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The Water Resources Research Act of 1964 authorizes an annual appropriation to support a competent, qualified water resources research institute, or center, at one University in each State and Puerto Rico. In this connection, the authors' describe the nature and scope of the overall research effort, evaluate the current projects and outline their suggestions with respect to promising areas of future water resources research.

LEGAL RESEARCH IN WATER RESOURCES

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IN 1961 the Senate Select Committee on National Water Resources made its report to the United States Senate. This report,[1] to a large extent, has been responsible for much of the action taken by Congress in the last four years to solve our growing water problems. It shocked many of our leaders through its documented evidence of the growing seriousness of water problems in many areas. It alerted the nation generally to the urgent need for definite action to alleviate these problems. It made specific recommendations to solve them.

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1. S. REP. No. 29, 87th Congress, 1st Session (1961) (also *see* 32 separate Committee prints of the 86th Congress, 2nd Session, 1960-61.)

THE WATER RESOURCES RESEARCH ACT

Among the major recommendations of the Committee was one that the Federal Government should undertake a coordinated, continuing, scientific research program on water. This recommendation led to passage of the Water Resources Research Act of July 17, 1964.[2]

The Act established an Office of Water Resources Research in the Department of the Interior and authorizes appropriations for an annual allotment of funds, continuing indefinitely, to support a competent, qualified water resources research institute or center at one University in each State and Puerto Rico.[3] In addition to the allotment, currently $100,000 yearly to each institute, the Act authorizes annual matching funds ($5 million) for proposals received from the institutes.[4]

Title II of the Act, as amended in 1966,[5] authorizes up to $10 million per year for grants, contracts, matching or other arrangements with educational institutions (including the Center Universities) private foundations or other institutions, private firms and individuals, and local, State, and Federal Government agencies to undertake research into any aspects of water problems related to the mission of the Department of the Interior which are deemed desirable and are not otherwise being studied.

Stated briefly the main intent of the Act is to supplement and strengthen the total United States water research effort. In the words of the Act the programs authorized are to "supplement and not duplicate established water research programs, to stimulate research in otherwise neglected areas, and to contribute to a comprehensive, nationwide program of water and related resources research."[6]

THE U.S. WATER RESOURCES RESEARCH EFFORT

A total of 4201 water resources research projects currently underway in the United States are recorded in Water Resources Research Catalog, Volume 3, prepared for the

2. Water Resources Research Act, Pub. L. No. 88-389 (July 17, 1964).
3. *Id.* Tit. I § 100.
4. *Id.*
5. Pub. L. No. 89-404, § 200 (April 19, 1966).
6. Water Resources Research Act, *supra* note 2, § 300.

Office of Water Resources Research by the Science Information Exchange of the Smithsonian Institution.[7] This does not represent all of the projects because some have not been recorded. This is more than twice the number that were listed in Volume 1, published in 1966.

This doubling of projects in a 3-year period reflects increased funds made available for water resources research by recent Federal legislation and Congressional appropriations. Largely as a result of new water programs, Federal expenditures for water resources research have doubled in the past three years from $70 million in 1965 to $136 million in 1968. They represent 2½ percent of Federal expenditures for all research.

Of the 4201 recorded research projects, three-fourths (3016) are Federally supported and one-fourth (1185) are non-Federally financed. These projects are being carried out by 606 performing organizations of which 135 are Federal agencies and 471 are non-Federal.

CATEGORIES OF WATER RESEARCH

In its "A Ten Year Program of Federal Water Resources Research," published in February of 1966,[8] the Committee on Water Resources Research of the Federal Council for Science and Technology divided water research into 44 subcategories grouped under eight major categories. A ninth covered "Manpower, Grants, and Facilities." A tenth category is now being considered namely, "Scientific Information" with appropriate subcategories.

Category I, "Nature of Water," is concerned with properties of water and aqueous solutions and suspensions. Category II, "Water Cycle," is concerned with analysis and interpretation of the natural occurrence, character, transport, and distribution of water. These two categories are viewed as basic research directed toward improving our knowledge of the nature of water and of the processes and dimensions of the hydrologic cycle.

7. Vol. 3 Office of Water Resources Research, U.S. Department of the Interior, Water Resources Research Catalog (Dec. 1967).
8. A TEN-YEAR PROGRAM OF FEDERAL WATER RESOURCES RESEARCH COMM. ON WATER RESOURCES RESEARCH OF THE FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY (U.S. Government Printing Office, Washington, D.C., February 1966).

In all the other categories, research is concerned with the application of this knowledge to the numerous problems of water management. With the proposed tenth category, "Scientific Information," emphasis will be placed on water research information, selective dissemination and retrieval, and to making the research results more usuable in helping to solve major water problems. A Federal Water Resources Scientific Information Center (WRSIC) for which funds were first appropriated for fiscal year 1968, is under general management of the Office of Water Resources Research.

The six categories III to VIII inclusive, deal respectively with "Water Supply Augmentation and Conservation," "Water Quantity Management and Control," "Water Quality Management and Protection," "Water Resources Planning," "Resources Data," and "Engineering Works."

Category V, "Water Quality Management and Protection" has the largest share of the 4201 recorded projects with nearly one-third (1370). Category II, "Water Cycle" is second largest with over a fourth (1128), and Category VI "Water Resources Planning" is third in rank with approximately an eighth of the projects (528).

The largest research project increases during the past three years occurred in these three categories, with Category V showing an increase of 1072 projects in operation; Category II, 680 projects; and Category VI, 312 projects. These three categories account for more than 93 percent of the increase in projects during the three-year period.

Only one of the nine major categories of water resources research showed a decline in number of recorded projects from 1965 to 1968. This is Category III, "Water Supply Augmentation and Conservation," with exactly 100 fewer projects in 1968 than in 1965.

RESEARCH UNDER THE 1964 ACT

Some 735 projects or more than a sixth of all recorded water research projects (4201) are operating under the provisions of the 1964 Water Resources Research Act. Some 435 of these 735 projects are financed with *allotment* funds ($100,000 annually to each of the 51 State Water Research Centers),

240 with matching funds, and the remainder (60) under Title II funds, "Additional Research." More than 1500 advanced undergraduate and graduate students are employed on these projects and are getting excellent training in water resources. This increases the trained scientific manpower pool available to meet growing needs of water research, planning, and development programs. This is in keeping with the purposes of the Act which emphasizes *research* and *training.*[9]

In addition to the 51 Center Universities, 54 other Universities are now affiliated with the 51 in the water research program, making a total of 105 participating under Title I of the Act. Additional Universities participating under Title II bring the total number to 117 Universities. Some 30 other research agencies including private organizations, State and local government agencies, and foundations are conducting projects under Title II provisions of the Act.

Category V, "Water Quality Management and Protection" ranked first in the total water research recorded projects of the nation and also in the Office of Water Resources Research (OWRR) program. However, Category VI "Water Resources Planning" is a very close second in the OWRR program (196 projects compared with 223 projects in Category V), while for the total national effort Category VI ranks third.

About one-tenth of total OWRR projects are in each of the two Categories IV and II, and 85 percent of the total OWRR program is in the four categories of VI (over 1/3), V (nearly 1/3), IV (1/10), and II (1/10).

THE WATER LAW AND INSTITUTIONS CATEGORY

In its "Ten Year Plan," the Committee on Water Resources Research listed as one of its 44 subcategories of water resources research, subcategory E of Category VI "Water Resources Planning," which is labeled "Water Law and Institutions." This subcategory is described as "a study of State and Federal water law looking to changes and addi-

9. Paragraph (b) of the preamble of the Act, *supra* note 4, states "it is the purpose of the Congress, by this Act, 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."

tions which will encourage greater efficiency in use; investigation of institutional structures and constraints which influence decisions on water at all levels of government."[10]

The Committee lists ten topics for research under VI E "Water Law and Institutions." These are:[11]

1. Policy Issues and Political Decision-Making on Objectives, Standards, and Criteria of Water Resources Planning and Development.
2. Planning under Conditions of Multiple Jurisdictions and Conflicting Objectives.
3. Definition of the Planning Region and the Scope of Water and Related Land Resources Planning.
4. Legal and Institutional Aspects of Water and Related Land Resources Management.
5. Institutional Tools for Optimally Coordinating Decisions in a Mixed System of Public and Private Enterprises (e.g., pricing policy including administered prices; standards; and other relevant forms of non-price rationing).
6. Case Studies of Special Problems (e.g., on organizational arrangements for regional planning).
7. Impact of Water Resources Development on Economic, Legal, Political, and Social Institutions.
8. Relation of Water Resources Planning to Planning for other Types of Public Investment and to Comprehensive Regional Planning.
9. Economic, Legal, Political, and other Institutional Factors in Interregional and Functional Water Transfers.
10. Water Laws as They Relate to Water Use Efficiency and Water-Resource Developments.

WATER LAW AND INSTITUTIONS RESEARCH

The 4201 recorded ongoing water resources research projects were analyzed to determine the extent and content of current research in this field. These projects were listed in Volume 3 of the Water Resources Research Catalog under four key categories—*Legal Aspects, Legislation, Water Rights,* and *Water Law.* A total of 82 projects or 2 percent

10. COMMISSION ON WATER RESOURCES RESEARCH, *supra* note 8, at 80-81.
11. *Id.*, App. D at 87-88.

of the 4201 projects were found to be involved in research in these four key word areas.

Some form of legal research can be legitimately included in all of the eight major water research categories, but logically most would be concentrated under Category VI, subcategory E.

Table I shows the breakdown of the 82 projects by Category and subcategory:

Table I

Distribution of Legal Research Projects by Categories

FCST Category	Subcategory		*Number of Projects* Subcategory	Category
II *Water Cycle*	A	General	1	1
III *Water Supply Augmentation*	B	Water Yield Improvement	1	1
IV *Water Quantity Management*	B	Ground Water Management	2	2
V *Water Quality Protection*	A	Identification of Pollutants	1	
	B	Sources and Fate of Pollutants	2	
	G	Water Quality Control	2	5
VI *Water Resources Planning*	A	Techniques of Planning	4	
	B	Evaluation Process	5	
	E	Water Law and Institutions	60	
	F	Nonstructural Alternatives	2	71
VII *Resources Data*	A	Network Design	1	
	C	Evaluation, processing, Publications	1	2
Total	12		82	82

The 60 projects in Category VI, subcategory E are distributed geographically rather evenly over the Nation with 22 in the Western Region, 20 in the Central, and 16 in the Eastern States. Two projects are nationwide.

The principal investigators in these projects come from a wide range of subject matter disciplines. The research is mostly single discipline oriented. In 47 or four-fifths of the 60 projects, only one discipline is involved. In ten of the projects two disciplines are involved; in two projects, three; and in only one project there are four disciplines involved. Altogether, ten disciplines are involved in the 60 projects.

Economics or agricultural economics are involved in 33, law next with 27, and political science third but involved in only 7 projects.

Table II shows the subject matter disciplines involved and the number of projects in which these disciplines are involved.

Table II

Disciplines Involved in Water Law and Institutions Projects (Category VI E).

	Disciplines	*No. of Projects*
1.	Economics or Agricultural Economics	23
2.	Law	15
3.	Political Science	6
4.	Engineering	1
5.	Geography	1
6.	History	1
7.	Law and Agricultural Economics	7
8.	Law and Engineering	2
9.	Political Science and Economics	1
10.	Law, Agricultural Economics and Anthropology	1
11.	Law, Agricultural Economics and Agronomy	1
12.	Law, Engineering, Agricultural Economics and Regional Planning	1
	Total	60

ORGANIZATIONS SUPPORTING LEGAL RESEARCH

The 82 legal research projects are being supported by 20 organizations. The Office of Water Resources Research is supporting 37 or nearly half of the total. The U.S. Department of Agriculture, Cooperative State Research Service (Experiment Station System), is supporting 16 or nearly a fifth, and the U.S. Department of Agriculture, Economic Research Service, 8 or about one-tenth. Thus, 60 or three-fourths of the total of 82 projects are supported by these three Federal agencies. The remaining fourth are scattered among 17 Federal, State, and private agencies.

Table III lists the number of projects supported by each of the 20 supporting organizations. Eight of the 20 are State Universities, 6 are Federal agencies, 4 are State resources agencies, and 2 are private research organizations.

Table III

Distribution of Legal Research Projects by Supporting Organizations

		No. of Projects
1.	Office of Water Resources Research	37
2.	USDA Cooperative State Research Service	16[a]
3.	USDA Economic Research Service	8[b]
4.	Resources for the Future	2
5.	Federal Water Pollution Control Administration	2
6.	Colorado State University	2
7.	Southern Illinois University	2
8.	Bureau of Reclamation	1
9.	Florida State Board of Conservation	1
10.	Geological Survey	1
11.	Georgia Institute of Technology	1
12.	Indiana University	1
13.	Michigan State University	1
14.	New Mexico Department of Game and Fish	1
15.	Stanford Research Institute	1
16.	Syracuse University	1
17.	Texas Parks and Wildlife Department	1
18.	University of Illinois	1
19.	University of Wyoming	1
20.	Wyoming Natural Resources Board	1
	Total	82

[a]Thirteen of the 16 projects are involved in two cooperative regional research projects entitled "Economic and Legal Factors in Managing Water Resources in Agriculture" and "The Economics of Water Transfer—an Appraisal of Institutions".

[b]Three of the eight projects carry the same title—"Legal Aspects of Water Rights in the East" but the work is being conducted in different locations.

EVALUATION OF CURRENT LEGAL RESEARCH

An analysis of the principal objectives of all 82 of the research projects recorded under the four key word areas—*Legal Aspects, Legislation, Water Rights,* and *Water Law*—reveals that legal phases were not the major research purpose in a majority of the projects. In more than three-fourths of the projects the basic purposes involved other disciplines such as economics, engineering, hydrology, public administration, geography, sociology, and political science, and touched only peripherally on legal research. Involvement of other disciplines resulted principally because of conflict of efficient

utilization of resources and changing social goals with legal constraints on water use. Much research in this category is being pointed toward needed changes in the laws and institutions to provide more effective utilization of water.

Not quite one-third of the 82 projects had legally trained personnel as principal investigators and 10 percent listed lawyers as consultants. This leaves 49 projects or three-fifths without any listed legal assistance in conducting the research.

Most of the projects with principal investigators schooled in law have tended to concentrate on inventory type research to relate what the laws and institutional regulations involving water actually are in the various States. Nonlegally trained principal investigators appear to be more interested in research on the effect of existing laws and institutions on efficient utilization of water and in recommending needed changes. This appears to be particularly true of economists.

Water research projects being conducted primarily by members of the legal profession include: Legal implications of weather modification; necessary court evidence for upholding water quality standards; legal aspects of water rights under both the riparian and appropriation doctrines; evaluation of intergovernmental relations for regional water planning; eminent domain as it relates to water appropriations; effects of pollution control on water rights; flood plain zoning; measures of legal protection from ground water pollution; and effects of Federal water policy at State and local levels.

APPLICATIONS OF RESEARCH FINDINGS

Some examples of beneficial use of results from legal research in water resources are experiences in Florida, Idaho, New York and Washington.

A book on Florida water law is being published as a result of work by Professor Frank E. Maloney of the University of Florida. This research, sponsored by the Florida Water Resources Research Center and OWRR, has also led to the drafting of a model water use code for Florida.

Dr. T. R. Walenta of the University of Idaho with support from the Water Resources Research Institute and

OWRR completed a critical study of the Idaho Code of Laws in the field of water resources which brought to light numerous deficiencies. Results of the study played a substantial part in new legislation passed by the 1967 Idaho Legislature. Additional revisions in Idaho's laws as recommended in the study are under legislative consideration for adoption.

Beneficial results of legal research supported by OWRR are typified by work accomplished by Dr. William H. Farnham of the Cornell University Water Resources and Marine Sciences Center. Results of an initial allotment project entitled, "Water and Related Land Resources Law and Political Institutions" led to revised wording of The Harmless Use Bill signed into law in 1966 which appears in the New York Consolidated Statutes, Conservation Law, Section 429-j.

Continuation of this work under a matching grant project has resulted in proposed additional revisions to The Harmless Use Bill which will be submitted to the coming session of the New York legislature. Changes suggested and reasons for the needed change are carefully explained in a report entitled, "The Improvement and Modernization of New York Water Law Within the Framework of the Riparian System," by William H. Farnham.[12]

Ralph W. Johnson, Professor of Law at the University of Washington, with support from the Washington State Water Resources Research Center, made a detailed appraisal of the existing 1917 State water code. The study pinpointed areas of deficiency if the code were to be responsive to water problems of the State. Findings of the study were presented in testimony before State water officials and members of the State Legislature. As a result, corrective legislation was enacted in the form of State Senate Bill No. 175 on March 9, 1967.

These examples deal with changes in water laws growing out of research on existing statutes and State water codes. They are evidences of but one of the many benefits that can result from careful research into legal aspects, legislation, water rights, and water law.

12. 3 LAND & WATER L. REV. 377 (1968).

PROMISING RESEARCH AREAS

1. River basin, transbasin and regional water development involve local, State and Federal laws and institutions. Legal conflicts, overlapping authorities, differing institutional approaches and varying water use standards pose veritable roadblocks to effective action. Regional research is needed to find a common thread of water law through all governmental levels that will advance water resource planning and use.
2. Weather modification appears on the threshold of a major breakthrough as a source of increased and more stable water supply. However, technology may have the know-how before the legal ramifications have been fully explored, much less resolved. Research is needed in this area to determine what is required to provide the legal flexibility to take advantage of this possibility of increased supply if and when it becomes available.
3. Both industry and government agencies are turning more and more to deep well injections as a means of disposal of dangerous pollutants. Land fill disposal of solid wastes, ground water recharge wells, and irrigation with partially treated sewage affluent are on the increase. These activities increase the ever present possibility of ground water pollution. Continued scientific and legal research is needed to evaluate this problem.
4. Increased use of water cooled nuclear powered electric generators is creating a mounting problem of thermal pollution. Rising water temperature poses serious questions about the effect on the aquatic ecology and the possibility of destroying a link in the food chain. In addition, in areas of limited water supplies, cooling can result in substantial loss of water supply through evaporation. These problems create possibilities of legal considerations for affected users. Research is needed to determine if new or amended legislation will be required.
5. As demand on our water resources increases continued research is needed in the area of water rights, priority of use and reallocation of use. If efficient utilization of scarce water supplies is to be obtained, what degree of protection is needed for prior users? What is harmful

use? What is reasonable use? What legislation is needed to provide greatest opportunity to optimize water use and still provide reasonable protection to prior users?

Legal and institutional research offers promise of contributing to the resolution of these issues. Validity of existing concepts should be questioned and alternative courses of action should be evaluated to improve our knowledge and insight on these problems.

6. As ground water resources have become an increasingly important source of supply, effort to integrate ground water—surface water use has been on the rise. In many areas legal and institutional conflicts exist between surface and ground water use. Research on how to best integrate laws to resolve these conflicts is needed to allow more effective use of the total water supply.

UNANSWERED QUESTIONS

Pressure for more efficient utilization of water will intensify as population increases and water problems mount. To resolve these problems requires man's continued search for better technical methods and improved legal and institutional arrangements for water management. Are we meeting this challenge in legal research on water problems?

The foregoing review raises questions. Is the current level of research on legal aspects of water utilization adequate? Are we researching the right kind of problem areas? Why are there so few legal researchers working in the area of water resources research? Does research on legal problems by nonlegal disciplines provide a better catalyst for legislative and institutional change than legal research? In other words does it require the showing of economic and social effects of outdated legal restrictions on water use before pressure for legislative change can become strong enough to initiate action? Could research money be more effectively utilized through more interdisciplinary research in this area?

These are some of the questions to be answered as we evaluate current projects and look to a future course of action in legal research involving water and resources which affect water.

CONCLUSIONS

Most research in water law and institutions has been single discipline oriented and aimed toward a specific aspect of the water problem. Results have been useful and many gaps in knowledge about water problems have been narrowed. However, if the water problems facing the nation are to be met to assure the present and future supply of water needed, it is apparent the research approach must be oriented to a much broader problem approach.

More emphasis will be needed on water resources planning and development for a total watershed or region. Such problem areas cross county, State and even national boundaries. This will call for interdisciplinary and interregional research to attack all aspects of interrelationships of resolving water problems.

Laws and institutional arrangements play an increasingly important role in water development. Needed legislative changes to provide the flexibility for technology to carry out its role can be the key factor to progress. Legal researchers, economists, sociologists, engineers, hydrologists, and water resource planners working hand in hand to determine the critical problems and needed solutions offers promise of providing the best basis for combined research effort that will assure attainment of desired goals.