



**Colorado Water Resources
Research Institute**

ACTIVITIES REPORT

FY1981-1984



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MESSAGE

The dynamic nature of water problems facing Colorado demands an equally dynamic responsiveness from the Colorado Water Resources Research Institute. Today's water problems are characterized by such complexity that old methods of dealing with them are no longer adequate. Research is essential to create new analytical tools and new information for water resource managers and users.

The Institute is in a unique position to fulfill its statutory role as a State entity, and also as the designated management center in Colorado for the federal water research program. It serves as a liaison between the scientific expertise of Colorado's universities and its water managers and public officials. This makes possible the most efficient problem-solving research and the transfer of new technologies and information to potential users throughout the state.

The Institute continues its historical commitment to involvement of graduate students in research projects. Thus, activities of the Institute not only provide valuable scientific and technological development, but also help to produce the scientists, engineers and water managers so necessary to economic development in Colorado.

Our reputation nationally and internationally in water resources education and research is certainly among the best, measured by volume and scope of research, our stature among water professionals, and recognition by organizations such as USAID, the World Bank, the National Science Foundation, other federal and state water management agencies, municipal governments and water users. Our goal is to produce practical results of use to Colorado citizens in solving Colorado water problems.

Norman A. Evans, Director



EXECUTIVE SUMMARY

The Colorado Water Resources Research Institute was established in 1964 to provide Colorado decision makers and water resource managers with scientific and technical assistance through water-related research. It has conducted water research for 20 years with federal funds, and was organized as a unit of Colorado State University by the Colorado General Assembly in 1981.

Helping potential users become aware of new technology is the primary purpose of the Institute's research and technology transfer program. This is accomplished through media such as newsletters, research reports, news articles, radio programs, and slide-show presentations. Practitioners are informed of the details of new technology and how it can be used through workshops, seminars and small group consultations. A follow-up step is to help the user adapt a technology so it fits a particular problem-solving situation.

A secondary function of the Institute is the professional training of future water resource planning and management practitioners. Some 250 Masters degree students and 165 Doctoral students have received training and experience working on research projects sponsored through the Institute.

This report provides an overview of Institute activities during FY1981-1984. Research projects, public service and educational activities described here illustrate the practical problem-solving mission of the Institute. More than 100 research projects have been completed to date, each on a water problem of priority concern to Colorado water users.



FUNDING

Summary

Total Institute Funding, FY1981-84: \$1,349,906.

Sources of Funding: 83.5% federal, 16.5% non-federal.

Average Number of Projects Conducted: 16 per year (23 in FY1981).

Average Number of Faculty Researchers: 25 per year (high of 32 in FY1981).

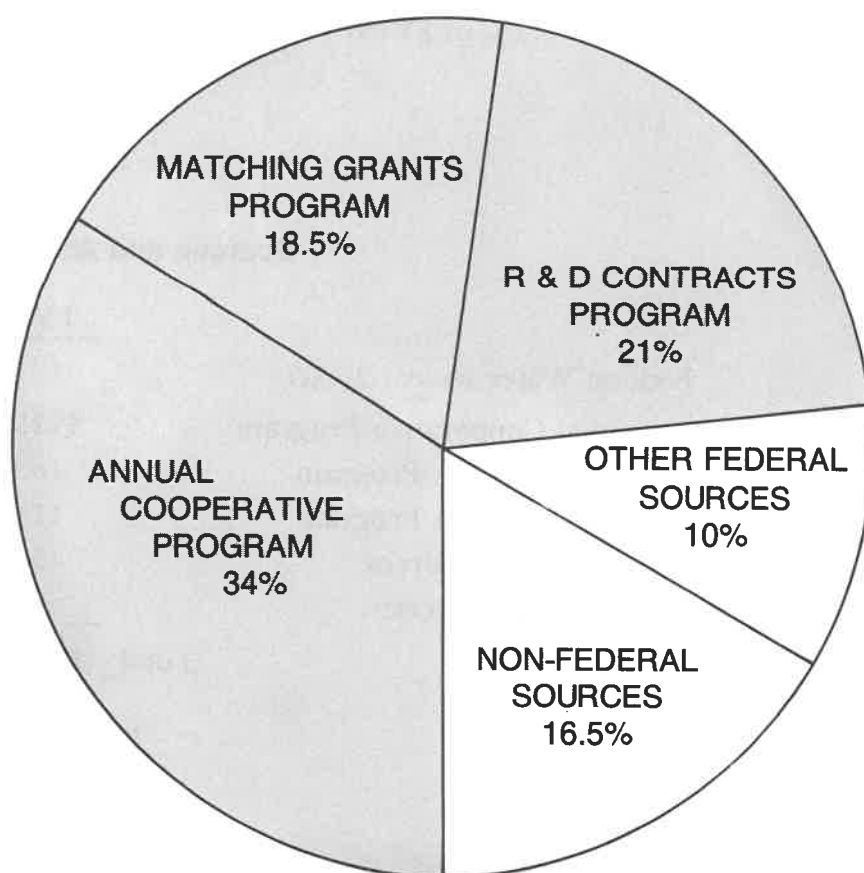
Average Number of Graduate Research Assistants: 15 per year (high of 31 in FY1981).

Sources of Funds

Federal funding for problem-solving water research and technology development sustained a modest but solid program at approximately \$500,000 annually from 1965 through 1979. No state General Fund appropriation was requested until FY1980 when federal funds were severely reduced, reaching a low level of approximately \$115,000 in FY1981, FY1982 and FY1983.

Funding for the Institute for the period FY1981-84 totaled \$1,349,906. The principal source of funding in this period was the Federal Water Research and Development Act of 1978 (P.L. 95-467). For the four-year period, sources of funding were on average as illustrated in the following chart.

Sources of Funding: FY1981-84
(Shaded area = Federal Water Research Act funding)



Funding levels from the Annual Cooperative Program remained comparatively stable, but funding from other sources has fluctuated widely over this period. The single exception was from non-federal sources, which has shown a steady increase from 5.7% in FY1981 to 26.4% in FY1984.

Sources and Amounts of Funds

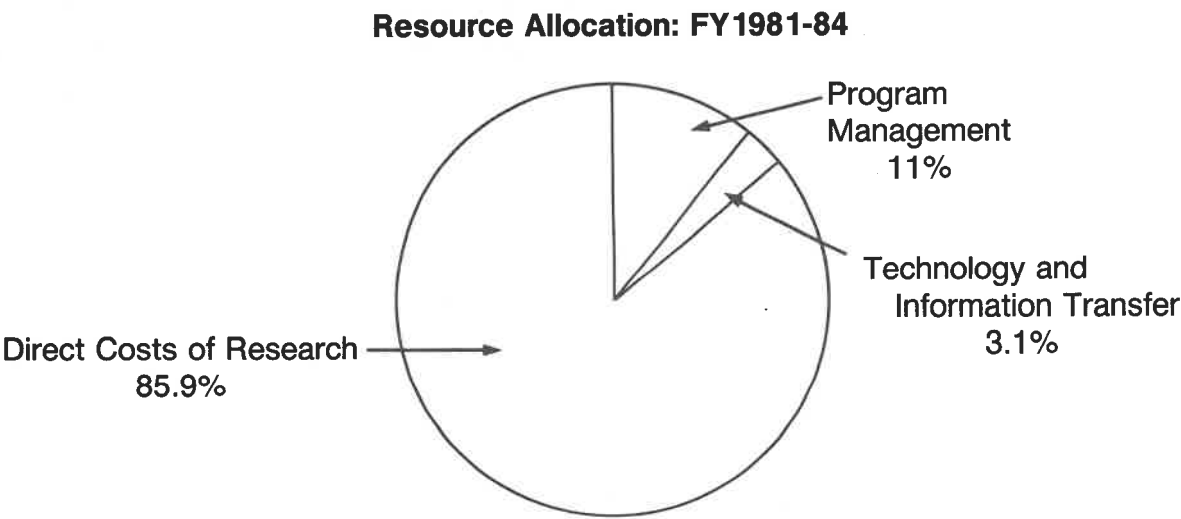
	FY1981	FY1982	FY1983	FY1984
Federal Water Research Act:				
Annual Cooperative Program	\$115,000	\$110,388	\$115,000	\$115,000
Matching Grant Program	162,836	88,296	-0-	-0-
R & D Contract Program	118,456	91,989	-0-	44,868
Other Federal Sources:	50,000	-0-	37,040	48,922
Non-Federal Sources:	28,800	53,400	64,917	74,994
Total	\$505,092	\$344,073	\$216,957	\$283,784

Projects and Personnel

In the four-year period FY1981-84, an average of 16 research and technology transfer projects per year were conducted by the Institute, with a high of 23 in FY1981. Allocation of personnel was determined largely by the needs of individual projects conducted. An average of 25 faculty members and 15 graduate students per year were involved in these programs. In FY1981, a high of 32 faculty and 31 graduate students were active in Institute projects.

Allocation of Funds

Funding received by the Institute for the four-year period FY1981-84 was allocated on average as illustrated in the following chart, and in each year as shown in the table.



	Resource Allocation: FY1981-84			
	FY1981	FY1982	FY1983	FY1984
Direct Costs of Research	\$440,092	\$279,685	\$186,006	\$253,784
Technology and Information Transfer	15,300	5,000	10,951	10,000
Program Management	49,700	59,388	20,000	20,000
Total	\$505,092	\$344,073	\$216,957	\$283,784



PRIORITIES

State and federal agencies and water managers have identified water problems they consider to be of significance to Colorado. This list includes 125 problems, of which 10 problems are considered highest priority.

Priority water problems for Colorado reflect four primary objectives: (1) maximize beneficial use of annual supply, (2) augment annual supply, (3) minimize water quality degradation, and (4) resolve competitive demands on water.

Ten Highest-Priority Water Problems

1. Excessive loss of Colorado's entitled water.
2. Sub-optimum use of groundwater in alluvial river aquifer systems.
3. Excessive consumption of water by noneconomic vegetation.
4. Multijurisdictional conflicts over interbasin water transfers.
5. Incomplete legal and administrative policies on management of bedrock aquifers.
6. Integrated management of confined aquifers, alluvial aquifers, and surface waters in the San Luis Valley.
7. Excessive surface water pollutant loads from urban runoff, diffuse surface and subsurface return flow salts.
8. Incomplete State strategy for the protection of groundwater quality.
9. Potential adverse economic and hydrologic impacts of changes in water right ownership, type, and place of water use.
10. Inadequate knowledge of potential for artificial recharge of aquifers.

FX1985



ACCOMPLISHMENTS

The Colorado Water Resources Research Institute has engaged in practical problem-solving water research in Colorado for 20 years. While a comprehensive report of the Institute's accomplishments is too lengthy to present here, the following selected examples illustrate the significance and relevance of this research to practical concerns of water users and managers in Colorado.

Integrated Basinwide Water Management

Colorado's South Platte River Basin drains 19,000 square miles in all or part of 23 counties, where nearly 70 percent of the state's population is located. It produces about 1.4 million acre-feet of water annually. However, an average of 300,000 acre-feet of Colorado's entitled water annually passes downstream out of the state because of inadequate storage or management. Availability of additional water could increase current crop production by about \$15 million annually.

A major research project conducted by the Institute in FY1983 identified options for improved management of the Basin's limited water supply.

A team of ten researchers from Colorado State University, Denver University, and the University of Colorado prepared a document designed to show the lay reader how new computer technology can provide information useful in achieving better voluntary water management. Computer technology developed by the Institute is available to test basinwide impacts of new management-strategy options of interest to water users and managers.

Surface and Groundwater Management

In large river basins such as the South Platte, the Arkansas or the Rio Grande in Colorado where a stream and an alluvial groundwater aquifer are in close hydraulic connection, management of water supply quantity and quality requires a sophisticated computational capability. Precise estimates of return flows are needed, based on actual basin management practices including diversions, storage, pumping, irrigation, climate and other factors.

To meet this need, a computer model named SAMSON was developed by the Institute to simulate the surface and groundwater hydrology of the lower South Platte Basin, approximately 90 miles in length. Daily groundwater pumping, return flow, and instream flow can be calculated for each one-mile section of the river.

Field application of this model to the Balzac-Julesburg reach of the South Platte River by the Groundwater Appropriators of the South Platte Basin, an association of groundwater users, tested the equity of their river augmentation plan. SAMSON has also been used to evaluate emergency drought measures for future use.

An important factor in research management is maintaining the continuity of effort toward solution of a problem. Stage-by-stage, and perhaps over a period of several years, the end products of several distinct research efforts are linked together to produce a technology of great benefit to Colorado. Computer simulation technology used in this study was a product of seven separate research and development projects conducted by the Institute since the early 1970s. These seven projects led to the technological advances described above, and also produced valuable advances in other aspects of groundwater modeling. For example, incorporation of water quality factors into the hydrologic model is an important and promising new technology being developed by the Institute.

Groundwater Recharge

In parts of the San Luis Valley, a major agricultural area of Colorado, a moratorium on issuance of permits for new water wells has been in effect for some time, due to injury to priority surface water rights from pumping. As demands for groundwater development for irrigation increase, artificial groundwater recharge will become increasingly important to survival of the agricultural economy of the valley.

The Institute carried out a successful artificial groundwater recharge demonstration project. The project was constructed and operated by the Trinchera Irrigation District to demonstrate this technology to local water users. Analysis of data from the project indicated a sustained seasonal recharge operation would have significant beneficial impact on groundwater levels.

A computer program was designed for planning and evaluating feasibility of additional recharge projects. This program may be used with relatively inexpensive microcomputers. It provides an effective way to transfer technical information to water users, and to evaluate potential recharge projects.

Urban Drainage

Litigation over assessments to urban property for surface drainage benefits in the period 1970-1975 virtually halted construction of municipal drainage projects in Colorado. In response, the Institute organized a research team consisting of Colorado State University engineers, a private-sector attorney, and personnel of the Metropolitan Drainage and Flood Control District.

A detailed method was developed to evaluate costs and benefits of urban drainage projects. This method allows: (1) costs to landowners to be equitably apportioned, (2) merit and rank of competing projects to be assigned, and (3) optimal timing of construction to be established. A second product of this research was state legislation defining drainage project benefits, which has helped reduce litigation since enactment.

A manual of drainage assessment procedures prepared by the research team is now widely used throughout the nation.

The practical value of this research was recognized when the project received the Consulting Engineers Council Award for Engineering Excellence.

Computer-Assisted Water Resources Planning

Advanced planning techniques are needed to identify optimal sizes and locations for water resource developments in each river basin in Colorado if available water is to be fully utilized. A generalized planning model was developed by the Institute. This model, available to water managers in two versions called MODSIM and CONSIM, takes account of reservoirs, transport and distribution systems, return flow, evapotranspiration, water right priorities and exchange agreements. It is capable of assuring on a monthly basis that existing water right priorities are satisfied, and can predict effects of exchanges of water rights within a basin.

MODSIM has been used by the Northern Colorado Conservancy District, Denver Water Department, City of Fort Collins, Western Area Power Administration, Bureau of Reclamation, Corps of Engineers, and private engineering firms. It has also been used to plan complex water systems in the Philippines and Cyprus.

Urban Water Conservation

Institute research has included urban water conservation as a problem area since 1976. A number of problems have been investigated, including water metering, efficiency criteria for municipal water use, lawn-grass water requirements and irrigation scheduling technology. Institute researchers found that substantial savings in water can result, without loss of lawn quality, if the public is informed about irrigating lawns efficiently.

Results of this research were adapted for the Denver Water Department and put to practical use in its now familiar "ET" program to reduce urban water use during the summer lawn irrigation season. In this program, daily newspaper and television announcements explain how to maintain lawns with a pleasing appearance, using minimal amounts of water.

A Denver Water Department survey shows that urban water demand was reduced by 200 million gallons in 1981, with a saving of \$1,174,280 in water treatment costs; in 1982 the saving was \$1,293,600.

Drought-Tolerant Crops

Important scientific advances have been made for the future of irrigated agriculture in development of salt and drought-tolerant crops. In a three-year Institute research project, Dr. Murray Nabors, Colorado State University botanist, developed a new, rapid technique for production of salt-tolerant strains of crop plants. He produced oats with twice the normal tolerance for salt in irrigation water.

While greatest progress toward commercial seed production has been made with oats, several other salt-tolerant crops have been developed with the cell-selection process pioneered in this research. This promising technique has attracted the interest of the World Bank, U.S. Agency for International Development, and International Agricultural Research Centers in the Philippines and Mexico.

Water Handbook for Metal Mining Operations

Federal and state agencies involved in water quality control in mining, as well as commercial companies, are finding the Institute's *Water Handbook for Metal Mining Operations* useful in securing compliance with applicable standards and mitigating adverse impacts on downstream water users. The handbook describes the chemical nature of mine drainages and methods for treatments of effluents from mining operations. It is particularly applicable to mines working complex sulfide ore deposits. Research which led to publication of the handbook was conducted at the Colorado School of Mines under Institute sponsorship.



SERVICES

The Institute provides a number of services for executive departments of state government, the Colorado General Assembly, municipalities, industry and the general public. Selected examples illustrate the diversity and utility of services made available by the Institute to water users and managers in Colorado.

Project AWARE

The Institute maintains a service called Project AWARE which is designed to keep state and federal agency personnel informed about proposed water research. Lists of new university water research projects are distributed to selected agency personnel, who are invited to notify the Institute of their interest in particular projects. Expressions of interest are brought to the attention of researchers. Subsequent contacts with interested agency personnel may modify the research to make it more useful to them.

Desertification

The Colorado General Assembly requested and the Institute coordinated a scientific evaluation of a Bureau of Land Management report on desertification in the western region. This report was subsequently used as the basis for a response from the General Assembly to the Bureau of Land Management on this subject.

CORECON

The Institute operates the Colorado REmote CONsole (CORECON) water information retrieval service, which allows the user to obtain abstracts of completed water resources research projects. Abstracts from the extensive Water Resources Scientific Information Center data bank can be obtained upon request through a computer terminal located at the Institute. This assists water managers and researchers in locating previous research related to a problem in which they are interested.

Expert Testimony

The Institute has provided experts to testify at General Assembly committee hearings on various issues. Objective and factual information on water-related subjects has been obtained by the General Assembly in this manner. This service is provided on request from members of committees, and on the initiative of the Institute.

High Plains Technical Advisory Committee

A study of groundwater depletion in the Ogallala Aquifer in eastern Colorado was completed in 1982. Technical experts from organizations relating to groundwater use in the High Plains participated in a workshop to design this study. The Institute served as manager of this workshop.

The study, performed with the Colorado Department of Agriculture and the State Engineer concluded there would likely be a 40 percent decline in irrigated acreage in the Colorado portion of the aquifer over the next 40 years under business-as-usual conditions. Under less favorable conditions there could be more drastic reductions: a 60 percent decrease by 1990; a 90 percent drop by 2000.

As a result, the High Plains Technical Advisory Committee was formed, comprised of state and federal agencies and water user organizations.

This committee provides technical assistance for irrigated agriculture. Its objective is to facilitate water conservation practices that will extend the useful life of the aquifer and, where necessary, to ease the transition to dry land agriculture. The Director of the Institute chairs the committee in 1984-85.

Grand Valley Salinity Control Education

The Institute and the Cooperative Extension Service are developing a salinity control education program for landowners in the Grand Valley. This is part of an intensive program to reduce salt load in the Colorado River from irrigated lands near Grand Junction, initiated by the Bureau of Reclamation. Its objective is to assist irrigation farmers to employ improved water management practices and to upgrade their water control structures and facilities.

Public education is essential for successful implementation of this program. The Cooperative Extension Service contracted to provide educational services, managed by the Institute with an Extension Irrigation Engineer assigned to the Grand Valley area. This specialist has conducted workshops and assisted in organizing farmer associations capable of contracting with the Bureau of Reclamation for needed construction work.

Technology and Information Transfer

Services to Colorado industry and municipalities are also provided by the Institute as part of its public service mission. These activities facilitate technology transfer and dissemination of information produced through Institute research to municipal water managers and industry planners.

For example, the Institute helped to organize an association of water conservation officers in Colorado municipalities. The purpose of the organization is exchange of ideas and information on water conservation strategies. Through it, Institute research on water conservation may be made readily available to local governments. The association meets annually under the auspices of the Colorado Water Congress.

During the past five years the Institute has distributed over 12,000 copies of reports containing the results of its research. While most of these were distributed within Colorado, many were requested by practitioners nationwide. Descriptions of new technology, methods and other scientific information are included in these reports. The Institute has issued 62 new research reports in the past five years, an average of about one per month.

A bimonthly newsletter is published by the Institute with current distribution of over 650. Recipients include local government officials, consulting engineers, industry, federal and state agencies, water-user associations, irrigation companies, and other practitioners. These publications help keep persons concerned with improving water management in Colorado informed about new Institute research.



COORDINATION

The Institute coordinates its activities and research program with other state and federal agencies, universities, and water users performing water-related research in Colorado to avoid duplication of research effort. Coordination activities are useful in program planning, management, and allocation of funding for Colorado water research.

Coordination with regional and national organizations provides similar benefits to Colorado. For example, the Institute participates in the Colorado River-Great Basin Consortium of Water Institutes and Centers (CWIC). CWIC is an association of water research centers in the seven states of the Colorado River Basin (Colorado, Arizona, California, Nevada, Utah, New Mexico, and Wyoming), formed in 1972 to identify and investigate water resource problems with interstate dimensions within the region. CWIC has conducted research of interest to Colorado water managers and users on reservoir and salinity management options for the Colorado River, and on water costs for energy development.

Additional information concerning regional water problems common to several states is obtained through similar associations of water research centers for the Missouri River and the Arkansas-Rio Grande River basins. In this way, research performed elsewhere becomes available to Colorado water users.

The National Association of Water Institute Directors (NAWID) is comprised of Directors of the 54 state water research institutes. NAWID gives the institutes a strong voice in administration of the federal grant program for water research, and has been effective in presenting testimony to Congress on legislative matters. The Colorado Director has served for several years on the governing council of NAWID.



ORGANIZATION

The Colorado Water Resources Research Institute was established as a unit of Colorado State University by the Colorado General Assembly in 1981. Previously it had conducted water research in Colorado for 20 years with federal funds.

The principal users of the Institute's research are agencies of local, state and federal government, industry, consultants and water-user associations throughout Colorado. Their assistance in identifying priority water problems and research needs is essential to formulation of Institute research programs. The Institute is organized to facilitate active and continuous communication between it and Colorado water users.

The Institute functions under the general oversight of a 10-member Policy Advisory Council comprised of three Colorado university presidents (or their representatives), four executive directors of state agencies, and three citizens appointed by the Governor.

Policy Advisory Council

Dr. James N. Corbridge
College of Law
University of Colorado

Mr. Tom Ten Eyck
AMOCO Minerals Corporation

Dr. David H. Getches
Colorado Department of
Natural Resources

Dr. Judson M. Harper
Colorado State University

Dr. Daniel Luecke
Environmental Defense Fund

Mr. Morgan Smith
Colorado Department of
Local Affairs

Dr. Thomas Vernon
Colorado Department of Health

Dr. Guy T. McBride
Colorado School of Mines

Mr. Maurice Parker
Fort Morgan, Colorado

Mr. Tim Schultz
Colorado Department of
Agriculture

Analysis of research needs and development of state and regional problem-oriented research programs are accomplished by the Director in consultation with a Research Planning Advisory Committee, a Technical Advisory Committee, and with potential research users. Identification of water problems and priorities of concern in Colorado is accomplished with the help of the Research Planning Advisory Committee, comprised of representatives of state, local and federal government agencies, associations of water users, and private sector consultants. Members are appointed to three-year terms by the Chairman of the Policy Advisory Council, with advice of the Council and the Institute Director. Membership of the Committee is currently being revised, due to vacancies created by routine changes in representatives of government agencies.

The Institute research program is formulated as a response to high priority water problems identified by the Research Planning Advisory Committee, and listed in a previous section of this report. Projects are selected for funding by the Director in consultation with the Research Planning Advisory Committee and the Technical Advisory Committee. Members of the Technical Advisory Committee are designated by the Presidents of Colorado State University, the University of Colorado, Colorado School of Mines, and Denver University.

Technical Advisory Committee

Colorado State University

Dr. Neil S. Grigg, Chairman
Department of Civil Engineering

Dr. Clarence Carlson
Department of Fisheries and
Wildlife Biology

Prof. Henry P. Caulfield
Department of Political Science

Dr. Robert E. Danielson
Department of Agronomy

Dr. David B. McWhorter
Department of Agricultural and
Chemical Engineering

Dr. Kenneth C. Nobe
Department of Agricultural and
Natural Resource Economics

Dr. Stanley A. Schumm
Department of Earth Resources

Dr. James V. Ward
Department of Zoology and
Entomology

University of Colorado

Dr. Nelson Caine
Department of Geography

Dr. James Corbridge
School of Law

Dr. Ernest Flack
Department of Civil Engineering

Dr. Charles Howe
Department of Economics

Dr. David Hubly
Department of Civil Engineering

Colorado School of Mines

Dr. Samuel B. Romberger
Dean of Graduate Studies and
Research

Dr. Keith Turner
Department of Geology

Denver University

Dr. J. Gordon Milliken
Industrial Economics Division
Denver Research Institute



PROJECT LIST

Project Title	Principal Investigator(s)
Water Supply Management:	
Planning and Management Alternatives for Future Water Policy Formulation in Colorado	H.J. Morel-Seytoux, Civil Engineering, CSU
Economic Impacts of Transferring Water from Agriculture to Alternative Uses in Colorado	S. Lee Gray, Agric. and Nat. Res. Economics, CSU Robert A. Young, Agric. and Nat. Res. Economics, CSU
Water Studies Inventory - 1981	Norman A. Evans, CWRRI
Water Studies Inventory - 1982	Norman A. Evans, CWRRI
Hydrologic Time Series - Indexed Sequential Modeling	John W. Labadie, Civil Engineering, CSU
Application of Program MODSIM to Integrated Analysis of Water Supply Alternatives	John W. Labadie, Civil Engineering, CSU
Impacts of Indexed Sequential Streamflow Hydrological Modeling on Hydrogeneration Capacity Estimates	John W. Labadie, Civil Engineering, CSU
Identification of Uses of Increased Streamflow Leaving the Rio Grande National Forest in the Rio Grande River	John W. Labadie, Civil Engineering, CSU
Methodology for Constructing and Evaluating Alternative Operation Strategies for the Colorado River Basin	John W. Labadie, Civil Engineering, CSU
Water Rights Policy Options for Deep Aquifers of the Denver Region	David B. McWhorter, Agric. and Chem. Engineering, CSU
Evaluation of Demand Management Policies for Conserving Water in Urban Outdoor Residential Uses	William B. Lord, Policy Sciences Associates
Study of the Effect of Water Conservation on New Water Supply for Urban Colorado Utilities	J. Ernest Flack, Civil Engineering, CU

Project Title	Principal Investigator(s)
Water Supply Management:	
Boulder Reservoir Project	John W. Labadie, Civil Engineering, CSU
A Study of the Effect of Water Conservation Programs on New Water Supply Acquisitions for Urban Utilities	J. Ernest Flack, Civil Engineering, CU
A Development of Generalized Water and Sediment Routing Technique in Watershed and River Systems	Simons & Li Associates, Inc.
The Input-Output Water Balance Model Application to Water Re-Use Planning	David W. Hendricks, Civil Engineering, CSU
Technology Assessment of Irrigation Scheduling and Crop Response	Warren A. Hall, Civil Engineering, CSU
Predicting Crop Production as Related to Drought Stress Under Irrigation	Robert A. Danielson, Agronomy, CSU
Salt and Drought-Tolerant Crop Plants for Water Conservation	Murray W. Nabors, Plant Pathology and Weed Science, CSU
Evaluation of Operational Policies to Enhance Artificial Groundwater Recharge - San Luis Valley, Colorado	Daniel K. Sunada, Civil Engineering, CSU
Application of Geomorphic Principles to Mined-Land Reclamation	Stanley A. Schumm, Earth Resources, CSU
Voluntary, Integrated Basinwide Water Resource Management, South Platte Basin, Colorado	Henry P. Caulfield, Jr., Political Science, CSU Norman A. Evans, CWRRI J. Earnest Flack, Civil Engineering, CU David W. Hendricks, Civil Engineering, CSU John W. Labadie, Civil Engineering, CSU David B. McWhorter, Agric. and Chem. Engineering, CSU H.J. Morel-Seytoux, Civil Engineering, CSU William L. Raley, CWRRI Robert A. Young, Agric. and Nat. Res. Economics, CSU

Project Title	Principal Investigator(s)
Water Quality:	
Feasibility of Financial Incentives to Re-Use of Low-Quality Water in the Colorado River	J. Gordon Milliken, Denver Research Institute
Cooperative Extension Service Non-Point Source Pollution Program	William L. Raley, CWRRI
Cooperative Extension Service-Water Institutes Regional Workshop	Norman A. Evans, CWRRI William L. Raley, CWRRI
Colorado River Salinity Control Optimization Model	John W. Labadie, Civil Engineering, CSU
Dissolved Solids Hazards Associated with Water Resources Development in the South Platte River Basin	David W. Hendricks, Civil Engineering, CSU Charles D. Turner, Civil Engineering, CSU
Geomorphic Controls on Diffuse-Source Salinity in the Upper Colorado River Basin	Stanley A. Schumm, Earth Resources, CSU
Passive Transport of Pathogens by Waterfowl	Alex T. Cringan, Fishery and Wildlife Biology, CSU
Public Education Program on Land Treatment Technologies	Norman A. Evans, CWRRI Carlos A. Seegmiller, Office of Instruc. Prog., CSU
Incorporation of Salinity Quality into a Hydrologic Model Designed for Day-by-Day Regulation of Conjunctive Use of Surface-Groundwaters	H.J. Morel-Seytoux, Civil Engineering, CSU
Monitoring Strategies for Groundwater Quality Management	James C. Loftis, Agric. and Chem. Engineering, CSU Robert C. Ward, Agric. and Chem. Engineering, CSU Thomas J. Sanders, Civil Engineering, CSU
Modeling Physics and Chemistry of Contaminant Transport in Three-Dimensional Unsaturated Groundwater Flow	Simons & Li Associates, Inc.
Groundwater Quality Control Strategy	Norman A. Evans, CWRRI

Project Title	Principal Investigator(s)
Ecosystem Issues:	
Effects of Releases of Sediment from Reservoirs on the Stream Biota	James V. Ward, Zoology-Entomology, CSU
The Endangered Species Act and Water Development Within the South Platte Basin	Lawrence J. MacDonnell, Natural Res. Law Center, CU James N. Corbridge, Natural Res. Law Center, CU
Low-Flow Criteria for Effluent Discharge Permits in Colorado	Thomas J. Sanders, Civil Engineering, CSU

A list of publications and samples of Institute newsletters are available from:

Colorado Water Resources Research Institute
326 Aylesworth Hall
Colorado State University
Fort Collins, Colorado 80523
Telephone: (303) 491-6308