5-1979

A Technical Focus for Documenting the Effectiveness of the Cooperative OWRT-Institute Water Resources Research Program

L. Douglas James

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Selected Papers and Presentations

Compiled by L. Douglas James

GENERAL SERIES
UWRL/G-79/02

Utah Water Research Laboratory
Utah State University
Logan, Utah 84322
May 1979

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1. PREFACE

For years, the cooperative water resources research program of the Office of Water Research and Technology and the water resources research institutes in the respective states has been experiencing considerable difficulty in generating agency, congressional, and user support of a sort that attracts sufficient funding to maintain a dynamic research program. Efforts to increase support have included recruiting greater interaction with research user groups, expansion of the technology transfer program, cultivation of interaction of center directors and research users with congress, shifting requests for added funding within the research program from the allotment funding given the respective states to matching grant and federally funded projects focusing on national priorities, and integrating the OWRT effort into a coordinated five-year research and development program. The results have improved the program and increased user support, but funding difficulties continue unabated. The highlight of the 1979 Annual NAWID meeting was Bill Walker's presentation of the problem and plea to all to get together and solve it.

The problem and its solution have been subjected to considerable debate for the last few years within both NAWID and OWRT. Each time, the effort to build a strong case has been forced into the corner of recognizing that OWRT files simply do not contain sufficient documentation to present program achievements.

The series of papers, committee reports, and summaries of workshop deliberations reproduced here for ready reference in the continuing effort to improve documentation of program effectiveness argue toward a concept of documentation that departs significantly from the emphasis

in the efforts to increase support referenced in the previous paragraph. The concept here is to document program content and application rather than to work for improvement through refinement of program administration. The new thrust would demonstrate research achievements with carefully prepared sets of research results that develop and maintain for each technical topic coming within the scope of the total OWRT program, a running summary of the current state of knowledge and of how it is being applied in problem solving. The running documentation would provide bases for 1) judging new proposals, 2) judging the contribution of completed research, 3) identifying OWRT contribution to the total state of the art, 4) abstracting technical knowhow for solving user problems and technology transfer and information dissemination programs, and 5) preparing testimony and answering questions in program presentations.

Key documents in the evolution of the concept comprise the body of this report. Its compiler entered the effort with an analysis of the effectiveness of the Utah allotment program presented at the technology transfer program at Fort Collins, Colorado, in June 1977. That paper provided the starting point for further development of the concept at a workshop chaired by Neil Grigg at the Arlington NAWID meeting in April 1978. The workshop discussions led to a NAWID resolution that OWRT and NAWID establish a joint ad hoc committee on documenting research effectiveness and that committee recommended a strategy beginning with a Phase I study to select promising topics for pilot efforts and a methodology for implementing those efforts. The Phase I study was awarded to David Howells. Phase II would begin to implement the actual documentation through pilot topical assessments beginning as a trial effort and continuing through interactive feedback with documentation successes and failures toward establishment of an effective system.

The purpose of this compilation is to set forth the thinking that led to the effort. The intent is to provide background for constructive discussion as obviously the system is described here in nowhere sufficient detail. The point is rather that thoughtful consideration of research management strategies is sorely needed.

L. Douglas James

2. DESIGN OF OWRT ANNUAL ALLOTMENT RESEARCH FOR MORE EFFECTIVE TECHNOLOGY TRANSFER *

By L. Douglas James, Donna H. Falkenborg, C. Earl Israelsen, Frank W. Haws and Mardyne Matthews

ABSTRACT

A review of the 29 research projects completed in Utah over the last twelve years under the OWRT Annual Allotment program revealed a great deal of variety in the success achieved. Some projects produced results that have received wide application. Other results seemed to promise considerable contribution to more effective water management but were never really accepted. Still other projects were never able to deliver more than the most general contribution to knowledge.

From statistics collected on proposal characteristics and on the efforts in disseminating findings and from interviews with principal investigators on these projects, the obstacles to achieving promised objectives or to others using the results were listed and analyzed. Data on the quality of the research results and the effort made to disseminate them were then analyzed for significant associations. The results generated suggestions for improving project selection and study design so as to enhance the probability of usable results. The conclusions provide help that program administrators can use to help principal investigators from the time of proposal inception, to enhance productive researcher-user contacts, and to provide follow-through after report completion.

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*Presented at the Second International Conference on Transfer of Water Resources Knowledge, Colorado State University, Fort Collins, Colorado, June 29-July 2, 1977.

DESIGN OF OWRT ANNUAL ALLOTMENT RESEARCH FOR MORE EFFECTIVE TECHNOLOGY TRANSFER

By L. Douglas James[1], Donna H. Falkenborg[2], C. Earl Israelsen[3], Frank W. Haws[4], and Mardyne Matthews[5]

Introduction

The general public and elected public officials frequently express dissatisfaction over the money and effort going into research projects only to produce reports that few can understand and whose limited copies largely gather dust in scattered personal libraries. The results, in their view, are not solving the problems that generated the political support required and promised to get the research program authorized and funded. Elected officials see regular requests for continuing funding, few solutions, and little public support.

Part of the problem is that research findings are not being applied. The ready recommendation is to do a better job of getting the findings to potential users through technology transfer or information dissemination programs. Simply adding this worthwhile component to the research program, however, fails to address the total problem. Research performance and the dissemination of the results should be highly interrelated

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components of the total research program. Researchers need to plan and conduct their studies to produce results that will, when disseminated, help solve problems. They need to organize their presentations to overcome the obstacles to effectively communicating the results. Technology transfer agents need to organize to communicate not only research content but also related concepts in the total state of applicable knowledge.

Few are likely to quarrel with the potential value of integrating research performance with technology transfer. Objectors are more likely to note its idealism. Practically speaking, how can a research administrator know in advance which candidate projects will produce readily transferable results? How can he guide principal investigators of selected projects toward producing such results? The skeptic may doubt whether it is really possible to do either, but the possibility that that viewpoint may be right is no reason not to try. The purpose of this exercise is to search for empirical relationships that water research program administrators can use to 1) select projects with a higher probability of generating operational technology transfer to problem solvers and 2) help would-be principal investigators toward that end from the time of proposal inception. The data base is the set of 29 research projects completed under the OWRT Annual Allotment program in Utah over the last twelve years.

The Total Research Program

A user-oriented research program needs to 1) identify water management problems people believe important, 2) determine if deficiencies in knowledge on how to deal with that problem mean that research is required, 3) perform needed research, 4) express research results in a form that

can be used to solve the problem, 5) disseminate the results to those who need to apply them to get the problem solved, 6) monitor remaining problems, and 7) followup as needed. Water management problems may exist for the non-technical water user (particularly in an era of the nonstructural measure) uncertain as to how to cope with a water supply, storm water, or water quality problem; for the engineer or other professional who finds that he cannot provide his clients reliable advice for a resonable cost; or for the scientist unable to pursue his research objectives further when he encounters a deficiency in his tools or knowledge. Water research thus has popular, professional, and scientific audiences; and it would be unwise to say that research directed toward one is any more important than research directed toward the others without empirical evidence on what is most needed to solve the problems at hand. Each direction has times when it is more important than the others.

Once the water management problem is identified, the research program administrator must determine whether the information is available and only needs to be collected, organized, and distributed (perhaps because previous researchers did an inadequate job of information dissemination) or whether research is needed to probe the unknown.

Where research is needed and the problems have sufficiently high priority, studies should be performed as funds and personnel permit. Seldom, however, would a research report be sufficient for problem solving. It more properly presents previously unknown information contributing to the solution. The next step is to integrate the research findings with what was previously known into a form that can be applied, and the following step is to distribute the results. The appropriate process for organizing and disseminating the results depends on the audience who must

apply them. The greatest effort is needed where the results must be expressed in popular form for lay users for their personal implementation (e.g., flood proofing or irrigation practices) or to increase their knowledge for group decision making when water management problems reach the political arena. The effort of technology transfer to professionals is of a different sort involving such instruments as user manuals, short courses, and, to really be effective, direct personal contact for training. Information dissemination to scientific audiences usually requires little more than spreading awareness of research reports and making them more readily available. The important point to be made here is the gross inefficiency of attempting to disseminate all three kinds of products to all three audiences. A well-managed research program will match the technology transfer effort for a given body of research results to the audience that must apply those results for the problem to be solved. A very well-managed program will construct the total research effort from inception to dissemination to best meet the needs of the user.

Transfer Scenarios

The people who need to interact within a total research program may be classified as users (general public, professionals, or other researchers), transfer agents or researchers. They interact in six patterns:

1. U-T-R-T-U The user (U) may perceive a water management problem on which he feels a need for advice and communicate that fact to a transfer agent (T) who, if he determines that research is required, communicates the problem to a researcher (R). The researcher completes his study and communicates the results to the transfer agents to pass on to the universe of potential users. This model is most applicable to cases

where large numbers of users, particularly in the general public, and differences in technical background make direct communication between researchers and users difficult. The best example is the agricultural extension system.

2. U-T-U Some of the needs may be answerable through expertise already available to the transfer agent. He can then respond directly without needing to involve the researcher. One of the most valuable contributions the transfer agent makes within the total research program is this type of response which frees the researcher for his primary responsibility.

3. U-T-R-U On some occasions, the need the users communicate to a transfer agent and the transfer agent passes on to a researcher may be either so technical or involve so few people that the best approach is for the researchers to work directly with the users. Certainly, it would be a mistake for anyone to rate research of interest to only a few users with a specialized problem as automatically less important than a study whose results are distributed to many users. A few users can make research applications (e.g., a new treatment for a problem industrial waste) with many beneficiaries (all those downstream whose water becomes cleaner).

4. U-R-T-U On other occasions, the users may communicate their special problem to a researcher who when he solves it finds that, either because of the large numbers of people who can benefit or because of difficulty experienced in conveying the meaning of the results, he can best disseminate his findings through a transfer agent.

5. R-T-U Many projects originate in the mind of a researcher who perceives a problem or an opportunity that the users never realized or at least never vocalized and performs a study of general value. The

results may then be disseminated by transfer agents among users. Some may feel this model to be less satisfactory than those originating with user-expressed needs, but the probable fact is that much more has been accomplished on researcher than on user initiative.

6. R-R The researcher originator may produce results that following researchers can use but that is not really directly applicable by users. This model is made more frequent by research funding in units too small to really address basic user problems. It is aggravated when funding agencies become disillusioned when their limited funds fail to solve one problem and then turn to the next topic to become politically popular. Any research program must contain some basic studies that only build information for other researchers; however, too many studies of this type means too much money going into a program from which the public sees too few results.

Role of the Technology Transfer Agent

These six scenarios show that the transfer agent has a dual role of communicating problems to researchers and communicating solutions to users. The first role is to ascertain user needs, respond directly to those that can be solved within the current state-of-the-art in order to conserve researcher time, and communicate defined research problems for further study. The second role is to integrate research findings into the body of applicable knowledge and convey the results to users in a way that will lead to their applying the results to solve the original problems.

The transfer agent role is critical for dealing with the general public, can significantly contribute to helping professionals, and may well even detract in communicating to other researchers. Conversely, a

research program without a capable transfer agent can be expected to do quite well in adding to the body of knowledge available to other researchers, achieve moderate success in helping professionals, but do little to solve problems perceived by the general public, or more importantly, to develop a broad base of popular support. The logical hypothesis stemming from this line of reasoning is that the current nationwide water research program funded by OWRT is, through some combination of Federal expectations and university rewards that favor research over extension, directed into a prevailing R-R scenario. The concept so often expressed on university campuses of using the OWRT Allotment program as seed money to help researchers get large projects is essentially an R-R approach.

Program Management Implications

If the logic of the above analysis is correct, a program without an effective technology-transfer component will only be successful at the more scientifically oriented end of the user spectrum. A program that cannot afford technology transfer should address research problems of the more scientific sort because those are the only kind that it is likely to solve. If this research direction does not promise to solve the more critical water problems to those providing the funding, greater effort needs to be spent to technology transfer.

Second, the choice among the six scenarios listed depends on the nature of the problem, but the success of a given project within its optimal scenario depends on the quality of the research performed. Furthermore, quality should be judged on the bases of both scientific and transferability components.

Empirical Data

In order to examine the above hypothesis and to probe relationships to guide research program administrators toward selection of more successful projects, data were sought on each of the 29 OWRT Annual Allotment projects that have been completed in Utah. As it turned out, only the most recent 24 of the 29 projects provided useful information because the larger scope and longer duration of the earlier projects made their statistics quite different. The five early projects had a much less formal proposal development, review, and selection process and averaged many more reports and publications. The trend toward formalization of proposal review common to OWRT Allotment programs in nearly every state has undoubtedly improved the scientific quality of the selected projects (improved performance under the R-R scenario), but that does not mean that it has added to program responsiveness to non-research users.

The results of each project were reviewed first by the senior author of this paper and second independently by three of the other authors with respect to the degree to which the results would help Utah water managers. In addition, each principal investigator was asked whether he achieved the target objectives of his proposal. The three ratings are tabulated on the left side of Table 1. The projects were only rated with respect to these indices according to whether they were among the top third, the middle third, or the bottom third on the basis of reasoning that the method of rating does not justify greater precision. A higher number is a more favorable rating. Occasional rating ties cause variations from exactly eight projects in each rating third. Also, an overall rating was computed as the sum of these individual ratings.

Table 1. Summary of allotment project research results.

Project	Result Ratings			Result Communication				
	Author	Reviewer	Researcher	Reports	Papers	Presentations	Purchases	Contacts
1	2	3	2	3	2	1	2	3
2	2	2	3	3	2	1	3	1
3	2	3	3	2	1	3	2	2
4	1	3	3	2	1	2	1	3
5	3	3	3	3	2	1	1	2
6	1	3	3	2	1	2	2	2
7	1	2	2	1	1	1	1	1
8	2	1	1	1	1	2	2	3
9	3	3	3	3	3	3	3	3
10	2	1	3	1	1	2	3	1
11	3	3	3	2	1	2	2	3
12	2	3	3	2	2	1	2	3
13	1	2	3	2	2	3	3	2
14	3	1	1	2	1	3	3	2
15	3	3	3	1	1	1	2	1
16	2	3	2	3	3	3	1	3
17	1	1	3	1	1	3	2	2
18	3	2	3	3	3	3	1	1
19	2	2	3	2	1	3	1	2
20	1	2	2	1	1	2	2	1
21	3	1	3	3	3	1	3	2
22	1	2	3	2	1	3	3	1
23	2	2	2	3	3	2	2	1
24	3	3	3	3	1	2	3	1

Legend: 1 = lowest third
2 = middle third
3 = highest third

Statistics on communicating research results to users were then compiled under the headings:

1. Number of resulting reports and papers other than those appearing in refereed journals as an index of the quantity of output. Actual numbers ranged from one to seven.
2. Number of resulting papers published in refereed journals as an index of the amount of high quality material produced and its reception by the scientific community. Actual numbers ranged from zero to four.
3. Number of presentations to user groups as an index of the effort spent in transferring results to potential users. Presentations ranged from zero to 40.
4. Number of orders to purchase completion reports as an index of interest in learning the results. Numbers ranged from zero to 125.
5. Number of contacts made with the principal investigator for information on project findings as an index of interest in applying the results. The range was from zero to 500.

Again the ratings were divided among thirds (right side of Table 1) and the five numbers were totaled as an overall rating.

These two overall ratings, one indexing quality of the research performed and the other indexing effort to communicate results to others, were then compared with the following attributes of the proposals and of how the results were used:

1. Length of the proposal as an index of the work put into developing a sound project.

2. Number of citations in the literature review as an index of the care taken to search out and build on the work of others.
3. Specificity of the proposed research procedure as an index of the effort put into developing a meaningful research strategy.
4. Ranking of the proposal given by the review committee at the time of project selection.
5. The predominate user group as judged by the nature of the findings: U = public, P = professionals, and S = other researchers or the scientific community.
6. Whether (scored 2) or not (scored 1) the research results were used to stimulate followup funding to continue the work.

These six items and the two overall ratings for each project are shown on Table 2.

Analysis of Data for Significant Relationships

Table 3 shows how average proposal characteristics, use of the research to get followon funding, and research audience vary among proposals with different ratings. The only statistically significant relationship proved to be that the fewer literature citations quoted in the proposal, the more successful the project was likely to be. This may be an indication that the researcher already well versed in his field references only selected key articles and then goes on to do a good job while a researcher breaking new ground cites many references but has greater trouble producing. If this interpretation is correct, these results reinforce the expectation that experience generates superior performance. While the relationships did not prove significant with a linear regression model, the numbers on Table 3 also indicate slight

Table 2. Comparison of proposal characteristics with research results.

Project	Proposal Characteristics				Audience	Followon	Rating Sum	Communications Sum
	Length	Citations	Specificity	Ranking				
1	1	1	3	3	S	1	7	11
2	1	2	2	2	P	1	7	10
3	1	1	2	2	S	2	8	10
4	3	1	1	1	P	2	7	9
5	2	1	3	3	U	2	9	9
6	2	2	1	2	S	1	7	9
7	1	3	1	1	S	1	5	5
8	2	3	1	1	S	2	4	9
9	1	3	1	1	P	2	9	15
10	3	2	2	2	P	2	6	8
11	2	2	3	3	U	1	9	10
12	1	1	2	1	U	2	8	10
13	3	3	1	1	P	2	6	12
14	3	3	3	1	P	2	5	11
15	2	1	1	1	U	2	9	6
16	3	2	3	2	S	2	7	13
17	3	3	3	3	S	1	5	9
18	2	3	2	3	S	2	8	11
19	3	3	1	3	S	2	7	9
20	1	2	2	2	S	1	5	7
21	1	1	3	3	P	1	7	12
22	2	2	2	2	S	2	6	10
23	2	2	2	1	S	1	6	11
24	3	1	3	1	P	1	9	10

Legend:
1 = lowest third
2 = middle third
3 = highest third
U = public
P = professionals
S = other researchers or scientists

Note: Rating and communications sums are added from corresponding columns on Table 1.

trends toward better results from projects initially receiving a higher rating and toward the more productive projects being aimed at public or professional applications rather than other scientists. The lack of correlation of administrative proposal ranking at the time of research funding with research results emphasizes the difficulty the review process has in selecting the best projects (a situation that may or may not be possible to remedy by upgrading proposal review). A higher correlation, however, would hopefully have resulted if the data had included all proposals and not just relative rankings for those funded.

Table 4 shows how the same six variables vary with the communication score. The only statistically significant relationship here proved to a tendency for researchers who are more specific in expressing their methodology in their proposals to also do a better job (perhaps because of being more specific) in communicating their results to users.

The analyses in Tables 3 and 4 are based on grouped scores, and the possibility also exists of using individual scores or at least groups of fewer items. The data were inspected for this possibility without finding any trends adding important information. One could also argue that individual items are too subjective to be as good a measure as a composite scale.

Table 5 shows an absence of significant correlation between the quality of research performed and the effort to communicate results to others. This absence suggests a need to devote greater technology transfer effort to those projects producing important but undisseminated results and to reduce the effort in disseminating less important information. Such a shift can be accomplished by assigning priority items to a technology transfer agent but more difficult to administer

Table 3. Proposal characteristics by ranked ratings.

Result Rating	Number	Average Proposal Characteristics: Length	Citations*	Specificity	Ranking	Follow-on	Audience
9	5	2.0	1.6	2.2	1.8	1.6	2P, 3U
8	3	1.3	1.7	2.0	2.0	2.0	2S, 1U
7	7	2.0	1.7	2.0	2.3	1.4	4S, 3P
6	4	2.5	2.3	1.8	1.5	1.8	2S, 2P
4 & 5	5	2.0	2.8	2.0	1.6	1.4	4S, 1P

*R^2 = 0.27, significant at 99.5 percent level. No other relationships statistically significant.

Table 4. Proposal characteristics by result communication score.

Communication Score	Number	Average Proposal Characteristics: Length	Citations	Specificity*	Ranking	Follow-on	Audience
12-15	4	2.0	2.0	2.0	1.8	1.8	1S, 3P
11	4	2.0	2.3	2.5	2.0	1.5	3S, 1P
10	6	1.5	1.5	2.3	1.8	1.5	2S, 2P, 2U
9	6	2.5	2.2	1.7	2.2	1.7	4S, 1P, 1U
5-8	4	1.8	2.0	1.5	1.5	1.5	2S, 1P, 1U

*R^2 = 0.07, significant at 90 percent level. No other relationships statistically significant.

Table 5. Ranked rating/communication score matrix.

Rating \ Score	12-15	11	10	9	5-8	Average Score
9	1	0	2	1	1	10.0
8	0	1	2	0	0	10.3
7	2	1	1	3	0	10.4
6	1	1	1	0	1	10.3
4&5	0	1	0	2	2	8.2
Average Rating	7.3	6.5	7.8	6.5	6.3	

$\chi^2 = 14.44$ $\chi^2_{75} = 19.37$

would be in a system relying primarily on the efforts of the researcher to communicate his results. The priority technology transfer role would be in assisting researchers who are better at producing than communicating.

Table 6 lists the items checked by the researchers as making their job more difficult or preventing achievement of their research objectives. The primary difficulty proved to be failures to anticipate and consequent inability to overcome problems in obtaining necessary data, executing the proposed methodology, and securing inputs from others on an interdisciplinary team. These factors reinforce the significant relationship in Table 3 in that a more specific proposal suggests more careful research planning and a reduced chance of becoming hurt by unforeseen difficulties.

Table 7 lists the items those who reviewed the project completion reports checked as likely to inhibit users from applying the results. Here, the primary problem, that the explanation was insufficient for the reader to make direct application, suggests a role for a technology transfer specialist in reviewing and helping improve completion reports before they are printed.

Conclusion

The qualitative analysis of the role of technology transfer in the total water resources research program in the first part of this paper concluded that the current system of providing minimal technology transfer funding is biasing program content toward research of primary interest to other researchers and eroding the program political support base. The data collected on 24 Utah projects showed a definite time trend toward the more recent projects being more oriented toward other researchers. The analysis suggested that program administrators can

Table 6. Items which researcher felt made more difficult or prevented achieving objectives.

Not able to obtain needed data	8
Unforeseen difficulties could not be overcome with available time and money	5
Objectives proved unrealistic after getting into study	4
Difficulty in obtaining necessary support from USU and UWRL colleagues	3
Other work assignments became too demanding	2
Not able to obtain sufficient cooperation from people outside USU	1
Could not find necessary student help	1
Needed equipment was not available	1

Table 7. Items which reviewer felt would inhibit potential users from applying research.

Research application requires supplemental explanation not easily acquired from report	14
Research application is so complicated that a busy user would not normally have time to develop an understanding of the results sufficient for application	7
Project did not really accomplish anything sufficiently worthwhile for application	5
Research of a theoretical nature and not of much value in solving real problems	4
Research of value in solving real problems but presented too abstractly to communicate to users	1

use researcher experience as the key to good results and performance in organizing a specific research methodology in the proposal as the key to success in passing results on to others. The logical conclusion is that the greatest need for additional technology transfer effort is in helping experienced researchers who do not propose a well-organized research methodology and consequently are unlikely to present well-organized results. The consequence would be a movement of research effort back toward greater concentration on problems of interest to professionals and the public.

3. DEVELOPMENT OF PROGRAMS TO EVALUATE AND DEMONSTRATE THE EFFECTIVENESS OF OWRT RESEARCH INVESTMENT

At NAWID Meeting, Arlington, Virginia
April 1978

COMMENTS BY L. DOUGLAS JAMES
Utah State University

Problem Statement

Many water officials do not perceive water resources research and specifically do not perceive the OWRT research program as helpful to them in making water use or management decisions. Some even perceive certain projects as threatening their effectiveness in serving the public. Such officials provide responses that range from apathetic to strongly negative when they are asked for comments on research effectiveness. As these opinions are communicated to people in the legislature and administrative budgeting processes, they generate reactions that are highly unfavorable to water research funding.

Problem Solving Approach

Alternatives for dealing with this situation in which potential users are not finding water research results useful and are complaining to budget makers that they are not being helped include 1) offsetting these negative comments with support from satisfied users, 2) getting users who are now dissatisfied to change their minds and become supportive, 3) providing research results directly useful to the budget makers. While an effective program to demonstrate the importance of research investment should combine all three elements, one can reasonably predict the second alternative to be more effective than the first and the third to be more effective than either of the first two. New converts tend to be more effective witnesses than are long time supporters, and personal experiences are more convincing than are second hand testimonials.

Two strategies can be considered for generating support for any or all of the three alternatives. One is to provide the new supporters, formerly dissatisfied, or decision makers research results that they personally recognize as helpful. The second is to perform a more elaborate analysis of the research produced, the uses people make of the results, and the benefits that result from those uses. Such research cost effectiveness studies are very hard to conduct because of a variety of theoretical and empirical difficulties. Even if these difficulties are overcome, one can wonder whether the results would be credible and effective in obtaining more funding. Theoretically, benefit-cost analysis is a much better tool for comparing alternatives whose results are similar in nature (water

resources projects) than for comparing alternatives whose results are diverse in nature (water projects v. educational programs), and different research projects produce results that vary greatly in nature. Practically, benefit-cost information has not proved to be as effective in gathering budget making support as have arguments based on descriptions of specific contributions to public welfare. The first strategy of expanding the clientel of satisfied users thus deserves special attention.

A logical way to gain satisfied users would be to document the complaints of the officials now expressing apathy or dissatisfaction, analyze the statements to determine the real causes of the problem, and synthesize plans of action for dealing with those causes. The goal would be to construct an action plan that will convert people who formerly could not see the relevance of the research into satisfied users. Those who themselves are not users should be convinced that those who are users are benefitting.

A Taxonomy of Probable Complaints

1. Policy Conflicts: The user is committed to or otherwise convinced of the correctness of a technical procedure or an agency mission. Such people are not going to be supportive of research that might bring that procedure or mission into question and are going to be critical of completed projects that have done so.
2. Validity: The user does not find the theoretical or empirical work to be valid or at least does not find the research results to be realistic for application to solving the problems he faces.
3. Completéness: The state of the science as developed in the research may be regarded as still at a highly theoretical level that is not yet applicable to real world situations. Followup research and development and demonstration efforts may be needed before the user can really be helped. The results of several related studies may need to be integrated into a state-of-the-art framework so that users won't have to synthesize applicable information from a number of research reports and technical articles.
4. Understandability: The level of sophistication of the study or the jargon in its exposition may prevent users, who could greatly benefit, from comprehending the implications of the results and the help that could be gained by applying them.

5. Procedural: An interested user may try to apply the research, find himself blocked by some complexity in making the application, be unable to obtain expert help to overcome these difficulties, and finally give up. The pressures of other work assignments often hasten the surrender.

Analysis of Complaints

1. Policy Conflict Complaints: Complaints of this sort can originate from a) a feeling that past studies on the topic are so complete and definitive that further work would be wasted effort, b) a fear that additional study would generate controversy that would make the public uncomfortable with existing institutional arrangements considered desirable by the officials in question, or c) a strong commitment to a cause such as environmentalism or project development on the part of an official who sees the project as providing ammunition on the other side. Since it is highly unlikely that such officials are possible to convince that the research they question should be supported, the issue in research administration is the degree to which it is proper to avoid research objectionable to influential figures in order to enhance the fundability of the total program. Should certain productive research areas be sacrificed for the good of the total program?
2. Validity Complaints: Complaints of this sort can originate from a) research results seeming incompatible with the experience of or first-hand information available to the complainer, b) bad user experiences on previous attempts to use the results of similar research, c) statements of assumptions made in the research that do not seem reasonable. The basic problem here would seem to be either that the researchers do not understand the real world problem sufficiently well to organize their study properly or that the methodology which researchers find interesting for theoretical reasons is not very useful in practical applications. The use of linear equations to represent a nonlinear world would be an example.
3. Completeness Complaints: Complaints of this sort originate primarily from the fragmentation of research programs into small projects which individually are not very useful to water officials.

Individual projects may have to be followed by further studies or be integrated with prior or parallel studies before the combined results are ready for application. A related complaint is that research reports end with recommendations for more research rather than with the answers users need. The issue in research administration is what criteria should be used to decide which research findings to release for user application and which should be held for further analysis in a world where studies never reach complete truth with certainty. Also, what criteria should be used for deciding when and what sort of effort to combine individual project findings into an integrated, user-oriented packet is warranted? Incompleteness in research needs to be distinguished from need for organized technology transfer.

4. Understandability Complaints: Complaints of this sort originate in communication barriers between the scientific community and practicing water officials. The former may not be able to describe their work in a language understandable to users, and the latter may not understand what they are being told well enough to ask the questions necessary to overcoming the difficulty. Basic communication problems exist in the human tendency to avoid subjects rather than be embarrassed by a reputation of asking foolish questions.

5. Procedural Complaints: Water officials are very busy people and have little time to read research reports and develop their contents into usable form. Water researchers are very busy people whose efforts shift to the new projects that pick up their salaries after old projects are completed. The water officials usually need some help to get started in making an application and become frustrated in an inability to get that help from the researchers best able to provide it. Many researchers become so familiar with the topics they study that they overlook documentation and discussion of aspects of their study that can be important barriers to the understanding of others. The issue for research program administrators is what can be done to establish and fund an effective continuing research communication effort.

Recommended Actions

1. Policy Conflict Recommendations
   a. Make sure that proposed research into controversial technical or institutional topics is well conceived. Objectives should be precisely defined to minimize false impressions, and methodology should be carefully defined to demonstrate scientific soundness.
   b. Conduct research from a detached point of scientific objectivity that clearly takes account of various points of view and minimizes interpretations of researcher bias.
   c. Analyze controversial research areas ahead of time, and proceed only when convinced that the project indeed holds high promise of improving water resources management practice. Unnecessary controversy stirred by poorly done work is extremely counterproductive.
   d. Perform special studies or reports directly for policy makers on topics of political interest. The help these can give to legislators can generate good feelings from key people in the legislative or administrative processes that can make these people strong supporters of water research programs. The researcher, however, should be ready for the counter arguments that will be presented by opponents of the advocated position in the political arena. Such studies are best begun with a request from an interested public official (congressman, governor, legislator, etc.).
2. Validity Recommendations
   a. Recruit users into the research team or at least into an advisory board monitoring research progress. Such users will be able to steer theoriticians into practical areas and become counted as defenders of the research results.
   b. Provide regular peer review of completed projects so that researchers can catch the embarrassing mistakes of one another.
3. Completeness Recommendations
   a. Require each research report to conclude with results for immediate practical application as well as with recommendations

on effective paths for continuing study.

b. Fund more research in continuing programs that provide researchers sufficient support to continue studies to the point of producing applicable results. The emphasis on using OWRT allotment funds as "seed money" in many universities biases the researcher toward producing results that will be interesting to other funding agencies and against producing results that will directly profit the user. If the work is done, why should anyone provide support for more research.

c. In many cases, tentative or approximate methods can be put to good use before the final results are in, particularly for long run planning applications.

d. Special effort and additional funds are needed for development research and technology transfer efforts to follow through on studies and research programs in a way that will communicate to users.

4. Understandability Recommendations

a. Require a generalist or a user prepublication review of each research report to make sure that the presentation is comprehensive, and to style a suitable technology transfer program.

b. Require workshops or other oral presentations in which researchers present the results of completed or in-progress projects to selected users.

c. Hire people who combine solid technical background with good writing capability to edit research reports.

5. Procedural Recommendations

a. Establish continuing technology transfer funding so researchers can spend short periods with users and provide computer programs, etc., to those who need them.

b. Periodically poll research users to uncover problems experienced in attempted research application.

Conclusion

The difficulties in demonstrating research effectiveness cannot be separated from the difficulties in making the research effective in the first place. This presentation combines the two problems in an holistic

analysis that may exceed the assigned scope of work but that is believed necessary for good results.

COMMENTS BY PAUL UTTORMARK
University of Maine

Program effectiveness and the ability to demonstrate effectiveness are linked to many aspects of the overall program, including problem identification, establishment of research priorities, project selection, user identification, and information dissemination/technology transfer. Success or failure in any of these activities contributes directly to the perceived benefits of the program. The items listed below describe some of the difficulties associated with demonstrating the effectiveness of the OWRT research program, with the intent that ways of offsetting these difficulties might be developed in the workshop.

- Much of the criticism leveled at the OWRT research program appears to be aimed at the Allotment Program. Whereas some of this criticism may be offset by improved documentation of non-federal fiscal contributions, there remain those aspects which relate to project relevancy and usefulness. Almost without exception, Allotment projects are small, with annual budgets typically in the $5,000-10,000 range. For the most part, only small-scale, highly localized problems can be "solved" with investments of this magnitude; and it is difficult to communicate the value of these contributions to the satisfaction of congressional committees concerned with broadscale national problems. On the other hand, if project results are focused on only one aspect of a more complicated problem, then the value of the findings may not be apparent until they are integrated with other results developed elsewhere and/or developed at another time. Should more effort be directed toward combining the results

of similar projects so that their composite impact would be more apparent? Should Institutes identify restricted topics for research emphasis and concentrate on these topics for a number of years, so that a larger-- and presumably more impressive-- "mass" of results could be attributed to the program? Does the effectiveness of the present program suffer from undue fragmentation?

- A "seed grant" philosophy has apparently guided the allotment program in many Institutes. Is this approach self-defeating, with the successful ventures being developed and expanded with funds from other sources (which presumably are "credited with the accomplishments"), while the OWRT program continues to be identified with the "losers"? Perhaps the philosophy should be reversed, with allotment funds used to augment larger projects funded by OWRT or from other sources. In this way projects could be restricted in scope, but the usefulness of the results would be more obvious because they could be portrayed in the context of a larger effort.

- One of the advantages of the OWRT research effort lies in the fact that OWRT is not a mission-agency, and therefore it is theoretically possible to conduct broader, more objective programs. However, the research topics of highest national priority would be expected to fall within the purview of mission-agencies-- e.g. water availability for energy development in D.O.E.-- which places OWRT in the position of either avoiding these high-priority research

Comments for Discussion
NAWID Research Program Committee
Subgroup 3

topics or increasing the probability of funding projects which duplicate efforts elsewhere. Avoidance appears to be the choice. Will this exacerbate the relevancy problem by keeping the program out of the mainstream of national concern? Are there steps which can be taken to develop a "program identity" while at the same time avoiding undue duplication of effort with the mission-agencies?

- Many, if not most (percentage?), research projects are designed to develop methodology or to provide information that contributes to improved decisions. Documentation of the research contribution then requires two assessments, 1.) were decisions improved? and 2.) did the improvement result from research, or more specifically from OWRT-funded research? Other than "testimonials from happy users," it would appear that research contributions of this type are very difficult to quantify and document. If documentation of accomplishments is essential, does this imply that funding should be restricted to projects which yield more tangible benefits?

- The problem of documenting effectiveness is not unique to OWRT or to the Institutes. How is "return on the research investment" measured elsewhere? Both Cooperative Extension and Sea Grant are involved in federally-funded programs guided by locally-determined priorities. In many respects they are similar to the OWRT program, yet they appear to have less difficulty

in demonstrating their cost-effectiveness. Is this the case, and if so can we learn from their efforts? In contrast, the RANN program in NSF has been judged to be a dismal failure. On what basis did it fail, and can knowledge of that experience be used to advantage in the OWRT program?

- The goal of conducting problem-oriented research responsive to state/regional needs often takes on the connotation that projects should yield results which are applicable immediately. (It is in this context that program effectiveness is generally evaluated.) Attainment of this goal is complicated because of the lag-time between the date of project proposal and the date of project completion. An assessment of "usefulness of results" is made at the time of project selection. However, is this assessment based on considerations of present need, or on the projection of needs which will exist at the time of project completion? If the need for information is stable, lag-time is not a serious factor. If the need is volatile, lag-time is critical. Over the past several years many serious water resource problems have arisen, each with a host of research needs-- stream standards, phosphates in detergents, mercury, best available treatment, PCBs, drought... The period of waxing and waning for many of these topics is comparable to a typical project period. Are we providing information for yesterday's decisions? It is said that one of the principal reasons for the shift from research grants to RFP-contracts within the federal mission-agencies was to reduce project periods

to a minimum. "Quick and dirty" assessments are more compatible with crisis management. Are rapidly-changing management problems affecting the actual or perceived effectiveness of the OWRT program? If so, how do we properly take this into account?

- Is there a real deficiency in our ability to evaluate and demonstrate the effectiveness of the OWRT program, or have questions of program effectiveness arisen because of different, and perhaps unrelated, concerns? In short, is this the problem, or is it a symptom of a different problem? There seems to be widespread recognition of the importance of water resources research, and the present level of investment is not particularly large. In addition, the OWRT program accounts for only about 10% of the annual federal expenditure. Yet the program seems to be attracting attention and criticism out of proportion with its size. Why is this the case, and is it possible that questions of program effectiveness are really manifestations of other problems?

RESEARCH WORKSHOP REPORT

BY NEIL S. GRIGG
North Carolina State University

The issues taken up by this workshop fall into three primary categories:

1. How should arrangements between OWRT and Institute Directors be worked out to maximize the effectiveness of all our programs,
2. How can research effectiveness be improved and better documented, and,
3. What positive and negative impacts will the proposed new legislation have on our institute programs?

The workshop reports are organized along the above three lines.

OPERATING ARRANGEMENTS

We see that in general new requirements will be placed on the Institutes in the future for conceiving, developing and executing statewide programs embracing research, technology transfer, and all of the associated items known as "program development". The impacts of the new legislation will be discussed later but its general impact will be to put a new added workload on the Institute Director. The form of new emerging relationships with regard to specific OWRT program activities seems to be as follows:

1. Allotment Program--OWRT sees the Annual Allotment Program as primarily a state program with increased responsibility for technology transfer and program development as well as research. This will include the development of 5-year program plans as well as any regional cooperation to be envisioned. Responsibility for developing initiatives will clearly be with the Institutes, not OWRT.

2. Matching Grant Program--OWRT sees the subjects for Matching Grant Projects to come primarily from state and regional needs, as identified by the Institutes, as well as from national focused problem areas of special interest to OWRT. The focused problem areas may come from compilations of state and regional needs identified by the Institutes. A concern expressed by the Center Directors is that OWRT make as clear as possible the criteria for and procedure of selecting winning projects. There is an emerging problem concerning the opening of the Matching Grant competition to others relative to future Institute Involvement. This will be

discussed later. The Institute Directors would like to stress the importance of the open, cooperative attitude between OWRT and the states in the future development of this process.

3. Other OWRT Programs--The Institutes can serve key cooperative roles with OWRT in research programs outside the matching grant and allotment programs. The question of how Directors can organize for such participation is an open one.

4. Multi-Agency Programs--The question was raised whether OWRT can serve as a broker in bringing together funding groups from Federal and other agencies to finance research outside the traditional OWRT programs. There seems to be a desire on the part of Institute Directors for more such initiatives but OWRT staff indicate that this could be difficult due to limited staff time and interagency protocol limitations. Maximum information flow from OWRT to the Institutes regarding such possibilities was suggested and the Directors favor OWRT sending rejected proposals to other agencies for consideration wherever possible.

5. Recommendations on Operating Arrangements

   a. OWRT is encouraged to maintain to the maximum extent possible open lines of communication with our Directors to include arranging for as much Institute participation in decision making as possible.

   b. OWRT is encouraged to clarify as soon and as clearly as possible operating procedures anticipated under the matching grant program.

   c. OWRT is encouraged to develop maximum Institute participation in organizing research programs which fall outside the annual allotment and matching grant programs.

   d. OWRT is encouraged to signal the Institutes as soon as practical concerning the most useful form for the envisioned 5-year plans, especially with regard to how they can serve as useful input to the budgeting and priority-setting processes.

DEMONSTRATING RESEARCH EFFECTIVENESS

The committee felt that we should consider not only ways in which to demonstrate the effectiveness of the OWRT research program, but also should consider means to increase the overall effectiveness of the research program. Toward this end, two types of recommendations were made. The first dealt with program management to increase research effectiveness, and second dealt with the need to document research effectiveness on a continuing basis jointly with OWRT.

1. Recommendations for program management within the Institutes to maximize research effectiveness.

A. Policy Conflict Recommendations

1. Make sure that proposed research into controversial technical or institutional topics is well conceived. Objectives should be precisely defined to minimize false impressions, and methodology should be carefully defined to demonstrate scientific soundness.

2. Conduct research from a detached point of scientific objectivity that clearly takes account of various points of view and minimizes interpretations of researcher bias.

3. Analyze controversial research areas ahead of time, and proceed only when convinced that the project indeed holds high promise of improving water resources management practice. Unnecessary controversy stirred by poorly done work is extremely counterproductive.

4. Perform special studies or reports directly for policy makers on topics of political interest. The help these can give to legislators can generate good feelings from key people in the legislative or administrative processes that can make these people strong supporters of water research programs. The researcher, however, should be ready for the counter arguments that will be presented by opponents of the advocated position in the political arena. Such studies are best begun with a request from an interested public official (congressman, governor, legislator, etc.).

B. Validity Recommendations

1. Recruit users into the research team or at least into an advisory board monitoring research progress. Such users will be able to steer theoreticians into practical areas and become counted as defenders of the research results.

2. Provide regular peer review of completed projects so that researchers can catch the embarrassing mistakes of one another.

C. Completeness Recommendations

1. Require each research report to conclude with results for immediate practical application as well as with recommendations on effective paths for continuing study.

2. Fund more research in continuing programs that provide researchers sufficient support to continue studies to the

point of producing applicable results. The emphasis on using OWRT allotment funds as "seed money" in many universities biases the researcher toward producing results that will be interesting to other funding agencies and against producing results that will directly profit the user. If the work is done, why should anyone provide support for more research?

3. In many cases, tentative or approximate methods can be put to good use before the final results are in, particularly for long-run planning applications.

4. Special effort and additional funds are needed for development research and technology transfer efforts to follow through on studies and research programs in a way that will communicate to users.

D. Understandability Recommendations

1. Require a generalist or a user prepublication review of each research report to make sure that the presentation is comprehensible.

2. Encourage workshops or other oral presentations in which researchers present the results of completed projects, or during the project period.

3. Hire people who combine solid technical background with good writing capability to edit research reports.

E. Procedural Recommendations

1. Establish continuing "technology transfer" funding so researchers can spend short periods with users and provide computer programs, etc., to those who need them.

2. Periodically poll research users to uncover problems experienced in attempted research application.

2. Documenting the effectiveness of the national OWRT program.

It was felt that a more organized effort should be made to meet the recurring need to identify accomplishments of the national OWRT program. This activity should be undertaken on a continuing basis jointly with OWRT, and should be sequenced to provide useful, up-to-date information at times consistent with the budget process.

A standardized, uniform policy for documenting program effectiveness at the national level is essential and should be organized through a joint effort between OWRT and NAWID. A policy decision must be made as to what fraction of efforts and funds need be expended for justification and "effectiveness demonstration" activities. Once this is decided an acceptable procedure must be established. A skeleton outline of such a procedure is suggested below:

A. Identify OWRT--Institute "Activity Components"

Examples: Focused research, accumulation of research results, user relations (technology transfer, etc.), generation of new knowledge (unfocused research), training and education of new scientists, redirection of productive program to water related activities, etc.

B. Identify OWRT--"Program Elements"

Examples: Contract research, matching grants, technology transfer, allotment program, administration.

C. Map the correspondence between "program elements" and "activity elements"

Examples: Contract research deals solely with focused research; matching grants are some marriage between focused research and increased knowledge base; OWRT administration funds organize accumulated research along topical lines; technology transfer deals primarily with user relations after and during research project.

D. Collect data from the program elements which support the activity element.

Examples: (1) Focused research program proposals must identify expected progress. Report must speak directly to program in that area.

(2) Research summaries should be written on accumulated research areas as the subject area demands.

(3) Multiplier effects of institute dollars should be documented.

(4) Records of contacts, meetings with users, requests for information, state funded reports, etc.

(5) Personnel flow documented as necessary (students, new people in area, etc.).

(6) Research publications tabulated on a regular basis.

The committee was not able to develop firm recommendations to document effectiveness of the national program. However the following resolution, calling for a NAWID committee to study this matter in more depth and develop a workable approach, was prepared and presented for consideration at the NAWID business meeting.

--WHEREAS there is a continuing need to document the effectiveness of the OWRT research program

--WHEREAS the responsibility for this documentation rests with both the Institutes and OWRT

--WHEREAS the documentation of effectiveness needs to be accomplished uniformly among the Institutes and OWRT

BE IT RESOLVED THAT NAWID establish an ad hoc committee, working jointly with OWRT, to design appropriate procedures by which research accomplishments and program effectiveness are documented on a continuing basis. These procedures should take into account the amount of resources available for documenting effectiveness, and should yield usable products in a time-frame consistent with the annual budget process.

IMPACTS OF PROPOSED LEGISLATION

The impacts that the proposed federal legislation will have on the research programs of the water resources research institutes were examined. The added responsibilities for program development and administration required for the annual allotment program implies that more time and funds must be provided for these activities and that there will be less emphasis placed on supporting research and student training. In turn, there will be a greater demand for matching grant funds to support academic researchers; but the institutes do not make the final selection of projects to be supported and the program will now be opened to other sectors of the research community. In the final analysis then, the research efforts of the institutes will probably decrease with the passage of the new legislation unless additional funds are made available to support the new activities required by the legislation.

1. Allotment Program--The proposed legislation requires that additional time be spent on program development and administration. Items such as the development of a five year research plan, additional regional cooperation, an expanded technology transfer program and the technical review of matching grant proposals will ultimately result in an improved institute program, but it will require additional staff and resources to accomplish these goals. With no additional funds available, the amount of research and training done under the auspices of the allotment program will have to decrease.

2. Matching Grant Program--With less funds available to conduct research under the allotment program, there will be a heavier demand for matching grant funds to carry out the water research activities of the institutes. The institutes have more input in the matching grant selection process because they will be required to provide a technical review of all academic proposals submitted from their states, and because these proposals must be relevant in terms of the five year research plan.

However, the program will now be opened to all sectors of the research community, and the universities will now be in competition with the previous users of their research results. This may present real problems in the area of developing consultation and collaboration with leading water related officials in the states.

4. REPORT OF JOINT NAWID-OWRT AD HOC COMMITTEE ON DOCUMENTING EFFECTIVENESS OF OWRT RESEARCH

Committee Members

NAWID: L. Douglas James, John C. Frey, Norman A. Evans

OWRT: F. William Koop, Jack C. Jorgensen, Demetres A. Vlatas

Committee Charge

NAWID Resolution, April 26, 1978

Whereas, there is a continuing need to document the effectiveness of the OWRT Research Program and

Whereas, the responsibility for this documentation rests with both the Institutes and OWRT and

Whereas, the documentation of effectiveness needs to be accomplished uniformly among the Institutes and OWRT

Be it resolved that NAWID establish an ad hoc committee, working jointly with OWRT, to design appropriate procedures by which research accomplishments and program effectiveness are documented on a continuing basis. These procedures should take into account the amount of resources available for documenting effectiveness, and should yield usable products in a time frame consistent with the annual budget process.

OWRT Research Objectives

Effective research produces results that accomplish the research program objectives. The legislatively mandated objective of the OWRT research program, as stated in PL 88-379, was "to stimulate, sponsor, provide for, and supplement present programs for the conduct of research, investigations,

experiments, and the training of scientists in the fields of water and of resources which affect water." The individual state institutes were to "conduct competent research investigations, and experiments of either a basic or practical nature, or both, in relation to water resources and to provide for the training of scientists through such research, investigations, and experiments. Such research investigations, experiments, and training may include, without being limited to, aspects of the hydrologic cycle; supply and demand for water; conservation and best use of available supplies of water; methods of increasing such supplies; and economic, legal, social, engineering, recreational, biological, geographic, ecological, and other aspects of water problems, having due regard to the varying conditions and needs of the respective states and to water research projects being conducted by others."

The implied goal, however, was more than just to stimulate more research for broadening human understanding, it was to stimulate research that would improve human welfare. In the terminology of the Principles and Standards of the Water Resources Council, the research program would need to produce, disseminate, and achieve application of information that would provide water resources management officials and, in a general sense, the people of the United States the understanding needed for water quantity and quality management to promote the economic development, environmental quality, and social well-being of our nation as a whole.

The effectiveness of the OWRT research program thus needs to be documented in evidence that the OWRT research program is in fact achieving these objectives, accomplishing its legislated mandate, and increasing the public welfare through better water management. A documentation effort immediately encounters several problems. First, the stated program

objectives are not always the sort of goals that can be completed and publicized as objectives fulfilled. Rather than saying we have arrived, we are more likely to have to say that we have reached another milestone in trying to do better. Success is when the greater value of the greater accomplishment exceeds the effort expended.

Research administration generally pursues this sort of success by selecting priority areas (problem categories where new knowledge is needed to manage water resources in a way that will do a better job of meeting human needs) and often specific tasks within those areas. Such specific tasks provide absolute objectives that the researcher can achieve (or rule his proposed approach to be impractical, inconclusive, incomplete, or impossible). Success in accomplishing these tasks, however, does not assure success in terms of improved water management. There, failure may still occur because 1) the achieved research task was not followed by the further research or other steps needed to produce implementable results, 2) the implementable results were not used by practitioners, or 3) the selected specific task was not really all that important.

All three considerations are important in evaluating the effectiveness of the OWRT program. First, are selected projects producing results that give answers? Second, is the technology transfer program getting implementable results into the hands of users motivated to apply them? Third, are the best projects being selected?

The Practical Problem

A particular project should relate to a specific problem which needs to be overcome in order to expedite a program mission expected to produce a particular social outcome (goal). Linkages between a particular project

objective and the broad program objective of PL 88-379 can become pretty fuzzy. To document effectiveness of research, one needs to make a convincing case that the project output contributes to achievement of interlinked hierarchal goals all the way to the broad overarching goal at the top.

In evaluating "effectiveness" of research, we need to be sure our yardsticks are good. Oftimes, there are some horizontal and vertical elements that have to fall into place before a particular result takes on an aura of usefulness. Who is to say that there may be some useful "stewing" going on while awaiting companion results or while awaiting the placing of another domino in the line of results so that the upward sequence of objectives can proceed. In addition to this "timing" and "combining" dependency, there is an informational flow detection problem. It is easy to tell whether a new mechanical device gets adopted and used. But how do you follow the informational flow emanating from a research finding placed in the head of a graduate student? How do we measure the value of a finding in terms of how it might find adaptation in solving problems of a totally different nature?

General Documenting Strategy

It would be extremely difficult to document the effectiveness of the OWRT research program in terms of general human welfare objectives. OWRT and the institutes currently have no control over the implementation process since they have no water resources management responsibilities in adequate resources for compiling the consequences of implementations made. It would be an expensive and time-consuming process to collect comprehensive information on user research applications and the resulting consequences.

The inability in the past of this sort of documenting strategy to generate political support confirms this hypothesis.

This conclusion forces a different approach. We cannot easily prove effectiveness in an absolure sense so we must fall back to the position of demonstrating that the research program is indeed well conceived for systematically identifying important problems, defining research needed to solve those problems, organizing projects to do that research, conducting the research to produce meaningful results, assessing the contributions of completed research for revising problem concepts and subsequent research designs, coordinating the results of the various projects to make sure that its parts are not duplicative and the whole is productive, and detecting, interpreting, and distributing important results. This is the kind of logical internal program consistency that budget makers understand. It is the format that has served other problem areas well. As examples, cancer and space research were sold on the basis of performance toward scientific objectives that the public appreciated.

Specific Documenting Strategy

Given this perception of the current situation, this committee recommends documenting research effectiveness by:

1. Selecting approximately three areas of water resources research.

2. Performing an analysis of how knowledge in each area has been advanced over the period since OWRR began in 1965.

3. Identifying how OWRT projects contributed to that advance.

Implementation Strategy

Adoption of the above documenting strategy poses several problems. What criteria should be used in selecting the areas to document initially?

Who should make the selection? What sort of documentation would be best? Who should do the documenting? This committee felt that specific answers to these questions could not be formulated within the time, effort, and funding (taken out of the hide of busy people with many other responsibilities and no money) that it had and that a better approach would be for OWRT to fund a two-phase documenting effort.

The first phase would be an approximately two-month, $2000 study to 1) select pilot areas to document, 2) draw up specifications that OWRT would use to procure that work, and 3) recommend procurement procedures and contractors to the extent appropriate.

The second phase would be three simultaneous, approximately six-month, $12,000 studies to document advances in the state of the art since 1965 and OWRT program contributions to those advances.

The three second phase reports would be followed by an assessment of the success of the documentation effort, whether more "second phase" documentations would be worthwhile and, if so, what topics should be covered, and what would be the best way to keep documentations, once completed, updated over time. In the long run, these documentations should become a valuable tool for identifying knowledge gaps and priority research needs.

The above estimates of time and cost reflect general orders of magnitude that may need to be modified somewhat to reflect an appropriate balance between the funds OWRT can make available for this purpose and what is needed to do a good job.

Criteria for Selecting Areas to Document

1. Widespread (by large numbers of people in many parts of the country) feeling that something better than what is now being done must be done in the area to meet important public needs.

2. An area that is both specific and carefully defined so that meaningful coverage can be achieved and unnecessary time is not wasted in deciding what to include. Urban water resources would be unreasonably broad. Control of pollution in urban runoff may be satisfactory. Modeling nitrogen pollutographs would be too narrow to have much appeal.

3. The state of the art is known to have advanced significantly since 1965 and OWRT is known to have been active in related research.

4. The different areas selected should not be closely related but diverse enough so that the effort will provide a good sense of documenting difficulties in various disciplines and settings.

5. Practitioners knowledgeable in the area, free to devote the necessary effort, and known to be relatively unbiased can be found.

Type of Documentation Desired

The specifications drawn to procure the documentation should be goal oriented, giving the contractor maximum flexibility to be innovative in producing the kind of documentation that he believes will work best. One reason for going to multiple documentations is to have multiple results that can be compared for merit. Over specification would force documentations into a commonality that would defeat this purpose. Goal oriented criteria should include:

1. A presentation that is credible to scientists and research administrators working in the area.

2. A presentation that is credible to water resources planners or managers including concerned lay citizens.

3. A presentation that is convincing to government officials, research administrators, legislators, and others involved in the budget process.

4. A result that others can refine easily to reflect new research results as they are completed.

Key First Step

The success of the proposed effort is going to depend in large part on getting the plan off to a good start. The committee does not believe that the RFP route would work for this purpose, but rather that negotiations should be initiated by OWRT with senior water scientists or water research administrators who have proven ability, time, and no strong bias. Possible names to consider include Carl Kindsvater, Maynard Hufschmidt, David Howells, Robert Smith, Bernard Berger, Daniel Leedy, Ray Linsley, Warren Hall, Leonard Dworsky, and Herbert Swenson.

Urgency of Schedule

This documentation effort will need to proceed promptly if it is to provide results timely enough to be useful. If it does not work, OWRT and NAWID need to learn that while they still have time to try alternatives. Quick action is urged.

Long-Run Implementation

The effort described above is envisioned as contributing to 1) better research, and 2) better documentation of the research that is done. The contribution to better research should come through helping 1) OWRT and the Centers (through the allotment program) select better projects, and 2) researchers do work better coordinated with the national effort in their field. The contribution to better documentation should come through helping 1) researchers present their results as contributions advancing a defined status of the state of the art, and 2) OWRT organize information obtained on research contributions quickly as needed for budgetary and program development purposes. Further analysis is needed once areas begin to be documented to develop optimal and convincing procedures for using the documentation in these ways.

5. REPORT

ON

DOCUMENTING THE EFFECTIVENESS

OF

OWRT RESEARCH PROJECTS IN MEETING NATIONAL NEEDS

PHASE I

April 15, 1979

by

David H. Howells
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(OWRT Contract No. 14-34-0001-9607)

OFFICE OF WATER RESEARCH AND TECHNOLOGY

U. S. DEPARTMENT OF THE INTERIOR

DOCUMENTING THE EFFECTIVENESS OF OWRT RESEARCH PROJECTS IN MEETING NATIONAL NEEDS

INTRODUCTION

The NAWID-OWRT Ad Hoc Committee on Documenting Effectiveness of OWRT Research has proposed the development of procedures whereby research accomplishments and program effectiveness of OWRT can be documented on a continuing basis. These procedures are to take into account the amount of resources available for documenting effectiveness and are to yield usable products in a time-frame consistent with the annual budget process. The Committee recommended that this be accomplished through the selection of approximately three areas of water resources research, analysis of those areas to determine how knowledge in each area has been advanced over the period since OWRR began in 1965, and documentation of how OWRT projects contributed to that advance. This report deals with Phase I of that study. Its purpose is to select three pilot areas which are currently important and include OWRT work and to define a strategy for Phase II--the detailed documentation effort.

SELECTION OF PILOT AREAS FOR DOCUMENTATION

Criteria

The criteria suggested by the Joint Committee for selection of areas for documentation are as follows:

1. There is a widespread feeling that something better than what is now being done in an area is required to meet important public needs.
2. The area is both specific and carefully defined so that meaningful coverage can be achieved and time is not unnecessarily wasted in deciding what to include.
3. The state-of-the-art is known to have advanced significantly since 1965, and OWRT is known to have been active in related research.
4. The selected areas are sufficiently diverse so that the effort will provide a good sense of documenting difficulties in various disciplines and settings.

5. Knowledgeable and unbiased practitioners are available in selected areas.

The first criterion is of fundamental importance. Unless the areas selected are generally viewed as timely and relevant expressions of national concern, documentation will be an exercise in futility. The last four criteria can best serve as screening devices for rejection or modification of relevant areas.

Time Frame for Problem Identification

Primary reliance will be placed on studies and reports released during the past five years. While no contemporary assessment of water resources problems can ignore the 1966 "Ten-Year Program of Federal Water Resources Research," prepared by the FCST Committee on Water Resources Research (COWRR), priorities and emphasis have shifted sufficiently during the intervening period so that it must serve as a background reference. A refocusing was attempted in the 1977 report of COWRR, and this is used as one of the information sources.

Sources of Information

Relevance is heavily influenced by current public perceptions and their expression through the democratic process to the Congress and its institutions. Potential sources of information in the Congress include key committees, the Library of Congress, and the General Accounting Office. Telephone calls were made to all of these and input received through comments of staff members and a staff report of the General Accounting Office entitled, "Water Resources Planning, Management, and Development: What are the Nation's Water Supply Problems and Issues?" The Library of Congress reported no studies pertaining to project objectives.

Other sources of information include:

- Water Policies for the Future - Final Report of the National Water Commission
- Water Resource Problems and Research Needs FY 1978 - Summary of State and Regional Water Resources Research Needs, prepared by OWRT and State Institutes
- Directions in U. S. Water Research: 1978-1982, COWRR update of 1977
- The Nation's Water Resources: The Second National Water Assessment by the U. S. Water Resources Council, April 1978
- OWRT Water Research and Development Priorities for FY 1979
- The President's Water Policy Initiatives, January 1979

The GAO report included problem areas identified by the Department of the Interior's Westwide Study Report on Critical Water Problems Facing the Eleven Western States (April 1975) and the Summary of the National Conference on Water (April 1975), and it was not felt necessary to make an additional review of these two reports.

Selection Process

Problem areas identified through these information sources are presented in the Appendix and summarized in Table 1. The table expresses the commonality of perception of water problems among the eight information sources in matrix form by relating the most commonly identified problems with information sources. Problem areas identified by two or less sources are not included. As can be readily seen, water supply augmentation and conservation and groundwater management are quite generally perceived as major problem areas. Also of high common interest are deficiencies in water law and allocation systems, water resources constraints on energy development, hazardous chemicals, groundwater contamination, and planning deficiencies.

The problem areas are next examined in terms of the five criteria presented on page 1 and page 2. There are difficulties here with respect to quantitative evaluation. Ideally, each criterion should be expressed through a numerical scale with weights assigned to the various criteria to reflect their relative importance. But, can this be done? A numerical expression for relevancy might be derived by using the proportion of information sources citing the basic problem area. If they were assumed to have the same weight, a problem area cited by all eight sources would carry twice the weight of one cited by only four. But, do they have the same weight? It is doubtful.

The second criterion requires that problem areas shall be sufficiently specific and well defined so as to be subject to analysis for the purpose of this project. Some problem areas can be disaggregated to the extent needed to accomplish this end, but others resist this. Conservation in irrigation might be divided into such manageable packages as delivery and application, evapotranspiration, soil-water-plant relationships, and so forth. Yet, a problem area like water law and allocation systems seems so complex and diffuse as to be beyond the pale of any meaningful documentation of research contributions. In between these extremes, how is one to assign values for relative specificity and definition?

The third criterion measures the advancement of the state-of-the-art and OWRT participation in such advances. No single individual is able to state categorically that the state-of-the-art in a diverse group of problem areas has or has not advanced significantly during the period of study, let alone assign values to represent the relative advance and degree of OWRT contribution prior to completion of Phase II of the project. The writer's approach to this was to assume that there is a direct relationship between the amount of literature produced and advances in knowledge in the fields addressed. If this is true, it should be possible to use the number of citations in Interior's Water Resources Abstracts file as a surrogate for advances in coping with associated problem areas. Thus, if WRSIC discloses a significant number of citations in a given area, one might assume that there have been significant advances. But, how is "significance" to be measured quantitatively?

The final two criteria clearly do not lend themselves to quantitative evaluation. The question of whether a problem area is sufficiently diverse to provide a good sense of difficulties in various disciplines and settings is an affirmative or negative judgment. It is the writer's opinion that with a few exceptions the knowledgeable and unbiased practitioners are available for analysis of areas experiencing significant state-of-the-art advances.

While numerical values might be assigned to most criteria through a procedure like the Delphi technique, it is doubtful that this would be practicable or attainable in the context of this project. Short of that, an effort to quantify the evaluation would give the impression of a degree of accuracy that does not exist. The process is essentially subjective and judgmental, and the criteria should be applied in that context. Each problem and sub-problem area should be examined in the light of each criterion and the judgment made as to whether it does or does not appear to meet the requirements. Different persons may reach different conclusions, and it may well be that this process should be conducted in group fashion. At this point, however, the writer must proceed alone and make the best decisions possible under the circumstances.

The next step in this analysis is to estimate the degrees of advances in the state-of-the-art and OWRT contribution through the surrogate of citations available through the WRSIC system. Descriptors were chosen so as to permit disaggregation of problem areas where desirable. The results of the WRSIC search are presented in Table 2.

Application of the selection criteria is summarized in Table 3. The following comments are provided concerning some of the judgments involved:

Desalination - 89 percent of OWRT projects were sponsored by the Office of Saline Water, and it does not seem appropriate to include as an item under this project.

Reclamation of stormwater runoff - the bulk of this work is believed to be associated with groundwater recharge, and that problem area heading will be used for this purpose.

Reuse of waste waters - this encompasses a multitude of different industrial processes, irrigation, saline-intrusion barriers, etc. There is a large grey area involving land application for waste treatment in which reuse is of secondary or even negative concern. For these reasons, it does not seem to meet requirements of Criterion 2.

Water yield improvement - to be manageable this area needs to be disaggregated into such sub-areas as water harvesting, phreatophyte control, land management, snow management, etc. This can be done. The writer is not aware, however, of any substantial advances in any of these areas, and the problem is dropped for this reason.

Municipal water conservation - while this area can be broken down into a number of sub-areas, it is tractable and more meaningful if handled as a whole.

Industrial water conservation - this area is industrial process-specific and would be difficult to handle as a single problem area. Results might be too fragmented if disaggregated. EPA dominated area and very doubtful if strong case could be made for OWRT contributions.

Irrigation water conservation - can be disaggregated into the following areas: delivery and application, evapotranspiration, and soil-water-plant relationships to meet Criterion 2.

State water law and allocation systems - viewed as too diffuse and not subject to meaningful disaggregation for this purpose.

Federal and Indian land entitlements - law and policy state-of-the-art apparently inadequate.

Interbasin transfer - no significant advances.

Interstate allocation - no significant advances.

Instream uses - no significant advances.

Constraints on energy development - a review of the most recent Catalog of Water Resources Research underway indicates a high diversity of water-energy relationships and dilution of research payoff across a broad area of concern. Level of OWRT participation insufficient to justify documentation effort.

Water pollution from hazardous chemicals - extremely large and uncharted area with no significant advances. Heavily dominated by EPA. Shortage of experts in this area.

Groundwater pollution - this is a very broad area but can be disaggregated to a sufficient degree to meet Criterion 2. Suggest saline water intrusion and underground waste disposal. Also, closely related to groundwater recharge.

Non-point (stormwater) pollution - complex area with no major advances. Heavily influenced by EPA.

Limitations tradition design concepts - dominated by EPA. Difficult to find experts with sufficient objectivity.

Flood plain management - WRSIC search indicates this can be disaggregated into flood plain insurance, flood plain zoning, and flood plain hydrology. Because of central interest in overall problem areas, it might be considered on that basis.

Conjunctive management of ground and surface water - suggest treating as surface-groundwater relationships and conjunctive management.

Conjunctive planning and management of water and land resources - too diffuse to be manageable.

Groundwater management - groundwater recharge, groundwater pollution, and conjunctive use are carried as separate problem areas. The remaining elements might be difficult to handle in a way that would serve the purpose of this project. USGS dominated.

Cost-benefit analysis - seems to meet all criteria.

Cost sharing - seems to meet all criteria, though number of OWRT contributions relatively low.

Environmental impacts - WRSIC search disappointing in terms of specific types of development. The writer is personally aware of more citations than indicated for channel improvement-channelization effects. On the basis of this search, however, suggest limiting to environmental impacts of reservoir construction and operation.

Social impacts - seems to meet all criteria.

If the number of literature citations is accepted as a surrogate for advances in the state-of-the-art and OWRT participation--as has been assumed--one should be able to use this as a guide in setting the final priorities among problem and sub-problem areas for analysis. But, there are limits to the applicability of this assumption. What number of citations might constitute a minimum opportunity for significant contributions and what minimum proportion should be OWRT? The WRSIC system currently contains 133,095 citations of which 8663 (6.5 percent) involve OWRT participation. The range of OWRT involvement among the problem areas meeting selection criteria is 7 to 26, with an average of 17 percent. The number of citations for these problem area ranges from a maximum of 225 down to 7, though the latter number is believed to be in error. Problem and sub-problem areas are arranged in order of the number of citations available in Table 4. The percent OWRT participation among total citations for each area is also given. Final selection involves a further review of numbers in light of Criterion 3. What minimum number of citations holds promise for documenting significant advances? Final selection also involves tradeoffs between the number of citations and percent OWRT involvement. The larger the number of citations, the

better the chance for demonstrating significant contribution. Yet, the relative contribution of OWRT research is likely to be proportional to relative involvement. It will be arbitrarily assumed that 25 citations represent a minimum citation base for each area and that no less than 10 percent of all citations in a given area must involve OWRT participation. These assumptions result in the following list of eligible areas:

Groundwater management
- Surface-groundwater relationships
- Groundwater recharge
- Conjunctive use of ground and surface water

Cost analysis in water resources planning

Social impacts of water resources development

Flood plain management
- Zoning and insurance
- Hydrology

Irrigation water conservation
- Evapotranspiration control

Of these eight areas, which three are to be selected? Should the effort be concentrated in groundwater management, which is so heavily influenced by USGS? The same could be said for evapotranspiration control with respect to USDA and the State Agricultural Experiment Stations. It is an impressive fact that OWRT has produced about one-fourth of all citations in four of the eight areas. Should not that, together with the number of papers, be a deciding influence? There is also the consideration that some of the areas are peculiarly OWRT's domain--filling in the voids and dealing with questions mission-oriented agencies have avoided. Cost analysis, social impacts, and flood plain management come to mind in this regard. While some of these considerations are contradictory, it is the writer's judgment that these considerations would, in balance, tend to winnow out the following three areas for initial consideration:

- Groundwater recharge
- Cost analysis in water resources planning
- Social impacts of water resources development

SPECIFICATIONS FOR ASSESSMENT OF OWRT CONTRIBUTION TO NATIONAL RESEARCH OBJECTIVES

The purpose of Phase II of this project will be "to document advances in the state-of-the-art since 1965 and the OWRT program contributions to those advances." This is limited to Title I and II Programs under the Water Resources Act, as amended.

The Joint NAWID-OWRT Ad Hoc Committee suggested that specifications should be "goal-oriented, giving the contractor maximum flexibility to be innovative in producing the kind of documentation that he believes will work best." "One reason for going to multiple documentation," said the Committee, "is to have multiple results that can be compared for merit." It felt that overspecification would force documentations into a common mold that would defeat this purpose. In this context, the primary purpose is to develop techniques for documentation--not documentation, per se. For, if documentation is the primary objective, product-oriented specifications would appear to be essential if the results are to be of any value in a collective sense. The four goal-oriented criteria identified by the Committee are very general and essentially say that presentations should be credible, convincing, and amenable to periodic updating. These pertain to the documentation presentations. Criteria are also required to guide the review of individual projects. The following are suggested:

1. Clear definition of problem.
2. If basic research, directed toward filling a clearly identified gap in basic knowledge which itself is relevant to solutions of recognized problems.
3. If applied research, addressed to solving specific problem.
4. Research objectives relevant to identified problem clearly stated and realistically attainable.
5. Research procedures adequate to attain objectives.
6. Research findings reasonable fulfillment of objectives.
7. Provisions for technology transfer.
8. Documentation of contributions to water resources science and technology, planning, and management.

The first seven criteria for the review of individual project reports should be subject to evaluation on a check-sheet basis using a scale of 1 to 10. Additional guidance is needed to evaluate Criterion 7. Provisions for technology

transfer might be idealized for the principal categories of research payoff as a basis for evaluation. Advances in science of primary interest to other scientists could be adequately addressed through completion reports available through NTIS as a minimal effort, followed by reporting in the scientific literature and presentation at scientific meetings. A combination of the first two might represent a mid-level effort and all three a fully satisfactory set of provisions. At the other end of the spectrum will be the pragmatic and immediately useable products. The vast majority will lie somewhere in between. A maximum effort on the applied side might include the following provisions:

1. Project completion report available through NTIS.
2. Reporting in the scientific literature.
3. Reporting in trade journals and other periodicals utilized by practitioners.
4. Presentation at scientific and technical meetings.
5. Presentation at other user meetings.
6. Preparation of special interpretive reports.
7. Preparation of audio-visual aids.
8. Workshops and meetings with interest groups.
9. Short courses.
10. Media coverage.

Many, if not most, of the reports available for the documentation effort will have been prepared in advance of applied technology transfer efforts. All one may see here will be advance provisions, not the final results.

The actual documentation effort will have to go beyond the research reports if there is to be any hope of identifying adoption and utilization of research contributions. Productive leads should be followed to the individual Institutes and other sources for elaboration and further documentation. Reports on research and technology transfer prepared in one state may lead to advances in another. Many Directors have been active in state planning and policy-making, and the products of their actions are just as germane as direct research payoff. This should be included in the documentation.

While some of the advances may be significant unto themselves, many will probably be of a lesser scale. How does one cope with these? The bits and pieces may not fit together into a pattern yielding a significant advance. Even where such advances can be demonstrated, there is often a considerable time lag

between the technology transfer initiatives and final adoption. This is particularly true in the policy, planning and management areas where there may be institutionalized resistance to change or political reasons for maintaining the status quo. It is the writer's opinion that documentation should include the identification of specific advances recognized as such by the contractor, whether or not adopted, supplemented with as many examples of acceptance and utilization as can be found. An advance is an advance, whether or not adopted at the moment.

Many interesting insights could be afforded by a review of the research proposals as well as final report or paper. For it is there that the contrasts between promise and product would be most revealing. Unfortunately, however, proposals will not be available for the vast majority of projects, and documentation will have to rely on the published literature. There will be shortcomings, but it will have to serve as best it can. The literature review for each problem area should include an intensive search of WRSIC as a minimum requirement. Contractors should cross-check funding agency participation with input into WRSIC abstracting so that steps can be taken to review alternative sources, if needed. The WRSIC search must be rigorously carried out by persons intimately familiar with that system. Otherwise, many citations may be left untouched.

A review of abstracts from the WRSIC search will serve to reduce the list of citations to those reports offering reasonable expectation of payoff. Indeed, a first-cut estimate of research contributions might be called for at that time before proceeding with a detailed review of the reports themselves. Convenient access to reports will be essential, and the Nation's Capital would seem to be the only location where all might be available. Thus, the contractor will almost certainly have to spend considerable time at that location.

PROCUREMENT TECHNIQUES

The work encompassed in documentation of the OWRT contribution to national research objectives will be credible only if it is viewed as an objective appraisal by the interests involved. The contract should be drawn so as to document the contributions without bias, one way or the other. The chips will have to be permitted to lie where they fall.

Procurement through consulting firms is bound to be expensive, and there is no evidence to indicate this procedure would be more effective than to contract with individuals. There are many university faculty members and retired

specialists in the problem areas living in the Washington region who might be interested in short-term assignments of this type. The source materials would be close at hand, and there could be frequent consultation with OWRT staff without costly travel.

Potential contractors should have a record of demonstrated experience in the problem area to be investigated and sufficient personal knowledge of the state-of-the-art so that they can proceed with confidence and authority.

It is recommended that work proceed through two steps. The first would involve a literature search and preliminary assessment through review of abstracts. At this point there should be discussions with OWRT staff to determine whether the evidence at hand justifies continuing to the more detailed and costly step of literature review and assessment.

SUMMARY AND CONCLUSIONS

Water resource problem areas for documenting the effectiveness of OWRT research were identified through discussions and review of reports from eight different sources ranging from Committees of Congress to the President's Water Policy Initiatives. These were screened through a set of criteria suggested by the NAWID-OWRT Joint Committee to assure relevancy and a reasonable opportunity for success in documentation. This produced a final group of eight problem or sub-problem areas for consideration. The three suggested for initial consideration are: groundwater recharge, cost analysis in water resources planning, social impacts of water resources development. Specifications for assessment and procurement techniques are discussed.

The difficulties of effectively documenting significant advances in water resources research should not be underestimated. One only needs to look at sister federal agencies with many times the OWRT budget to note the lack of tangible evidence of such advances. Can OWRT, with only 6.5 percent of total citations to its credit, do what larger and better funded agencies have not done? Possibly. But there is risk in that inconclusive findings could be misinterpreted. It might be prudent to take on a single promising area on a trial basis and await results before proceeding further.

Table 1. WATER RESOURCE PROBLEM AREAS OF PRIMARY INTEREST TO FEDERAL AGENCIES AND STUDY GROUPS

Identification Water Problem Areas	(1) Committees of Congress	(2) G.A.O.	(3) N.W.C.	(4) OWRT WRRI	(5) COWRR Update	(6) WRC 2nd N.A.	(7) OWRT 1979	(8) President's Water Policy
WATER SUPPLY AUGMENTATION								
Reclamation of waters of impaired quality through desalination	x	x	x	x		x	x	x
Reclamation of stormwater runoff	x	x	x	x	x	x		
Reuse of wastewaters	x	x	x	x	x	x	x	
Water yield improvement	x	x	x	x	x	x		
WATER CONSERVATION								
Municipal	x	x	x	x	x	x	x	x
Industrial	x	x	x	x	x	x	x	x
Irrigation	x	x	x	x	x	x	x	x
WATER ALLOCATION								
State water law and allocation systems		x	x	x	x	x		
Federal and Indian Reserved Entitlements		x	x		x			x
Interbasin transfer		x	x	x				x
Interstate allocation		x	x	x				x
Instream uses		x	x	x				x
Constraints on energy development	x		x	x			x	x
WATER POLLUTION								
Hazardous chemicals	x		x	x	x	x	x	
Groundwater	x		x	x	x	x		
Non-point (stormwater) sources			x	x	x	x		
Limitations traditional design concepts	x		x	x	x			
Relevancy of water quality objectives	x		x	x				
Economic, social, and environmental benefits and costs of alternative water quality management strategies			x	x	x			
Erosion and sedimentation			x		x	x		
FLOODING								
Flood-plain management			x	x	x	x	x	
WATER RESOURCES PLANNING AND DEVELOPMENT								
Conjunctive management of ground and surface water			x	x	x	x		x
Conjunctive planning and management water and land resources		x	x	x	x			
Groundwater management	x	x	x	x	x	x	x	x
Cost-benefit analysis in water resources planning		x	x	x				x
Cost sharing and repayment	x	x	x	x				x
Environmental and social impacts of water resource development			x	x	x			x
Consideration of alternative means of supply in planning		x	x	x		x		x

(1) Telephone interviews with senior staff members of Congressional Committees.
(2) "Water Resources Planning, Management and Development: What are the Nation's Water Supply Problems and Issues?" Staff Study, General Accounting Office, July 28, 1977.
(3) "Water Policies for the Future," Final Report by National Water Commission, June, 1973.
(4) "Summary of State and Regional Water Resources Research Needs," FY 1978, OWRT-State Water Resources Research Institute, Oct. 1, 1976.
(5) "Directions in U. S. Water Research: 1978-1982," COWRR (Final Draft) April 1977.
(6) "The Nation's Water Resources," Second National Assessment, USWRC, April 1978.
(7) Proposal Guidelines for FY 1979, OWRT.
(8) Second Progress Report on Implementation of the President's Water Policy Initiatives, Jan. 23, 1979.

Table 2. WRSIC CHECK OF LITERATURE CITATIONS AND OWRT ACTIVITY IN WATER RESOURCES PROBLEM AREAS

Problem Area Descriptors	WRSIC Citations	
	Total	OWRT
Desalination	1430	962*
Imapired waters	1288	106
Runoff conservation (groundwater recharge)	1410	200
Water reuse	2301	200
Water yield improvement	1764	125
Water conservation	4196	216
" - rationing	8	0
" - water demand	231	22
" - water management	1631	64
" - water reuse	366	25
" - water shortage	82	3
" - water supply	710	32
" - water utilization	590	42
" - municipal	131	20
" - industrial	277	21
" - irrigation	161	52
Irrigation efficiency	831	86
" design	231	19
" effects	632	43
" operation and maintenance	117	8
" practices	1167	69
" systems	890	59
" -soil-water-plant relationships	325	25
" -water delivery	100	7
Evapotranspiration control	379	73
Evapotranspiration control-water conservation	264	44
Evaporation control	152	49
Legal aspects	9932	216
Water law	4010	165
Water rights	1709	132
Water administration	2072	109
Institutional aspects	904	107
Interbasin transfer	185	16
Equitable apportionment	131	0
Water policy	2437	188
Water utilization	3436	335
Competing uses	617	38
Instream uses	52	7
Energy	69	16
Natural use	71	2

(continued)

Table 2 (continued)

Problem Area Descriptors	WRSIC Citations	
	Total	OWRT
Water pollution	30130	3837
Chemical wastes	1305	22
Groundwater pollution	1134	283
Saline water intrusion	774	60
Water pollution-stormwater	1646	82
Wastewater disposal	1717	99
Underground waste disposal	1717	99
Injection wells	520	49
Waste disposal wells	174	9
Water pollution/treatment	18845	863
Groundwater	6241	865
Groundwater management	5783	165
Groundwater mining	210	21
Groundwater recharge	1410	200
Surface-groundwater relationships	863	225
Conjunctive use	226	59
" -optimum development plans	27	10
" -water management	109	32
" -water resource development	96	19
Flood plain management	561	40
Flood plain insurance	568	92
Flood plain zoning	191	25
Flood plain - River flow	155	41
Flood plain - Non-structural alternatives	672	23
Flood control	3334	182
Flood protection	1451	33
Floodways	710	4
Environmental effects		
Water resource development	3119	260
Channel improvement	387	3
Reservoirs	486	30
Dredging	550	2
Waterways	92	2
Cost-benefit analysis	1649	151
Cost analysis	1248	164
Cost sharing	330	21
Intangible costs	29	4
Discount rates	169	18
Economic efficiency	1082	109
Social aspects-water resource development	427	103

*OSW 852
OWRT 110

Table 3. APPLICATION OF SELECTION CRITERIA TO WATER PROBLEM AREAS

Water Problem Areas	Selection Criteria				
	1	2	3	4	5
WATER SUPPLY AUGMENTATION					
Reclamation of waters of impaired quality through desalination	x	x	a	x	x
Reclamation of stormwater runoff (groundwater recharge)	x	x	x	x	x
Reuse of wastewaters	x		x	x	x
Water yield improvement	x	x		x	x
WATER CONSERVATION					
Municipal	x	x	x	x	x
Industrial	x	x		x	x
Irrigation	x	x	x	x	x
WATER ALLOCATION					
State water law and allocation systems	x		x	x	x
Federal and Indian Land Entitlements	x	x		x	x
Interbasin transfer	x	x		x	x
Interstate allocation	x	x		x	x
Instream uses	x	x		x	x
Constraints on energy development	x			x	x
WATER POLLUTION					
Hazardous chemicals	x		b	x	
Groundwater	x	x	x	x	x
Non-point (stormwater) sources	x	x	b	x	x
Limitations traditional design concepts	x	x	b	x	
FLOODING					
Flood-plain management	x	x	x	x	x
WATER RESOURCES PLANNING AND MANAGEMENT					
Conjunctive management of ground and surface water	x	x	x	x	x
Conjunctive planning and management of water and land resources	x		x	x	x
Groundwater management	x		x	x	x
Cost-benefit analysis in water resources planning	x	x	x	x	x
Cost-sharing and repayment	x	x		x	x
Environmental impacts of water resource development	x	x	x	x	x
Social impacts of water resource development	x	x	x	x	x

1. Relevancy
2. Specific and well defined
3. State-of-the-art has advanced significantly since 1965 and OWRT is known to have been active in related research.
4. Sufficiently diverse to provide good sense of difficulties in various disciplines and settings.
5. Knowledgeable and unbiased practitioners available

a. Office of Saline Water. No work under OWRR and little under OWRT. Would not be appropriate category relative to Institute program.
b. EPA dominated.

Table 4. ELIGIBLE PROBLEM AND SUB-PROBLEM AREAS IN ORDER OF NUMBER OF WRSIC CITATIONS FUNDED BY OWRT

Problem and Sub-problem Areas	OWRT Citations	
	Number	Percent Total
Surface-groundwater relationships	225	26
Groundwater recharge	200	14
Cost analysis in water resources planning	164	13
Social impacts of water resources development	103	24
Underground waste disposal	99	6
Flood plain management (zoning and insurance)	92	16
Saline water intrusion	60	8
Conjunctive use of ground and surface water	59	26
Irrigation water conservation (evapotranspiration control)	44	17
Flood plain hydrology	41	26
Irrigation water conservation (soil-water-plant relationships)	25	8
Municipal water conservation	20	15
Irrigation water conservation (delivery and application)	7	7

APPENDIX

WATER RESOURCES PROBLEM AREAS
Identified by Information Sources

1. Congressional Committees

Senate:

Committee on Public Works and Environment
Committee on Energy and Natural Resources

House of Representatives

Committee on Public Works and Transportation
Committee on Interior Affairs
Committee on Science and Technology--Subcommittee on Environment and Atmosphere

a. Anticipated water supply shortages with a major crisis if more constructive steps are not taken. Need for development of alternative water sources by reclamation of estuarine and brackish groundwaters through desalination techniques, capture of surface runoff, groundwater recharge, reuse of wastewater, and other means.

b. Conservation and more efficient use of existing water supplies.

c. Reliable analysis of water resource constraints on energy development.

d. Protection of groundwater resources from contamination, with emphasis on hazardous chemicals.

e. Reexamination of conventional water supply and wastewater management concepts, with emphasis on water carriage systems, use of rivers for waste disposal, relevancy of water quality objectives in light of non-point pollution. Unconventional approaches.

f. Policy questions on cost sharing, pay-back, discount rates, types of projects eligible for federal funding, and so forth. Use of the benefit/cost criterion to exclude projects with high social and environmental value.

2. General Accounting Office

Staff Report "Water Resources Planning, Management, and Development: What are the Nation's Water Supply Problems and Issues?"

a. Adequacy of existing water resource plans and programs to meet competing demands for water use. Lack of reliable data on water usage and projected demands.

b. Alternative new sources of water through precipitation and snow-melt management, water from geothermal extractions, desalting brackish surface and ground water, recycling and reuse of wastewater.

c. Allocation between competing needs for agriculture, municipalities, industry, energy, Indian lands, in-stream uses, and environmental quality. Project consistency with river basin plans. Discount rate, repayment assurances, consultation and coordination with state and local government. Coordination between water quantity and water quality. Interagency and intergovernmental coordination.

d. Conservation and reuse to reduce demand and make more efficient use of water supplies. Reduction of losses in existing systems and water use efficiency in new planning. Promotion and practice of conservation by federal agencies. Use of lower quality waters where high quality unnecessary. Consideration of conservation in planning and institutions.

e. Adequacy of water law relative to contemporary needs, reallocation, hydrologic relationships between surface and groundwater and conjunctive management, in-stream use, interbasin transfer, incentive for conservation, federal and Indian reserved water entitlements, interstate allocation and management, and state water rights laws and administration.

f. Adequacy of federal benefit/cost analysis for full and realistic consideration of beneficial and adverse effects of water projects. Analysis of environmental and social consequences. Consideration of alternative means to meet water needs. Display of beneficial and adverse impacts of alternatives to facilitate trade-offs.

3. National Water Commission Report (1974)

a. Role of policy decisions in the ultimate demand for water, inability to forecast reliable future demands, and need for alternative future planning. Willingness-to-pay principle as a measure of demand. Cost sharing. Improved economic analysis with room for project approval on the basis of non-economic objectives where public interest indicates.

b. New and improved technologies for augmentation of available water supplies through desalination, use of marginal quality waters, reclamation of storm water runoff, wastewater reuse, weather modification, and other means.

c. Water conservation and more efficient use of existing supplies.

d. Effects of non-point sources of pollution and alternative means of control.

e. Economic, social, and environmental benefits and costs of various levels of wastewater treatment and ambient water quality standards.

f. Environmental and socioeconomic impacts of water resource project development and management strategies.

g. Relationships between energy production and water use and effects of heat and consumptive use on water resources.

h. Relationships between water quantity, water quality, and land use planning and improved coordination.

i. Reexamination of water law and management institutions for surface and groundwaters in light of contemporary needs.

j. More attention to groundwater management, including groundwater quality.

4. National Summary of Water Resource Problems and Research Needs, FY 1978 by OWRT and State Water Resources Research Institutes

This report, prepared in 1976, presents an analysis of the nation's major water problems as construed from state and regional assessments. Categorical headings in order of budgetary allocation are as follows:

a. Control of pollutants entering surface and groundwaters

b. Water supply augmentation and conservation

c. Effects of pollution on surface and groundwaters

d. Wastewater and water treatment processes

e. Environmental, economic, and social impacts of water resource development.

f. Improved water resources planning and management methods, institutional arrangements, and data collection and utilization.

5. COWRR Update - Unpublished Report "Directions in U. S. Water Research: 1978-1982"

This report is a catalog of needed research and is not amenable to summarization for purposes of this study. Used to determine COWRR concurrence with problem areas identified by other sources.

6. Second National Water Assessment of the U. S. Water Resources Council (1978)

The most frequently identified water problems reported in the Second National Water Assessment were:

a. Inadequate water supplies with increased demand and competition and conflicts between municipal, industrial, energy, and agricultural uses; withdrawal and in-stream uses; water quantity and water quality; flow regulation and downstream uses; and interbasin and intrabasin interests. More effective planning and development of surface and groundwater, reclamation of surface runoff, reuse of wastewater, desalination, and realignment of water use with appropriate water quality to conserve high quality waters for best use are suggested.

b. Diminishing artesian pressures declining spring and streamflows, land subsidence, and salt water intrusion are strong evidence of excessive use of groundwater at some locations.

c. Lack of information regarding extent, volume, recharge rate, and effect of various pumping schemes needed for groundwater management.

d. Need for reduction in water demand through more efficient water use and conservation.

e. Better management of surface and groundwater through improved understanding of hydrologic interrelationships, recognition of hydrologic relationships in law, and conjunctive management.

f. Modification of water rights law and allocation systems in accord with present needs.

g. Legal and institutional problems associated with interbasin transfer.

h. Surface water quality management, particularly with respect to non-point sources of pollution, toxic substances, eutrophication, and off-shore dumping.

i. Degradation of groundwater quality from surface drainage, landfill leachates, deepwell waste injection, and salt water intrusion. Lack of data on sources and effects and understanding of groundwater mechanisms and fate of pollutants.

j. Continued rise in flood damage from occupancy of flood-prone lands. Expansion of information and education on risks of flood-plain occupancy. Increased emphasis on economic incentives through shift of responsibility to property owners and local governments.

k. Erosion and sedimentation. Depletion of land, economic and environmental effects on stream systems, maintenance of navigation and reservoir storage, channel and shoreline degradation, and transport of nutrients and agricultural chemicals.

l. Effects of dredging and filling on natural ecosystems. Improved spoil disposal.

m. Economic and environmental effects of drainage. Parallel problems of protecting valuable wetlands while providing drainage for agriculturally valuable farmlands.

7. OWRT Guidelines for FY 1979 Research Project Proposals

a. Water conservation and more efficient use of available supplies.

b. Water problems of urbanizing areas.

c. Water reuse.

d. Saline Water Conversion.

e. Design improvement and increased efficiency of non-structural methods of flood control.

f. Socio-economic impacts of water diversions to energy development.

g. Institutional problems of groundwater management.

h. Water management planning procedures.

8. President's Water Policy Implementation Initiatives

The purpose of the President's water policy and initiatives is to develop a more comprehensive and integrated approach to national water resources management in light of the following problems:

a. Growing competition for water among consumptive users, irrigators, energy producers, municipal and industrial users, between the states, between consumptive and instream flow users, between economic development and environmental quality, and between present and future users.

b. The costs of projects are increasing, and it has become more difficult to provide funding. The backlog of construction grows steadily.

c. The supply of good sites for water projects is diminishing and the political, environmental, economic, and safety considerations place substantial limitations on future alternatives.

d. There is a fragmentation of institutional arrangements in water resources management. While states have primary responsibility for water policy within their boundaries, they are not integrally involved in setting priorities and sharing in federal project planning and funding.

e. Water supply systems in older urban areas are deteriorating.

f. Environmental problems associated with water resources development are increasing.

g. Non-renewable water resources lack requisite institutional arrangements needed for management.

h. Improved planning and management of federal water resources programs to prevent waste and to permit necessary water projects which are cost-effective, safe and environmentally sound to move forward expeditiously.

i. A new national emphasis on water conservation.

j. Enhancement of federal/state cooperation and improved state water resources planning.

k. Increased attention to environmental quality.

6. CONCLUDING COMMENTS

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Learn by Doing

In advancing to Howells' report, the cooperative NAWID-OWRT effort to document research effectiveness has made considerable progress, but actual documentation is yet to begin. The question at this point is whether it is better to plan the methodology for going about the documentation in greater detail or to proceed with some actual efforts. None can yet argue that we know what will work and how to do it best. The issue is rather whether it is more cost-effective to learn by doing or by formulating and analyzing the alternatives. The attempt of several pilot documentations by different individuals on different topics and using different formats would at this point seem to be the more productive learning experience. Reasons for this recommendation include:

1. Several loosely structured pilot documentations on diverse topics will provide diverse results that can be compared and considered before selecting the eventual standardized methodology.

2. The effort has advanced to a point where actual documentation attempts are needed to judge whether this approach will prove practically productive and to teach those involved how to do a better job.

3. Since it is possible in the initial passes at documentation to avoid great depth and detail, one can explore techniques in a relatively inexpensive mode without committing the time and funds required for a more extensive job.

4. Information initially collected in a documentation form that later proves deficient can later be converted to a more effective form

much more economically than one could document to the preferred form from scratch.

5. Even should all documentation approaches in this effort prove ineffectual in the program management purposes envisioned, state-of-the-art papers perform other useful roles such that the effort will in no case be wasted.

Continuation of the debate started in the NAWID workshop that discussed Howells' report on which pilot topics to select first is unlikely to be constructive. If the effort proves worthwhile, topics not selected initially will be performed later anyway. If the effort does not prove worthwhile, all one needs in a pilot topic is an arena for a fair test. This suggests some additional criteria for topic selection including, 1) a smaller topic that one can document at less cost, 2) a topic where the required information is readily accessible (e.g., stored in central systems with available computer access such as WRSIC or NTIS and not in the files of diverse private corporations), and 3) a topic that rational review would show to be tractable for documentation.

Before commencing the pilot documentations, four specific issues deserve some thought. These are addressed below under the headings of 1) targeted applications, 2) nature and content of the ideal documentation, 3) documentation methodology, and 4) institutional issues in implementation. The goal in presenting these issues is to get the effort started as productively as possible and is definitely not to add excuses to delay action.

Targeted Applications

Since it is usefulness in its intended applications that determines the value of the documentation effort, it is important to keep these applications in mind in designing a documentation form that will best contribute to the desired ends. Some applications that currently seem promising may eventually prove unfruitful, but those deserving initial consideration include:

1. Proposal Evaluation. An effective research program requires that those writing proposals be fully acquainted with the state of the art that they would advance and that funding agencies reckon potential contribution toward advancing that state in making funding choices. Readily available and well documented state-of-the-art descriptions provide a common basis for proposal writers that will save them a great deal of time in searching the literature and provide funding agencies a more objective basis for funding selections and for defending selections.

2. Research Project Contribution. Completed studies are most useful when the results are interpreted in the context of previously known information on the state of the art and then are made available as part of that state. Routine evaluation of completion reports for identification of their contribution to advancing the state of the art would greatly help users by reducing the effort at user evaluation necessary to use the results.

3. Research Center Contribution. The advances in the state of the art achieved by a given state water resources research center equals the sum of the project contributions. The advances could be identified by state of origin and summed for this sort of evaluation as one basis for inter-center comparisons of effectiveness.

4. OWRT Research Contribution. The advances in the state of the art achieved collectively by the OWRT program includes the sum of the state advances plus those achieved through OWRT efforts not funded through state centers.

5. Technology Transfer Facilitation. The portions of the state-of-the-art documents that find that knowledge has advanced to a point effective in problem solving provide a ready foundation for technology transfer efforts. The documentation can thus be very helpful in setting technology transfer priorities.

6. Preparing Authorization and Appropriation Testimony. The existence of working state-of-the-art papers provides ready references for selecting accomplishments within a desired time frame to highlight in program presentations and testimony according to the interest of targeted individuals and users. One can prepare testimony much more expeditiously from a single document than by having to contact individual centers throughout the country. Of course individual contacts could still be used for supplemental information as desired.

7. Integrating Program Improvement Efforts. OWRT now has separate and, at least from external appearances, uncoordinated efforts to improve center effectiveness, prepare testimony for program budgeting, develop a technology transfer program, and review proposals. The key to overall program effectiveness, however, is close coordination among all these efforts within a single program designed to achieve agency goals; and the most important single contribution of the documentation proposed here is that it provides a theoretical, though admittedly not yet proven as an operational, model for the badly needed coordination.

The Ideal Documentation

The documentation must contain both descriptions of advances in theory and of how the advances can be and are being used in real-world problem solving. The initial documentation effort will have to be expanded as old work previously overlooked is uncovered and as new work is completed.

The form of the documentation used to keep running track of current knowledge and recent advances would logically, in the beginning, be patterned after material currently found in specialized texts, state-of-the-art papers, and in the literature reviews frequently incorporated into dissertations, proposals, and research reports. The main differences between those efforts, with which all researchers are familiar, and the research documentation being proposed here are with respect to scope and detail of the coverage and the form of the citation.

Scope of coverage enters because of the importance of the problem focus for the OWRT documentation as opposed to the discipline focus of most of these other efforts. Problem solution frequently require interdisciplinary efforts and the contributions of multiple disciplines should be included. Since problems vary considerably in the sorts of expertise that should be consulted, a more simply scoped problem makes more sense for a pilot effort.

Detail of coverage enters because of the extreme importance of giving proper recognition to all contributions. Literature reviews often emphasize contributions rather than their sources and frequently, particularly for older work, quote secondary rather than original sources, leaving the reader who wants to seek out original sources to work back toward them through reference chains. For this documentation, the emphasis

on identifying sources requires a great deal more care in giving proper credit. One would expect differences of opinion on whom should be credited for what and a need for collective judgment mechanisms that would reduce introduction of unnecessary personal bias into the process.

Citations giving credit need to be in the form of very explicit statements on exactly what contributions the named individual made. Joint citations should be minimized. Provision should be made for users familiar with recent work in a documented area to recommend changes in the document that would give more equitable credit assignments. Consequently, the end document needs to be a dynamic entity, periodically updated with corrections and new advances, but one for which the updating process is institutionalized in a way that minimizes error or bias.

Coverage of the total documentation effort should be scoped to match the scope of the OWRT program. The coverage of an individual documentation should be scoped to some problem area or subarea within an academic discipline such that users could easily determine content by documentation topic. Overall documentation of the current state of knowledge should follow a carefully constructed taxonomy of subtopics and be carefully cross indexed. The statement should identify OWRT contributions by state of origin, contributions by NAWID centers achieved through research outside the OWRT program, and other contributions from both the public and private sectors and from both the United States and overseas.

The statement of problems in whose solution the knowledge can be applied should be built from the contributions of users, researchers, and program administrators. Division can be made between problems of immediate application and likely problems of long range application through further development.

The listing of known applications should identify the work being done by the center directors and other staff to promote application as well as areas where the information dissemination is being done by others.

Documentation Methodology

Methodologically, documentation of advances in the state of the art need to be separated from documented problem solving. The starting sources for documenting the state of the art should be available textbooks, state-of-the-art papers, and literature reviews and the various available systems for making computerized literature searches on selected topics.

One would logically begin by compiling relevant state-of-the-art type works, identifying sections by topic giving the most comprehensive treatment, and organizing these sections into a composite first draft. Cited references in the draft would then be traced back to sources, and the text would be expanded to add significant contributions.

Since the OWRT research results were first reported in 1965, that date provides a reasonable starting point for the documentation. In other words, there is no need for the purposes of this effort to identify who contributed what to the state of the art as it existed on that date. The need is to identify advances and cite sources for the advances achieved since then.

The composite draft should be distributed for solicitation of inputs from leading scientists and research administrators, including center directors. Such individuals should be asked whether, to the best of their knowledge, the significant advances are listed, the advances listed are really the significant ones, and the credits are assigned to proper sources.

Howells recommends use of retired university and government scientists for the initial documentation effort. In many cases such individuals may work well; but in other cases, recent advances may have carried the state of the art beyond the point where the college graduates of 40 years ago are qualified to make expert judgments. In these specialized cases, particularly, judgments are needed to differentiate advances in knowledge having a significant problem-solving potential from more esoteric advances that do not promise much in the way of beneficial application.

Once an initial documentation is completed, the burden in maintaining it must be placed on the OWRT staff working with advisory boards and consultants as necessary. Newly received proposals need to be reviewed to see if they reference relevant completed work still uncited in the dynamic working documentation. OWRT project reports need to be reviewed as received and their contributions added to the compiled documentation. WRSIC files and other relevant sources need to be consulted periodically for new advances.

There can be no doubt that a system such as that described above would have tremendous benefit to many users beyond that received by OWRT in documenting the effectiveness of its own program. Any doubts as to whether or not such a system should be established must rather center on issues of cost or whether sources can be found for the necessary manpower and funds. If costs for a proposed documentation mode seem excessive, one can bring the program in line either by capturing some of the funding from beneficiaries outside the OWRT-NAWID system or by reducing the scope and detail of system coverage. The former strategy would require establishing fees to charge various users and uses of the documentation while the latter strategy relates to defining an appropriate level of system

thoroughness and to leaving out problems of marginal contribution to the total OWRT program.

Stress needs to be placed on the fact the system presented here implies a shift in OWRT staff assignments to this program, but that the shift may actually strengthen the other programs. For example, the preceding section on targeted applications suggests that the shift may well improve the overall effectiveness of the OWRT program by providing a better basis for proposal evaluation, project report review, and technology transfer planning. In other words, the program advocated here can contribute to the overall quality of the OWRT program by upgrading program formulation decision making at all levels. A stronger program should be proved so by good documentation.

One practical problem in working out the details of the documentation is that the WRSIC system used to search for relevant water resources abstracts is dependent on the key words selected as descriptors and identifiers. As new topics become in vogue, those topics become the key words for a large number of studies that would not have previously used that word in the abstracting. One cannot assume that a search based on a currently popular key word will retrieve all applicable past work. The searcher must instead identify and use the key words that were used in past years for the studies of interest. This problem pertains to any literature search including those used for the literature review for proposals.

The descriptions of past and current applications of research results in problem solving may well prove more difficult to compile and maintain than are the state-of-the-art documentations. If experience proves this so, the financial constraints may require shifting to a

lesser level of effort on problem-solving documentation. Our experience thus far suggests that we do a reasonably good job of preparing texts and state-of-the-art summaries of knowledge in specific areas, but efforts to compile descriptive information on applications made of research results have been routinely unsuccessful.

The most important point to make in concluding this section is that all the methodological discussion is only meant to suggest ways to get started. Major modifications can and should be made through learning by experience.

Institutional Issues

In pioneering the documentation approach recommended here, OWRT would be breaking new ground, and this imposes a significant burden. But one very important reason exists for OWRT to take the lead in breaking this sort of new ground. Action agencies that build dams, reduce water pollution, or keep damageable property off of flood plains have a much easier time than a research agency in identifying achievements to which they can point with pride. An agency can point with pride by keeping track of its products, how well they perform as well as what they are. The Corps of Engineers, for example, estimates flood damages prevented, navigation traffic, and recreationist activity-days resulting from its projects. It does not simply count projects. OWRT is doing little more than counting projects; a better selling job requires documenting what those projects achieved. That is the goal of giving a technical focus to the documentation effort.

Other institutional issues are found in the assignment of responsibility for documentation and its maintenance within OWRT, coordination between OWRT and NAWID, equitably dividing credit between OWRT and other

federal agencies and between OWRT and the sources of nonfederal matching funds for OWRT projects. All of these need to be carefully considered. Perhaps the key issue is one of finding the necessary funds and manpower, and this could perhaps be eased by having other research funding agencies participate in the cost to the level participation can be justified by increased research efficiency.

Concluding Statement

The credible documentation of research program effectiveness is no simple task. In fact, it is an extremely difficult one for which we as yet have no practical guidelines on how far to go. The most practical way to proceed is to try to do our best and see what we can produce together, cooperatively, for our own good and for the good of all those we serve.

Academia has long been highly critical of many federal water resources program funding decisions and of how those programs are being presented and sold to the public. Here we have a research program that is really our thing. The challenge is ours, with OWRT, to do better.