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Views on U.S. Water Resources Research and Technology Transfer Programs

By

M. H. WATT

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VIEWS ON U.S. WATER RESEARCH AND TECHNOLOGY TRANSFER PROGRAMS

By

MAMADOU H. WATT, Director

The D.C. Water Resources Research Center of

The University of the District of Columbia
4200 Connecticut Ave., N.W. Washington, DC 20008

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VIEWS ON U.S. WATER RESEARCH AND TECHNOLOGY TRANSFER PROGRAMS

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1. INTRODUCTION

Did you know that an energy-efficient, low-pressure, drip irrigation system designed for grain farmers in the southern high plains of the United States was created by water research scientists? Are you aware that the fracture-trace mapping for locating water wells that vastly improved the well-drillers' chance for success was developed key university researchers? And did you know that a university study which resulted in improved drought management techniques has. put to rest concern about the water supply of Washington, D.C., the capital of the United States? Few people are aware of the enormous contribution that water research has made to the national economy by providing technical and management innovations. While the application of water research results has impacted industry, government and the general economy, few of the users and even the researchers

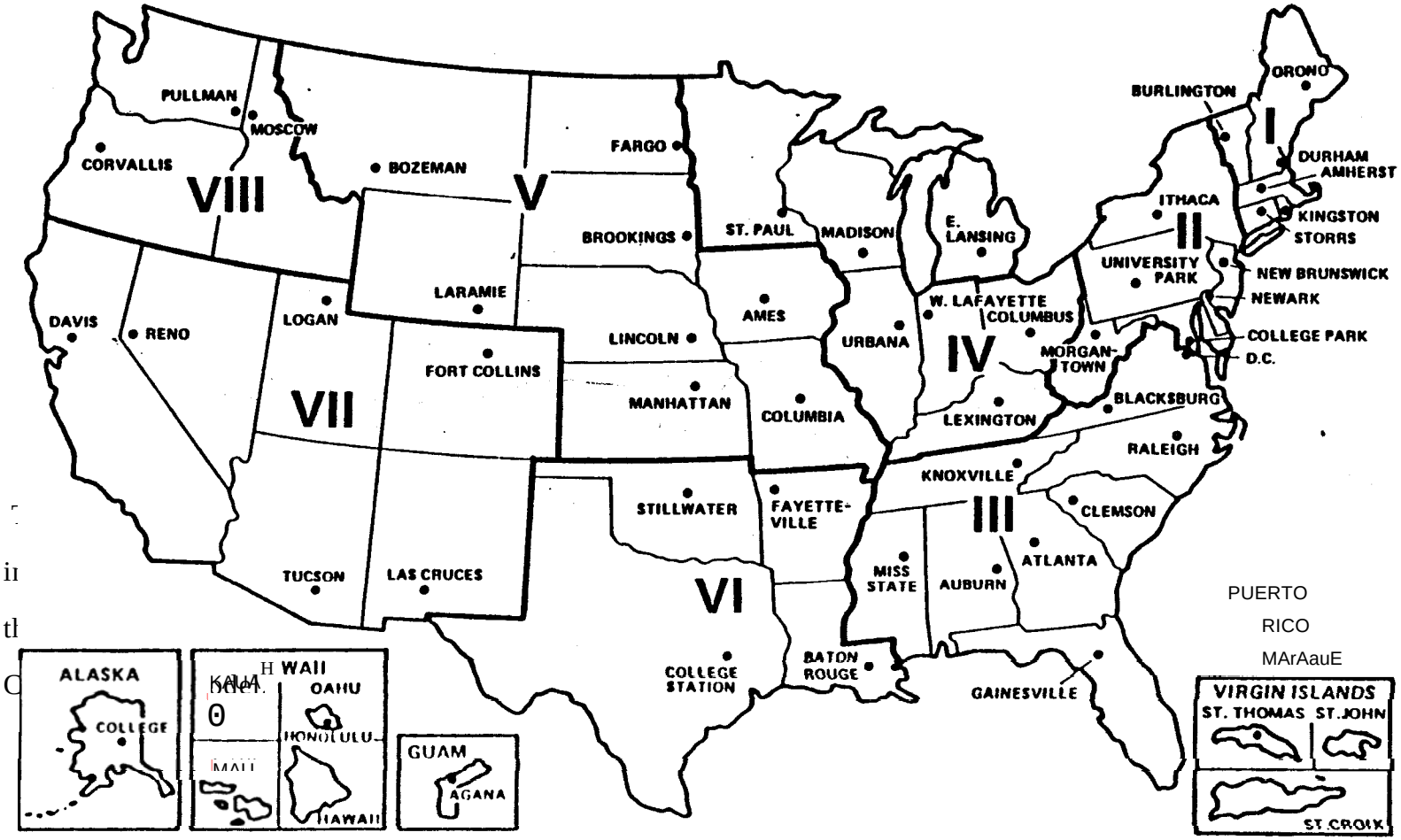
Tour to the People's Republic of China in August 1983. Dr. M. H. Watt is Director/Professor of the D.C. Water Resources Research Center of the University of D.C., 4200 Connecticut Ave., N.W., Washington, D.C. 20008 U.S.A.

themselves are fully aware of the research contributions. The problem is that research is often viewed as an esoteric activity involving scientists who work behind the scene and have low visibility. Research suffers from this lack of awareness, especially during periods of fiscal austerity. When there are fiscal pressures, the first target for cutbacks, even before training programs, is usually research. However, the demand for meeting basic human needs, and for greater economic development, plus the increased complexity of social changed all point toward a required expansion of the knowledge and understanding of this essential resource.

2. WATER RESEARCH IN AMERICAN UNIVERSITIES

University water research sponsored by the U.S. Department of the Interior is conducted through 54 water resource research centers/institutes. These institutes are located in each state and in the District of Columbia, the Virgin Islands, Puerto Rico and Guam (Fig. 1). The institutes work in cooperation with

Fig. 1 A. Institute Locations and Regions



Department of the Interior

local, state and regional officials to conduct research, technology transfer, training of scientists and engineers in the field of water resources or related areas. Within the research programs are other subprograms. These include the water research institute program, the matching grant program, the focused research and development program, the program on the conversion of saline and other impaired waters, and the technology transfer and information dissemination program.

The university water research institutes are funded mainly through the Department of the Interior, Office of Water Policy. University research programs are also coordinated with other agencies within the U.S. Department of the Interior, such as the U.S. Geological Survey and the Bureau of Reclamation. These centers have been in existence since 1965 and were created by act of Congress.

High quality research is performed on water research problems identified at the state level and the research is integrated centrally at the Department of the Interior. The water research of the universities has long been credited with making substantial direct *contributions* both in the short and long term, not only to the personal health of the people, but also to the economic growth of the country.

A recent study by a Congressional task force on research and education produced striking evidence that university research in partnership with the government and other agencies continues 'to be a prime contributor to the high productivity of the economy (Ret. 1). The task force found that for every dollar invested in research the economic benefits ranged from several hundred dollars to almost four thousand dollars. This is based on the short-term return economic analysis. Additionally, close to thirty-eight thousand students have been trained as water research scientists, engineers and technicians by the universities' water research programs. The universities have also developed means to rapidly transfer the research results to the user and to the community. Essential support is provided to water resource managers and officials in developing public policies, laws, and regulations.

In 1980, the Department of the Interior mandated each state water research institute to develop a five-year research program by defining research goals and objectives. The National Association of Water Institute Directors (NAWID), synthesizing the fiveyear plans prepared by the institutes, singled out the following as critical national problems: groundwater contamination; pollution of surface water from non-point sources, which include atmospheric fallout with precipitation; drainage from mining activities; drainage from urban areas; drainage from agricultural

activities; water shortages; compliance with water quality standards; degradatrion of water-based fish and wildlife habitat and flooding.

In developing these goals, there was close-consultation with water resource and other related agencies to avoid duplication of research efforts.

There are also mission-oriented agencies with specific mandates to address particular problems. University research does not duplicate the activities of these agencies.

3. MAJOR WA'T'ER RESEARCH ORGANIZATIONS IN THE UNITED STATES

The major federal water research programs are found in the following agencies: the Department of Agriculture, the Department of Commerce (namely, the National Oceanographic and 'Atmospheric Administration), the Department of Energy, the Department of the Interior, the Department of Transportation (U.S. Coast Guard), the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the U.S. Army Corps of Engineers, and the Tennessee Valley Authority. Most of these are mission-oriented agencies with the main goal of acquiring and disseminating knowledge for the good of the people. Operating under statutory authority, they all- have primary objectives and policy and scientific research priorities.

The effectiveness of the research organizations is complemented by extension and the technology transfer programs.

The two leading federal agencies in the sponsorship of university water research are the Department of the Interior and the Department of Agriculture.

The mission of the Department of the Interior is to stimulate, sponsor, provide for and supplementation and training of scientists in the field of water 1

resources and other resources which affect water (Ref. 2). The mission of the Department of Agriculture is to enable people engaged in the production, processing and marketing of agricultural products to meet the food and fiber needs of the public efficiently while bringing a fair share of economic and social returns to the producers and marketers for their investment and labor. It also includes the improvement of resource management and conservation. Although many of the agencies produce, publish and distribute their own reports, ultimately all the reports of government funded research projects are transmitted to the National Technical Information Service (NTIS), an agency of the Department of Commerce. The National Technical Information Service was established in 1970 for the purpose of making the results of technological research and development more readily

available to industry, business and the general public by maintaining a clearinghouse for the collection and dissemination of scientific, technical and engineering information. Therefore, the NTIS is the only central source of research reports and analysis from all the departments and agencies involved in research. All the research reports are indexed, abstracted and announced to the public (Ref. 3). A broad exposure is given to these publications to include published bulletins and announcements on a regular basis. Descriptions of the reports are stored in a computer data base which can be searched and retrieved by subject or by author. Fig. 2 gives the agencies and research activities. Although government agencies have already established objectives which they are legally mandated to pursue, there is a growing tendency to increase public participation and rely on public input. It is important to add that, through the years, most of these government agencies have developed strong ties with their international counterparts throughout the world.

4. DESIGN OF WATER RESEARCH PROGRAMS

Water problems are region-specific. What might be critical in one region might be of secondary importance in another. However, there are some basic processes that are habitually used in

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Fig. 2 U. S. GOVERNMENT INVOLVEMENT IN WATER RESEARCH

	USDA	DOC - NOAA	DOE	DOT - USCG	EPA	NASA	NSF	US ARMY COE	DEPT OF STATE	NIH
Economics/Social/Statistics	X	X	X.		X			X		
Agricultural Research & Cooperative Extension	X									
Land Grant Experiment Stations										
Rural Life/Forestry	x									
Soil Conservation	x									
Policy Research	X	X								
Basic Fundamental Research	X	X				X	X			X
Climatology/Meterology/Atrnospheric		x				x				
Hydrologic Research	X	X		X		X	X			
Water for Energy Production/Hydropower			X.					X		
Environment/Ecologic Effects			X	X	X					
Renewable Energy			x			x				
Water Resources Planning & Engineering Research								x		
Land Management										
"Coastal Zone Management										
Marine Pollution		X								
Endangered Species/Fish and Wildlife	x									
Commercial Fishing										
Recreation	x									
Shipping		X		X						
Mines and Mineral Research										
Water quality/quantity/Conservation	X			_X	X	X	X	X		X
Desalination/Water Reuse					X		X			
Groundwater	X.						X			
Navigation				x				x		
Health					X					X
Monitoring and Technical Support	X			X	X					
Modelling/Simulation/Computer Applications	X	X		X	X	X	X	X		
Remote Sensing		X				X		X		
Materials Research								x		
Technology Transfer	X	X	X		X	X				
Training and Education	X			X	X					
International	X		X						X	X

development of water research programs. The model used here is that followed by the D.C. Water Resources Research Center (D.C. WRRC). Like the other 53 water resources research centers, the D.C. WRRC mainly follows the processes which include research problem identification, problem classification and ranking, selection of research projects, management of these research projects and transfer of research results. A prerequisite to the design of water research programs is a thorough knowledge of the water resources situation of the area or the region involved. The geological characteristics, meteorological characteristics, hydrological and biological characteristics must all be known. A complete description of the surface water and ground water of the area must also be done. Additionally, an examination of the use of the water resources and of the current water-related programs will identify the major water resource problems, specifically focusing on the gaps in the water resources research activity, and highlighting the important areas not being addressed by the mission-oriented agencies.

4.1 Problem Identification

The early phases of problem identification include the development of a list of problems obtained from a questionnaire sent to the water resource agencies, water experts, community

groups and to other interested community members. The opinion survey results are compiled into a list of problems which are further synthesized and grouped into appropriate researchable objectives.

Then an advisory committee composed of representatives of water resources agencies, universities and other organizations is set up to analyze and identify the most critical and important objectives. For the D.C. area, the response to the opinion survey was broken down as, follows: 11% from the D.C. government agencies, 33% from federal government agencies, 38% from university professors and 19% from legislative branches of the federal and the local government (Ref. 4). Participation of people other than university experts is essential in *planning* water research for the following reasons. First, because the regions involved are large and complex and therefore tend to have a large diversity of problems. Second, broad participation tends to increase community awareness and support. Greater awareness fosters a positive exchange between the academic community, the water resources managers and the public.

4.2 Problem Classification and Ranking

In classifying and ranking the problems, water resources managers and researchers must interact to use experience and

knowledge from both sides in order to categorize the problems in the proper water research field and to rank them according to the local needs (Table 1). The water resources-managers, through their daily involvement with water problems, have a better feel for the degree of criticality of a given problem. The researcher then contributes by analyzing the complexities involved in addressing such a problem. However, expertise might not always be available at the level needed for critical problems. In the long-range plans, such aspects as training, information transfer and potential changes in policies and program directions must be taken into consideration. The product of problem classification and ranking can be displayed in a matrix form or as a prioritized list of problems. The matrix form uses two classification systems based on the type.of problems to which the research is addressed and the system or process involved (Table 2). The "critical" or "severe" problems can be highlighted on the matrix. However,, if the problem objectives are specific enough, it might be preferable to present them in a prioritized list (Table 3). Both the problem identification and the problem classification and ranking must undergo periodic revisions to reflect current needs.

Table l. WATER RESEARCH CATEGORIES

NATURE OF WATER

A Properties
B Aqueous solutions and suspensions

WATE R CYCLE

A General
B Precipitation
C Snow, ice, and frost
D Evaporation and transpiration
E Streamflow and runoff
F Groundwater
G Water in soils
H Lakes
I Water in plants
J Erosion and sedimentation
K Chemical processes
L Estuaries

WATER SUPPLY AUGMENTATION AND CONSERVATION

A Saline water conversion
B Water yield improvement
C Use of water of impaired quality
D Conservation in domestic and municipal use
E Conservation in industry
F Conservation in agriculture

WATER QUANTITY MANAGEMENT AND CONTROL

A Control of water on the surface
B Groundwater management
C Effects on water of man's nonwater activities
D Watershed protection

WATER QUALITY MANAGEMENT AND PROTECTION

A Identification of pollutants
B Sources and fate of pollution
C Effects of pollution
D Waste treatment processes
E Ultimate disposal of wastes
F Water treatment and distribution
G Water quality control

*The U.S. Department of the Interior - WRSIC

Table 1. WATER RESEARCH CATEGORIES CONT.

WATER RESOURCES PLANNING

A Techniques of planning
B Evaluation process
C Cost allocation, cost sharing, pricing/repayment
D Water demand
E Water laws and institutions
F Nonstructural alternatives
G Ecologic impact of water development

RESOURCES DATA

A Network design
B Data acquisition
C Evaluation, processing and publication

ENGINEERING WORKS

A Structures
B Hydraulics
C Hydraulic machinery
D Soil mechanics
E Rock mechanics and geology
F Concrete
G Materials
H Rapid excavation
I Fisheries engineering

MANPOWER, GRANTS, AND FACILITIES

A Education - extramural
B Education - in-house
C Research facilities
D Grants, contracts, and research act *allotments*

SCIENTIFIC AND TECHNICAL INFORMATION

A Acquisition and processing
B Reference and retrieval
C Secondary publication and distribution
D Specialized information center services
E Translations
F Preparation of reviews

Table 3. THE D.C. WATER RESEARCH PROBLEMS

THIRD ITERATION

RANK	PROBLEM
1	Non-point source pollution, particularly sediment and siltation, is degrading surface waters.
2	Sewage sludge disposal is inadequate.
3	Impacts of current disinfection methods of waste water treatment effluents.
4	Effects and fates of nutrients on receiving waters are unknown.
5	Toxic and hazardous substances are threatening surface water quality.
6	Criteria for determining satisfactory local water quality standards are inadequate.
7	There are many undesirable effects of urbanization/land use policies on water quality downstream from development, e.g., viruses, heavy metals, sediment, debris, loss of submerged aquatic vegetation, organic toxic substances.
8	There is a lack of coordination and cooperation for waste disposal *management.*
9	Sewage treatment capacity is inadequate for the future.
10	Deterioration of sewage transport lines threatens future water quality, and promises to be an expensive future public works project.
11	Periodically the Potomac River provides an insufficient supply of drinking water; reserve or alternate supplies are not available.
12	Combined sewers overflow pollutes the receiving waters.
13	Provide training for water and waste water treatment plant personnel, at management, technical and engineer levels.

4.3 Selection of Research Projects

Request for proposals which provide the research priorities and guidelines are sent to universities and other interested researchers who in turn prepare proposals and submit them for evaluation. The guidelines sent in the request for proposals are exhaustive and include such items as the format to be followed, the instructions on how to fill out forms, etc. The uniform format allows for an easier and more equitable evaluation of the proposals submitted.

After preliminary screening, the evaluation of the proposals is left to the Technical Evaluation Committee which comprises the Faculty from area universities and representatives of the area water resource agencies. The criteria for evaluation of the proposals include the priority of the problem addressed, the relationship of the proposed work to the solution of the problem, the proposed methodology, the qualifications of the researcher(s) involved, the cost of the project and the availability of the background support for the proposed project, etc. The probability of success of the project is also a factor in the selection process. Close scrutiny is given to such items as duplication of research as well as research that consists of tabulation .of simple data acquisitions or tabulation and analysis of data already existing without being part of an integral research effort.

Some fundamental problems might arise in evaluating research problems, however.

The groups comprising the technical committees are not homogenous; therefore, biased judgments can be made on technical preferences for given fields of water resources (Ref. 5). Problems such as those popularized by the news media may cloud the selection process. Care must be taken not to fund only the high priority areas and neglect the problems which are classified as low priority. Due to the desire to respond to the end user's need, the researchers might tend to neglect the basic and more fundamental research. Basic research, although not yielding immediate, tangible benefits, is of great importance and can lead to creative and innovative solutions for the future.

4.4 Management of Research Projects

The role of the management in research projects is to make sure that the project will meet the established objectives within the time and the budget allocated. The researcher interacts with his peers and other experts in the field to develop his project. The principal investigator is fully responsible for his project and conducts it independently. However, his project is monitored and he may be required to submit periodic progress reports. The fiscal management, in the case of the universities, is done by the financial accounting offices of the universities or the principal investigator's department.

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The library maintained by the research center and other specialized libraries are available to the researcher. Publications and copies of the presentations produced in the course of the project are reported to the center. The final reports, including both the technical and financial reports, follow an established format and are submitted at the end of the project. The final report is distributed to appropriate agencies for their comments. It is then sent to the funding agency for final review and production. Subsequent to completing the written report, the principal investigators may utilize report findings to publish journal and other scientific articles. They may also deliver lectures or present papers at conferences based on their research project. The difficulties encountered in project management are multiple and depend on individual investigators and their respective universities. The approval process, the delay in the delivery of equipment, instrumentation and final report delinquencies are a few examples of project management problems.

5. TECHNOLOGY TRANSFER AND INFORMATION DISSEMINATION

5.1 Definition and Purpose

Until recently, technology transfer was considered an interesting subject but still remained on the periphery of research activities. Today technology transfer has assumed new importance and is now considered an integral part of research programs. Its importance is recognized at the local, national and international levels. It is essential to the practical application of research and development. Technology transfer, including information dissemination, involves a combination of activities resulting in the adaptation, the adoption or demonstration of new technologies or ideas (Ref. 6).

It is a tool by which the end results of research can be measured. In these times of fiscal constraint, technology transfer will take on a new dimension of continuously monitoring the impact of benefits provided by research. Since accountability is a determining factor in the survival of many programs, research must account for its product and provide measures, to the extent possible, of its short-term and long-term productivity. There is evidence to indicate that the priority of research areas strongly influences the type of technology transfer which takes place. If the research projects conducted are not meeting the present and future needs of society, no matter how attractive the result may appear, the technology transfer involved is likely to be ineffective.

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The purpose of technology transfer is to expedite the useful application of new or improved technology generated by research. The information provided must be appropriate and timely. The users of research results may be officials, policymakers, managers, researchers, teachers, students, private interest groups and the general public. Additionally, technology transfer provides researchers and scientists with current information which can help to prevent duplication of research and thereby increase innovation. It also provides the direction and the state-of-the-art for a particular technology. It gives a measure of the advancements of knowledge. A further purpose of technology transfer is to create an increased public awareness concerning specific problems.

5.2 The Process of Technology Transfer

The design of technical transfer programs requires a knowledge of the needs of researchers, plant and systems managers, design engineers, as well as that of policymakers, businesses and the general public. The technology transfer specialist must, therefore, be well grounded technically and also be knowledgeable of the social habits, institutions and needs of the community.

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Communication, both formal and informal, is essential to the process. The research findings which consist mainly of new ideas, products or processes must have relative advantages over previous findings and be compatible with existing institutions, values and attitudes. These innovations must be presented in a manner that is both useful to and useable by the decision maker. They must be communicable and understood on their own merits. Because of the diversity of interest groups concerned with water resources, the adoption of an innovation related to water resources will often require group decisions. This makes the task of. the water resource specialist even more difficult. The qualities of the technology transfer specialist will therefore include thoroughness, consistency and perserverance. The reputation and the credibility of the performing organization are valuable assets to the technology transfer process; but personal contact remains the most valuable tool in technology transfer. Through personal contact trust can be developed, many ideas can be exchanged, and a deeper understanding of an innovation may be developed. It is important to note, however, that during the technology transfer process both the specialist and the user must be willing to share work and credit.

5.3 Products of Technology Transfer

The access to ongoing and completed research information is predicated on the continuous evaluation and.availability of the research findings of universities, private industry and government programs. A further requirement is a continuing assessment of water problems and existing or developing water technologies.

Subsequent to these activities, priorities are set and technology transfer products are designed, produced, and disseminated.

Products that meet the quality control requirements are tailored to specific uses. Technology transfer products range from highly technical manuals to workshops or seminars for the community. In general, technology is transferred through the following means:

- reports which present a synthesis of information on a given technology for technical managers and scientists;
- a description of the state-of-the-art or a short description of a process or a technique for a non-technical reader;
- manuals, handbooks or guidebooks designed to provide sufficient information for the needs of water resource professionals;
- newsletters, description sheets or bulletins which provide concise or broad information for general audiences;
- audio-visual presentations on slides or films;

conferences, seminars and workshops which provide direct opportunity for interaction and communication between technical water research professionals and managers and policymakers;

exhibits and field trips which provide the general public with basic water resource information of general interest.

A few examples of the technology' transfer products developed by the water resources research centers are: the publication of bibliographies of water research publications related to a given region; the directories of water research organizations; the directories of water research expertise available in a given area; a handbook *explaining* desalting techniques for planners; a computer simulation program for water management; a process manual for community flood plain management; and a capsule report development and demonstration. The information dissemination on water conservation devices, etc.

The D.C. Water Resources Research Center, like the other centers, maintains a library containing a variety of publications from the networks of research centers and agencies. However, the Department of the Interior retains the role of the national coordinating agency for dissemination of the scientific and technical information on water resources research technology Development and demonstration. The information dissemination is performed by the Water Resource Scientific Information Center (WRSIC) which maintains abstracts and prepares summaries

of research projects and bibliographies. The information is put into the WRSIC information system which is placed into computers and is accessible through on-line computer terminals. WRSIC also publishes a semi-monthly abstract journal, the "Selected Water Resource Abstract."

6. CQNCLUDING REMARKS

For a minimal investment cost, water research in U.S. universities has produced relatively1formidable results and high economic benefits. Although this paper only examines research and technology transfer, there are other aspects of the program that are equally meaningful. Research programs have attracted and oriented students towards the field of water research and have provided opportunities for advanced training in the field of water resources. Local technical expertise is a recognized and valuable force in helping solve local problems and/or in applying solutions developed elsewhere to their states. The research centers have developed expertise outside the government agencies. These experts form an independent body that can perform important review and advisory functions. The centers have the capability to synthesize the research results and present them in a way that is understandable and acceptable for practical applications.

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Finally, the research results provide a basis for preparing educational materials for all levels of education, including primary, secondary and higher education.

However,, the efforts in water research barely scratch the surface of the water resources problems. In the United States, in China, as well as in many countries of the world, drought, floods, water quality and quantity problems are urgent, if not life-threatening problems. The need to train water scientists, technicians and operators to produce technological and management innovations, and to adequately implement research results has never been greater.

It takes two solutions to approach water resources problems: the technological solution and the human solution. These two solutions must go hand-in-hand if research is to be effective. Technology alone does not take into account social and institutional barriers. The research, the development and the application must be planned within the context of physical and social dimensions. However, the fundamental requisite to continuation of research is the understanding and farsightedness of responsible decision makers. Perhaps our origin is from water, but research holds the key, which can unlock greater opportunities to better manage these resources on which our future rests.

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