chief Irrigation Engr., General Directorate of Topraksu                                    | Certificate |
| Hsieh, Juei-lin | B. of Ag.                        | Taiwan       | AID                              | 9 mo.                    | 9/72-6/73         | Water Resources                        | Engr., Taiwan Provincial Water Conservancy Rec., Grad. Sch. 6/73, M.S.(B), C.E., Sum. 73   | Diploma     |
| Matlosa, H. M.  | B.Eng., C.E.                     | Lesotho      | UN thru Bur. of Rec.             | 1 mo.                    | 9/72-10/72        | Hydrology                              | Withdrawn by Sponsor   |             |
| Kim, Eui Jae    | Lawyer                           | Korea        | AID                              | 6 wk.                    | 10/12/72-11/23/72 | Prevention of Water & Air Pollution    | Chief of Industrial Admn., Industrial Section, City of Seoul                               | Certificate |
| Kim, Jong-Surk  | DVM, Vet. Med.                   | Korea        | AID                              | 6 wk.                    | 10/12/72-11/23/72 | Prevention of Water & Air Pollution    | Asst. Chief Examiner, Public Nuisances & Environmental Control Hygiene Lab., City of Seoul | Certificate |
| Georgiev, B. V. | Diploma from High Inst. for C.E. | Bulgaria     | UN-IEE                           | 3 mo.                    | 1/73-3/73         | Hydraulics & Hydraulic Models          | Research Worker, Bulgarian Academy of Science  | Certificate |
| Budeiri, Z. M.  | B.Sc., C.E.                      | Jordan       | FAO                              | 5 mo.                    | 1/73-5/73         | Water Resources                        | Deputy Director General, JRTRC Rec., Grad. Sch. 6/73, M.S.(B), C.E., Fall 73               | Certificate |

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| Participant        | Highest Degree          | Home Country | Financial Assistance Provided by | Length of Time in School | Dates      | Special Interest            | Remarks   | Award       |
|--------------------|-------------------------|--------------|----------------------------------|--------------------------|------------|-----------------------------|---|-------------|
| Al-Afifi, M. A.    | B.Sc.,<br>Ag.           | Yemen        | FAO                              | 8 mo.                    | 1/73-8/73  | Irrigation Agronomy         | Soil Specialist & Head of Soil Section, Ministry of Ag. & Agrarian Reform, Grad. Sch. Fall 73, M.S. Agronomy, Fall 74 | Certificate |
| Lopez, Antonio Y.  | B.S.,<br>C.E.           | Colombia     | AID thru Univ. of Nebr.          | 9 mo.                    | 1/73-9/73  | Water Resources             | Engr. Hydrologist, SCMH. Grad. Sch. Fall 73, M.S., C.E., Fall 74  | Diploma     |
| Kwon, Soon-Kuk     | B.S.<br>Ag. Engr.       | Korea        | AID                              | 12 mo.                   | 1/73-12/73 | Water Control & Utilization | Jr. Research, Inst. of Ag. Engr. & Utilization, Grad. Sch. Wtr. 74, M.S., Ag. Engr., Sum. 74                          | Diploma     |
| Choopiban, Viset   | B. of<br>Engr.,<br>E.E. | Thailand     | UN thru Bur. of Rec.             | 3 mo.                    | 3/73-6/73  | Power Systems               | Electrical Engr., Nat'l. Energy Authority   | Certificate |
| Ahmad, Chaudry N.  | M.Sc.,<br>Chem.         | India        | FAO                              | 9 mo.                    | 3/73-12/73 | Soils & Irrigation          | Asst. Research Officer (soils) with Directorate of Land Reclamation, Grad. Sch. Wtr. 74, M.S., Agronomy, Spr. 75      | Diploma     |
| Agrawal, L. P.     | B.Sc.,<br>Engr.         | Nepal        | Ford Foundation thru UN-IEE      | 3 mo.                    | 9/73-12/73 | Irrigation Management       | Engineer, Dept. of Irrigation, Hydrology, Meteorology, Grad. Sch. Wtr. 74, M.S., Ag. Engr., Spr. 75                   | Certificate |
| Harleston, Alex E. | B.S.,<br>C.E.           | Sierra Leone | UN                               | 12 mo.                   | 3/73-3/74  | Water Engineering           | Sr. Executive Engr. Ministry of Works, Grad. Sch. Spr. 74, M.S., C.E., June 74  | Diploma     |

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| Participant         | Highest Degree         | Home Country | Financial Assistance Provided by | Length of Time in School | Dates     | Special Interest                  | Remarks   | Award       |
|---------------------|------------------------|--------------|----------------------------------|--------------------------|-----------|-----------------------------------|---|-------------|
| Shrestha, Sundar K. | B.S., Chem.            | Nepal        | FAO                              | 12 mo.                   | 6/73-6/74 | Plant Virology                    | Asst. Plant Pathologist, Plant Pathology Section, Dept. of Ag. Ed. & Res.   | Diploma     |
| El Balla, Ahmed F.  | B.S.                   | Sudan        | FAO                              | 12 mo.                   | 9/73-9/74 | Hydrology of Sub-surface Aquifers | Hydrologist, Ministry of Irrigation   | Diploma     |
| Kemprasit, San      | B.S.                   | Thailand     | AID                              | 9 mo.                    | 9/73-6/74 | Water Resources Engr.             | Civil Engr., Rural Development, Grad. Sch., Sum. 74, M.S., C.E., Wtr. 74  | Diploma     |
| Im, Jeong Nam       | B.S., Ag.              | Korea        | FAO                              | 9 mo.                    | 6/73-3/74 | Soil Physics                      | Sr. Soil Physics Res. Officer, Soil Survey Div., Inst. of Plant Environment, Office of Rural Development, Grad. Sch. Spr. 74, M.S., Agronomy, Sum. 74 | Diploma     |
| Wolde Mariam, Yebio | B.S., Ag.              | Ethiopia     | FAO                              | 6 mo.                    | 9/73-3/74 | Irrigation Agronomy               | Agronomist for Irrigation Research, Grad. Sch. Spr. 74, M.S. Agronomy, Fall 74  | Certificate |
| Solanes, Miguel R.  | Doctorate, Law & Govt. | Argentina    | UN                               | 12 mo.                   | 9/73-9/74 | Water Resources Mgmt.             | Specialist in Water Law & Administration, Grad. Sch. Fall 74, Economics, Wtr. 75 changed to Pol. Sci. M.S., Pol. Sci., Fall. 75                       | Diploma     |
| Merkheil, M. K.     | B.S.                   | Afghanistan  | UN                               | 6 mo.                    | 1/74-6/74 | Design of Civil Engr. Structures  | Civil Engr., Provincial Dev. Dept.  | Certificate |

| Participant         | Highest Degree  | Home Country | Financial Assistance Provided by | Length of Time in School | Dates      | Special Interest                          | Remarks   | Award       |
|---------------------|-----------------|--------------|----------------------------------|--------------------------|------------|---|---|-------------|
| Mommandi, Amanullah | B.S.            | Afghanistan  | UN                               | 12 mo.                   | 1/74-12/74 | Water Resources Development               | Civil Engr.-Costing, Water Survey & Irrigation Authority, Ministry of Ag. & Irrigation, Failing in Grad. Sch. when entered I.S., Returned to Grad. Sch. Wtr. 75, M.S.,C.E., Spr. 75 | Diploma     |
| Ahmadzai, Ahmad S.  | B.S.            | Afghanistan  | UN                               | 12 mo.                   | 1/74-12/74 | Water Resources Planning                  | Asst. of Planning Engr., Water & Soil Survey Authority, Ministry of Ag. & Irrigation, Failing in Grad. Sch. when entered I.S., Returned to Grad. Sch. Wtr. 75, M.S., C.E., Fall 75  | Diploma     |
| Bhattarai, Badri P. | B.S.,<br>B. Law | Nepal        | AID                              | 3 mo.                    | 1/74-3/74  | Groundwater Investigation/<br>Water Chem. | Lab Tech., Groundwater Investigation Project, Ministry of Ag.   | Certificate |
| Jafar, Ata M.       | B.E.,<br>C.E.   | Pakistan     | AID                              | 12 mo.                   | 1/74-12/74 | Water Law & Related Aspects               | Executive Engr., Irrigation & Power Dept., Govt. of Buluchistan, Quetta, Grad. Sch. Wtr. 75, M.S.,C.E., Wtr. 75   | Diploma     |
| Chavenia, Tomas O.  | B.S.,<br>C.E.   | Philippines  | FAO                              | 3 mo.                    | 3/74-6/74  | Water Resources                           | Irrigation Supt. I, Pili-Bulan-San Francisco Rivers Irrigation System, Sorsogon   | Certificate |

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| Participant                     | Highest Degree  | Home Country  | Financial Assistance Provided by | Length of Time in School | Dates      | Special Interest                                      | Remarks   | Award       |
|---------------------------------|---|---------------|----------------------------------|--------------------------|------------|---|---|-------------|
| Masagli, Amelia<br>Clara Simone | Lic.,<br>Pol.Sci.,<br>Pub.Admin.,<br>Sociology        | Argentina     | UN                               | 9 mo.                    | 3/74-12/74 | Social & Administrative<br>Aspects of Water Resources | Asst. Research,<br>INCYRH (CELA),<br>Mendoza, Grad.<br>Sch. Wtr. 75,<br>Returned home Fall<br>75, Degree to be<br>granted when thesis<br>is completed | Diploma     |
| Turbak, Abdulanis<br>Sulaiman   | B.S.,<br>Ag.Engr.                                     | Saudia Arabia | FAO                              | 6 mo.                    | 3/74-9/74  | Irrigation & Drainage                                 | Head & Instructor<br>of Irrigation Drain-<br>age Section, Farm<br>Engineering Training<br>Centre, Riyadh  | Certificate |
| Lanna, Antonio<br>Eduardo Leao  | Inge-<br>nieur<br>Civil,<br>Maitrise<br>en Hydrologie | Brazil        | IIE                              | 6 mo.                    | 6/74-12/74 | Water Resources Systems                               | Professor at Centre<br>d'Hydrologie Applique<br>de Porto Alegre,<br>teaches hydrology-<br>analysis of systems   | Certificate |
| Tharatabhand,<br>Chalood        | B.S.,<br>Ag.  | Thailand      | FAO                              | 12 mo.                   | 6/74-6/75  | Soil Fertility  | Soil Fertility<br>Officer, Kalasin<br>Project, Grad. Sch.<br>Sum. 75  | Diploma     |
| Thunya-Udom,<br>Boripat         | B.S.,<br>Ag.  | Thailand      | FAO                              | 12 mo.                   | 6/74-6/75  | Irrigation Agronomy                                   | Rice Researcher,<br>Kalasin Project,<br>Grad. Sch. Sum. 75  | Diploma     |
| Udomsiang, Prayoon              | B.S.,<br>Ag.  | Thailand      | FAO                              | 9 mo.                    | 6/74-3/75  | Various Aspects of Agri-<br>cultural Extension        | Extension Officer,<br>Kalasin Project,<br>Grad. Sch. Spr. 75  | Diploma     |

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| Participant           | Highest Degree                               | Home Country | Financial Assistance Provided by | Length of Time in School | Dates        | Special Interest                                  | Remarks  | Award       |
|-----------------------|--|--------------|----------------------------------|--------------------------|--------------|---|--|-------------|
| Abraha, Berhane       | M.S.,<br>C.E.                                | Ethiopia     | UN                               | 12 mo.                   | 9/74-9/75    | Water Resource Systems Engineering and Economics  | Regional Manager, Co-manager of Water Supply Project, Natl. Water Resources Commission, Addis Ababa                            | Diploma     |
| Bhorntus, Chavalit    | B.S.,<br>C.E.                                | Thailand     | Royal Thai Embassy               |                          | 9/74-        |   | Engineer, Highway Dept., Material Testing & Research Div., Bangkok   |             |
| Kadri, Sadek Ahmed    | B.S.,<br>Geology                             | Libya        | FAO                              | 3 mo.                    | 9/74-12/74   | Development of Groundwater Resources & Irrigation | Geologist, General Water Authority, Govt. of Libya   | Certificate |
| Bayhon, Henry         | B.S.,<br>C.E.                                | Philippines  | Engineering Consultants, Inc.    | 3 mo.                    | 1/75-3/75    | Hydrology & Water Resources                       | Sr. Hydrologist, UPRP-NIA  | Certificate |
| Campos, Jose Humberto | B.S.,<br>C.E.                                | El Salvador  | WMO                              | 8 mo.                    | 1/75-8/75    | Hydrology & Data Processing                       | Hydrologist Engineer, Direccion General de Recs. Nat. Renov.   | Certificate |
| Duarsa, Putra         | Dip.,<br>C.E.                                | Indonesia    | AID thru Bureau of Reclamation   | 3 mo.                    | 1/75-3/75    | Water Resources Development                       | Mgr. for Operations & Logistics, Brantas Multi-purpose Project, Dir. General of Water Resources Div., J. L. Surabaya 2A Malang | Certificate |
| Hampel, Karoly Ferenc | M.Sc.,<br>Hydraulic Engr.,<br>M.Sc.,<br>Math | Hungary      | FAO                              | 5 mo.                    | 1/30/75-6/75 | River Mechanics                                   | Deputy Leader of the Dept. of Planning Works, Institute for Hydraulic Planning, Budapest                                       | Certificate |

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| Participant            | Highest Degree                    | Home Country  | Financial Assistance Provided by | Length of Time in School | Dates      | Special Interest                    | Remarks   | Award       |
|------------------------|-----------------------------------|---------------|----------------------------------|--------------------------|------------|-------------------------------------|---|-------------|
| Lackhan, Marine Praine | B.S., Forestry                    | Port of Spain | FAO                              | 11 mo.                   | 10/74-8/75 | Watershed Management                | Deputy Conservator, Ministry of Agr., St. Clair   | Diploma     |
| Liao, Tsung-shen       | B.E., Hydraulic Engr.             | Taiwan        | AID-thru Chinese Embassy         | 6 mo.                    | 1/75-6/75  | Water Resources Systems Engineering | Assoc. Engineer, Taiwan Land Resources Development Committee, Quezon, Grad. Sch. Sum. 75, M.S., C.E., Fall 75 | Certificate |
| Palteng, Serafin A.    | B.S., C.E.                        | Philippines   | Engineering Consultants, Inc.    | 3 mo.                    | 1/75-3/75  | Water Resources Development         | Chief, Plan Formulation Section, Natl. Irrigation Admin., Quezon  | Certificate |
| Soriano, Bernardo      | B.S., E.E.                        | Philippines   | WMO                              | 3 mo.                    | 1/75-3/75  | Hydrology                           | Sr. Meteorologist, Pagasa, Quezon City  | Certificate |
| Vivero, Julio E.       | B.S., Prof., Math                 | Panama        | WMO                              | 8 mo.                    | 1/75-8/75  | Hydrology & Data Processing         | AID Engineering, IRIE, Panama   | Certificate |
| Acajabon, Arturo D.    | B.S., C.E.                        | Guatemala     | UN                               |                          | 3/75-      | Hydrology                           | Civil Engr., I.C.N. Guatemala City  |             |
| Hernandez, Valter      | B.S., C.E., Master of Engineering | Brazil        | Hidroservice                     | 3 mo.                    | 3/75-6/75  | Water Resources Systems Engineering | Head of Hydrology Dept., Hidroservice, Aso Paulo  | Certificate |
| Hsieh, Sheng-yen       | B.S., Hydraulic Engineering       | Taiwan        | AID thru Chinese Embassy         |                          | 3/75-      |                                     | Asst. Eng., Taiwan Land Resources Development Committee, Taichung, Grad. Sch. Spr. 75,                        | Diploma     |

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| Participant               | Highest Degree                 | Home Country | Financial Assistance Provided by | Length of Time in School | Dates     | Special Interest            | Remarks  | Award       |
|---------------------------|--------------------------------|--------------|----------------------------------|--------------------------|-----------|-----------------------------|--|-------------|
| Kanit, Siritanapivat      | B.S.,<br>Eng.<br>M.S.,<br>Eng. | Thailand     | AID                              | 3 mo.                    | 3/75-6/75 | Water Pollution Control     | Head, Industrial Inspector Section, Ministry of Industry, Bangkok  | Certificate |
| Krajewski, Christian      | Dip.,<br>Eng.                  | West Germany | Self                             | 3 mo.                    | 3/75-6/75 | Water Resources Engineering | Works on all problems of the Rhine-Waterway, Federal Ministry of Transport, Bonn   | Certificate |
| Saić, Hadi Darmawan       | Engi-<br>neer                  | Indonesia    | AID                              | 3 mo.                    | 3/75-6/75 | Groundwater Hydrology       | Geologist, Geological Survey of Indonesia, JL Diponegoro 57, Bandung   | Certificate |
| Simpson, Alfred<br>Thomas | B.Sc.,<br>Geology              | Fiji         | UN                               | 14 mo.                   | 3/75-5/76 |                             | Geologist, Fiji Govt., Suva  |             |
| Azizi, Abdul Hamid        | B.S.,<br>C.E.                  | Afghanistan  | UN                               |                          | 6/75-     |                             | General Director & Project Manager of Water Mgmt. & Planning Dept.   |             |
| Gebeto, Petros            | B.A.,<br>Econ.                 | Ethiopia     | UN                               | 12 mo.                   | 8/75-8/76 |                             | Acting Head, Planning & Programming Office, Natl. Water Resources Commission, Addis Ababa  |             |
| Carlos, Tucci             | M.Sc.,<br>Hydrology            | Brazil       | UNESCO                           | 9 mo.                    | 9/75-5/76 |                             | Professor, Institute de Pesquisas Hidraulicas, Univ. of Rio Grando do Sul, Will receive Ph.D. from above Univ. upon completion of work in I.S. |             |



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| Participant       | Highest Degree             | Home Country              | Financial Assistance Provided by | Length of Time in School | Dates     | Special Interest | Remarks  | Award |
|-------------------|----------------------------|---------------------------|----------------------------------|--------------------------|-----------|------------------|--|-------|
| Wrege, Mario Luis | M.Sc.,<br>Hydrology        | Brazil                    | UNESCO                           | 12 mo.                   | 9/75-9/76 |                  | Asst. Prof., Center for Applied Hydrology, Inst. for Hydraulic Research, Univ. of Rio Grande do Sul, Porto Alegre. Will receive Ph.D. from above Univ. upon completion of work in I.S. |       |
| Simo, Joseph      | Engineer<br>of Meteorology | West Province<br>Cameroon | WMO                              | 6 mo.                    | 1/76-6/76 |                  |  |       |

APPENDIX . . . C

Abstract Titles

- C-1 . . . Water Lifters and Pumps for the Developing World
- C-2 . . . Sediment Stable Canal Systems
- C-3 . . . Geology and the Water Resource System
- C-4 . . . The International Conference on Global Water Law Systems
- C-5 . . . Baluchistan Water Code Proposal
- C-6 . . . Optimal Irrigation Decisions with Limited Water
- C-7 . . . Methodology For the Selection and Timing of Water Resources  
Projects to Promote National Economic Development
- C-8 . . . Selected Periodicals for Social Scientists
- C-9 . . . Numerical Model of Flow in a Stream-Aquifer System
- C-10. . . Water Management for Small Irrigation Reservoir in Northeast  
Thailand
- C-11. . . Irrigation Scheduling for Peru
- C-12. . . Water Conservation Practices for Dryland Farming

## ABSTRACT OF THESIS

## WATER LIFTERS AND PUMPS FOR THE DEVELOPING WORLD

By Alan D. Wood

This thesis presents a state-of-the-art on water lifters and pumps which are, or can be, utilized throughout the world and particularly in developing areas. A brief review is given of the historical development of these devices. Through an extensive literature review and survey of manufacturers and research organizations, this thesis inventories the wide range of water lifting methods which are randomly discussed by these sources and sets forth; (a) a unifying classification format, (b) the basic operation and typical applications of each class, and (c) a review of applicable prime movers. In addition, criteria used in the selection of water lifters and prime movers is presented with emphasis on water requirements, availability, and cost analyses. In this manner, the present status of water lifting in both developing and developed countries is reviewed and several recent projects by international organizations, e.g., AID, are identified which seek to improve existing methods, develop new ones, and disseminate educational material. Through this state-of-the-art, similar and additional areas of water lifting which need technological or sociological attention are then explicitly or implicitly identified.

211(d) Series, March 1976

ABSTRACT OF THESIS  
SEDIMENT STABLE CANAL SYSTEMS

By Darrel Martin Temple

The considerations required for the design of sediment transporting channels as components of a branching canal system are discussed. Attention is given to the selection of compatible approaches for the determination of channel geometry and bed material transport capacity to be used in conjunction with sediment routing relations. A generalized procedure is presented which includes sediment equilibrium considerations as a part of the system design criteria.

The development of methods currently in use for the design of individual channels in erodible material is reviewed as are various computational techniques for the estimation of bed material transport capacity. In general, no specific approach or computational technique may be considered best for all application due to the large number of variables involved, the complexity of their interrelation, and the variability of field conditions. Emphasis is therefore placed on the concepts, assumptions, and data on which a specific method is based rather than on the mechanics of its application.

Relations describing the requirements for sediment equilibrium within a branching irrigation canal system or subsystem are presented and their implications with respect to individual channel design are discussed. In general, equilibrium considerations will require that relatively higher sediment concentrations be allocated to diversions from larger channels of the system if sediment removal by bed clearance is to be minimized or eliminated.

Successful application of any of the techniques discussed is dependent on the proper evaluation of field conditions unique to the specific situation and on consideration of each component in relation to the overall system.

## ABSTRACT OF DISSERTATION

GEOLOGY AND THE WATER RESOURCE SYSTEM  
OF THE INDUS PLAINS

By Alfred J. Tamburi

An interdisciplinary study of the water resource system of the Indus Plains has produced new geologic and technologic perspectives which will enhance the development of the resource.

Geologic investigations have revealed new resource potential as well as potential geologic hazards. For example, study of sediment source areas in the Indus Basin reveals that geology is an important influence on sediment production in the fluvial system. Reinterpretation of the classical geologic history of Pakistan in the continental drift context has also had important consequences for the water resource system. These consist of new energy sources for groundwater pumping and location of regions of tectonic instability in the canal command areas.

It is suggested that the geothermal energy potential of a portion of the Indus Plains be developed to provide low cost power for groundwater pumping. The energy outlook for Pakistan would be improved both by the substitution of geothermal power for hydrocarbon power, and by new areas of hydrocarbon potential discovered as a result of geologic interpretation in the drift context.

Re-interpretation of Pakistan's geology in the continental drift context has also resulted in an improved understanding of tectonism in the Indus Plains. The effects of tectonism on the rivers and canals are then investigated, and recommendations made for the minimization of adverse effects.

New techniques suitable for the investigation of secular crustal deformations are described, and it is proposed that geophysical methods be used to determine deformation rates for ongoing tectonism in the Indus Plains. Such an application would also serve to monitor induced subsidence caused by groundwater extraction in the Indus Plains.

Technologic innovations have also produced a new perspective for water resource development. Innovations in dam building technology with advances in anti-seismic design of earth dams make re-evaluation of the surface storage program essential.

A technology to construct earth dams by direct blasts in the kiloton range has been developed in the Soviet Union. This method, together with investigations of landslide dynamics and nuclear explosions undertaken in the U. S., is suggested for development of large scale storage on the upper Indus. This single project is suggested as an alternative to the World Bank Plan for surface storage in the Indus Basin.

Improved definition of the return period for damaging earthquakes in Pakistan suggests that the seismic danger has been underestimated for several proposed surface storage sites. In addition, adequate anti-seismic design will require extensive design changes in the proposed earth dams. In contrast, blast development of a single large scale storage site on the upper Indus is considered more attractive due to the inherent seismic stability of an embankment created by blasting.

Together, the geologic and technologic investigations suggest several development alternatives whose economic implications should be evaluated as rapidly as possible.

## ABSTRACT

## THE INTERNATIONAL CONFERENCE ON GLOBAL WATER LAW SYSTEMS

By Dr. George E. Radosevich

The International Conference on Global Water Law Systems was convened in Valencia, Spain, with the intent to focus upon particular basic issues to analyzing and improving water laws in light of the role and function of the law and its relationship to other disciplines and sectors of socioeconomic activity. The Conference was an effort designed to: (1) build upon the materials assembled in past meetings and publications while attempting to establish a systematic foundation of knowledge of major water law and administration systems around the globe; and (2) to develop an analytical methodology for the interface of interdisciplinary, intersectoral and intergovernmental inputs to new or improved laws and codes.

Among the water law systems reviewed were the Spanish, French, British, Italian, Soviet, Hindu-Bali, Moslem, Latin American, Israeli, and the variations found in the United States and select Asiatic countries in preparing or revising water codes and administrative arrangements.

Water laws must be dynamic and, thus, ought to be the product of evolutionary processes. However, the water laws and organizational structures that at one point in time were designed to be solutions to particular problems often become the problem. Through inflexibility, lack of explicit policy provisions and gaps in subjects included, constraints to the introduction of new technologies and improved water management practices frequently occur. Three key issues or problems identified as impediment to water resources optimization were discussed in light of needed changes in the law - allocation and reallocation of water supplies; integration of water quantity and water quality control; and, management and conjunctive use of ground and surface waters.

Center For Economic Education

CSU, March 1976

## BALUCHISTAN WATER CODE PROPOSAL

Prepared by Dr. George E. Radosevich

Baluchistan, although almost at the beginning of her provincial status, needs a water code without any further delay. A good water law would give Baluchistan and Baluchistanis a blueprint for cooperative action toward development of water resources, tools with which to work and a framework upon which to build. Some laws are needed because an emergency has arisen and a bad situation needs to be patched up. Some are needed to put a stop to undesirable practices and activities. But many wise laws are enacted to prevent emergencies from happening and to protect the people from even the beginnings of harm. A water code at this stage of Baluchistan development can be such a law.

Too often people think of law as a barrier, a restriction on action and lose sight of the fact that the law is the foundation of activity, that a good law puts powers and procedures into people's hands which enable them to take action, to build and develop.

The proposed code will be such a forward-looking law. It will give legal protection to existing and future water uses. It will set up a procedure for utilizing, developing, conserving and managing the water for the maximum benefit of the people. It will continue and improve the protection of water quality so that many people can use and enjoy the same water. It will protect from private use some water needed for use by all people or for some public purposes and prevent unnecessary harm to streams. It will provide organizations that will enable citizens to combine for their mutual interest to provide water, use water, and protect themselves from water with provincial and federal aid where appropriate. The proposed code will not impose unnecessary and burdensome restrictions on people. Much of the Code is permissive, to be used only when people want help, it makes available techniques, procedures and organizations that can be called upon and used when desired.

The proposed code is designed to provide the basic guidelines for allocations development, control, management and administration of the water resources of Baluchistan in a uniform and predictable manner for



the good of all its citizens. Emphasis is placed not only on economic and technological efficiencies but equally upon the social efficacy.

The code is drafted to cover all present and prospective issues of water development and management in a broad context, with flexibility for agency rule making to fit the particular provincial and local administrative needs.

## ABSTRACT OF DISSERTATION

## OPTIMAL IRRIGATION DECISIONS WITH LIMITED WATER

By Herbert G. Blank

A multiple crop irrigation planning model was developed to determine crop acreages and irrigation timings and amounts under two objectives. The objectives were maximization of expected return and minimization of variance due to random precipitation. The model is applied to a representative farm in the irrigated area near Fort Morgan, Colorado.

Recent experimental data from field trials on corn at Colorado State University were used. An evapotranspiration ET prediction model was developed which reconstructed soil moisture over the season for varying irrigation treatments. Regression analysis was used to determine parameters in production functions relating ET in various time periods to yields. An additive and a multiplicative relation were tested.

A dynamic programming model was developed which determined optimal amounts of irrigation at pre-scheduled times for a single crop. The adopted ET prediction model and first the multiplicative and then the additive production functions were incorporated into this program. Initially the problem is solved with unlimited water available at a pre-determined price. The model is solved again with water limited in various time periods. The results of this program simulate the situation when the crop competes with other crops for the limited water supply. Secondary data were used to determine timings and amounts of irrigation water for various production levels of the other crops considered in the study.

The multiple crop case incorporates the results of the single crop model. A deterministic and a non-deterministic case were studied. In the first case all variables were assumed to take on their expected values, thus reducing the problem to a deterministic linear program of maximizing return. In the second case, probabilistic rainfall, a supplement to known surface and groundwater supplies, was introduced.

A simulation program, evaluating expected return and variance for various precipitation planning policies was formulated and run.

The multiple objective problem was reduced to a single objective of maximizing expected return since the change in variance for the policies tested was small. Finally, employing the optimal precipitation planning policy, the effect of restricting the known seasonal irrigation supply was evaluated. Expected return decreased and the variance of income increased as the water supply was increasingly restricted.

211(d) Series, October 1975

## ABSTRACT OF PAPER

METHODOLOGY FOR THE SELECTION AND TIMING OF WATER RESOURCES PROJECTS  
TO PROMOTE NATIONAL ECONOMIC DEVELOPMENT

By Dr. Wendim-Agegnehu Lemma

The methodology developed in this paper 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 inter-relationships. 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 and improvement.

ABSTRACT OF A BIBLIOGRAPHY OF  
SELECTED PERIODICALS FOR SOCIAL SCIENTISTS

By Forrest A. Deseran

The selected periodicals included in this monograph have been diligently assembled by Mr. Forrest Deseran in the course of his work on the 211(d) Project. The compilation of such material results from the perusal of literature in connection with the broad topic of social aspects of water resources development and modernization, and as part of the 211(d) Institutional Grant at Colorado State University. Such a list is not only useful for future researchers at Colorado State University but for other people who within the limited resources in the Rocky Mountain area have to search hard in order to track down pertinent material. This bibliography contains not only titles and their availability in the major libraries in Colorado but also useful brief annotations as to the special areas of concern of key journals. Mr. Deseran provides a particular service by concentrating on elusive material in what one may broadly refer to as the sociology of natural resources and technology assessment. Throughout this compilation a common thread unites various disciplinary areas by relating the broad themes of planning, development, and modernization.

This document is perhaps an atypical by-product of the far-reaching consequences of the 211(d) Grant. While it is not always possible to document the visible and tangible results of a given monograph, the Sociology Department as well as other social sciences at Colorado State University are benefited in a variety of ways from the dialogue with physical scientists, from the exposure to problems of developing countries, and from the need to develop both common vocabulary and tools for addressing difficult interdisciplinary and transcultural problems. It is in this context that one sees this particular monograph as an expression of the larger commitment of social scientists at Colorado State University to the area of natural resources and development, and as part of developing both the capability and interest in pursuing the theoretical and practical aspects of natural resources studies.

211(d) Series, July 1975

## ABSTRACT

## NUMERICAL MODEL OF FLOW IN A STREAM-AQUIFER SYSTEM

By Dr. Catherine E. Kraeger Rovey

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.

## ABSTRACT

## WATER MANAGEMENT FOR SMALL IRRIGATION RESERVOIRS IN NORTHEAST THAILAND

By Mongkol Chotisasitorn and Dr. Robert C. Ward

The primary aim of this report is to evaluate the water use efficiency of small irrigation reservoir 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.

## IRRIGATION SCHEDULING FOR PERU\*

by

William E. Hart

SUMMARY AND RECOMMENDATIONS

Irrigation scheduling is a method for predicting the plant's future need for water based upon measurements made in the immediate past, and historical data. The past measurements allow estimation of the current plant moisture status, and the historical data allow extrapolation to the future. Irrigation scheduling has as its objective the management of water so that it is applied only at the time and in the amount needed. In water-short areas this can result in increased yields through an extension of cropped areas. In water-surplus areas it can help to alleviate drainage problems which may result from excess water applications. It can also reduce loss of nutrients through deep percolation. That benefits can and are being realized through irrigation scheduling is manifested by the fact that over 100,000 ha of land are under such control in the western United States. A commercial operator who offers this service (along with some agronomic ones) charges approximately \$10 per ha.

The concept of controlling irrigations through measurement of the soil moisture conditions is presently practiced to some extent on approximately 30,000 ha of Peruvian sugar cane. The soil moisture content is determined through soil sampling, and an equivalent soil moisture stress is calculated. Water is allocated to fields based upon the known moisture stresses and certain economic factors relating to cane age.

Most irrigation scheduling systems now in use in the United States attempt to estimate current moisture contents and predict future ones through climatic observations. It is demonstrated in this paper that this procedure can be used on sugar cane in Peru and effectively eliminate much of the expensive moisture sampling and analysis now in progress. Future predictions of time to irrigate can also be made.

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\*Adapted from Appendix A of Final Report under contract AID/ta-BOA-1165 Lima, between the Colorado State University and USAID/LIMA.



As a result of these investigations, it is recommended that the Instituto Central de Investigaciones Azucareras (ICIA) implement such a system on cane lands now under the current moisture control system, and that investigations be carried out to ascertain crop and stress coefficients specifically geared to Peruvian sugar growth.

Irrigation scheduling for non-cane crops must be introduced in a different manner. Whereas ICIA has a long history of research in the sugar cane industry, no such similar entity exists for the remainder of Peru's crops. Therefore irrigation scheduling should be initiated on these other crops through a pilot study under the Direccion General de Aguas (DGA) of the Ministry of Agriculture (MINAG). The arid coastal valleys are the areas of Peru most likely to benefit from irrigation scheduling, and plans have already been made for an evapotranspiration and irrigation methods study on 280 ha of the Canete Valley. Ideally, the irrigation scheduling pilot program should be made in conjunction with this study and would have three primary objectives.

(1) To determine the feasibility of such a program in non-cane crops of Peruvian coastal valleys. The fields and land holdings are considerably smaller than those existing in the cane areas, and in the United States where irrigation scheduling is now practiced. Thus problems (and hopefully solutions) associated with the establishment of a system under these conditions will be determined.

(2) To establish crop and stress coefficients. Although such coefficients have been determined for some crops of Peru, it is necessary to verify these under Peruvian coastal conditions. The coefficients for some important Peruvian crops have not yet been established anywhere in the world.

(3) To act as a training ground for technicians. Extension is a necessary part of an effective irrigation scheduling program. By assigning an excess of trained personnel to this project, a cadre of field advisers will be established. If the system proves feasible and is extended to other areas, these people will make up the first body of extension workers.

If irrigation scheduling proves feasible for the Canete Valley, it should be spread throughout that valley, and then into other coastal valleys. This spread should take place in an orderly manner, with close supervision by a central office in the DGA providing overall coordination and evaluation.

## ABSTRACT OF PAPER

## WATER CONSERVATION PRACTICES FOR DRYLAND FARMING

By Dr. Kenneth G. Bringle

"Dryland Farming" is a catchall term often used to describe any type of farming that is not irrigated. Climatic limitations are placed on the term in order to define the type of agriculture discussed. The dryland farming areas of the United States are used for comparison of different types of dryland areas and cultural practices. A comparison of temperate zone regions with dry subtropic or tropic regions is not applicable.

211(d) Series, September 1975



APPENDIX D

Sample Letters Received by the Director,  
Dr. E. V. Richardson

UNITED NATIONS  NATIONS UNIES

POSTAL ADDRESS - ADRESSE POSTALE UNITED NATIONS, N. Y. 10017  
CABLE ADDRESS—ADRESSE TELEGRAPHIQUE UNATIONS NEWYORK

REFERENCE.

26 May 1976

Dear Mr. Richardson,

On behalf of Mr. E. Fano to whom you addressed your letter of 15 April 1975 I would like to thank you very much for the very interesting M.S. Thesis by Roland Wood "Water Lifters and Pumps for the Developing World", and the information on low cost small lifting device by Mr. S.V. Allison of the IBRD.

We find the Report on Water Lifting extremely useful and would not hesitate to recommend it for publication. In fact, such a publication could be very useful to developing countries in introducing new inexpensive methods of water lifting or improve existing ones.

We have carried out in some of our groundwater projects studies on water costs which include, of course, evaluation of pumping water from well. In most cases this was done for calculating costs of pumping water from high yield deep wells, which is not exactly what you are interested in. We cannot send you the reports of these studies as they were printed in limited number of copies and we still have not received authorization to distribute them by the respective Government.

Mr. S.V. Richardson  
Professor of Civil Engineering  
211(d) Director  
Colorado State University  
Fort Collins, Colorado 80523

UNITED NATIONS  NATIONS UNIES

- 2 -

As for your interests in water demands I enclose a copy of a recent United Nations Publication, "The Demand for Water: Procedures and Methodologies for Projecting Water Demands in the Context of Regional and National Planning". In it you will find answers to some of your questions.

With best regards,

Yours sincerely,



Uri Golani  
Special Technical Adviser  
(Hydrogeology)  
Water Resources Branch  
Centre for Natural Resources,  
Energy and Transport

**OCDE**ORGANISATION DE COOPÉRATION ET  
DE DÉVELOPPEMENT ÉCONOMIQUES**OECD**ORGANISATION FOR ECONOMIC  
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75775 PARIS CEDEX 16DIRECTION DE LA COOPÉRATION  
POUR LE DÉVELOPPEMENTDEVELOPMENT CO-OPERATION  
DIRECTORATE  
MT-549

June 4, 1976

Dear Mr. Richardson,

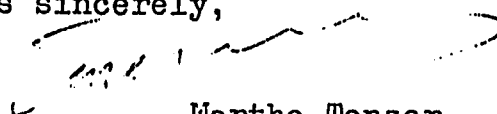
I am sorry for the delay in acknowledging the receipt of your letter of April 15 with the enclosure. Actually I wanted to take the time to first read Mr. Wood's thesis.

I have no technical comments to provide you with, since these aspects are outside my field of competence. I may however tell you that I was particularly interested in Chapter 6, which emphasizes the need for further research and improvement in the technology. This is too often forgotten. The review of the various types of water lifters and the analysis of the driving devices which can be used to power the lifters merit to be put to the attention of various bodies involved in water supply activities for developing countries. May I therefore suggest, if you have not already done so, to make Mr. Wood's study available to the WHO International Reference Centre for Community Water Supply, the Hague, who could make this valuable information available to its correspondents. (As you may know, the Reference Centre will be holding an international workshop on hand pumps in the Hague next July). UNICEF should of course also be made aware of this work. I would like to add that I am in total agreement with Mr. Wood's concern (p. 278) for education and maintenance.

I intend to bring this study to the attention of a few experts who will be meeting in July, under OECD auspices, on the subject of energy sources for small-users applications. They will no doubt be interested in that part of the study which deals with solar energy and wind-mills. I would therefore be grateful if you saw the possibility to send about 12 copies of Chapter 5 and 6 of the thesis.

Thanking you for sending me this material, I remain

Yours sincerely,



Marthe Tenzer  
Special Counsellor  
for Scientific and Technical  
Cooperation

Mr. E.V. Richardson  
Professor of Civil Engineering



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CHAPEL HILL, NORTH CAROLINA 27514 USA • 919/967-3215

ENVIRONMENTAL SERVICES CORPORATION

June 11, 1976

Dr. E.V. Richardson  
211(d) Director  
Engineering Research Center  
Foothills Campus  
Colorado State University  
Fort Collins, Colorado 80523

Dear Sir:

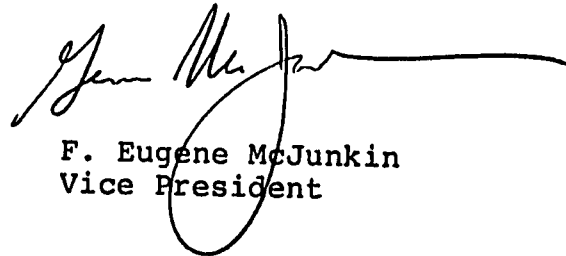
I want to again express my appreciation for the copy of Mr. Wood's report on pumps which you were kind enough to send me at Hans van Damme's request.

By copy of this letter I am asking the International Reference Center to send you a copy of my interim draft guidelines on hand pumps and to place your name on the distribution list for the next edition following the expert meeting in July.

Also as I indicated, I will send you a copy of my new book, Water, Engineers, Development, and Disease in the Tropics, when (maybe if?!) AID send me some copies.

Your program sounds very interesting. I hope that we will keep in touch.

Respectfully,



F. Eugene McJunkin  
Vice President

cc: Ir. Ebbo Hofkes