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WATER RESOURCES RESEARCH

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HEARING

BEFORE THE

SUBCOMMITTEE ON WATER AND POWER RESOURCES

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

UNITED STATES SENATE

NINETY-FIRST CONGRESS

SECOND SESSION

ON

S. 3553

A BILL TO AMEND THE WATER RESOURCES RESEARCH
ACT OF 1964 TO INCREASE THE AUTHORIZATION FOR
WATER RESOURCES RESEARCH AND INSTITUTES, AND
FOR OTHER PURPOSES

S. 1051

A BILL TO AMEND THE WATER RESOURCES ACT OF 1964

JULY 20, 1970



Printed for the use of the Committee on Interior and Insular Affairs

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WATER RESOURCES RESEARCH

MONDAY, JULY 20, 1970

U.S. SENATE,
SUBCOMMITTEE ON WATER AND POWER RESOURCES
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:05 a.m., in room 3110, New Senate Office Building, Senator Frank E. Moss, presiding.

Present: Senators Moss, Bible, Allott, and Hatfield.

Also present, Jerry T. Verkler, staff director; Stewart French, chief counsel; Daniel A. Dreyfus, professional staff member; and Charles Cook, minority council.

Senator Moss. The hearing now will come to order.

This is a hearing of the Water and Power Subcommittee of the Senate Committee on Interior and Insular Affairs. The hearing today has to do with S. 3553 and S. 1051.

The purpose of the hearing before the Water and Power Resources Subcommittee this morning is to take testimony on these two bills to amend the Water Resources Research Act of 1964.

The Water Resources Research Act was enacted July 17, 1964. The principal concepts of the act grew out of the recommendations of the Senate Select Committee on National Water Resources.

S. 3553 would amend the Water Resources Research Act (78 Stat. 329) to increase the amount authorized to be appropriated for a water resources research center in each of the States from \$100,000 to \$250,000 annually for each center. It also would provide for future automatic adjustments in the authorized amounts and would provide for the establishment of information retrieval and dissemination activities at each research center.

S. 1051 would amend the act to authorize the consortium of universities of the Washington, D.C. metropolitan area to receive institute grants, the same as would go to each center in each State.

The text of the bills and the reports of the Department of Interior and the Office of Management and Budget will be included in the record at this point.

(Bills and reports follow :)

[91st Cong., second sess.]

S. 3553

A BILL To amend the Water Resources Research Act of 1964 to increase the authorization for water resources research and institutes, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 100(a) of the Water Resources Research Act of 1964 (78 Stat. 329; 42 U.S.C. 1961a), is amended (A) by striking

out "\$100,000" and inserting in lieu thereof "\$250,000", and (B) by adding a sentence at the end of the subsection to read as follows: "The amounts authorized to be appropriated by this subsection to assist each participating State shall be increased or decreased in fiscal year 1972 and each year thereafter in proportion to the average increase or decrease of the costs of such research and training as determined by the Secretary of the Interior in accordance with a suitable formula to reflect the average increase or decrease adjustments in Federal employee salaries as determined by the United States Civil Service Commission based on findings derived from Bureau of Labor Statistics figures comparing Federal salaries with industrial salaries."

SEC. 2. The second sentence of section 100(b) of the Water Resources Research Act of 1964 (78 Stat. 329; 42 U.S.C. 1961a) is amended by inserting after the word "problems", the following: "and scientific information dissemination activities, including identifying, assembling, and interpreting the results of scientific and engineering research deemed potentially significant for solution of water resource problems, providing means for improved communication regarding such research results, including prototype operations, ascertaining the existing and potential effectiveness of such for aiding in the solution of practical problems, and for training qualified persons in the performance of such scientific information dissemination;"

[S. 1051, 91st Cong., first sess.]

A BILL To amend the Water Resources Research Act of 1964

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 306 of the Water Resources Research Act of 1964 (78 Stat. 329) is amended by inserting immediately before the period at the end thereof a comma and the following: "and the District of Columbia".

SEC. 2. The Water Resources Research Act of 1964 (78 Stat. 329), is amended by inserting immediately after section 306 the following new section:

"SEC. 306A. In the administration of title I of this Act, the Consortium of Universities of the Washington Metropolitan Area (a corporation incorporated pursuant to the District of Columbia Nonprofit Corporation Act) shall be authorized to receive grants under such title to assist it in establishing and carrying on the work of a competent and qualified water resources research institute, center, or equivalent agency in the District of Columbia."

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., July 17, 1970.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This responds to your request for the views of this Department on S. 1051, a bill "To amend the Water Resources Research Act of 1964", and S. 3553, a bill "To amend the Water Resources Research Act of 1964 to increase the authorization for water resources research and institutes, and for other purposes." We note that S. 3721, a companion measure, is also before the Committee and our comments on S. 3553 apply to it as well.

We recommend that S. 1051 be enacted, if amended as suggested herein, and that S. 3553 not be enacted.

S. 1051 would amend the Water Resources Research Act of 1964, as amended (42 U.S.C. 1961 *et seq.*), to extend its application to the District of Columbia, and to authorize the Consortium of Universities of the Washington Metropolitan Area to receive grants for a water resources research institute under the provisions of title I of that Act.

S. 3553 would amend title I of the Act to increase from \$100,000 to \$250,000 the amount authorized to be appropriated under section 100(a) to assist each state in establishing and carrying on the work of its water resources research institute. It would provide for adjustment of this authorization up or down each year beginning in fiscal year 1972, based on increase or decrease of the costs of water resources research and development as determined by the Secre-

tary in keeping with a formula based on adjustments in salaries of Federal employees. The bill also would amend section 100(b) to provide specific authority to use funds for dissemination of scientific and technical information as well as for research and training regarding water resources. We understand that S. 3553 and the companion measure originated in recommendations from the Universities Council on Water Resources and the National Association of State Universities and Land Grant Colleges.

Subsection 100(a) of the Act (42 U.S.C. 1961a(a)) authorizes \$100,000 annually to assist a participating state to establish and carry on the work of a competent and qualified water resources institute, center, or equivalent agency at a landgrant college or university or some other institution designated by Act of the legislature of the state concerned.

We favor section 1 of S. 1051 which would include the District of Columbia as a participant in research programs under section 100 of the Act, but we defer to the Government of the District of Columbia with regard to its proposed deletion of section 2. The provisions of section 2 would name the Consortium of Universities of the Washington Metropolitan Area as the sponsor of the water resources research institute which would be established. The Act now embraces the states and the Commonwealth of Puerto Rico. The increasing emphasis on research involving problems of metropolitan water supply makes it appropriate that the District of Columbia share in research programs under section 100 of the Act. We understand that the Government of the District of Columbia agrees but proposes deletion of section 2 designating the Consortium (American, Catholic, George Washington, Georgetown, and Howard Universities) as the institute sponsor. This change would allow the operation of the existing section 100(b) whereby, as a general rule, the local land-grant college, in this case the Federal City College, receives the funds. Although the Consortium has been widely recognized for its work in encouraging cooperation and sharing of educational resources, it would not be appropriate to single out the District of Columbia as the one jurisdiction in which the land-grant institution or other institution designated by the jurisdiction did not administer the institute. The Federal City College would, of course, under the present terms of section 100(a) of the Act, be authorized to arrange with other colleges and universities within the jurisdiction to participate in the work of the institute. In this way, the Federal City College could utilize the resources of the Consortium, particularly during the college's present formative period.

While we believe, with regard to S. 3553, that increased research effort is needed to find solutions to such critical and urgent water problems as those relating to improving water resources planning, development and management policies, practices and methodologies, metropolitan water resources problems, protection of estuarine areas, and water supply augmentation and protection, this can best be accomplished by expanding the research authorized by section 101 and by title II of the Water Resources Research Act, as well as other authorized Federal water research programs. By doing so, Federal water research funds can be directed and managed so as to focus on problems of major concern. Such management and control is not possible under the present section 100 annual allotment program with the state water resources research institutes.

The Office of Management and Budget has advised that there is no objection to the presentation of this proposed report from the standpoint of the Administration's program.

Sincerely yours,

WALTER J. HICKEL,
Secretary of the Interior.

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF MANAGEMENT AND BUDGET,
Washington, D.C., July 20, 1970.

HON. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs, U.S. Senate, New Senate
Office Building, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in reply to your request for the views of the Office of Management and Budget on S. 3553 and S. 3721, bills "To amend the Water Resources Research Act of 1964 to increase the authorization for water resources research and institutes, and for other purposes."

The office of Management and Budget recommends against enactment of S. 3553 and S. 3721 for reasons so stated in the report of the Department of the Interior.

Sincerely,

WILFRED H. ROMMEL,
Assistant Director for Legislative Reference.

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF MANAGEMENT AND BUDGET,
Washington, D.C., July 20, 1970.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate, New Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: This is in reply to your request for the views of the Office of Management and Budget on S. 1051, a bill "To amend the Water Resources Research Act of 1964."

The Office of Management and Budget would have no objection to the enactment of S. 1051 if amended as recommended by the District of Columbia Government.

Sincerely,

WILFRED H. ROMMEL,
Assistant Director for Legislative Reference.

Senator Moss. I am pleased that we are hearing these bills today. The original Water Resources Research Act came out of this committee, and I believe has been eminently successful. It is because of the degree of success that we need additional funding. Also costs have gone up and the area for research has been broadened as the needs for water have increased. For that reason I introduced S. 3553, and I am hopeful that we can make the record today so that the committee will be prepared to mark up a bill and we can get it through the Congress this year. I think it is of great importance.

We have a number of very eminent witnesses this morning. It is going to be necessary to move along as rapidly as we can because the Senate will go in session, and we may then be precluded from continuing.

So wherever it is possible I am going to ask witnesses to summarize their written statements, and by that I mean shorten the length of time. Sometimes you ask a witness to summarize and he puts in his written statement and then talks longer than if he had read the statement word for word. If you chose to summarize—to pick out and emphasize points that seem of unusual importance—be prepared, of course, to answer questions that may arise in the minds of those who sit on the committee listening to the testimony.

I have a statement from Senator McGee for inclusion at this point.

STATEMENT OF HON. GALE MCGEE, A U.S. SENATOR FROM THE
STATE OF WYOMING

Mr. Chairman, First, let me thank you and the Committee for permitting me to make this statement on S. 3553 and S. 3721, increasing the annual authorization for the Water Resources Research Institutes which have been established at universities in each of the fifty states. I appear before this Committee for two specific reasons. The first is to express my endorsement and strong support for this pending legislation and to urge favorable action by your Committee.

My second purpose is to submit to the Committee the prepared statement of Paul A. Rechar, who is the very able Director of the Wyoming Water Resources Research Institute. Mr. Rechar is unable to appear personally before your Committee. However, he has prepared an excellent statement outlining the accomplishments and future plans of the Wyoming Institute.

Since its inception, the Wyoming Institute has concerned itself with, among other things, programs involving water quality, water utilization, water re-

source planning, and related ecological problems. Also closely related to these areas, the Institute has involved itself in scientific research and experimentation in such fields as game and fish resources, irrigation requirements, coupled with data processing and the co-ordination of all of these programs with our own State agencies.

I do not intend to testify here in detail today. Mr. Rechard's statement expands on the brief comments which I have made, and I am certain the Committee will find it of great value during its deliberations on the pending bills. His statement affirms my conviction that the Water Resources Research Institute Program is a highly successful endeavor.

Mr. Chairman, water is one of our most valuable resources. We must zealously guard it. The additional authorization called for in this legislation will return to us benefits worth many fold the dollar investment which we are making. I urge that the Committee favorably report this bill. Again, Mr. Chairman, let me thank you for this opportunity, and I will appreciate your including Mr. Rechard's statement in the Committee hearing record.

Senator Moss. I don't believe Congressman Robinson is here yet.

I am going to call on the Honorable Carl L. Klein, Assistant Secretary for Water Quality and Research at the Department of the Interior. I understand he will be accompanied by Mr. Hershey, Director of the Office of Water Resources Research of the Department.

Glad to have you gentlemen here this morning, and we look forward to hearing your testimony, Secretary Klein.

**STATEMENT OF HON. CARL L. KLEIN, ASSISTANT SECRETARY,
WATER QUALITY AND RESEARCH, DEPARTMENT OF THE INTERIOR;
ACCOMPANIED BY H. GARLAND HERSHEY, DIRECTOR OF
THE OFFICE OF WATER RESOURCES RESEARCH**

Mr. KLEIN. Mr. Chairman, members of the committee, inasmuch as I only have a 4-page statement, I think that it would be well if I read it instead of summarizing it and winding up longer.

Senator Moss. All right.

Mr. KLEIN. I am pleased to appear before you today to testify concerning S. 1051, S. 3553, and S. 3721, pending legislation to amend the Water Resources Research Act of 1964, as amended. I have with me H. Garland Hershey, Director of the Office of Water Resources Research. My testimony on these bills supplements and clarifies the position in our legislative report of July 17, 1970.

S. 1051 would amend the act to extend its application to the District of Columbia. It also would authorize the consortium of universities of the Washington metropolitan area to receive grants as water research institutes under section 100 of the act. This section authorizes \$100,000 annually to a land-grant university in each State and in the Commonwealth of Puerto Rico to establish and operate a competent a qualified water resources institute.

The other bills, S. 3553 and S. 3721, would amend the act principally to increase from \$100,000 to \$250,000 the amount to be appropriated under section 100 to assist each State in establishing and operating its water resources research institute. I will comment first upon these bills and then return to S. 1051.

S. 3553 or S. 3721, would authorize an increase of \$150,000 each year for the water resources research institute in each State. This would be a 150 percent increase. An appropriation matching the proposed increased authorization in full would be \$12,750,000 per year.

This is in comparison to \$5,100,000, the amount now authorized in the act and appropriated in full for each of the last 4 years.

The Department of the Interior has been the leader in all types of water resources research. The Federal Water Quality Administration (FWQA), the Office of Saline Water (OSW), and the Office of Water Resources Research (OWRR), which come under my office, expanded budgets for water research in fiscal year 1970; and again in fiscal year 1971; and, we trust in fiscal year 1972. At the same time, the Geological Survey of the Department has had increases in funding for water research. All of these increases are in conformity with President Nixon's desire to augment the quality of our lives in the decade of the 1970's and with Secretary Hickel's determination to solve our water problems in this decade.

Interior is proud of its record of accomplishments in this field of research, as well as its program of action based on its research.

Nearly all of the water resources research fund is well directed, and is coordinated to avoid duplication, to achieve results, to enable Interior and the Government of the United States to reduce pollution, to find more economical, efficient ways to produce fresh water from salt water, to perform productive research on urban water supply, and to enhance the quality and availability of our waters.

The research of the Geological Survey is coordinated with FWQA and OWRR; that of FWQA with the Coast Guard, in one area; with the U.S. Fish and Wildlife Service in another; with OSW and the Bureau of Reclamation in still another. OWRR coordinates with all of these and other Federal agencies with respect to section 101 and also title II of the Water Resources Research Act.

In only one instance does this cardinal rule of supervision as to direction and utilization of taxpayer's funds go unheeded in the law. The funding provisions of title I, section 100, provide no effective guidance, criteria, or direction. We are without proper legislative authority to guide use of these funds into a comprehensive program or programs. I will say, however, that custom and usage has done pretty well in this field.

On the other hand, section 101 of title I and title II of the act do provide adequately for effective guidance, criteria, and direction. For these reasons we are attempting to build up these segments of the OWRR program.

Therefore, we feel that the authorization for funding under title I, section 100 of the Water Resources Act should remain at the present level. If any State university has a research proposal which cannot be accomplished within the annual allotment of \$100,000, it should endeavor to get approval and funding under the other portions of the Water Resources Act, the Federal Water Pollution Control Act, or other Federal programs.

We are pleased to recommend the enactment of S. 1051, if amended as provided in our legislative report.

Increased emphasis on research involving metropolitan water supply makes it appropriate that the District of Columbia share in the programs under section 100 of the act.

The Government of the District of Columbia is ready to proceed as a participant in this program, but has proposed that section 2 of the bill be deleted. That section would designate the consortium—American, Catholic, George Washington, Georgetown, and Howard Uni-

versities—as the sponsors of the institute. The deletion of the section 2 would permit the operation of the general rule under section 100(b) whereby the local land-grant college—in this case the Federal City College—receives the funds. We recognize that the consortium has received recognition for its efforts in encouraging operation and shared use of educational resources. Nonetheless, we agree with the Government of the District of Columbia that we should not single out the District of Columbia as the one jurisdiction in which the land-grant institution or other institution designated by the jurisdiction does not administer the institute. Of course, the present forms of section 100 of the act would authorize the Federal City College to arrange with other colleges and universities in the District of Columbia to participate in the work of the institute. We believe that this provision would permit full use of the resources of the consortium. Therefore, we agree with the deletion of section 2 of the bill as the District proposes.

That concludes my statement, Mr. Chairman. And we will be pleased to answer any questions you may have.

Senator Moss. Thank you, Secretary Klein.

Your recommendation as far as S. 3553 is that it not be enacted. You indicate you feel that the \$100,000 annually is adequate for the research to be done by the State universities or whatever organization is certified by the State. And you say that if they have projects that cost more money, they could apply to one of these other Federal departments for additional funds. But how does this affect them in their long-term planning? They can apply, but how do they know for sure they are going to get the money from the Federal departments?

Mr. KLEIN. There is no way of knowing. However, I say this to you, Mr. Chairman, that if the project is a good one, they will get the funds one way or another from within our jurisdiction. When we had a good project from the State of Washington, the University of Washington, I believe it was Washington State, was it not, where we were not able to fund it under the Office of Water Resources Research, we were then able to fund it under FWQA. We have very good working relations in Interior on the different types of funding that comes in and since we have the majority of water resources research we see to it that it is worked out. If there is a problem that we can't work out in one place, it goes elsewhere to be handled.

Senator Moss. Isn't it true that \$100,000 a year couldn't finance any very extensive research project in any given institution?

Mr. KLEIN. No. These are not meant for that purpose, I believe, Mr. Chairman. The long term extensive ones are meant for water quality and the type that we have in Geological Survey, although we have some that continue for more than 1 year within OWRR.

Senator Moss. How much money do you have in the Department, or the various offices that come under your jurisdiction, for research purposes annually?

Mr. KLEIN. This year, sir, I had \$82 million. And in fiscal year 1971 it is expected too that will go up by at least \$20 million. And we hope in fiscal year 1972 that it will go up at least \$20 million additional. Most of this, of course, will be in the field of water pollution.

Senator Moss. Well, that would mean you would have over a hundred million available in the coming fiscal year?

Mr. KLEIN. We believe so; yes, sir. That has not been finally determined because the supplemental FWQA budget is still in the Bureau of the Budget. This is to match the new Public Law 91-224 that was enacted by Congress recently on oil spills and the like.

Senator MOSS. And there is only, let's see, \$5 million authorized under the Water Resources Research Act—well with Puerto Rico, \$5,100,000.

Mr. KLEIN. Yes. This is the full authorization under title I, section 100. We have had difficulty in the past in arriving at the appropriation for full authorizations under section 101, title I, and also title II. And it has been our aim, and we may be able to accomplish this in fiscal year 1972, of having full funding of the authorizations as the bill now stands, as the act now stands.

Senator MOSS. What type of research has come out of the funding for these universities, or other State units? Has it been ineffective? Has there been little, if anything, produced or has there been good research?

Mr. KLEIN. I will let Garland Hershey, the Director of Water Resources Research, address himself to that except when I was in Illinois the vice chairman of my commission utilized these funds for a very good purpose there, and I do know that a great deal of this goes through very effective procedures and good results.

Senator MOSS. Dr. Hershey, could you respond to that?

Mr. HERSHEY. I think that is true, that is, what Secretary Klein said is true in most of the other States involved. Some excellent research, useful research, has come out of the institutes under section 100 of title I.

Senator MOSS. Has there been effective coordination—information passed from one to the other so that research is not duplicated?

Mr. HERSHEY. Yes; I think this has been covered as well as it can be under present procedures. This is one of the great problems not only in water resources but in other areas as well. This is one of the big thrusts that we have on now, to increase the transfer of information. But insofar as possible, particularly in avoiding duplication and overlapping of research, we think an excellent job has been done.

Senator MOSS. Very good.

Senator BIBLE, do you have some questions?

Senator BIBLE. Thank you, Mr. Chairman.

The thing that concerns me, Secretary Klein, is what happens in the future if the proposed reorganizational bill involving the Department of Interior as well as other departments and governmental agencies is effectuated. And I don't know whether it will be or won't be. How does that affect this water resources program?

Mr. KLEIN. The Office of Water Resources Research and the Office of Saline Water, which are two of the offices under my jurisdiction, will as I understand it presently remain in Interior. I do not know what further reorganization is even contemplated in Interior to place them with one or a different division.

Senator BIBLE. Are you saying then that the President's proposed reorganization plan, if approved, or you want to take in the reverse approach to it because it requires disapproval to make it ineffective as you know, it would leave the water resources sections of the Department of Interior intact as they are operated today?

Mr. KLEIN. Yes; it would. Both this and the Office of Saline Water. Both of you gentlemen are interested in that, too.

Senator BIBLE. And would your position in the Department be the same as it is today?

Mr. KLEIN. I doubt it.

Senator BIBLE. Well, there must be some change then if it isn't the same.

Mr. KLEIN. I don't know exactly because the Executive order that went forward from the President did not cover it, sir.

Senator BIBLE. Just silent on that point?

Mr. KLEIN. Well, it said it would transfer the functions enumerated in the Federal Water Pollution Control Act to the new agency but how they will be transferred is not yet known at the present time, sir.

Senator BIBLE. Well, when would it be known?

Mr. KLEIN. I don't know, sir.

Senator BIBLE. Who would know?

Mr. KLEIN. I think you would have to direct your questions to a source above my authority, sir.

Senator BIBLE. Is that the Secretary of Interior?

Mr. KLEIN. I think above that, too, sir.

Senator BIBLE. To the President of the United States?

Mr. KLEIN. Yes, sir.

Senator BIBLE. The only purpose in my questioning, Mr. Chairman, is to determine where all of these water resource functions might end up at the time that we end our congressional session this year so that can be considered in whatever we do here. We don't want a situation where we have an agency in Interior that's had most of its responsibilities and its power taken away.

Let me ask a second question. Now, the objection to the recognition of the consortium of Howard University, American University, George Washington, and Georgetown is due to the fact that the Federal City College is classified as a land-grant college?

Mr. KLEIN. Yes, sir. Second, the administration problem involved here would give us difficulty.

We have the equivalent of these consortiums in other States already where the land-grant college gets this \$100,000 and parcels it out. And we think that this same approach would be used herein, that it should be the land-grant college and the others should participate through the land-grant college as they do in some of the other States.

Senator BIBLE. Well, have they participated in the past? I don't know.

Mr. KLEIN. I do not know. Possibly Dr. Hershey could address himself to that question.

Senator BIBLE. Have they received money in the past, the Federal City College?

Mr. HERSHEY. I don't believe—no, Federal City College has not.

Senator BIBLE. I see Charlie Horsky in the audience here. I guess he is the authority for the Federal City College. They are new in origin and it may be that they don't have the expertise or the department or whatever to take proper advantage of this particular grant of money. Have they ever filed an application to date?

Mr. HERSHEY. No; they have not, sir.

Senator BIBLE. Well, Dr. Horsky will speak on this point. I have no feeling one way or the other on it. I believe I am the author of the

language that required the recognition of this consortium. That was only because they do have a need for this type of water quality research in the metropolitan area of the District of Columbia, and I thought they should participate just as my own State of Nevada does. I have no great feeling one way or the other on this. If Federal City College is the proper agency or institution to operate in conjunction with the Federal Government, they in turn as you point in your statement could enter into other agreements with the so-called consortium. Is that the thinking behind this suggested amendment?

Mr. KLEIN. Yes, sir.

Senator BIBLE. I mean criticism of the suggested amendment?

Mr. KLEIN. Yes, sir. We are a little bit afraid this would be a step whereby you would then have consortiums in other States—

Senator BIBLE. You would rather proceed through the land-grant college route?

Mr. KLEIN. Yes; and not dilute the ability to properly use these funds.

Senator BIBLE. How many land-grant colleges do you cooperate with at the present time?

Mr. HERSHEY. Fifty.

Senator BIBLE. Fifty?

Mr. HERSHEY. I think there is only one State in which the land-grant college isn't a cooperator.

Senator BIBLE. Are there land-grant colleges in each of the 50 States?

Mr. HERSHEY. Yes; there are.

Senator BIBLE. I didn't actually recognize that. So you operate in every instance with the exception of one with the land-grant college?

Mr. HERSHEY. Yes, sir.

Senator BIBLE. What is the one exception?

Mr. HERSHEY. Georgia Tech in Georgia.

Senator BIBLE. Why don't you operate with a land-grant college there in Georgia then?

Mr. HERSHEY. Because the Georgia Legislature designated Georgia Tech rather than the land-grant college, which is the privilege of the State under section 100(a) of the Water Resources Research Act.

Senator BIBLE. As you know, the Water Resources Research Act included Puerto Rico within the definition of a State for the purpose of having a water resources research center. S. 1051 would add the District of Columbia to the act and that is what we were just talking about. Quite possibly the viewpoint of the Federal City College is the correct one. I don't know.

Please give us your views on whether it might be appropriate to also include the Virgin Islands.

Mr. KLEIN. If I may I will address myself directly to that.

In May the President's Water Pollution Control Advisory Board met in the Virgin Islands and I was there as the Chairman of the Board. The problem there is that there is no ground water. They have cisterns for the runoff from roofs and the like, and the problem there is that the rain does not come evenly. It comes in floods. For 4 months, for instance, they had no rain, and they had drought conditions. Lastly the Office of Saline Water has helped in the past, and the Islands themselves have set up a number of desalting units.

Senator Bible, you know that desalting units take good engineers to operate. As a result of careless operation or change in personnel who are not properly trained the desalting units have come down and been out and they have been paying as high as \$3 a thousand for water and they have had to import it from Puerto Rico. Their big problem here is not a water resources research institute but somebody to train desalting personnel.

I sent a unit down there under Dr. Chung-ming Wong, the Director of OSW, to help them get their desalting units back into shape, because this was their big need. They do not need research on water because they depend upon rain and desalting. And I would like to give this a real hard look before I would include the Virgin Islands, although they need water; they can't get any ground water, and this is a real problem.

Senator BIBLE. How do you know they can't get any ground water?

Mr. KLEIN. I have asked at the College of the Virgin Islands.

Senator BIBLE. We are always having breakthroughs. Your Department is always telling us about the great breakthrough that you are coming up with.

Mr. KLEIN. Yes, sir.

Senator BIBLE. And your very fine headman of Saline Water has some exciting possibilities in mind, and you are also asking the Appropriations Committee for additional dollars to do these exciting things. Maybe if you go another thousand feet down in the Virgin Islands you get ground water. I don't know. Do you know?

Mr. KLEIN. The answers that I have gotten thus far, and this includes the whole Lesser Antilles, is that it is just impossible to get the ground water—

Senator BIBLE. That may be a correct conclusion.

Mr. KLEIN (continuing). In that area. It might be that something can lend itself to this, and I think what we should do before we come up with annual appropriations is look to see whether it can be utilized properly. And possibly a justification for the university at the Virgin Islands would be sought first before we go forward with any answers on the bill.

Senator BIBLE. Well, I assume that the chairman of this committee plans on getting this done in the very near future. We have got to adjourn by October 1, so we can campaign and try to get back and work in this committee again next year.

You say you want to take a real hard look at it. How long will that real hard look take you?

Mr. KLEIN. I would have to get an answer.

Senator BIBLE. How long is it going to take you to get that?

Mr. KLEIN. I don't know how long it will take the university to give me an answer.

Senator BIBLE. If we add the Virgin Islands in here, what would you do about it? Would you suggest a veto?

Mr. KLEIN. I would have to have an answer from the University of the Virgin Islands, further verified by Dr. Hershey and his staff.

Senator BIBLE. I think we just ought to put the Virgin Islands in and see what happens, Mr. Chairman. I just wanted to find out whether he wants them to be included or doesn't want them to be included. I don't think the answer has been responsive.

Mr. KLEIN. I would say to you at this time that I would rather not have that included. I would want a positive answer from that, a justification before I go ahead with spending any money.

Senator BIBLE. All right. Very well. Now, how about Guam?

Mr. KLEIN. Guam is a good possibility because there is no doubt that they are going to need this in the Micronesia area.

Senator BIBLE. Well, then, if we put Guam in you would say that was fine?

Mr. KLEIN. I cannot give an answer for the administration on that.

Senator BIBLE. Well, who can give the answer for the administration, the Secretary of the Interior, Bureau of the Budget?

Mr. KLEIN. I could give you an answer within 7 days.

Senator BIBLE. Well, that is better. I hope you can give us an answer on the other within 10.

That is all the questions I have, Mr. Chairman.

Mr. KLEIN. Would the Senator wish to have an answer in writing on both of those within the next 7 to 10 days?

Senator BIBLE. I would defer to the final wishes of the chairman, but I think this is important legislation.

Senator MOSS. Well, we would like an answer in writing so we can include it in the record.

Mr. KLEIN. Fine.

Senator MOSS. Ten days.

Mr. KLEIN. Thank you.

(The data requested by Senator Bible follows:)

U.S. DEPARTMENT OF THE INTERIOR, OFFICE OF THE SECRETARY,
Washington, D.C., August 11, 1970.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate, Washington,
D.C.

DEAR MR. CHAIRMAN: This supplements our report of July 17, 1970, on S. 1051 and S. 3553, bills to amend the Water Resources Research Act in several respects. In the hearing of July 20 on these bills before the Subcommittee on Water and Power of your Committee, the Department was asked to recommend whether the territories of Guam and the Virgin Islands should be included in the program of water resources research institutes under section 100 of the Act. At present, the 50 states and the Commonwealth of Puerto Rico are participants. S. 1051, as introduced, would include the District of Columbia in the program.

We recommend that the legislation not include Guam and the Virgin Islands in the program.

The people of the Virgin Islands and Guam are citizens of the United States. Aside from the fact that, by geography, these territorial islands are a natural center for water resources research, they are also peculiarly dependent upon water resources for a continuing healthy economy. There exists in these territories a need for intensified effort on their part in the areas of research, investigation and experiments in conservation and optimum use of available supplies of water, methods of increasing such supplies, and economic, social, engineering, recreational, and ecological aspects of water problems. At the request of the Committee, we submitted more detailed statements on the water supply situation in these territories in preparation for the hearing.

It should be noted that the educational resources of the University of Guam and the College of the Virgin Islands are quite limited, although developing. At present, it would appear to be more productive for these institutions to seek matching grants and other funds for specific water resources research projects under section 101 or title II of the Act, or under such other research authorities as those of the Federal Water Pollution Control Act and the Saline Water Conversion Act. We will give prompt consideration to all requests from the territories for such assistance.

We are enclosing the transcript of the hearing, which has been reviewed, corrected and supplemented where required. We appreciate the opportunity you have provided for our review.

The Office of Management and Budget has advised that there is no objection to the presentation of this supplemental report from the standpoint of the Administration's program.

Sincerely yours,

CARL L. KLEIN,
Assistant Secretary of the Interior.

WATER SUPPLY IN THE VIRGIN ISLANDS

The Virgin Islands comprise about 80 small islands approximately 50 miles east of Puerto Rico and 1,200 miles southeast of Florida. The largest islands are St. Croix, St. Thomas, and St. John. Historically, from the time of the early settlement of the Virgin Islands, sources and quantities of fresh water have been limited.

Island residents traditionally have relied mainly upon rainfall catchments for potable water. In an average year of rainfall these catchments and roofs yield about 50 gallons of water per day per 1,000 square feet of catch area. In addition to water collected from roofs, roads, paved hillsides or other impervious surfaces, supplies are obtained from shallow, dug wells, a few springs, and by barge shipment of water, mainly from Puerto Rico. Virgin Islands law states that residents must have gutters to collect rainfall and that each dwellings have a cistern. For each new dwelling, the code requires that a cistern be constructed with a volume of 10 gallons per square foot of roof area.

Hydrologic evidence from infrequent studies over the past 50 years indicates a diminishing of the natural waters of the Virgin Islands. The decline in ground water levels and parallel decline of the base flow in the streams are believed due both to changes in land use which modifications in vegetation, evapotranspiration, and recharge to ground water reservoirs, and to climatic change with diminishing rainfall.

In the period 1962-68, the Virgin Island Water and Power Authority has installed four desalting plants to supplement chronic water shortages accentuated because of a growing economy brought about by a rapid influx of tourists. St. Thomas has three units capable of providing 3,775,000 gallons of fresh water per day. On St. Croix the authority installed a one million gallon per day plant which started up in 1968. Earlier, in 1964, on St. Croix, Harvey Aluminum installed a 1,500,000 gallon per day plant.

On May 1-2, 1970 at a meeting of the President's Water Pollution Control Advisory Board in the Virgin Islands, Assistant Secretary of the Interior Carl L. Klein identified the islands' principal water and related land problems. He called attention to the scarcity of potable water during the dry season, erosion of top soil, sedimentation of recreational coastal waters, and pollution of the Islands' waters by solid wastes and flooding. Among recommendations made by the Advisory Board were consideration of a central water supply for the three Islands and the addition of the Virgin Islands to the group eligible for grants under the Water Resources Research Act of 1964.

WATER SUPPLY OF GUAM

Guam is a tropical island of about 212 square miles in area. It is the largest and southernmost of the Mariana Islands and has an average rainfall of nearly a billion gallons of water per day. The flow in streams and the recharge and discharge of ground water differ considerably with locality according to the permeability and other characteristics of the rock.

The source of more than half of the water used on the island is the Fena Valley Reservoir, which has a usable storage capacity of 2,500 million gallons. It is the only reservoir on Guam capable of carrying over the runoff stored during one wet season into the next. During 1959, the driest year of record, the reservoir could have maintained a constant draft of 12 million gallons per day (mgd) through the dry season and still have been refilled to full capacity the following wet season.

Ground water supplies used in Guam in 1962 included about 1.5 mgd from Almagosa Springs, 0.5 mgd from Bona Springs, an unknown amount diverted daily from small springs, and 2 to 4 mgd pumped from wells in northern Guam.

Water shortage is not a problem on the island although inhabitants in rural or isolated areas still catch rainfall on rooftops or other impervious areas for household use. The water problems or conditions meriting attention are those of distribution and of safeguarding the supply. Per capita use is high and use of water not always efficient. A technical program assessing the water resources available and defining more clearly the exact hydrologic situation would benefit the island.

A severe infestation by a coral predator, "crown of thorns starfish," on the reefs of Guam has led to the establishment of a control program under the direction of the University of Guam. Since 1967, this starfish has killed more than 90 percent of the living coral along part of the island's coastline. Two theories have been advanced to explain the population explosion of starfish. One is that the larvae has been provided with a specially favorable environment by reef destruction which destroys the natural predators of the larvae. Another theory is that human activity from widespread use of persistent insecticides has upset the ecological balance. This is a water-related problem of serious concern to Guam and to other populated Pacific islands. Certainly, an investigation of the role of insecticides in starfish infestation is warranted.

Senator Moss. Senator Hatfield.

Senator HATFIELD. Mr. Klein, is your basic objection to the increase in \$100,000 to \$250,000 an objection based upon budgetary philosophy or just basic research philosophy?

Mr. KLEIN. It is based upon both in part, Senator Hatfield. No. 1, is that the original bill called for certain authorizations, and the fundings have never gotten to the full amount of the authorizations.

Senator HATFIELD. You are speaking now of the figure between \$3 million and \$5 million?

Mr. KLEIN. Yes. Under section 101 of title I and under title II, we have never fully funded that by appropriations, and it is our thought that we should first—and we have been working toward this—fully fund the past portions of the bill before any other authorizations, increase in authorizations go forward.

Senator HATFIELD. Why haven't they been funded?

Mr. KLEIN. Well, we have had budgetary restrictions in previous administrations and in this administration, but we have been increasing it in, under this administration since I have been Assistant Secretary, in the 1970 budget and the 1971 budget, and we are expecting, I believe, to fully fund it in 1972, are we not? We are hopeful.

Senator HATFIELD. Were the requests made by the agency for full funding in each case?

Mr. KLEIN. Not in 1970 and 1971. There were increases but not full funding. And 1972 is the first time we have really been asking for the full funding under the present act.

Senator HATFIELD. You had a second point you were going to make.

Mr. KLEIN. The second point is the question that by custom and usage we have been guiding the program under section 100, title I, but we have not been able to really coordinate it with all of the rest of the program of water resources research where we can delineate with programs and priorities of the Office of Science and Technology under the President, for instance. And previous administrations have guided where the water resources research funds should go. We have been able to ask them to do this but we cannot tell them, we cannot refuse the funds. But by custom and usage with the gentlemen from the universities we have been succeeding pretty well. And we do not think that it should go to any further authorizations or fundings without having full guidance as to where the funds will go.

Senator HATFIELD. Mr. Secretary, would you draw a distinction between the type of project that the central research agency undertakes and that type of project which is the typical one that's undertaken by the institutes within the States?

Mr. KLEIN. I think I will let Dr. Hershey respond as to the delineation, between the differences as to what we would ask and what the States would do. I think that is what the Senator is asking.

We, of course, under section 101 and under title II have been directing our main thrust at urban water supply. What differentials do the universities make under 100?

Mr. HERSHEY. Under section 100 they attack local, State, and regional problems involving the State. Now, they go beyond this in some cases, or course, but primarily this is what section 100 was set up for.

Senator HATFIELD. You would characterize them as being very practical projects?

Mr. HERSHEY. In general, yes.

Senator HATFIELD. Well, they are meaningful to that particular section because they are dealing with the specific problems of that section?

Mr. HERSHEY. That is correct.

Senator HATFIELD. And they are developing solutions to those problems?

Mr. HERSHEY. That is right.

Senator HATFIELD. And if you have 49 out of 50, that means you have covered the United States pretty well, haven't you, that is in dealing with practical problems of all States and regions?

Mr. HERSHEY. Yes, sir.

Senator HATFIELD. Therefore, these projects have day-to-day meaning and they have very vital meaning to the development of those areas, do they not?

Mr. HERSHEY. Yes; they have.

Senator HATFIELD. But I understand then by your testimony, Mr. Secretary, that—the second to the last paragraph on page 3—

If any State has a research proposal which cannot be accomplished within the annual allotment of \$100,000, it should endeavor to get approval and funding under the portions of the Water Resources Act, the Federal Water Pollution Control Act, or other Federal programs.

Now, you answered that, I believe, in some way to Senator Moss, but may I phrase it this way. It is a very significant thing. If the Oregon State University Water Research Institute, which is a very excellent one as you know, had a very important project that they wanted funded which meant a great deal to the Pacific Northwest, since we are rich in water resources and therefore more cognizant perhaps of the need for conservation of water resources, would you mean by your statement that we could get that funding?

Mr. KLEIN. Senator, I will just put it to you this way, that where we have had problems and they have been brought to my attention—usually on important ones they have been—I then sit down with the different agencies under my control and attempt to reconcile them so that if we don't get the money one place, it comes out some other place. As I stated earlier, we had one particular problem in the State of Washington, which again is in your area, and we are trying to solve a problem that affects the Columbia River, and we were not

able to get it done through the office of Water Resources and Research but through the Federal Water Quality Administration.

Senator HATFIELD. But you could sit down with me and the director of the Oregon University Water Research Institute and we could probably find some way to fund the projects that we would like to undertake.

Mr. KLEIN. Yes, as long as they fit somewhere along the line. If they are important and they should be done, we extend every effort in order to try to get them done.

Senator HATFIELD. Could we get a list for the record—Mr. Chairman, it seems to me it would be very important at this time to have a list of the various projects that are undertaken by both the Department's research agency and by the various States in order to perhaps make a comparison as to the practicality or the exotic character of these various projects and what kind of coordination there may or may not be. Don't you think it might be helpful to the committee?

Senator Moss. Yes; I think so.

Could you furnish us, Mr. Hershey, a list—

Mr. KLEIN. Ten days, Mr. Chairman?

Senator Moss (continuing). Within this 10-day timespan so that we can put it in the record?

Mr. HERSHEY. We will be happy to.

Mr. KLEIN. I might say to the Senator that this is covered actually in the yearly report and we will be glad to furnish it.

Senator HATFIELD. With State projects, individual State projects?

Mr. KLEIN. Yes. And we would be glad to cover it more specifically as the Senator desires and as the chairman has ordered.

Senator Moss. Yes; if you would.

(The list of individual State projects requested by Senator Hatfield and supplied by the Department are on p. 23.)

Senator HATFIELD. What basically concerns me here is that over the years we have found in the Bureau of Mines that in the so-called regional or field offices a very outstanding record of research was compiled. It was so very outstanding for a number of reasons. One was that they were dealing with specific practical problems, problems of that area but which were problems that had application throughout the United States.

No. 2, throughout that research program there were many spinoffs that enhanced the whole economy of this Nation because of research. It was not classified research so that it became lost in the files of bureaucracy but was practical research in that it was applied, applicable research and developed many fine businesses and industries and jobs for people.

I am very much persuaded that there is always that result from practical research, especially when it is dealing with river basins, inventories of water resources or correction of imbalances that may exist in local areas. The problems are real. They are real to the people who live there. The work is practical in the sense that they have a laboratory, a natural laboratory within which to work out these problems. Now, contrast that with some of the more exotic projects which may be pursued within, say, the isolation of a central research agency. And I am not saying your projects are of that type. I am say-

ing there is a tendency, when they are not related to a regional or on the ground problem, to move toward the exotic. That may be fine, too. I am not against basic research, but I do believe that with the urgent needs of water conservation and water utilization I would hate to see anything limit the scope of these local institutes. I know that for every dollar that's been invested in this one laboratory—I speak from personal experience here—I am sure many dollars have been returned and benefits accrue not only to Oregon alone or the Pacific Northwest but to the whole field of water research. That is why I want to see that programs move ahead, increased and expanded. I think when you talk about the President desiring to augment the quality of our lives in the decade of the 1970's, the implication is that it is going to be done with the Department. You list the various agencies. I am glad to see the President of the United States, and the first President by the way, has given us the emphasis and leadership that we have needed in the whole environmental field, but I wouldn't want the scope of our thinking to be limited in that all things emanate from Washington. Out of Oregon and out of some of these other States come some of the greatest progress known to our whole history. And I need not recite the long list of things the States have done. That is why I am interested in working through these State agencies who are also training personnel at the same time.

Let me ask you this final question.

Can you give me a comparison as to the kind of new scientists, the new engineers and the new personnel, people who are acquiring expertise and an educational value out of the research programs of the central agencies as compared to those programs that are being carried on within the environments of the universities and other institutes of States.

MR. KLEIN. If I may, Geological Survey does its research in-house and while the Office of Saline Water contracts all of it out of the Washington Office because they have a limited office, FWQA with its large amounts of money in research contracts out almost all of it. It doesn't stay here either. And it comes into FWQA from nine different regions. So this is a clearing point here, and I believe that Dr. Hershey looks upon his office as a clearing point also. And when he gets down to the final analysis of where these go, it is not decided just by the people who are here but by a group of experts who are brought in to analyze the contracts, the applications that have come in and then decide where they should go, and these people are from various walks of life and from various areas of the country.

So we do not just direct it from a central office in Washington. We try to decentralize it as much as possible.

As to what happens on this, again, I will go back a little to my own experience, and I have seen people at the University of Illinois become trained in this field because of the work they have done for the Office of Water Resources Research or other aspects from the State agencies or from the Federal agencies elsewhere. And this is why I would rather see it contracted out at all times than kept in-house on the research except for necessary laboratory work and a few other items that should be done in-house. But I believe our philosophy in Interior is not to keep it in-house but to contract it out and to build up this background of people who know what they are doing and to develop their potential.

Senator HATFIELD. Do you have any figures as to the number of people involved in these institutes on the research projects and the new trainees and experts that we get from such projects as compared to other techniques of contracting?

Mr. HERSHEY. I have no comparison, but about 2,000 students, mostly graduate students a year, are involved in OWRR work. Now, these people aren't given grants directly but they work as research assistants or projects that have been set up through the institute working under an expert researcher, scientist or an engineer. So that annually about 2,000 students within OWRR are involved. I am sorry that I don't have figures—

Senator HATFIELD. Could you get from the States the numbers that are involved in a comparative analysis to the 2,000 that you—

Mr. HERSHEY. I am not sure I understand, Senator.

Mr. KLEIN. It would take a little while, I am sure, to get this. But I am sure that the water resources research institutes in each State, the 50 plus one, 51, would be glad to aid in this and send us their figures. I think if we asked for 2 years, 1970 and 1969, we could get it for comparative purposes, but I do not believe we could get it back quickly enough for purposes of the record in that matter.

Senator HATFIELD. Mr. Secretary, are you going to push for the \$5 million figure?

Mr. KLEIN. You mean the \$5,100,000?

Senator HATFIELD. Yes.

Mr. KLEIN. We always have. We always have had full authorization—

Senator HATFIELD. Authorization, but are you going—

Mr. KLEIN. We have had full appropriation for the present authorization under section 100. It is section 101 of title I and title II under which we have not had full appropriation, and we are going to get full appropriation for the entire authorizations in the act.

Senator HATFIELD. I think many times it has been at about \$3 million, hasn't it, compared to the \$5 million figure?

Mr. KLEIN. Not under section 100.

Senator HATFIELD. 101.

Mr. KLEIN. 101, yes.

Senator HATFIELD. That is the one I am referring to. Are you going to push for the five, full five?

Mr. KLEIN. I have already done that, sir.

Senator HATFIELD. You are going to stand firm on that?

Mr. KLEIN. Yes, sir.

Senator HATFIELD. I have no further questions.

Senator Moss. Thank you.

(Subsequent to the hearing the following supplementary material was received from Senator Hatfield:)

U.S. SENATE,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C., July 31, 1970.

HON. CLINTON P. ANDERSON,

Chairman, Subcommittee on Water and Power, Senate Committee on Interior and Insular Affairs.

DEAR SENATOR ANDERSON: At the recent hearing before our subcommittee on S. 3553 and S. 1051, our subcommittee increased funding for regional water research programs was the focus of the hearing.

I supported the increased authorization. As costs rise, the same dollar does less and more money is needed by the States. Some of the most important ad-

vances in water resource needs and demands have come from field operations in the States. Now is the time to redouble our efforts to solve water problems which will become more critical unless we act wisely today.

The Water Resource Institute at Oregon State University has given great help at the local, state, and regional level.

After the hearing, I called Robert M. Alexander, Director of the Water Resources Research Institute at Oregon State University, and he supports the increase in funding. I asked for a statement from him, and I ask that his fine statement appear in the Hearing Record following this letter.

Thank you.

Sincerely,

MARK O. HATFIELD, *U.S. Senator.*

OREGON STATE UNIVERSITY,
WATER RESOURCES RESEARCH INSTITUTE,
Corvallis, Oreg., July 22, 1970.

HON. MARK O. HATFIELD,
U.S. Senate, Senate Office Building, Washington, D.C.

DEAR SENATOR HATFIELD: In response to your question on present activities of the Water Resources Research Institute and programs to be initiated or strengthened if appropriations are increased, we are pleased to provide the following information. The response will cover the three principal areas of research, education, and community service.

Some of the significant ongoing research can be separated into four categories.

1. Thermal Effects

Studies are underway to probe the possible beneficial uses of heated water from condenser cooling in nuclear power plants and other sources. One project involves the cycling of the heated water through underground pipes using the soil as the heat sink. Crop production benefits from the warmer soil. Other efforts are directed toward use of the heated water for irrigation and in developing greater fish yields in coastal areas. The effects of temperature increases on fish populations are also under investigation with a view to establishing acceptable standards for use of inland streams as discharge areas for coolant waters.

2. Organic Wastes

For a number of years, joint research with the pulp and paper industry has been sponsored to determine the effects of pulp mill effluents in receiving waters. The work has centered on the effects on fish life—both direct impact on growth reproduction and other life processes, as well as indirect influences through the food chain. Information from these and related studies has been employed extensively in the recent major effort to establish water quality standards throughout the nation. A project was initiated recently to improve the handling of organic wastes from the food processing industry. In addition to water pollution abatement, other goals are water re-use patterns and the recovery of valuable by-products.

Our lakes are also under scrutiny. A survey and classification of Oregon lakes is yielding data designed to establish a base for gauging the outlook for their continued use as home and recreational sites. Systems analysis is being employed to help predict the process of decay and degradation of quality (eutrophication) in lakes and reservoirs. A related study, through the techniques of simulation, is aimed at better understanding of the effect of various pollutants and of varying conditions on this process of eutrophication.

3. Hydrology and Watershed Management

The annual allotment (\$100,000/year) has made it possible for faculty and graduate students to participate more fully with the task force conducting the major study of resource management of the Alsea Basin. The study group, as I'm sure you will recall from your earlier contacts with this project, includes representatives of federal and state agencies as well as the timber industry. Research results are helping to set standards for proper road building, logging practices, and stream management to reduce the water pollution problems of siltation and temperature increase. Allied projects measure the loss of water through both natural and man-made processes and explore ways of reducing such losses.

4. *Institutions and Social Impacts*

Enhanced understanding and improved technology is of value only as institutional arrangements are provided for their application. Several projects, including major work at the University of Oregon Law School, have been conducted in the institutional and related social areas. Projects have been designed to assess the social cost and benefits of water diversion; to analyze the decision-making process in water resource development plans; to examine the structure of alternative water management institutions; to evaluate the impact on a community of reservoir construction; to investigate the relationship of federal and state agencies in recreational matters. Considerable progress has been made researching the thorny tangle of conflicting water rights and inadequate water laws. Publications as a result of legal research have been of direct help to Governor McCall's staff. These include "Oregon's Water-Management Districts" and a volume on "Legal Aspects of Interregional Water Division". Scheduled for completion in 1971 is a comprehensive "Survey of Oregon Water Law".

Most of the subjects over which we have just skimmed require additional funds to continue and intensify. Inflation devours a substantial portion of the \$100,000 annual allotment and the outlook is for increasing salary costs and price levels—making it impossible to maintain even the current level of research.

Certain additional critical problems on which work could be undertaken with added funding, in the water quality area alone, would include: (1) assembling basic physical and biological information on estuaries to aid in the effort to improve the management of these resources which are now being exploited at a rapid rate; (2) conducting studies on many biological and physical aspects of the thermal effects problem concerning which information is now totally inadequate; (3) assessing the effect on life processes of the many exotic materials (e.g., mercury) being released inadvertently or purposely into the aquatic environment, and (4) analyzing social benefits against social costs of many proposed public and private capital investments in water resource developments which tend to alter the ecological structure.

Training of students is an extremely important aspect of the Institute's program. During the past five years over 100 graduate and undergraduate students have received support from the Institute. They have been able to work alongside and under the supervision of experienced faculty members who are addressing themselves to significant water-related problems. Approximately 20 separate disciplines have benefited from the input of federal funds. Aside from the faculty and students who work directly on research projects, an infinite number of other students are aided through use of equipment, facilities and the expertise provided and generated by these funds.

Community service requirements are demanding more attention from the universities. State agencies, citizens' groups, private industry, local governments, and other organizations seek the help of the Institute with its access to the multiple skills on campus. The recent flare of ecological awareness has resulted in a greater need for the talents, in a proper mix, of biologists, economists, behavioral scientists, lawyers, and physical scientists. Those charged with planning and operating water resources institutions and programs request help from the academic world. Increased funds under the annual allotment would permit the Institute greater total effort and flexibility in responding to these requests.

The Institute sponsors each term weekly public seminars on important aspects of water resources preservation and development. These are attended by a wide audience which extends beyond the academic community. Proceedings are published to make the seminar subject matter available to the interested public and governmental agencies. The Governor's Special Assistant on Natural Resources reports that this particular series of booklets has been of special assistance to the Executive Office.

A vital part of public involvement is the necessity to communicate research results to potential users. The Institute now publishes a newsletter on a periodic basis giving the results of investigations. Reports contained therein cover projects, not only within Oregon, but also studies from all over the national which are pertinent to similar conditions in our state. Distribution is made to federal and state agencies, legislators, private industry, and appropriate individuals and committees—especially at county and municipal levels. The objective is to reach most of those who are active in the planning or decision-making aspects of water development. The limitations of the current annual allotment make it impossible to expand this and allied services to meet growing obligations. Among these allied

services, now in an embryonic stage, is the development on campus of a water resources data depository for state-wide use.

In this area of improving communications, additional funds would make it possible to sponsor more conferences, symposia, short courses, and study institutes. These would be tailored to meet the needs of agencies and individuals who are active in the solving of local, state and regional problems. This permits an exchange of ideas, a blending of philosophies, between action-oriented personnel in the agencies and faculty members. Both federal and state agencies have expressed a requirement for a program of continuing education for their staff members. They seek exposure to the latest ideas in their fields of specialization and access to the innovations often available at the universities. Social and cultural considerations must have an impact on technological skills and knowledge.

Very truly yours,

ROBERT M. ALEXANDER, *Director.*

Senator MOSS. Before I call on our ranking minority member for his questions, I want to acknowledge that I have a number of visitors in the audience this morning that I am delighted to see. Future Homemakers of America, young ladies, are in the back of the hearing room. I am pleased that they are here, and I am glad to recognize them. I am sorry that I haven't time to break off and meet with them personally, but welcome to the hearing.

We will now hear from Senator ALLOTT of Colorado, the ranking minority member.

Senator ALLOTT. Some of my questions I will get at in another way later, but I would like to ask, Mr. Secretary, first of all, what do you think the major accomplishments of research institutes have been?

Mr. KLEIN. I cannot give you a full background history. I would have to ask Dr. Hershey or maybe his deputy, Mr. Eaton, for that. Since I have been the Assistant Secretary we have directed the major part of the funds toward urban water supply, realizing that this has been an area that has not been taken care of in the past and is a must for the future. We have gone into this particular item in order to alleviate a need.

Senator ALLOTT. Would you like to have Dr. Hershey expand it?

Mr. KLEIN. Yes. Would you like to go a little bit further, Dr. Hershey?

Mr. HERSHEY. Yes, I would be glad to.

I think that there are several major advances. One is that additional people, because of the additional money involved additional professional people have redirected their interest into the water resources field directly. This includes not only engineers and other scientists but lawyers, and people in other fields.

A second major point is that over the years a large number of young people have also gotten into the field and been well trained so that they can take a place and do professional work, which is very greatly needed in water resources in the United States. As you know, the interest in and the need and demand for more work in the water resources is burgeoning all the time and there aren't enough people even now to take care of it. But this program along with others has helped fill a very much needed gap.

Now, in addition to this some of the research that has been done has been highly useful as well. Perhaps that should be at the top of the list. However, these other two points I think are vitally important.

Senator ALLOTT. What would you place at the top of your research accomplishments?

Mr. HERSHEY. I am afraid I would have to think about that, Senator.

Senator ALLOTT. Well, suppose you think about it a little bit and supply a statement for the record, will you please.

Mr. HERSHEY. I will be glad to.

Senator ALLOTT. Then I would like to ask the Secretary this question. What specific research is now underway that increased funds would further?

Mr. KLEIN. I beg your pardon.

Senator ALLOTT. What specific research is now underway that increased funds would enhance or further?

Mr. KLEIN. Well, within water resources research we have expanded, as I said, research on urban water supply problems, and we find going into this that we are going to have to go a little bit larger in order to get more of the answers faster, because we are running into real problems on urban water supply.

I will not go into such other factors as to saline water quality at this time. They have many more ramifications. The amounts that are involved in water resources research are small compared to the other programs, and still they are very, very important.

Senator ALLOTT. Let me ask this question then. Do you think that a grant program is necessary, a Federal, hundred percent grant as opposed to a State matching program?

Mr. KLEIN. We believe—and this is why we supported section 100—that you have to have a basic 100-percent grant program. And then thereafter, sir, we believe that matching grants of one sort or another where we do have the possibility of making a 100-percent grant is better because it involves more participation, a full participation by the agency that puts up part of its own money. We think that this is better for the full program.

Senator ALLOTT. Well, isn't the tendency in such a case to confine the research programs to the immediate problems that they are probably most apt to be working on, and that is with relation to the particular region or area where they are located? For example, the research with respect to the Colorado River Basin is hardly in a general way applicable to the water problems of the East. So don't you tend, by making a wholly Federal grant, to put a barrier between the research programs in a given area or a given State away and the people in that State who are responsible for the development of water in that State?

Mr. KLEIN. But you do have, for instance, in the State of Colorado \$100,000 directly to the land grant university for the basic problems within that State. And this is where we find that most of them have been going, within the State itself. But for problems over and beyond that, we find that again that—although they keep themselves chiefly to those problems within the States—yet these gentlemen who operate the water resources institutes do have communication with each other and with the Office of Water Resources Research, and do guide themselves into fields applicable to the entire country as well as to the State.

Senator ALLOTT. Then could I ask you one further question. Do you recommend the grant to Puerto Rico, which is included already, sir?

Mr. KLEIN. Yes. We do recommend that because they have a problem of burgeoning population there and they do have ground water in the area that can be developed.

Senator ALLOTT. Do you know of any reason why Puerto Rico couldn't contribute to the development of this itself? You know the United States takes no taxes out of Puerto Rico whatever.

Mr. KLEIN. I could not give an answer to the Senator at this time, sir.

Senator ALLOTT. Thank you.

Senator MOSS. Thank you very much Secretary Klein.

Senator ALLOTT. I must say those are rather tough questions, but Mr. Evans is here from Colorado and hopefully I will have an opportunity to have him explain to me some of these differentiations in these programs and their practical application.

Senator MOSS. Thank you. We do appreciate your coming here to testify. I know the Secretary has another commitment and we are glad to excuse him at this time. Although if Mr. Hershey or the others want to remain, of course, we will be glad to have them here during the remainder of the hearing.

Mr. KLEIN. Dr. Hershey will remain, Mr. Chairman. In the event you wish to direct any further communications or have anything further of the bureau, of the Office of Water Resources Research we will be glad to furnish it.

Senator MOSS. Thank you very much, Dr. Hershey. We will ask you to remain.

(The material on water resources research requested by Senator Allott and supplied by the Department follows:)

OFFICE OF WATER RESOURCES RESEARCH—EXAMPLES OF RESEARCH RESULTS AND APPLICATIONS

ALABAMA

Project B-019-ALA is contributing to knowledge of deep-well liquid waste disposal methods. Basic factors studied include volume of pore space in underground reservoirs that would accommodate liquid waste and presence of impermeable barriers to prevent contamination of the fresh water resource. An annotated bibliography of more than 2000 references to the hydrology of limestone terranes was an outgrowth of another study (B-007-ALA), the bibliography to be published as a part of the International Hydrologic Decade.

ALASKA

An investigation has been completed in Alaska (B-006-ALAS) to determine the feasibility of using warm, summer streamflow to recharge groundwater aquifers in the Anchorage area and to restrict use of cold, winter water for recharge. The purpose is to provide a means of raising the temperature of the Anchorage municipal water supply to combat annual freezing problems that plague the municipal water distribution and sewer systems. This investigation shows that groundwater temperature can be raised by artificially sealing the recharging stream beds thus reducing recharge of the aquifers by cold winter water and by using warm, summer streamflow for recharge through artificially constructed recharge areas or wells.

ARIZONA

In the State of Arizona, current annual water use represents an overdraft on a dwindling groundwater reserve. Therefore, it becomes especially important to be sensitive to the earliest possible application of research results for the public benefit. Several projects supported under P.L. 88-379 are either ready or are now in use to assist the State and region in its struggle to balance the water budget.

The research project closest to yielding substantially increased amounts of water is that which was started as our first OWRR-supported effort, namely, allotment project A-001-ARIZ, and substantially expanded as A-005-ARIZ.

Entitled, "The Development of Economic Water Harvest Systems for Increasing Water Supply," these innovative investigations have developed a system and procedures for harvesting additional water, coupled with an economical storage system. The system is centered on a machine, devised as a part of the research, called the Gravel Extracting Soil Shifter (GESS).

The system is able to harvest and store additional water at costs that are attractive in comparison with the cost of alternative municipal supplies. Experimental systems are being operated at the Water Resources Research Center, the Santa Rita Experimental Range, the Atterbury Experimental Watershed and for the U.S. Forest Service at Happyjack, Arizona. The promise is great for economic savings. Furthermore, it seems clear that the additional water which can be produced is limited only by the land area which can be used for this purpose. The system has also been demonstrated effectively as a practical technique for sealing water-storage areas to eliminate seepage losses.

Matching grant projects B-001-, B-002-, and B-004-ARIZ have made findings of considerable practical value. This research has produced a computerized analysis of trace chemical distributions for the entire State. A significant accompanying result of real importance was the development of a well-testing device which by means of an inflatable packer is capable of isolating the water-producing horizon of deep aquifers. As a result, it is possible to determine whether relatively narrow zones contribute substantial chemical contamination which if isolated could open up considerable water production previously assumed to be of an inferior quality. Alternatively this mechanism is of great value in the determination of lateral movement of contaminants in the ground water.

In the management area, particularly involving the systems methodology, research findings under allotment project A-020-ARIZ, "Economic Feasibility of Selective Adjustments in Use of Salvageable Waters in the Tucson Region," is ready for application. It was concluded that under either cost-minimizing or benefit-maximizing criteria, aggregate net benefits to the region could be improved by shifts of salvageable water use to more intensive crops in the agricultural sector and from agricultural uses toward increased recreational uses. Follow-up studies have been organized to demonstrate the mechanism for application of these findings which will provide a practical means for increasing the efficiency of water use for more than one purpose.

ARKANSAS

Results of the joint Arkansas-Oklahoma projects, B-001-ARK and B-006-OKLA, dealing with water resources planning of interstate waters, have been used by the Arkansas-Oklahoma Compact Committee in recommending apportionment of the water resources of these States.

CALIFORNIA

The Water Resources Center, located at the University of California at Los Angeles, administers a water research program extending to 9 of the major educational institutions of the Thousand-Mile Campus. Considering the fact that one person of every 10 in the United States resides in California, long an area dependent upon water importation to meet its needs, related problems are many and varied. Large sums of State money are being expended for water-related research. Even so, highly selective OWRR assistance has enabled practical application of research effort which otherwise could not have been carried out. A large reservoir of research competency is available throughout the State, not only at the many universities but among the hundreds of research-oriented private business firms and consulting organizations located there. Space permits only a small sample of 3 projects to illustrate the broad spectrum of accomplishments.

"Mechanics of Flow in Open Channel Systems," matching grant project B-037-CAL, deals with the complex problems involved in the design and operation of open-channel systems as well as water-flow measurement and control works in such important water supply features as the California Aqueduct. The research findings have already been employed in a practical way to help solve practical hydraulic problems in connection with the design, construction, and operational aspects of the Aqueduct and the Delta-Mendota Canal, an expensive and immensely important undertaking, and has resulted in appreciable savings in design requirements and hydraulic losses.

"Potential Usefulness of Antitranspirants for Increasing Water Use Efficiency of Plants," B-054-CAL, is concerned with the conservation of water which

otherwise escapes to the atmosphere in large amounts through the process of transpiration from vegetation. As water values increase with each passing year and competition for supplies becomes greater, the practical worth of saving large quantities of this commodity assumes tremendous importance, both money-wise and in terms of maintaining the well-being of our people. This research, being conducted by one of the Nation's foremost experts in the field, has developed exciting new knowledge which, in field tests, is providing successful avenues of approaching this long-standing problem. Some tests have shown a reduction of water losses by as much as 50 per cent. It is clear that this work has far-reaching practical usefulness. The principal investigator has been working with the State Division of Highways to reduce water losses from trees, shrubs and other vegetation planted along the roads for ornamental and soil-holding purposes.

Matching grant project B-061-CAL, "Optimization of Water Resources Development" began as an allotment project and has created a great deal of interest as it successfully moved forward into such highly pertinent problem areas as developing optimum operating policies and establishing guidelines for more efficient management of water in large integrated systems of reservoirs such as those which supply California's Central Valley Project. The State Department of Water Resources is applying the results of this research in connection with planning and operational problems of the California Aqueduct. The findings also are being used on the important San Luis Project. In addition, the research principles being pioneered and worked out here are pertinent to the solution of water development problems throughout the Nation and elsewhere in the world.

COLORADO

Long range plans and priorities for statewide water resource development are being formulated by the Colorado Water Conservation Board with the help of the U.S. Bureau of Reclamation. At the request of these agencies a study (B-059-COLO) was designed by the Colorado Natural Resources Center to measure the role of water in the total State economy. An economic input-output model will result which will become the foundation for a State water plan. Personnel of the State and Federal agencies are actively participating in every stage of the project, many of whom are getting valuable training in the process.

Colorado's Water Pollution Control Program is now moving from the standard-setting and stream classification stage into one of refinement in the surveillance and enforcement program along with greater attention to forward planning and operational efficiency. Project A-010-COLO was initiated jointly with the Colorado Water Pollution Control Commission to make an analytical review of current organization, procedures and policies. Useful recommendations have been made concerning: (a) technical staff reorganization for better management efficiency; (b) development of a long-range planning function within the staff; and (c) greater utilization of Federal funds to augment State funds in water pollution control, especially pertaining to planning. This critique from an external position gives timely guidance to the State agency as it moves ahead in its program development.

Ground transportation routes in the Intermountain West of necessity coincide with river and stream systems. Highway embankments often form one bank of a river channel, crossing and recrossing many times for topographical reasons. Water erosion of embankments and at bridge abutments is a serious problem for which solutions have been found in projects A-002-COLO and B-014-COLO. Through laboratory models, erosion control design procedures were developed and provided to highway engineers for use along the Colorado River and to the Denver Water Board for use in stabilizing banks of streams being used to transport water for the city of Denver.

Flood runoff from watersheds in the mountain region has been difficult to estimate because of lack of historical records and the extreme complexity of precipitation events. Public agencies such as the Highway Department, the Soil Conservation Service, and the Bureau of Reclamation, along with municipalities concerned with urban drainage, have requested research to improve flood flow estimates for use in design of highway drainage, dams, canal protection floodways, and other facilities. Projects A-002-COLO, B-005-COLO, B-030-COLO, and B-054-COLO have provided new analytical techniques and procedures for making better flood flow estimates in the mountain watersheds of Colorado.

Title II Project C-1195 (Morton W. Bittinger and Associates) is progressing satisfactorily towards the objectives of (1) identifying and classifying inter-

state aquifers, (2) studying in detail the interstate problems involved with the aquifer (Ogallala Formation) lying across the Colorado-Kansas State line, and (3) relating the results and conclusions from the study of the particular situation to similar interstate ground water problems.

CONNECTICUT

Under project A-010-CONN a new technique for the control of soil erosion has been developed and demonstrated. The technique, which involves the proper sizing and strategic placement of rock fill, is being used to direct highway water runoff without soil erosion and has, also, been used to obtain more efficient spillway operation of dams of several small lakes.

In April 1969, the Connecticut Water Resources Research Institute joined with the Cooperative Extension Service of the University of Connecticut and the Connecticut State Department of Health in conducting a conference on treating and conditioning municipal water supplies. This was one aspect of the Institute's goal to serve the public and to put to practical use results of pertinent research projects.

DELAWARE

Project A-003-DEL produced some extremely useful data for decision-making on current water supply and water-based recreation problems of the State. It also developed significant recommendations for improving the States legal and administrative structure for water resources which led to State reorganization of its administrative structure.

On the strength of their achievement on this and other projects, the University of Delaware Water Resources Center was called upon by the Delaware Water and Air Resources Commission to undertake research on the allocation of ground-water in the State of Delaware.

Project A-008-DEL produced very promising results for increasing the capacity and efficacy of sewage treatment plants by aeration of the untreated sewage in the pipelines leading to the treatment plants. This can result in very significant savings in the total capital costs involved in sewage treatment.

The University of Delaware has been tentatively selected to undertake a Title II study on improved water resources planning for the Christina River Basin, in and around Wilmington. Local, State and Regional officials are watching the study with keen interest.

FLORIDA

Professor Maloney's book on Florida water law (A-001-FLA) is one of the most comprehensive on State water law in the East and is providing the base for preparation of Florida's Water Use Act.

At the University of Florida a study (C-1082) is nearing completion on applied criteria for municipal water-rate structures. It will include a comprehensive treatment of municipal water systems in the U.S.—number, type, ownership, descriptions of facilities, extent and kind of State regulation, structure and administration of publicly-owned systems, practices and policies, water use patterns, water pricing theory, and finally, applied criteria for water rate structures. Cost data of a well-regulated utility are analyzed to demonstrate effects of different rate basis on rate structures. Water utility executives and policy-making officials should find this report valuable for use in examining and evaluating their own policies and practices.

A Title II project concerned with water cycles, water resources planning and urban development in the Rookery Bay, Florida, area, although only underway for a few months, already has had beneficial effects. As a result of a meeting of representatives of the Conservation Foundation and the University of Miami—the two institutions conducting the study—with other interested parties and a development corporation executive, conflicts of proposed developments with project objectives were pointed out. The development plan was changed to ensure maintenance of a naturally-vegetated shoreline and existing flow paths for tidal exchange of water into and out of Rookery Bay.

GEORGIA

In terms of number of people and industrial plants served and quantity and quality of water available, the Atlantic Coastal Plain Aquifer is among the world's most important artesian aquifers. A Georgia study (A-006-GA) seeks a detailed understanding of its physical character for constructive conservation of this resource.

Results were applied to a practical public problem of mineral leasing and water supply in the Savannah, Georgia, area. A committee was appointed to evaluate the feasibility and effect of phosphate mining in the coastal area near Savannah. Priority was given by the committee to the effect of mining operations on the Coastal Plain aquifer because of possibility of breaching overlying impermeable clays confining the aquifer. On the basis of information obtained in this research project, the hydrology of the aquifer indicates any breach of overlying impermeable clays would allow salt water to enter the aquifer and pollute Savannah wells. Had it not been for this research project, this information would not have been available.

Several Georgia projects have responded to widespread interest in urban water resources. Six hundred copies of a report on the relationship between metropolitan planning and river basin planning (B-009-GA) have been distributed and a second printing is under consideration. Most metropolitan areas were found to be handicapped because no one metropolitan government is authorized to represent the area for negotiation with river basin interests; and usually there is no river basin management agency with whom metropolitan representatives could negotiate. Significant changes that could be made in local, State, and Federal water planning procedures are suggested which would give more and better control to metropolitan areas over development and use of their water resources.

HAWAII

Despite its lush vegetation, usually beautiful weather and high precipitation rates in the rainy areas, the State is not without numerous and severe water-related problems. Also, owing to its island location far from the mainland, the University of Hawaii has had to build a water-research competency not previously available. Furthermore, as knowledge has increased, its painstaking review, analysis and summarization have become increasingly vital to the success of research in solving water problems.

One such important allotment project is A-024-HI, "Inventory of Published Information on Hawaiian Water Resources." The need for this type of material has been acute and its availability as a result of this carefully organized research has resulted in widespread benefits to technical workers in a number of professional disciplines. The result has been a comprehensive, annotated and indexed bibliography, covering all phases of water resources in Hawaii. The pay-off will be in real dollar-economies as well as the reduction in amount of duplicative research efforts, the avoidance of erroneous assumptions on original hydrologic conditions and trends. This amounts to tremendous savings of time for research personnel who otherwise would have had to devote their attention to seeking out the information from unknown sources.

Matching grant project B-011-HI entitled, "Geophysical Exploration for Hawaiian Ground Water" and earlier associated work has produced a significant increase in practical knowledge about the extremely important water-bearing basaltic lava flows. Geologic and hydrologic conditions in these areas are so greatly different from continental circumstances that standard methods are not directly applicable. A number of highly complex techniques have been analyzed in detail with encouraging success in developing new and modified procedures not heretofore available. These are now being put to practical use in water-deficient areas on ground-water surveys for both State and private enterprise.

An unusual and practical research effort is being conducted by General Electric TEMPO as a Title II project. It is entitled "Mathematical Modeling of Fresh-Water Aquifers Having Salt Water Bottoms." It is concerned with the analysis of sea-water intrusion into the Honolulu aquifer.

Water for Honolulu has been supplied principally from wells. Since the first artesian water flowed in 1879, from the well called by the Hawaiians "Wai'ani'ani" or "Crystal Waters," land which has been useless except as sparse pasturage was turned into a fertile paradise. Unfortunately, the early settlers failed to realize that the clear, sparkling water flowing in such abundance from the many wells that they drilled actually floated on salt water permeating the lava that forms the island. As the wells were allowed to flow unchecked, with much of the water wasted to the ocean, the salt water rose into many of the wells, causing their abandonment.

Although today's Board of Water Supply of the City and County of Honolulu has corrected the old, wasteful practices, the Board's planners estimate that rapidly-increasing demands may cause groundwater on Oahu to approach the limits of development between the years 1990 and 2000. Needless to say, the Board

hopes to postpone as long as possible turning to the use of desalted or reclaimed water at a cost of 30 to 40 cents or more per thousand gallons when groundwater can be pumped at a cost of less than 5 cents per thousand gallons.

General Electric TEMPO has been examining the practicability of applying modern mathematical techniques, including the use of large digital computers, to predict changes in salinity that would occur under various patterns of pumping from old and new wells. It is considered that even in the most advanced techniques now in use for calculating the flow of groundwater cannot handle the problem of predicting salinity. However, extension of the available techniques and development of new ones promises great potential payoff. The Board of Water Supply was unable to support the research cost. Therefore, because the results of a successful research project would be applicable to many coastal and oceanic highland aquifers where sea water intrusion is the severe problem, the Office of Water Resources Research agreed in 1969 to join in support of a two-year research project.

Although the initial research is not yet finished, first steps have been taken toward developing advanced mathematical techniques. An intensive study of one critical area of the Honolulu aquifer has been carried out. This work has provided a better understanding than ever before of the highly complex transition zone between fresh and salt water. The research thus is being kept closely related to the real-world problem of managing the Honolulu aquifer. Valuable guidance has already been provided for operating existing wells, designing new ones, and obtaining data vital to the understanding of the vital water resource upon which Honolulu's economy is based. This research has demonstrated the capability to provide practical, immediately-applicable methods by which this important island community can prolong the life of existing wells, design and drill new ones at the lowest cost, and continue to provide high-quality water to more than 500,000 customers as well as to the thousands of tourists who annually visit the City and County of Honolulu.

IDAHO

To determine the most productive use of irrigation water from ground water sources in Idaho, an investigation (B-006-IDA) has been underway since 1967 to establish relationships between pumping lift and the price farmers can afford to pay for water. It has been shown that in Cassia County, Idaho, under average conditions at an irrigation efficiency of 55 percent—water can be economically lifted from a maximum depth of 389 feet for a 200-acre farm; from 679 feet for a 400-acre farm; and from 767 for a 600-acre farm. The investigation is being extended to encompass a greater portion of the state. However, results are already being used by the State Reclamation Engineer to establish reasonable levels of pumping lift in administration of state ground water laws.

With passage of P.L. 90-542, The Wild and Scenic Rivers Act, the Nation has shown its concern about unrestricted river development that provides little or no attention to maintenance of a quality environment. To provide planners with a tool for use in future planning involving undeveloped river stretches, the State of Idaho is conducting an investigation (B-014-IDA) to develop a methodology for evaluation of wild and scenic rivers. This study is expected to: identify and estimate present and future quantities and values of natural resources in selected study areas; describe and quantify as far as possible benefits derived from esthetic values and personal enrichment from river areas; develop a model for evaluation of alternative uses of related resources of the areas and, present recommendations for alternative use and development levels for wild river areas.

ILLINOIS

Research on stream channels characteristics has provided an expedient and simple means of estimating the average depth, width, cross-sectional area, velocity, and discharge at any particular location on a stream. By means of graphs or equations, these data find practical use in evaluating pollution conditions for projected waste discharges. These channel characteristics will also have great value in flood control, water supply development, and other aspects of water resources planning.

A report on intergovernmental relationships in the administration of water resources is finding use by water resources agencies throughout the country. This exhaustive study recommends legislation to improve administrative and institutional structure.

Practical methods are being designed to apply stochastic non-linear mathematical models to actual water problems in Illinois river basins.

INDIANA

A recently completed study disclosed that critical shortages of manpower in the water resources related occupations exist in Indiana. As a result, a new associate degree curriculum has been developed for the training of technicians. Significantly, this program has the support and acceptance of industry and others seeking the employment of such personnel.

Research recently initiated using systems analysis techniques for water resources planning and management practices is expected to improve utilization of water in the Wabash River basin.

Recognizing that many reservoirs are being constructed in areas with high siltation rates, researchers are providing planners with tools and information for predicting soil stability from watershed characteristics.

IOWA

An important interdisciplinary study (A-001-IA) on physical and economic factors associated with the establishment of stream water quality standards has been completed for Iowa. The ability of streams to assimilate organic wastes was determined on a state-wide basis. Results will be useful to planners and legislators in determining physical, economic, and legislative requirements to effectively maintain water quality standards.

Results from an Iowa study (A-021-IA) using effluent from an anaerobic swine lagoon pointed up the value of soil in reducing pollution. Effluent was applied as irrigation water on cropland containing a pipe drainage system to maintain favorable soil moisture conditions. Reduction in COD was excellent with a 97% average removal. Removal of nitrogen averaged 80%. Chlorides were not significantly reduced by any treatments. All treatments proved very effective in removal of phosphates, each removing 99% or more of those applied. Evidence indicates the methods developed can provide an effective means of utilizing the effluent for a useful purpose and, at the same time, reducing water pollution.

KANSAS

Project A-028-KAN has developed a new type of disinfectant utilizing a resin-halide ion for use with water supplies, which does not add harmful or irritating substances to the water so treated. Total kills were observed in water containing bacteria in concentrations up to 10^6 - 10^9 organisms per milliliter yet the actual concentration of the disinfectant in the water was undetectable at levels less than 50 parts per billion. The disinfectant has not been released for general use but is expected to find wide use in disinfection of potable water supplies, in hospitals, and in industrial processes.

Projects A-008-KAN, A-011-KAN, A-015-KAN, and A-026-KAN pertaining to feedlot pollution in Kansas have resulted in legislation requiring approved detention ponds and disposal procedures for feedlot effluent. In an integrated approach to the feedlot waste problem, the Institute has characterized the nature and amount of feedlot runoff, the effect of feedlot pollution on the ecology, and repopulation trends of fish in polluted areas, and has studied improved methods of feedlot waste disposal including the oxydation ditch for swine waste and biological treatment of beef animal waste. This work has led to a large-scale demonstration project in feedlot waste disposal at a feedlot with capacity for 20,000 cattle. (Not funded by OWRR.)

A program to determine potential water supply gains that would be realized in Kansas if precipitation augmentation programs were operational yet subject to practical constraints has been computerized through project A-023-KAN. This project has been of direct interest to the National Water Commission which is utilizing information gained in this study for preparation of a state-of-the-art report on the overall subject of precipitation augmentation.

Research supported by the Institute in projects A-005-KAN and B-010-KAN has demonstrated the accuracy and utility of micrometeorological methods in measuring evapotranspiration. This capability makes possible the study of numerous management systems involving soil-water-atmosphere relationships designed to increase water use efficiency and to reduce evapotranspiration. Because of the importance of the problem and attention focused by institute

research, Kansas has established an evapotranspiration laboratory which is cooperating closely with the Institute.

A digital computer model which stimulates unsaturated ground water flow in the presence of evapotranspiration losses has been developed in project B-018-KAN. The model has direct application to problems such as: irrigation system design and scheduling; aquifer recharge; prediction of precipitation runoff; prediction of evapotranspiration; and development of basin hydrology simulators. An early version of the model has been used by the U.S. Geological Survey in a ground water recharge study in Western Kansas.

Personnel from the Federal Water Quality Administration have shown strong interest in modeling and design techniques developed during studies of the aeration phase of waste treatment processes in projects A-029-KAN and A-031-KAN. In addition, it has been demonstrated that lime-soda ash sludge (produced in many water treatment plants) has value in treating municipal waste water. Adoption of this practice would assist in removing undesirable constituents from waste water and eliminate the present practice of disposing the water treatment sludge directly or indirectly in the streams.

Title II project C-1649 is successfully applying modern high speed computer technology and mathematical methodology to the modeling and optimization of water resources systems, including multiple reservoirs with multiple purposes, water resources systems under unsteady state conditions, stochastic modeling and optimization, and modeling and optimization of the capacities of interconnecting streams.

KENTUCKY

The economic impact of flood control reservoirs has been under continuing study in project A-006-KY since 1966. Major Federal water planning agencies have shown special interest in reports emanating from this study. In his 1970 annual report, the principal investigator stated that the Tennessee Valley Authority is making a serious effort to apply project research findings in developing an improved reservoir operation scheme. Another Kentucky study emphasizes need for social science research in reservoir construction programs involving social changes.

LOUISIANA

The Louisiana Institute has completed an important multidisciplinary study involving several annual allotment and matching grant projects. This study developed a feasible means of halting the threat to the ground-water supply of Baton Rouge caused by movement of saline water to the area of withdrawal for city and industrial use. City-Parish Council members are giving serious consideration to the project recommendations which will ensure a permanent supply of fresh water, reduce expected land submergence and provide a good opportunity to develop a new recreational park as a by-product of the study.

MAINE

In project A-007-ME studies were conducted to determine the effect of salt applications to de-ice highways on the sodium and chloride levels in (1) streams and rivers, (2) private water supplies contiguous to highways, and (3) soils bordering highways.

Analyses of seven rivers in Maine over a two year period indicate that sodium and chloride concentrations are not affected by highway salting.

Analyses of wells along Maine highways indicate that levels of sodium and chloride much higher than normal and that 25 percent of the wells were unfit for potable supplies because they contained in excess of 250 ppm of chloride.

Sodium saturation along some highways approached 15% and chloride levels in the soil-water system produced the equivalent of an alkali condition.

State highway officials have responded to the results of the project by providing additional funds to further inquiry into the effects of highway salting.

Under project B-003-ME the feasibility of managing a river system guided by continuous monitoring of the chemical profile has been demonstrated. Four buoy systems are now operational for scanning critical positions along the chemical profile. The stage has been set to allow extrapolation of these results to other rivers by the development of a control system which is independent of particular details of the model. Ultimately, it is believed that the system will be capable of programming and controlling effluent discharges, streamflow, impoundment releases, instream aerators, and so forth.

MARYLAND

In Maryland, thermal pollution from electric generating plants has been one major area of research by the Water Resources Research Center and its affiliated Natural Resources Institute. Projects A-002-MD, A-011-MD and C-1401 have produced incisive results in documenting the harmful effects of thermal pollution on shellfish and finfish as well as the biota in their food chain. Results of these studies were used in establishing thermal loading limits in the official Maryland Water Quality Standards, prepared in accord with the requirements of the Water Quality Act of 1965. These studies also attracted national and international attention, with the Institute selected as the site for a Thermal Workshop, attended by approximately 200 scientists from the U.S. and foreign countries.

Poultry raising and processing are major industries of Maryland's Eastern Shore, providing the subject matter for Project A-006-MD. This project demonstrated the potentials for handling the waste effluent from poultry processing plants by spraying it on grassy fields, at a fraction of the costs of previous waste disposal methods.

Under several related Title II projects, Hittman Associates of Columbia, Maryland developed a system for forecasting and evaluating municipal water requirements. This system proved quite popular with both local and State water officials and planners and has been successfully applied in several cities in Maryland and Louisiana. It is currently being used by a consulting firm for a Corps of Engineers' study of water demands for the states of Louisiana, Arkansas, and Tennessee.

MASSACHUSETTS

Project A-001-MASS is providing the basis for a classification of all lakes and ponds in Massachusetts which will represent the most complete and valuable data base for lakes yet developed in the State.

Project A-022-MASS, a short intensive study of attitudes of decisionmakers in the Springfield metropolitan area in regard to water pollution control aided in defining the many diverse and often hidden factors that go into the shaping of attitudes and traditions and which must be taken into account when developing planning goals.

Project A-019-MASS demonstrated the hazard of using chlorinated hydrocarbon pesticides on land when drainage or wind could carry this toxic material to breeding areas of valuable marine aquatic forms.

Project A-055-MASS provided a technique for water conservation that is now being used in cranberry producing areas of Cape Cod.

Water and the Cities: Contemporary Urban Water Resource and Related Land Planning (C-1469). Abt Associates, Inc.

In this research effort, ten case studies of urban water resource and related-land planning were undertaken, based on interviews with urban planners, citizens' groups and engineering consultants, and on current planning documents. Water quality management, waterfront land use, water-related recreation and open space, and metropolitan growth were identified as critical problem areas in planning the interactions of urban activity and the water resource.

Metropolitan growth has posed serious problems of coordination and control in the planning of service extensions, flood control and drainage, and water quality management. Though jurisdictional fragmentation, overlapping and competition will continue to constrain metropolitan water resources planning, urban planners can by their policy of service extensions and development controls exercise some control over growth patterns. The "limited access sewer line" and "blue-green" drainage planning are potentially valuable methods for controlling metropolitan growth and waterfront land use, but their success is largely dependent on their integration into broader regional plans.

The research results are documented in the report "Water and the Cities—Contemporary Urban Water Resource and Related Land Planning" which may be obtained from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia.

Research on Data and Analytical Systems for Preparing National Water Assessment (C-1415). A. D. Little, Inc.

Basic physical water parameters for a national assessment data structure and system have been identified, classified, and arranged consistent with relationships useful in interpreting water supply and requirements and quality situations on a

nation-wide geographic basis. This data structure or system is to provide the basis for water accounting and reporting of water situations in periodic Water Resources Council national assessments by river basin subregions, major drainage basins, and the nation as a whole.

Simultaneously, a physical evaluation model, or assessment analytical system is being selected from among several alternative modeling techniques that may prove useful in describing and reporting regional water situations in terms of supply-demand, water quality standards and extreme event situations. Consideration has been given to the coupling and interaction of both data and analytic structure into a dual system.

MICHIGAN

Data from several allotment projects pointed out that streams from Michigan's lower peninsula contributed more than 11,000 pounds of phosphorus per day to Lake Michigan. These research findings influenced the decision by the State regulatory authority to require 80 percent removal of phosphorus from municipal sewage effluent in the Lake Michigan drainage basin by 1972.

Research on recovery and identification of viruses in dilute suspension revealed that almost all viruses suspended in river water can be recovered using concentrations of 50 parts per million of flocculant.

A study of urban water policies and decisionmaking in the Detroit metropolitan area showed the importance that must be assigned to political and institutional factors. These factors tend to restrict development of a regional system more so than do economic or social forces or projected business, industrial, and residential demands.

MINNESOTA

Research results from project (A-021-MINN) provided basic information for legislative action on reorganization of State water resources agencies in Minnesota which is expected to greatly improve water resources administration.

Open water distribution and abundance of net plankton as an index of eutrophication of Lake Superior was studied in project (A-011-MINN). A continuous plankton recorder was used which provided a means for assessing effects of pollution and ensuing eutrophication in a manner heretofore unobtainable. Results are proving useful in water quality decisions and the data provides valuable reference levels for comparing future trends of eutrophication, productivity and water quality of the Great Lakes.

MISSISSIPPI

Results of project A-023-MISS, dealing with the mechanism of stream meandering, and including study of velocity patterns, sediment movements and variations in meander geometry, were reported to be of immediate practical use to engineers concerned with river regulation, bank protection and channel improvement.

MISSOURI

In the "New Lead Belt" of Southeastern Missouri, research is underway to attempt to develop methodologies for maintaining the present high quality of streams as mining activities proceed. Suggestions stemming from the study (A-021-MO and B-021-MO) for future stream pollution abatement include; (1) separation of mine discharge water from milling wastewater; (2) increased detention time for milling wastewater; and (3) baffling or below-surface withdrawal of water from settling ponds to retain surface film of milling reagents. There has been close cooperation between mining industry and research workers who, together, are testing the effectiveness of baffles and other measures in pollution control. Other Missouri studies are indicating that rural water districts, as they are being developed in that State, are providing ample supplies of pure water in rural areas and may be helping reverse the movement of people from country to cities.

MONTANA

Effects of DDT on the ecology of a water-dominated environment is being investigated in the Flathead Lake area of western Montana (A-016-MONT). DDT-based insecticides are used extensively throughout the area for control of insect pests of cherries. Results to date show that disturbing quantities of DDT are present in fish and wildlife species of the area and some evidence has

been found showing lethal levels of contamination have already been reached in some species. For example, the osprey population appears to be declining in the Flathead Lake area because of DDT contamination. This contention is supported by presence of from 37 to 59 ppm of DDT residue in a number of addled osprey eggs containing well-developed, but dead, embryos. Data also indicate that high enough levels of DDT may be present in migrating kokanee salmon to affect eagles in the area that utilize spent salmon for food.

NEBRASKA

Project A-003-NEB successfully completed research on an irrigation water conservation system using a parallel steep back slope terrace system with underground tiled waterways. This system greatly reduces water and soil losses on sloping lands while being compatible with modern farming systems using high speed equipment. This conservation system also has the potential of reducing flood hazards by reducing the peak rate of runoff from agricultural watersheds and reducing the amount of sediment carried in waters downstream. Results of this research have stimulated interest in improved conservation systems and methods over the entire State of Nebraska. Steep back slope terraces and tiled waterways are being installed in a number of locations. Computerized methods developed by the project are being used to design parallel terrace systems allowing the installation of improved terraces with a great reduction of technical input time. This project clearly illustrates that minimal time lag between research results and practical application is possible.

The objectives of projects B-007-NEB and A-013-NEB are to analyze the statutes, court decisions, and administrative procedures governing the laws of ground waters and streams in Nebraska and make recommendations for change. Consideration is being given to modifying the law in Nebraska on riparian rights, transbasin diversions, conflicts between surface and ground-water users, use preferences, and supplying water to industry located outside municipal boundaries. The study will also affect the legal rules governing irrigation and reclamation districts. The results of this research are being put to direct practical use by administrators and legislators in formulating the Nebraska State Water Plan. These projects will be the primary basis for future water rights legislation in the State.

Research under project A-017-NEB at the hydrometeorology research facility, established at Mead, Nebraska, with support from OWRR, has determined the quantities of water which are consumed by certain crops in the climate of the Eastern Great Plains. These amounts are greater than has been thought because of strong influxes of hot and dry air from other regions which create a very strong evaporational demand. Under weather conditions which occur frequently in spring and early summer as much as one-half inch of water is consumed each day. Instrumental and mathematical methods have been tested at this station against standard measurements of evaporation (lysimeters). These methods may now be used to evaluate regional water needs and also to provide guidance on a district or farm scale as to when and how much to irrigate. Research is also underway to develop methods for making agricultural water use more efficient. Good production today is ten pounds of plant material with a consumption of about 1000 gallons of water. It is theoretically possible to achieve this production with far less water. Methods to increase water use efficiency which warrant further research include the applications of reflectant materials to plants, the use of windbrakes and the alteration of crop geometry and spacing—all to maximize growth while reducing water use.

NEVADA

The Center for Water Resources Research of the Desert Research Institute has devoted a great deal of attention to seeking practical solutions for State of Nevada water problems. Three of the numerous research projects which illustrate this fact are described briefly here.

"Chemical and Flow Regimes of Great Basin Springs," allotment project A-022-NEV, deals with springs as a major water resource of the Great Basin. Many communities and enterprises are wholly or partly dependent on this source of water. This project examines and critically analyzes the variability, within the year and from year-to-year, of flow and quality of water of typical springs. Results are related to geology, hydrology, precipitation and air temperature. From this information, methods have been developed for determining long-term

limits within which flow and quality may vary and for predicting yearly flow and quality based on previous winter snowpack. The methods are applicable to any spring.

Solid practical results have already been achieved. Using the data and methods developed by this research, users at one group of springs, namely, Martis Creek Springs, have established long-term, assured yield and quality. This has permitted them to proceed on a rational basis with a major development which will have important favorable consequences to the local economy. In another case, the research records and predictive approach have been used in evaluating the availability and quality of water at the important fish hatchery in the Ruby Marsh area.

The research methods employed parallel on a smaller scale the significant river basin studies for allocation of water and economic development. They are based on knowledge and prediction of the variable yield and quality of the water resource and have widespread application throughout the State.

Research on "Analog Computer for Hydrologic Research" was made possible by support provided under allotment project A-003-NEV and matching grant project B-005-NEV. The first electric analog model of the Las Vegas Valley groundwater basin was developed and used to determine the effect of selected pattern of development of groundwater and as a tool to assist State administrative agencies in the determination of water availability in an extremely short water area. Its utilization by the Nevada State Engineer in approving or denying applications for underground waters is illustrative of the practical usefulness of this research-developed tool.

A related analog was also used for a study to decide upon an operational plan to obtain maximum annual power production from Grand Canyon and Hoover Powerplants. This study was useful to the Colorado River Commission of Nevada in its analysis of the operation of the two plants.

The same analog was utilized on the Corps of Engineers upstream reservoir study on the Humboldt River. The study revealed that the downstream users would not be adversely affected by the upstream storage. It was made for the Elko Fair and Recreation Board to assist them in making the correct decision and in obtaining the necessary support for construction of a much needed facility.

"Application of Simulation Theory Water to Resources Planning and Management" was supported under Title II projects C-1105 and C-1919. The purpose of this study was to develop a method for analyzing and evaluating various types of management decisions affecting the optimal operation of a complex river system. The Truckee-Carson River System was chosen as a field laboratory for developing, testing, and evaluating new planning under a realistic situation. A method was worked out for combining into a model the system hydrology, streamflow synthesis, and an optimization technique. State and federal agencies are currently involved in a resolution of serious water management problems of the Truckee-Carson River System. The management model developed under this project has drawn wide interest from all concerned agencies in the direct application of this model which will lead to important practical changes in water management practices.

The Pyramid Lake Task Force was appointed by the Governors of Nevada and California and the Secretary of the Interior. The problem is to find a solution to the problems facing the Pyramid Lake Indian Tribe. The Task Force, investigating the existing water supply which is insufficient to stabilize Pyramid Lake, has shown a special interest in the water management research model. Members of the Task Force have observed the capabilities of the model and intend to apply this research tool to evaluate and compare various management policies for Lake Tahoe and other upstream reservoirs as well as the effects of water-use change on the water supply available to Pyramid Lake.

NEW MEXICO

Project B-015-NMEX is rapidly completing irrigability and soils classification reports and maps for each county and for the State. This work is basic to an overall state water plan now in process of development by the State Engineer's office in cooperation with several State and Federal agencies.

Project B-012-NMEX resulted in a report entitled "Patterns of Policymaking in Water Development—A Case Study of the Colorado Basin Bill." This political science report is a study of the political processes connected with the development of the Colorado River Basin Act of 1968 with special emphasis on the New Mexico role in shaping this policy.

Project A-008-NMEX, "Hydrogeology of the lower Rio Grande Valley and Adjacent Intermountane Areas of New Mexico" developed a report on the hydrology of the Mesilla Valley and the surrounding area. The report is basic to the overall understanding of the water supplies for this area where rapid population increases are occurring. As can be expected, information on the water supply is vital to the orderly development of this area.

Project A-013-NMEX is contributing to nitrogen removal from natural waters. The procedure developed is the following: a gravel column is completely submerged and the water is forced through the column from bottom to top. The nitrogen content is reduced from 30 milligrams per liter to 2 milligrams per liter by reducing the nitrates to nitrogen gas. This system is promising in waste water treatment and fish hatcheries where in many cases the supply of high quality water is quite limited because this system would permit recycling.

Title II Projects C-1361 and C-1630 have successfully developed information which will be used in soil and water management techniques for salinity control. These techniques are needed to control the soil salinity without increasing the pollution of the ground water supplies and for maximum efficiency of water use. Management techniques resulting from this research effort are needed not only in New Mexico but in most of the Southwest.

NEW YORK

At the Cornell Water Resources Center, studies of the supply of water available in New York State and the Northeast in relation to present and future water demands were conducted. Part of the results of those studies have been used by the Corps of Engineers in planning for future water needs in the Northeast (A-001-NY), by the New York State Agricultural Resources Commission (B-002-NY), and by the program of the New York State Water Resources Commission and other agencies (B-014-NY).

Under projects (A-010-NY) and (C-1640) procedures have been developed involving mathematical models and computer techniques for determining alternative policies to achieve various goals under conditions where several purposes have to be served. This program has led to a joint effort between Cornell and Harvard University to develop programming models for the Delaware River. A spin-off from this program is a report "Stochastic Methods for Analyzing River Basin Systems" which has been adopted as a text by numerous Universities offering courses in the water resources field.

Systematic Study and Development of Long-Range Programs of Urban Water Resources Research (C-1125).

The American Society of Civil Engineers is assisting the Office of Water Resources Research in outlining and developing a national program of urban water resources research. The objective of the research is to provide guidelines for initiating and expanding a program of long-range studies in urban water problems.

A final report for the first project year has been published comprising close to 700 pages. Among the subjects covered in the report are:

Two prefeasibility studies to determine the possible effectiveness cost and time requirements for a comprehensive systems engineering analysis of all aspects of urban water.

Two prefeasibility studies to determine the possible effectiveness, cost and time requirements for a general economic analysis of cost and pricing parameters of all aspects of urban water.

A state-of-the-art study of mathematical models and related simulation methods potentially usable for analyzing urban rainfall-runoff-quality processes.

Requirements for the assessment of drainage damage and alternatives to direct storm water runoff control, such as the utilization of research basins or other storage schemes.

Discussion of political, economic, legal and social problems related to urban water management.

The report "urban Water Resources Research" may be obtained from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia 22151.

The Use of Systems Analysis in the Development of Water Resources Management Plans for New York State (C-1126). New York State Conservation Department, Division of Water Resources.

The research project is being carried out in concert with a State planning study in the Oswego River Basin. At this point in time, development of two simulation models has been nearly completed. One, which deals with the flow of water during flood periods, computes lake levels, rates of flow in major streams, and stages of major streams on short time intervals. The second model routes, or budgets, monthly flows and operates the system of lakes to meet needs at key points for uses such as navigation, water supply, waste assimilation, irrigation, recreation, fish and wildlife enhancement, and power.

Also, an optimization model utilizing dynamic programming has been developed and is being tested. Hopefully, it will be able to point out the most promising means of operating the system from the infinite number of possibilities.

The models have been used as the framework for the development of ancillary data and have aided the Oswego study in the regard. In the plan formulation process, the models will provide the analytical tools for studying issues of basin-wide impact.

Benefits from Integrated Water Management in Urban Areas—The Case of the New York Metropolitan Region (C-1114). Barnard College, Columbia University, New York, New York.

The extended record drought, 1962-1966, experienced by the New York Metropolitan Region and the Northeastern United States raised the following question which formed the focus of this study—given the existing managerial and engineering structures of the water systems of the NYMR would an alternative network arrangement have distributed the available water supply more efficiently? In order to test the hypothesis the behavior during a six year period of the individual water agencies in the NYMR were examined. Three models were structured: (1) an input-output flow model that traced water movement and permitted the calculation of transfer coefficients, (2) a linear programming model that employed the transfer coefficients to stipulate water exchanges among the agencies, and (3) a linear programming model that used flexible transfer coefficients and a weighted objective function that directed any surplus to specified agencies.

The input-out model revealed that the system exhibited a high degree of stability throughout the drought because transfer coefficients did not change much. Simulations using fixed transfer coefficients showed the network to be vulnerable to stress. The use of flexible transfer coefficients, new links, or expanded links in the second linear programming model relieved stress by shipping water to deficit agencies.

The simulation models defined the state of the water system as the linear programming solutions were optimal. Hence, the answer to the initial query is yes; the real world system operated suboptimally.

Copies of the report describing the results of this research are available from the Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia 22151. The report is entitled "Benefits from Integrated Water Management in Urban Areas—The Case of the New York Metropolitan Region" and is identified by the clearinghouse No. PB 184 019.

NORTH CAROLINA

A recent survey of 105 large multipurpose reservoirs in the Southeast conducted under a matching grant revealed that these reservoirs have attracted over 60,000 homes and summer cottages, 1,000 commercial establishments, and are experiencing an annual visitation of over 100 million persons. Well over half of this development has occurred since 1960. This rapid exploitation is occurring in a governmental vacuum. Under ten percent of the reservoirs surveyed had land use plans, zoning, or subdivision regulations to guide the development of adjacent non-public land. Even rarer in Southeastern reservoir areas are such public services as water and sewer connections, garbage collection, and adequate police and fire protection.

When completed, this study will recommend various mixes of land acquisition and land management policies to optimize the quality and public usefulness of lands adjacent to reservoirs. The Corps of Engineers, TVA and private power companies have indicated considerable interest in the results of this study.

"The Uptake and Concentration of Fluoride by the Blue Crab, *Callinectes sapidus*," is the title of a North Carolina project (A-030-NC). The study has contributed further information on ecological effects of increased fluoride levels in the Pamlico Estuary as a result of phosphate mining. Special attention was given to fluoride accumulation in crab tissues and to the effect of fluoride on crab growth. At 20 ppm fluoride in the water, the growth increment of crabs decreased 4.5 percent per molt. The cumulative effect over a 20-molt life cycle of a typical blue crab would be a 52 percent reduction in final average size. Fluoride concentrations higher than 20 ppm had an even greater inhibitory effect on growth. Exposure of crabs to water with 200 and 400 ppm fluoride for extended periods showed crab muscle tissue can accumulate enough fluoride to present a potential public health problem.

A dramatic example of the importance of the annual allotment in generating needed research activity was reported recently by the North Carolina Water Resources Research Institute. One of early efforts was to encourage a research program dealing with more efficient use of water by industry and the in-plant control of wastes. In working with food processing industries the problem was one of getting together a group, finding someone to provide leadership, and providing initial financial support during project development stage. North Carolina State University provided an initial \$6400 and an additional \$2500 in Federal funds was provided from the FY 1969 annual allotment.

Because of its importance to water pollution control, the poultry processing industry was selected for the initial effort. Industrial resistance was high and a prolonged period of plant visits and consultation with industry executives was involved. This finally developed into a full-fledged demonstration project, however, which was funded by FWQA in 1969.

NORTH DAKOTA

In North Dakota the economic impact of construction of the Garrison Diversion Irrigation project was studied (B-002-NDAK). The initial phase of the project will permit irrigation of 250,000 acres. Ultimately, 1,000,000 acres are scheduled for irrigation when the project is completed. Results indicate that the expected \$12,979,000 annual increase in agricultural income resulting from the initial 250,000 acres would result in an additional income of \$28,184,000 (multiplier effect) in the local economy. These results have been used extensively by State and Federal agencies to show the impact of irrigation development in North Dakota on the State and national economies.

Effects of application of sugar refining lagoon effluents on agricultural production and biological, physical and chemical properties of Fargo clay are being studied in North Dakota (A-019-NDAK). Initial results on alfalfa, sudan grass and soybeans indicate no significant difference in crop yield from plants irrigated with effluent compared to those with water. Although preliminary, results are encouraging that this method will be a practical means of effectively utilizing sugar refining lagoon effluents without polluting surface or ground water.

An on-going research project (B-007-NDAK) is designed to evaluate methods of irrigation for the purpose of identifying design or designs which maximize returns to resources in a subhumid climate. Results will provide basic information needed to estimate physical adequacy of a given design as well as associated economic evaluation.

OHIO

A study of public investment criteria for water oriented recreation in the Lake Erie basin has considered the practical implications and utilization of various funding measures. These include pollution taxes, user charges, and other revenue sources.

Findings from research projects on acid mine drainage are being used in seeking practical and more optimum remedial measures.

Of significant potential use is a continuing study relating onshore economic activity of the western basin of Lake Erie to pollution inputs.

OKLAHOMA

Project A-003-OKLA designed and tested an improved water supply system which will produce ample domestic water from small farm ponds.

Project A-010-OKLA produced a technical report entitled "An Evaluation of Recent Approaches for the Design of Biological Waste Treatment" which has been widely distributed to planners and engineers throughout the United States.

Projects A-004-OKLA and A-015-OKLA, have resulted in significant improvement in the understanding of principles and techniques of furrow irrigation water distribution.

Projects A-002-OKLA, B-008-OKLA, B-017-OKLA, and A-018-OKLA have greatly benefited the oil refining industry in their continuing effort toward the improvement of the quality of their industrial effluent.

Project B-006-OKLA and a related project of the University of Arkansas (Project B-001-ARK) have jointly produced information which is serving as a basic data source for the proposed Oklahoma-Arkansas Interstate Compact on distribution of the waters of the Arkansas river.

Project B-012-OKLA related to research on row crop spacing and orientation has indicated that peanut yield may be increased by as much as 75 percent with a net reduction in water requirement per acre.

Title II Project C-1023 (University of Oklahoma) developed a usable fully computerized mathematical model designed to forecast and/or predict future municipal and industrial water requirements.

OREGON

As a result of research on project B-001-ORE, it is shown that the application of a thin layer of petroleum "mulch" over cultivated soil slightly increases the soil temperature but also considerably reduces the loss of soil moisture through evaporation. Thus by maintaining a more humid environment at the "seed level" in the soil germination conditions are significantly improved.

Work on project B-009-ORE provides a strong indication that heated water (thermal pollution) from nuclear power plants can be beneficially utilized in agriculture by stimulating plant growth and extending the growing season in cold climates. With the growing demand for irrigation water in the Northwest, the findings of this project could provide a significant breakthrough in cold weather irrigation plus a means of dissipating thermal pollution.

PENNSYLVANIA

Project A-002-PA produced a means of neutralizing acid mine streams through the construction of crushed limestone barriers. This process has proved so successful that the State of Pennsylvania is now undertaking a major program of rehabilitating its more than 40,000 miles of streams polluted by acid mine water through the use of crushed limestone barriers. State officials feel that this project alone has more than repaid the total 5-years investment in studies undertaken by the Pennsylvania State Institute for Research on Land and Water Resources.

Project A-005 is studying the carbonate hydrogeologic environment and their relationship to land use, and water resources development and management. Although this project has a couple more years to run, it has produced interim results of considerable practical value in alleviating or preventing frost heave and other failures of structures, flooded basements, lagoon and septic tank failures, and groundwater and surface water pollution.

The Pennsylvania Institute for Research on Land and Water Resources has pioneered in some very significant work on the beneficial uses of sewage effluent by spray disposal. This sewage effluent has been used successfully in rehabilitating acid spoil banks from coal mines (Project B-020 PA). It also has produced dramatic results in irrigating crop lands, pasture, open spaces, and second-growth forest. This process of spray effluent disposal recycles the nutrients in stimulating plant growth but also serves to replenish the groundwater supply.

These projects have led to the construction of a system serving the University and town of State College that will soon dispose of 4 to 5 million gallons of sewage effluent daily by spraying it over land areas.

The Pennsylvania State Institute has also undertaken a series of projects (A-007-PA, A-009-PA, A-014-PA, and B-033-PA) concerned with the economics of water resources development and management. This research is still continuing but it has already yielded good practical insight into costs, benefits, and priorities that are of value to local and state water resource agencies. For example, Project A-009-PA came up with a very practical methodology for town officials to judge whether they should provide treated water to a large industrial plant or see it close down because of poor quality water available in the river nearby.

PUERTO RICO

Information from a Puerto Rico project (A-005-PR) will be most useful in conserving water used in irrigating sugarcane. Experimental results show that 20 inches of water per acre can be saved without affecting sugar yield if sugarcane is irrigated frequently during the first part of the growing season and irrigation is stopped five months prior to harvest.

In the area of water demand, tangible results have already been realized in the project "Quantitative Analysis of Water Use Patterns in Puerto Rico." The results of the industrial phase have produced reliable estimates on the amount of water required by factories to produce a unit of certain selected products (water ratios) which will be of value in improving industrial location and site planning in Puerto Rico.

RHODE ISLAND

Research on project A-025-RI seemed to confirm the suggestion that water may be a route for transmission of avian viruses from birds possibly to humans. The need for improved methods of monitoring inland water for viral pollution was strongly emphasized and this project will undoubtedly make a major contribution to this end.

In studies concerned with domestic water supplies (A-017-RI) it was shown that sodium hypochlorite can be effectively employed for oxidation of iron and manganese in water leading to an improved method of removal by cartridge filtration.

SOUTH CAROLINA

Many individual projects of the Clemson Water Resources Research Institute will be directly applicable to existing water resources problems. The study of legal problems will assist policy-makers and legislators in defining the most needed statutes and institutional arrangements for water management in South Carolina (B-003-SC). Research on current land use in estuarine areas will be used as an input by the State Task Force on tidelands to develop a comprehensive management plan (B-012-SC).

SOUTH DAKOTA

Effects of chlorinated hydrocarbon insecticides on freshwater seed shrimp were studied in South Dakota (A-015-SDAK). It was determined that from 1 to 10 parts per billion of aldrin and dieldrin in water will virtually kill 100 percent of the seed shrimp. Exposure of shrimp to sublethal doses does not appear to build up resistance. At concentrations near the lethal limit, aldrin and dieldrin are rapidly accumulated from water by seed shrimp. After 24 hours of exposure seed shrimp concentrate up to 1,800 and 1,600 times respectively the aldrin and dieldrin concentrations in the water. The seed shrimp body per se accumulated most of the residue. However, dead shrimp tend to return much of their accumulated insecticides to the water. Seed shrimp, because of their indiscriminate filter-feeding habit, may function as "recyclers of otherwise dormant insecticidal residues." Reintroduction of residues into the ecosystem and subsequent transfer to higher links in the food chain may pose a serious threat not only to higher aquatic animals but also to terrestrial animals which derive use or benefit from both aquatic life and water itself.

A companion study (B-002-SDAK) analyzed the Lake Poinsett ecosystem for chlorinated hydrocarbon residues. The study found that although current DDT residue levels were well below the tolerance limit of 5 ppm on a whole body, wet weight basis, the DDT residues did tend to concentrate in crayfish at 18 times those of the water levels, with plankton and algae a 37-fold increase, fish a 790-fold increase and aquatic insects a 7300-fold increase. Results indicate future planning on water quality control in South Dakota will need to take into consideration both the persistence and build-up of insecticides in lakes and streams.

TENNESSEE

Project A-003-TENN was concerned with leakage of farm ponds and means of preventing such leakage. Five-hundred permeability tests with eight soil-dispersing chemicals were conducted on various Tennessee soil types to determine effectiveness of these materials in reducing water losses due to seepage through highly structured silt and clay soils. Sodium phyrophosphate and sodium carbonate, as described in a bulletin of the University of Tennessee, were most effective. Wide application of results is reported among Tennessee farmers.

Of the approximately 16 million acre-feet of water used annually in Texas, 80 percent is for irrigation. Research has resulted in a detailed examination of the total agricultural resource base in the State and estimates of the impact of levels of irrigation water, through water resource development on this vital agricultural industry (A-001-TEX). Research has developed several models which provide to water resource planners, the quantitative effect on Texas agriculture of alternative allocations of irrigation water (A-001-TEX and B-005-TEX). The results indicate that Texas has considerable physical and economic potential to expand irrigation agriculture. Also, they indicate that without further water resource development, the agriculture industry will make a decreasing contribution to the total State economy in the years ahead. These models for resource employment including projection to the year 2020 were used by the State water resources planning agency for establishing the irrigation water requirements in developing the Texas Water Plan.

The recently developed and highly powerful optimization technique including geometric programming has been applied to water resources planning in Texas (A-011-TEX). Advances in optimization theory have been made and actual water resources problems have been solved to demonstrate the utility of this methodology. The research on water resources planning problems demonstrates that the planning process using nonlinear and geometric programming is improved over the approach. Utilizing dynamic programming techniques, a unique model integrating and optimizing the quality and quantity managements of a river basin has been developed (B-024-TEX). In this model, the economic trade-off, relationships between the water users and the water polluters, the interaction of river quality and quantity, and the economics associated with reservoir operations have also been included in the consideration. Analytical procedures are being developed to accelerate the planning process and provide the planner with the ability to re-evaluate his plan continually in light of technological and economic changes which may have occurred since the inception of the original plan (B-059-TEX). Close coordination of these research activities with the State water resource planning agency has resulted in the development of several practical planning models and the rapid application of optimization techniques to statewide water resources planning.

Research has shown that radar data can be used to indicate accurately the areal and temporal variation of rainfall. Although the total volumes of rainfall and runoff are generally erroneous, the actual shape of the hydrographs are predicted rather well. A technique for hydrograph synthesis has been developed which utilizes a modification of the familiar Snyder procedure and the Pearson type III function. Research on a stochastic model reveals the feasibility of using a sixth-order Markov chain in rainfall run-off simulation. When combined with the radar and techniques developed by hydrograph synthesis, the model holds considerable promise for use as a streamflow forecasting tool (A-200-TEX). This approach has been extended to runoff from an urban basin which was 84 percent urbanized with 23.6 percent of the areas impervious and a completely rural basin (A-010-TEX). The effects of urbanization have been characterized. The time-to-peak in the urban basin was less than one-half that for the rural area. In addition, peak discharge per unit was doubled. The research results are being used by some Texas cities to reevaluate the potential areas of flooding and develop a better control program for the city.

In the potentially water short High Plains of Texas, approximately $2\frac{1}{2}$ -3 million acre-feet of water annually accumulates in the 35,000 playa lakes and about 90 percent of the water is lost to evaporation. Research has developed a method to artificially recharge this water into the Ogallala Formation (B-016-TEX and B-041-TEX). A recharge system composed of lateral drain lines with porous backfill material installed in the lake bed and a multipurpose irrigation and recharge well have been successful for recharge. In one year, 25 acre-feet of water was recharged through the system with no reduction in well capacity. Also, pit recharge has been found to be effective, especially with frequent sediment removed. Research has developed a new method of recharge which consists of vertical shafts filled with porous materials and results indicate they maintain high recharge rates without appreciable sediment removal. This research has resulted in installation of several playa lake water recharge system on the High Plains.

Title II Project C-1098 (TRACOR) made a significant contribution towards determining the extent to which urbanization affects the hydrologic performance

of a watershed. The research resulted in the formulation of mathematical expressions which describe the effects of urbanization on the unit hydrograph.

Project C-1158 (University of Texas at Austin) is successfully studying the horizontal dispersion effects in shallow estuaries of irregular shape. The hydrodynamic model and the long-term dynamic salinity model developed under this project are currently in use by two different Texas agencies. For the past two years, the Texas Water Quality Board has incorporated the hydrodynamic model and the essential features of the salinity model into the Galveston Bay Water Quality Management Study. Beginning May 1, 1970, the Texas Water Development Board decided to use the hydrodynamic and the long-term salinity models in their basic estuary studies. The models are being used further to refine a cooperative data collection program between the Texas Water Development Board and the U.S. Geological Survey. In addition, the Texas Water Development Board will use the models to determine variations from base line conditions brought about by changing inflows, to determine inflow requirements, and to investigate alternatives for maintaining salinity. The models also are providing input for proposed ecological studies to insure the preservation of coastal estuaries (excluding Galveston Bay) under projected conditions imposed by the Texas Water Plan.

Title II Project C-1377 (Texas Water Development Board) has achieved a major step toward development of a computer-oriented planning system for use in planning of large, multi-basin systems of reservoirs and connecting river reaches and pump-canals such as the proposed Texas Water System. Planning problems associated with the Trans-Texas Division of the proposed Texas Water System were used to guide development of the program and procedures. Follow-on applications of these programs, sensitivity analysis, and program improvements are being carried out in project C-1681.

Title II Project CX1537 (Texas Tech University and High Plains Underground Water Conservation District No. 1) has achieved remarkable progress towards the objective of developing a highly flexible, generally applicable digital computer model of an unconfined aquifer that can be used as a tool for management of the aquifer.

UTAH

A Utah study (B-004-UTAH) on economic effects of water allocation among alternative industrial (non-agricultural) uses estimated increased demand for water in the State between 1963 and 1975 to be 1,455,000 acre feet. Crops are expected to require 1,203,000 acre feet and non-agricultural sectors 252,000 acre feet. As was suspected, the marginal income value of water to the State was found to be lowest for crops. The marginal income value was highest for some of the services categories. The study was regarded as providing a basis for forming a list of priorities on the relative marginal value of alternative uses of water, and on the relative needs and scarcity of water.

Another Utah project, A-002-UTAH has resulted in the development of improved telemetry techniques that are being put to use in operational programs of the U.S. Department of Agriculture.

VERMONT

Studies of the glacial biology of the Champlain Valley has provided extensive information on the amount and location of ground water supplies, sand and gravel resources, and areas where erosion could become a problem. The information has also been used in evaluating the success of an erosion control program instituted by the Soil Conservation Service and Corps of Engineers on the Winooski River.

With the State Department of Water Resources, Center researchers are making an intensive study of the ecology of a part of Lake Champlain adjacent to the proposed site for a nuclear power plant. The findings will provide information to allow Vermont State decision-makers to validly assess the effect of the proposed power plant on the vicinal ecology.

VIRGINIA

Under a Title II project the Virginia Institute of Marine Science engaged in hydraulic and mathematical model studies to improve understanding of estuarine processes.

It is significant that the utility of both mathematical or theoretical modeling and hydraulic scale modeling was demonstrated in efforts to develop solutions

to practical estuarine resource use and development problems even while the research program progressed. Specifically involved were (a) preliminary evaluations of the effects of a proposed tidal exclusion dam on the James River estuary and (b) development of studies of dispersion and diffusion (with FWQA-Charlottesville) of the upper tidal reaches of the James for pollution control purposes.

Another example of immediate application of research results in Virginia is a legal study conducted at Virginia Polytechnic Institute. Project A-008-VA was concerned with the statutory and case law dealing with water resources in Virginia. The first printing of the report (500 copies) was exhausted within six months. The demand is such that a second printing is in press.

WASHINGTON

A study has recently been completed by the State of Washington Water Research Center that resulted in a report titled, "A Conceptual Study of a State Water Plan." This report is intended to provide guidance to the Washington State Department of Water Resources in their forthcoming preparation of a State Water Plan.

The pollutional effect waste discharge from small pleasure craft has on bacteriological quality of otherwise unpolluted water of two harbors is being investigated under project A-024-WASH. With anticipated increased use of similar harbors in the future by pleasure craft, water quality degradation can be expected. Results are expected to aid the Federal Water Quality Administration in formulation of an effective control program for sewage from vessels and in assisting the Washington State Board of Health in establishing local regulations to help control the problem.

WEST VIRGINIA

The Bureau of Business Research at West Virginia University completed a study on forecasting urban water demand (C-1212). Since water supplies systems are generally built to function for decades and area-wide systems of storage and distribution cannot be planned and constructed overnight, it is becoming increasingly important to project and plan for future metropolitan water needs.

This study makes a useful contribution to improving the methodology of forecasting. An analysis of factors associated with variation in water usage indicated that a general measure of area income and a general measure of overall area size are factors most closely associated with urban water usage. Five alternative projections of water demand for 141 standard metropolitan statistical areas were made, based on different assumptions relating to area size, income, and water rates. These projections should prove most useful to metropolitan planners and administrators responsible for assuring future water supplies.

In West Virginia a significant portion of the research program is devoted to serious water quality problems caused by acid-mine wastes. These projects (A-001, A-006, and A-017-WVA) have examined toxicity of such wastes to various fishes and determined effects on distribution, growth and abundance of fish species in the Monongahela River. It was found that fish species vary in their tolerance to acidity. The brown bullhead is most tolerant of West Virginia species. Since it is fairly abundant and favored by anglers, sport fishery management in acid waters is urged to focus on this species. These studies have been useful in establishing water quality criteria for conservation of fishes.

A West Virginia study (A-008-WVA) investigated geochemical behavior of iron and manganese in a reservoir fed by streams containing acid mine drainage. Results, especially those showing vertical profiles of iron and manganese concentration by seasons, were used in selection of the intake level for a municipal water supply.

WISCONSIN

The State's flood plain and shoreland management and protection program has received material assistance from a project partly supported under the Water Resources Research Act. This study, dealing with physical and institutional means for adjustments within flood plain hazard zones, led in turn to a contract between the Water Resources Council and Members of the project to prepare a report on the legal aspects of flood plain regulations.

Results from research on the circulation of Lake Superior have shown that strong and relatively narrow (1-10 miles wide) counterclockwise currents occur along the perimeter of the lake. These boundary currents have direct bearing on waste disposal practices and pollution in the lake. Overall results

of this project are expected to find practical application in improved water resources management of Lake Superior and the Great Lakes generally.

As a result of two allotment projects for research on Lake Butte des Morts, the faculty at the Wisconsin State University at Oshkosh have formed a multi-disciplinary group to study lake environments and the university has established a limnology laboratory to support continued work in this important field.

WYOMING

Recent work completed on project A-001-WYO indicates the feasibility of utilizing new sprinkler irrigation technology—specifically self-propelled, circular sprinkler systems—to profitably cultivate land in the Green River Basin previously considered marginal or even sub-marginal.

In Wyoming, considerable effort (A-001 and B-002-WYO) is also being made to define considerations that must be taken into account when planning for possible transmountain diversions of water from the Green River Basin to the Platte River Basin in Wyoming. Consideration include: Present and future demand for water; legal constraints on diversion; augmentation of present supply of water by methods other than trans-mountain diversion such as weather modification; and capital investment involved in implementing diversions. In establishing present and future demand (value) of water in its present setting in the Green River Basin, a detailed investigation is underway to determine present and expected future value of game and fish resources of the Green River Basin that would be affected if large water diversions are made from the Green. Information obtained will be of significant value to planners and decisionmakers concerned with diverting Wyoming's waters.

Senator Moss, Congressman Tom Foley has come over here. He wants to introduce Dr. Agnew who will come on a little later. So we will ask Dr. Agnew to be introduced at this time, although he won't be the very next witness. I know that Congressman Foley has commitments over on his side of the Capitol and must get back to them, and that is the reason I asked him to make this introduction now.

STATEMENT OF HON. THOMAS S. FOLEY, REPRESENTATIVE IN CONGRESS FROM THE FIFTH CONGRESSIONAL DISTRICT OF THE STATE OF WASHINGTON

Mr. FOLEY. Thank you very much, Mr. Chairman. I appreciate the subcommittee's indulgence in allowing me to introduce at this time Dr. Alan F. Agnew who will appear later this morning and present testimony on behalf of the State of Washington and on behalf of the National Association of State Universities and Land Grant Colleges Committee on Water Resources.

Dr. Agnew is a very distinguished public official and scientist in the State of Washington who is presently the director of the Water Research Center of the University of Washington and Washington State University. The center is the creature or institution of both universities. It is located at Washington University at Pullman, Wash.

Dr. Agnew took his professional degrees from the University of Illinois and Stanford University where he received his Ph. D. He was for 13 years associated with the U.S. Geological Survey, following which he was the director of the geological survey for the State of South Dakota. Following that for 6 years Dr. Agnew was the director of the Water Resources Center of the University of Indiana. And last year he came to the State of Washington, where as I say, he is now director of the Water Research Center of the State of Washington. He is a scientist, a distinguished public official. He is appearing today on

behalf of the State of Washington Water Research Center and also on behalf of the National Association of State Universities and Land Grant Colleges Committee on Water Resources.

I am sorry that I won't be present for his testimony, as I wish to be, but I do have some commitments this morning before the House Rules Committee that I know the chairman of the subcommittee will understand.

I certainly commend his testimony to you and concur fully in it.

I might say, Mr. Chairman, it is a rare opportunity to come back to this committee where I had the pleasure and honor of working as a professional staff member for 3 years before my election to the House of Representatives. I always appreciate the opportunity, and I especially appreciate the courtesy of the subcommittee this morning.

Senator Moss. Well, thank you, Congressman Foley. We are delighted to have you return to this committee where you served with great distinction on our staff for a considerable period of time before you were chosen to represent your district in the House of Representatives. And we certainly appreciate the introduction of Dr. Agnew. We are looking forward to his testimony. We know him by reputation and the very fine work that he does. And we are sure that he will add greatly to our record.

We are glad you could come long enough to make the introduction, and we are happy to excuse you because we know of your commitments over in the House of Representatives this morning.

Mr. FOLEY. Thank you, Mr. Chairman.

Senator Moss. Thank you very much. And we will call you in due time, Dr. Agnew.

Thank you.

Senator BIBLE. As you know, Mr. Chairman, if I might say before Congressman Foley leaves, he was a very valuable staff member working under the chairman of this full committee for a number of years. This may be a good training ground for future Congressmen. At least Congressman Foley has shown that expertise and ability. And I am delighted to see an old friend at this committee hearing this morning.

Mr. FOLEY. Thank you, sir.

Senator BIBLE. Good to see you.

Senator Moss. Thank you.

I think Congressman Robison is here now. Would you come forward, please?

STATEMENT OF HON. HOWARD W. ROBISON, REPRESENTATIVE IN CONGRESS FROM THE 33D CONGRESSIONAL DISTRICT OF THE STATE OF NEW YORK; ACCOMPANIED BY LEONARD B. DWORSKY, DIRECTOR, CORNELL UNIVERSITY WATER RESOURCES AND MARINE SCIENCES CENTER, AND DAVID J. ALLEE, ASSOCIATE DIRECTOR

Mr. ROBISON. Thank you, Mr. Chairman.

Mr. Chairman, I have with me this morning with your permission, Leonard Dworsky, who is the director of the Cornell University Water Resources and Marine Sciences Center, and David J. Allee, assistant director of that same center.

Senator Moss. We are pleased to have you gentlemen here this morning. And we look forward to hearing the testimony that the Congressman has for us.

Mr. ROBISON. Thank you, Mr. Chairman and members of the committee.

I would like consent that my full statement be put in the record and I will try to highlight it for you since it is rather lengthy.

Senator Moss. I appreciate that. The full statement will go in the record as though given in full and you may proceed to highlight it.

Mr. ROBISON. Along with Representative John Saylor, of Pennsylvania, Mr. Chairman, I am the original House sponsor of H.R. 15957, to amend the Water Resources Act of 1964, and am pleased to appear here today in support of S. 3553, the counterpart to that bill in the Senate.

Our bill has two purposes. First, it would increase the authorized funds for support of the water resources research institutes located at 51 land-grant colleges in each State and Puerto Rico. The present funding level as we have discussed here this morning is \$100,000 per institute per year. Our bill would increase that amount to \$250,000 per institute per year and would also provide for an automatic increase or decrease as determined by reference to a formula reflecting Federal employee salaries, the purpose of which I suspect is to keep it in relation to changes in the cost of living insofar as the background of the operation would be concerned.

Secondly, the bill would authorize these 51 institutes to develop more formal programs for transferring their research results into practice. At present, there is no explicit authorization for this kind of outreach, with the result that there is too little direct communication on a systematic level between the researcher and his logical counterpart, the individual or locality with a problem. And it is probably true by way of historical comparison that our agricultural research programs did not begin their maximum period of effectiveness until the technology transfer function was similarly institutionalized at our universities.

This bill is relatively modest, by current standards, both in its proposed funding level and in its breadth. But the impact of this legislation may I think have more concrete results in work being done with localized water problems of the sort Senator Allott was referring to a moment ago—all over the Nation than practically any other piece of legislation in this field we might consider this year. And I think this becomes more apparent when one reviews the important contributions which the institutes made in the past 5 years.

For a review of those contributions I would refer you to the 1969 annual report of the Office of Water Resources Research of the Department of Interior entitled, "Cooperative Water Research and Training," and the same kind of picture can, of course, be obtained from the reports of the individual institutes. For example, in my district, the Cornell University Water Resources and Marine Sciences Center under the leadership of Mr. Dworsky to my left has summarized its work in the last 5 years in its report, "Service to New York State, A Summary Report 195-60." And Mr. Chairman, with your approval I would like to submit this to the committee for its files.

Senator Moss. It will be incorporated by reference and maintained in the committee file.

Mr. ROBINSON. I might add that by involving members of the university faculties on a wide range of disciplines as this program does, the program has had a "ripple" effect throughout all of our land grant colleges and universities and beyond. The problems of water environment were suddenly expressed at the university on an urgent but understandable level, and the faculties have responded. Besides which the institutes have an impetus for an effective Federal-State partnership, something I think tremendously important for us to continue developing in the years ahead.

Actual contributions by the States in direct and collateral assistance to this program approach 50-50 funding. There are many examples where imitation of a very modest research project in the allotment program has stimulated a vigorous research program supported by other Federal and non-Federal funds. In some cases the expenditures for the expanded research may be 20 to 50 times the cost of the original research proposal. For example, a Montana study funded at not over \$10,300 per year to study rainfall distribution has led to nearly \$1.2 million in grants from other agencies. The statistics on training of qualified personnel are equally impressive. And one of the Senators had a question on this a moment ago. To supplement this training many of our universities design curriculum and special degree granting programs in the field of water resources. While 1,976 students received income by working on institute projects, some 4,300 benefited directly from supplies and equipment acquired through the program, and most important, 4,976 graduated in water-related programs, all in 1969 alone.

For these and other reasons the program I think has been a major success. But the present funding level is singularly inadequate to continue a topflight effort. As in other areas, but particularly so in research and research-related activities, inflation has taken its toll. In addition, the original authorization was predicated on problems recognized at the time of enactment. Even the most knowledgeable scientist in 1964 did not I suspect fully anticipate the multitude of emerging problems associated with the rapidly changing environment.

It is important, too, that funding for such institutes be augmented through this approach, and not by other Federal sources. This authorization is a constant, year-to-year funding device rather than a project by project authorization. These, then, are "hard" funds which the university may use this year—and more importantly, for which the university may plan its activities over future years. Only in a steady, continuing program can a university recruit the kind of quality personnel necessary to insure that the program will continue to be the effective impetus for progress that it has been the past. We need to hold good people in positions of responsibility in these institutes, and this is the way to do it.

Finally, the water resources research institutes are ideally situated to assume responsibility for information dissemination at the local and State level. They would be authoritative and objective sources of information, not burdened by their responsibility for particular action programs. They would fill the gaps that industry and government now leave open. Their programs include the relationships with the users in local and State government, planning agencies, consulting engineers, and other practitioners. They are currently involved with

these groups in the identification of research needs and the development of research projects responsive to those needs. But this feedback process would be greatly improved by more formal programs to transfer technology.

What they lack is legislative authorization for the appropriations and related activities necessary to develop the second phase of their programs—the interpretation and dissemination of water research findings. Such programs could utilize existing State extension services such as agricultural, engineering, and industrial, where appropriate, in the same way that the institutes currently utilize faculty and laboratory facilities for research. Where such services are not available, they would be developed along lines best fitted to the university and the unique needs of each State. Such special tailoring of each program is essential to effectively using the resources available and truly responding to each State's very different needs.

Federal funds presently authorized for institute annual allotments and matching grants are designated for research and related training. There is no specific authorization for information interpretation and dissemination programs, nor funds for this purpose. An already effective program can best be made even more responsive to the urgency of the situation in this way.

To complete my formal testimony, Mr. Chairman, I would like to include now for the record a copy of a letter from Mr. Dworsky to Dr. H. Garland Hershey, Director of the Office of Water Resources Research of the U.S. Department of Interior, which letter reviews the past 5 years of the Cornell University Water Resources Institute and outlines a strategy for the next 5 years. Under Dr. Dworsky's leadership the Cornell Institute has been an exceptional one. Now he and the directors of the other 50 institutes in all our States and Puerto Rico need our help and need an expression of our commitment, and I urge you to make that commitment by supporting S. 3553.

Before I conclude, Mr. Chairman, I would like to also submit for the record a statement prepared by Mr. Allee, who is, as I said, an associate director of the Cornell Institute who is currently on leave from that university as visiting professor with a program planning group, civil functions of the Office of the Secretary of the Army. His statement, he tells me—he assures me is reflecting his individual views and is in no way an official position of any agency.

And finally, a telegram from Charles E. Palm, who is the dean of the New York State College of Agriculture at Cornell University, submitted in support of this legislation but presented by Dean Palm as chairman of the National Association of State Universities and Land Grant Colleges' Division of Agriculture.

Senator Moss. Thank you, Congressman Robison, for your statement. The documents that you have referred to will all be printed in the record following your testimony.

(The statement and documents follow:)

STATEMENT OF REPRESENTATIVE HOWARD W. ROBISON, 33RD DISTRICT OF
NEW YORK, IN SUPPORT OF S. 3553

Since, along with Rep. John Saylor of Pennsylvania, I was the original sponsor of H.R. 15957, to amend the Water Resources Act of 1964, I am pleased to appear today in support of S. 3553, this body's counterpart to our bill.

The bill has two purposes. First, it would increase the authorized funds for support of the Water Resources Research Institutes located at fifty-one land

grant colleges in each state and Puerto Rico. The present funding level is \$100,000 per Institute, per year. The bill would increase this amount to \$250,000 per Institute, per year, and would provide for an automatic increase or decrease as determined by reference to a formula reflecting Federal employee salaries.

Second, the bill would authorize these fifty-one Institutes to develop more formal programs for transferring research results into practice. At present, there is no explicit authorization for such outreach, with the result that there is little direct communication, on a systematic level, between the researcher and his logical counterpart—the individual (locality) with a problem. It is probably true that our agricultural research program did not begin its maximum period of effectiveness until the technology-transfer function was institutionalized at the universities.

The bill is relatively modest, by current standards, both in its proposed funding level and in its breadth. But the impact of this legislation may have more concrete results in work being done with localized water problems I think all over the nation than practically any other piece of legislation in this field we may consider this year. This becomes more apparent when you review the important contributions which the Institutes have made in the past five years.

For a review of these contributions I refer you to the 1969 Annual Report of the Office of Water Resources Research, U.S. Department of the Interior entitled "Cooperative Water Research and Training." The same kind of picture can be obtained from the reports of the individual institutes. For example, in my own district, the Cornell University Water Resources and Marine Sciences Center has summarized its work over the last five years in its report "Service to New York State: A Summary Report 1965-69." By involving members of the University faculties from a wide-range of disciplines, the program has had a "ripple" effect throughout all the land grant universities and beyond. The problems of water environment were suddenly expressed at the University on an urgent, but understandable level—and the faculties have responded.

The Institutes have furthered essential work in many areas, including the following:

(a) Findings and analytical techniques to improve the planning of public projects by every level of government; for example, the optimization of power generation, peaking power and water releases within the California Water Plan, or a new approach to integrating urban area water systems developed for the New York City area.

(b) Pollution control measures to prevent degradation of the environment or enhance it; for example, stream bank stability criteria in conjunction with highway construction to prevent sediment pollution, or money saving instream aeration systems.

(c) Identification of manpower needs, such as the study that was the basis for a new technician training program in Indiana.

(d) Studies that provide a better basis for water quality standards and regulations; for example, a study on phosphorus in Lake Michigan or others on the effects of pollution on fish survival.

The Institutes have been an impetus for an effective Federal-state partnership. Actual contributions by the states in direct and collateral assistance approach 50-50 finding. There are many examples where initiation of a very modest research project in the allotment program has stimulated a vigorous research program supported by other Federal and non-Federal funds. In some cases the expenditures for the expanded research may be 20 to 50 times the cost of the original research proposal. For example, a Montana study funded at not over \$10,200 per year to study rainfall distribution has led to nearly \$1.2 million in grants from other agencies. The statistics on training of qualified personnel are equally impressive. To supplement this training many universities design curriculum and special degree granting programs in the field of water resources. While 1,976 students received income by working on Institute projects, some 4,300 benefited directly from supplies and equipment acquired through the program, and most important, 4,978 graduated in water related programs, all in 1969 alone.

For these, and other reasons, the program, I think, has been a major success. But the present funding level is singularly inadequate to continue a topflight effort. As in other areas, but particularly so in research and research-related activities, inflation has taken its toll. In addition, the original authorization was predicated on problems recognized at the time of enactment. Even the most knowledgeable scientist in 1964 did not, I suspect, fully anticipate the multitude of emerging problems associated with the rapidly changing environment.

Greater emphasis needs to be given to the role of biological phenomena, ecological processes, and social or behavioral analysis. Three-quarters of the professional investigators in the program are engineers, economists or other quantitative analysts reflecting an essential emphasis on planning and systems analysis. This work is critical and should be expanded. But, now these Institutes need the resources to move more vigorously also into areas where recent events have spotlighted long-standing needs in our natural and human environmental arena. The planning and development of water and related resources must proceed on an improved basis of ecological evaluation. And it is clear that our understanding of "people problems" must move ahead along with the "water problems." The human needs, processes and organizational alternatives of water resources management at different levels of organization must be more fully explored on a scientific basis.

It is important, too, that funding for such Institutes be augmented through this approach, and *not* by other Federal sources. This authorization is a constant, year-to-year funding device, rather than a project by project authorization. These, then, are "hard" funds which the University may use this year—and more importantly, for which the University may plan its activities over future years. Only in a steady, continuing program can a university recruit the kind of quality personnel necessary to insure that the program will continue to be the effective impetus for progress that it has been in the past. We need to hold good people in positions of responsibility in these Institutes, and this is the way to do it.

As mentioned above, S. 3553 also provides authorization for the accelerated dissemination of the results of scientific engineering research which is deemed potentially significant for solution of water resource problems. There is a demonstrated need to improve communication between research users and researchers if the research supported by this investment is to be responsive to the needs of water planning and management agencies and the resulting new information is to flow into the hands of practitioners in a form which can be utilized by the large variety of disciplines and levels of skill involved. For example, it seems clear that the consulting engineers, particularly those in small firms, would welcome the support this program could provide. It certainly can make available in effective form the interdisciplinary kind of information not now easily found by practitioners. Agencies and firms today tend to be narrowly based in terms of the mix of specialties, while the newly pressing problems call for broader approaches.

Closing an information gap is a two-way process—both the generator of information and its receptor must be actively engaged in the process. Often, however, initial impediments may be so great that communication is ineffective without provision of special aids and specialized personnel, and that seems to be widely true for researcher-practitioner communication in the water resources field. Four kinds of action can break down this barrier:

- (a) Identifying scientific information potentially significant for problem-solving.
- (b) Repacking such scientific information for ready comprehension by practitioners and other decisionmakers.
- (c) Providing means of communication designed to facilitate ready access and use by both the generator and the recipient of such re-packaged information.
- (d) Facilitating feedback that will alert researchers to the scientific information needs of those involved in resources decisions and actions.

The Water Resources Research Institutes are ideally situated to assume responsibility for information dissemination at the state and local level. They would be authoritative and objective sources of information, not burdened by their responsibility for particular action programs. They would fill the gaps that industry and government now leave open. Their programs include the relationships with the users in local and state government, planning agencies, consulting engineers and other practitioners. They are currently involved with these groups in the identification of research needs and the development of research projects responsive to those needs. But this feedback process would be greatly improved by more formal programs to transfer, as I said, this technology.

What they lack is legislative authorization for the appropriations and related activities necessary to develop the second phase of their programs—the interpretation and dissemination of water research findings. Such programs could utilize existing state extension services such as agricultural, engineering and industrial, where appropriate, in the same way that the Institutes currently

utilize faculty and laboratory facilities for research. Where such services are not available, they would be developed along lines best fitted to the university and the unique needs of each state. Such special tailoring of each program is essential to effectively using the resources available and truly responding to each state's very different needs.

Federal funds presently authorized for Institute annual allotments and matching grants are designated for research and related training. There is no specific authorization for information interpretation and dissemination programs, nor funds for this purpose. An already effective program can best be made even more responsive to the urgency of the situation in this way.

I have no doubt that the Institutes are equal to the proposed new responsibility. At Cornell, for example, the Water Resources and Marine Sciences Center has, from its inception, carefully considered the problem of transmitting research findings and other technical material into usable form for public purposes.

An early program there resulted in the development of an information and retrieval system of current periodic literature. A permuted Title Index to the periodical literature covering over 200 publications of the 4,000 received by the Cornell Libraries was published for the years 1963 through 1967 on an experimental basis. Each annual publication listed approximately 2,000 published items of literature and, in effect, provided a handy library reference at desk-top availability. Subscribers in government agencies, private engineering companies and universities were very pleased with the activity and, in 1967, the Department of the Interior supported the publication of 1,000 copies for government offices and their research grantees and contracts. This effort was terminated in 1968 due to lack of funds. A special publication along these lines was developed for the literature on thermal pollution and was also well received.

Another early effort of the Center was to establish a mailing list to serve the principal government (Federal, state, and local) water resources agencies; consulting engineers; conservation organizations; universities; and selected individuals with copies of pertinent research reports. This, too, was well received and the Cornell Center has continued this activity on a modified basis as costs of research have increased. Following an initial mailing, subsequent reports are sold at cost of publication to those desiring copies.

For nearly four years the Cornell center has proposed research programs which would provide, for example, funds for the translation of project findings into public policy recommendations through citizen review and policy boards; or which would allow a good deal more effort to be applied toward insuring that the results of research projects were quickly made available for public purposes in a usable manner. These first activities indicate that a fully developed program for insuring greater and early public use of the findings of the water research centers will have much value.

To complete my testimony, I would like to include—for the record—a copy of a letter from Leonard Dworsky to Dr. H. Garland Hershey, Director, Office of Water Resources Research, United States Department of the Interior, which succinctly reviews the past 5 years at the Cornell University Water Resources Institute and outlines a strategy for the next 5 years. Under Dr. Dworsky's leadership, the Cornell Water Resources Institute has been an exceptional one. Now he, and the Directors of the other 50 Institutes in all our states and Puerto Rico, need our help and need an expression of our commitment. I urge you to make that commitment by supporting S. 3553.

CORNELL UNIVERSITY,
WATER RESOURCES AND MARINE SCIENCES CENTER,
Ithaca, N.Y., March 25, 1970.

DR. H. GARLAND HERSHEY,
*Director, Office of Water Resources Research,
U.S. Department of the Interior,
Washington, D.C.*

DEAR DIRECTOR HERSHEY: I am pleased to provide these program notes to accompany the annual allotment program for fiscal year 1971 of the Cornell University Water Resources and Marine Sciences Center. These program notes (1) review the five year program of the Center; (2) describe program adjustments made toward the end of the first five year period; (3) summarize the current program; and (4) outline a future program strategy for the next three to five year period.

Review

The initial annual allotment program of the Center (1964-65) attempted to concentrate on water resource planning and development features important at that time. These included (1) the Great Lakes and the Finger Lakes; (2) Systems Analysis; (3) Water Supply-Demand (Planning); and (4) Water Law and Political Institutions. The work accomplished in these study areas is described in more detail in the recently published Five Year Report of the Center.

Early in the five year period the Systems Analysis program became self-supporting under Title II grants (from the Office of Water Resources Research) as a result of the excellent work of Professor Loucks. This work has continued and has resulted in Professor Loucks becoming established as a national leader in the field.

The Water Law and Political Institutions program also became self-supporting under Title II grants during this period. Professor Farnham has produced significant reports and has drafted legislation for the modernization of New York Water Law. The Center is completing the manuscript of an extensive treatise on New York and Eastern Water Law. Professor Dworsky is developing a text on water management institutions generally including a case study on the Hudson River Institutions for water quality management under a Title II grant.

The Water Supply-Demand studies were initiated prior to the establishment of the Corps of Engineers North Atlantic Water Supply Study and the New England River Basin Commission. These initial studies were useful to the Corps of Engineers program and led to contracts with the Corps for industrial water supply projections and to other studies concerned with industrial water use. As the official agencies developed their new programs the Center Supply-Demand studies shifted to other water resources planning areas. Two of these; water based recreation and planning evaluation studies have become most significant. These programs, too, have become self-supporting under a series of Matching Grants (Title I of the Water Resources Research Act) and a modest contract with the U.S. Water Resources Council. Professors Allee and Kalter have been primarily responsible for leading the effort in these areas.

The Great Lakes and Finger Lakes studies developed moderately but continuously during the five year period. Professor Brutsaert developed an excellent series of reports on evaporation and water balance. Professor Liggett initiated new studies involving lake circulation. The work of Professors Barlow and Gates on eutrophication and the effect of wastes on lakes initiated a new era of studies on Cayuga Lake. This work was expanded substantially under a program jointly funded by the Center and the Office of Research, College of Agriculture, and later was further enlarged under a contract with the New York State Electric and Gas Corporation. Professor Mulligan, after initial support by the Center developed a self-supporting program under Matching Grants for aquatic weed control using the ponds facilities of the College of Agriculture. The Center has made substantial efforts to assist Professors Liggett and Oglesby receive grants from the Atomic Energy Commission and the Federal Water Pollution Control Administration, but the efforts have not been successful to date. This program remains one of the principal programs of the annual allotment funds and we will continue to help make it self-supporting.

Program Adjustments

Initially the allotment program was used to support projects under the four areas selected for concentration although an early attempt was made (without success) to support a faculty position to assist in developing the lakes study program (aquatic biology with emphasis on pollution control and eutrophication). In a policy decision (1967) the Center Governing Board agreed as a start to support up to three faculty positions as a means of strengthening the opportunity for research in selected areas. As a result, three faculty positions were supported: in Aquatic Biology (limnology) in the Department of Conservation; in Civil Engineering (sanitary engineering technology); and in Rural Sociology (the public's role in decision making and the planning process; public education).

Current Program-Summary

The current program of the Center under the allotment program includes continued work under the three faculty support positions described above; and additional effort in lakes and estuarine studies (nutrients; quality standards for selected fish species; and water based recreational planning). In addition new programs have been initiated by Professor Loucks on the application of

systems analysis to urban water problems (Title II); and by Professor Allee on water resource information transfer in cooperation with the Extension Service (Matching Grant). Programs on water law and political institutions; water resources planning evaluation techniques; and on aquatic weeds under either Matching Grants or Title II Grants are continuing.

Future Program Strategy

The Center Governing Board has evaluated the Center's program to date, faculty interest, emerging opportunities and the relation of these to Cornell's location and educational program. The Board believes that two major areas of concentration should be developed during the next 3-5 year period.

The first area of concentration is to exploit the environment at the doorstep of Cornell-Cayuga Lake and the Finger Lakes. Accordingly a program under the title Finger Lakes Environmental Studies is recommended. The specific projects relating to this title in the appended Fiscal Year 1971 Annual Allotment Program are:

Euthropication in the Finger Lakes—Assoc. Prof. Ray T. Oglesby, Dept. of Conservation—\$7,100.

A Study of the Nutrient Inputs into Cayuga Lake and Seneca Lake—Assoc. Prof. Gene E. Likens, Div. of Biological Sciences—\$7,700.

Microbiology and Water Quality in a Tributary of Cayuga Lake—Prof. Norman C. Dondero, Dept. of Food Science—\$9,600.

Buried Aquifers in Filled Interglacial Valleys, Finger Lakes Region, New York—Assoc. Prof. Arthur L. Bloom, Dept. of Geological Sciences—\$2,000.

A comprehensive research (funding) prospectus dealing with Cayuga Lake and the other Finger Lakes is under preparation to aid in the development of this program. The prospectus will lean heavily on the several research projects already funded by the Center, the work carried out under the New York State Electric and Gas Corporation cooperative program and the case study currently underway (Professor Dworsky, C.E. 2545).

The second area of concentration is Urban Water Problems, a matter that is receiving the highest priority in the Department of the Interior under specific directions from Secretary Hickel. This is a new developing area and it is proposed to build this program around a new Title II grant received by Professor Loucks. No funds under the Annual Allotment Program are provided for this program. It is planned to develop a substantial proposal for special funding for this area.

A third general program area is to continue support for the three faculty positions and the research programs related thereto under the specifications laid down by the Governing Board.

A fourth general program area is to continue support for the development of Engineering Methods and Technology. The specific projects relating to this area under the Fiscal Year 1971 Annual Allotment Program are:

Design of Wastewater Treatment Systems to Satisfy Effluent Quality Requirements Based on Intended Use—Asst. Prof. Alonzo W. Lawrence, Dept. of Water Resources Engineering—\$10,625.

Concentration and Removal of Pesticides and Other Recalcitrant Molecules from Water Supplies by Ultrafiltration—Asst. Prof. Victor H. Edwards, Dept. of Chemical Engineering—\$7,500.

A feasibility Study for a Mobile Submersible Vehicle to be Used for the Control, Management, Study of Natural Processes, Protection and Conservation of Inland Waters—Prof. Edmund T. Cranch, Dept. of Theoretical and Applied Mechanics—\$5,000.

It is anticipated that the Project proposed by Professor Cranch will facilitate an expanded program in materials and other technology in relation to the marine sciences.

In addition concentration will be continued in the area of water law and political institutions, with the new addition of sociological studies under Professor James R. Finley, Department of Rural Sociology (A Study of Water Resource Public Decision Making—\$13,000).

Programs will also be continued as opportunity allows (under self-supporting funding) in the areas of water resources evaluation techniques related to water resources planning; water based recreation and other related resource economics activities.

As you know, Congressman Robison has introduced H.R. 15957 which authorizes an increase in annual allotment funds from \$100,000 per year to \$250,000 per year. If this bill is enacted we will, of course, want to reassess the entire Center program.

We wish to take this opportunity to express our deep appreciation to you and to Associate Director Eaton for keeping the Office of Water Resources Research program running so smoothly during the transition in Directorship. We hope you will make known to Assistant Secretary Klein and to Secretary Hickel how important it has been to have this transition period occur without a break in program and forward progress. We look forward to highly productive years under your leadership, supported by the substantial understanding and knowledge of the Office of Water Resources Research program residing in Associate Director Eaton. Together, in our opinion, you comprise one of the most vigorous and productive research administration teams in government today.

Sincerely yours,

LEONARD B. DWORSKY, *Director.*

EXAMPLES OF INDIRECT BENEFITS OF THE WATER RESOURCES RESEARCH ACT OF 1964

(By David J. Allee¹)

The Water Resources Research Act of 1964 has made possible the development of multi-disciplinary groups of specialists committed to solving the water problems of the nation. At most universities this is only possible with the continuing stable support available through the annual allotment funds provided under this Act. The availability and strength of such groups provided benefits to governmental agencies—the prime movers in water resources matters—well beyond the direct research and training outputs properly documented through the program.

One category of such benefits is illustrated by some of the research and planning activities of the U.S. Army Corps of Engineers. First, the Corps has had growing success in a fellowship program that puts a faculty person and his graduate student to work through a thesis project on a research need of the agency. At the cost of supporting the graduate student, the Corps obtains a product that otherwise would cost many times more. Second, the Corps has made good use of expert advisory groups in many of its studies. These groups draw heavily from the ranks of Title I participants. Third, the Corps sends both civilians and officer personnel for short course and advanced degree study to schools that feature strong water resource programs. Fourth, it has a gradually expanding number of visiting scholars, such as myself, who have been able to make a modest contribution and, perhaps more important, have taken back to the campus a better understanding of our nation's water problems.

Another category of indirect benefits is illustrated by university involvement in the current effort of the Water Resources Council to update the guidelines for project evaluation procedures. At the time of the recent increase in the interest rate applicable to water resources projects and plans, members of the Congress made it clear that a general overhaul and benefit-cost evaluation was called for. A Task Force of the Council issued proposed procedures featuring a new four-objective framework to replace the old single-emphasis benefit-cost ratio. The Council invited the agencies and the universities to organize teams to test the new procedures. Cornell, Michigan State, Michigan, Oklahoma, MIT and Wisconsin (and in more limited ways Oregon State and Stanford) responded effectively and at short notice by assigning a seminar of faculty and students to the task. Actual projects were visited and the reports are now available from four of the university teams and others are in the process. Members of these seminars have recently met with the Council and agency personnel to iron out some of the problems in applying the new procedures. The possibility of a much broader and sounder basis of evaluation of our water resources program may become a reality because of this effort. But this response on the part of the universities would have been meager and unbalanced, only critical and not constructive, without the Title I program. Attached are two publications—one issued by a Title I center and one issued by a non-Title I center—that came out early in the discussion of the new evaluation procedures. These illustrate these points.

¹ Associate Director, Cornell University Water Resources and Marine Sciences Center. Currently on leave as Visiting Professor with the Program Planning Group (Civil Functions), Office of the Secretary of the Army. This statement reflects individual views and in no way is an official position of any agency.

[TELEGRAM]

JULY 19, 1970.

HON. HOWARD W. ROBISON,
Congressman from New York,
House of Representatives,
Washington, D.C.

Hope you will support S. 3553 and S. 3721 at the hearing on July 20. These bills will amend the Water Resources Research Act of 1964 to increase the authorization for water resources research and institutes, and for other purposes. Your support of this legislation through joint sponsorship of H.R. 15957 is commended. Growing need for water resources research in the land grant universities is imperative with the new emphasis on solving problems of environmental quality. Speaking as chairman of the National Association of State Universities and Land Grant College's Division of Agriculture, we feel the urgency for increased research support in our programs related to water resources management. I know that Director Leonad B. Dworsky of the Cornell University Water Resources Center is providing you with factual data on the New York and national programs.

CHARLES E. PALM,
Dean, New York State College of Agriculture,
at Cornell University.

Senator Moss. I am most pleased to have you as the principal sponsor of this same legislation on the House side come here to testify for us. It seems to me that you made quite a compelling and eloquent statement as to the needs.

I might ask Dr. Dworsky while he is here, do you find that there is a considerable need for increased funding above the \$100,000 that comes now under the program?

Mr. DWORSKY. Yes, sir. The use of that money I think would be most important to us in that it would allow us to provide for a longer term view of our research rather than on a project basis. I think also that our record that the Congressman has kindly introduced into the file and also into the record would show that we have initiated a good many projects but we have not had the critical mass of money necessary to make these as effective as they might be.

In other words, I think that our projects can stand surveillance on their own right now, but I do think that the money we might get would be much more effective in making the projects that we could put together a much more useful package.

Just by way of example, for instance, our major thrust for the next 3 to 5 years has to be on the lakes of New York. As you know these are one of the most beautiful sets of lakes in the country. They are world renowned. We are getting into the same problems that everybody in the country is getting into, beautification, threat of powerplants, beating, land utilization, feed lots, even in this very beautiful vacation land. And our problem right now as our program shows is we have a series of four projects which we put together, and we could be much more effective in that program if we had initial funds to make it a more critical mass.

Senator Moss. When I asked the Secretary about the necessity for higher funding so that there could be long range planning, he responded by saying, well, if the universities or the institutes come to the Department with a good project, they would get money there. What is your reply to that?

Mr. ROBISON. I could comment and let Mr. Dworsky back it up. Mr. Chairman, with relation specifically to Cayuga, which has been the proposed site of a nuclear powerplant and that in turn created a con-

siderable concern in the immediate vicinity, we have been seeking through Cornell University and through the Department of Interior project moneys to do the basic research that would help both the utility and the community understand the proper relations between the proposed nuclear powerplant and the status of the lake itself. I don't know, Mr. Dworsky, how long it has been that we have been after those project moneys, but it is far too long—a year, year and a half, whatever. Meanwhile, the institute has been continuing to do work on these problems on its own in meeting the local needs but tailored to fit the whole region.

Do you want to add something?

Mr. DWORSKY. I think this explains it quite well. We have been seeking funds for a year and a half, nearly 2 years I think, trying to get project funds. And here we would have to be rather specific with respect to a project. And we really need an interdisciplinary approach. We need a well-rounded program on the lake to understand it, lake circulation, the problem of beautification, the problems of the chemical balance in the lake, and these sorts of things. We have not so far received this particular request. We have had other requests at Cornell, a large school. It has many programs going on.

Mr. ROBISON. I wish Senator Hatfield were still here because I would like to have incorporated what he said earlier into my own statement, my own thoughts about the most effective and efficient programs in research. And his thought as I understood it being that they don't all emanate from Washington. Most of them can be stimulated at the local level and I think far more efficiently and economically serve the needs than many of the project grants that come out of Washington.

Senator MOSS. Well, when you apply for funds from the Department, it is not certain you will get them. If you are arranging a project that takes long-range planning—what you will do 4 years, 5 years ahead—you really have to know that the money is going to be there in the second year and in the third year and the fourth year. You can't start a project and say, now, we will go down and try to convince somebody that we need that money. Isn't that the real problem of applying for money out of someone else's funds?

Mr. DWORSKY. Yes, sir; that is one of the important problems that we have.

Senator MOSS. Well, I appreciate your testimony. And I concur with Senator Hatfield, too. I think some of the very exciting and most advanced kinds of research are coming out of our institutes. We have to resolve the problem of diversification, of course.

Mr. DWORSKY. I think the point Congressman Robison made with respect to Senator Hatfield's comments might be just elaborated on for a moment. The thing that is most effective in project design is to have an ability to have some money that can provide for several years of effort, and then on that basis develop the kinds of coalition of faculty and students that apply themselves to these particular tasks. Otherwise, you don't have the opportunity to develop the utilization of university competency in the best way possible. And I might say, Senator Moss, that I was instrumental in the early days of the writing of the legislation for the 1948 Water Pollution Control Act. I have a great respect for the college program people in Government. I think they are excellent. I think they are fine dedicated people. I think everyone would

agree with me that what we need more than ever today is not merely a delineation of ideas and objectives of the people in the Federal agencies but that we must have room for the initiative of faculty people and particularly young vigorous students who come up with ideas that really we haven't thought about. And there is in a sense—though I don't like the term—a kind of generation gap. It is not that we can't understand each other. It is that they understand the problems today perhaps better than we do in the sense of seeing them in a different way in their generation under their criteria. And I think that we have got to have an opportunity to respond to these people. And I think that we can do a very substantial complementary job in the universities. We cannot do it all. It is obviously impossible. The Federal agencies must do their job. But we can do a very substantial complementary job, and this bill I think will help it greatly.

Senator Moss. Thank you very much.

Senator Bible.

Senator BIBLE. I have no questions. I simply want to compliment the Congressman for a very able and very detailed statement that he has made in support of this program. I think he has given us a good analysis of it. And, Doctor, I certainly do appreciate your being here this morning because I know of the work of Cornell University in this particular field. It has been very important.

I have no questions specifically.

Senator Moss. Thank you.

Senator Allott.

Senator ALLOTT. I have no questions.

Senator Moss. Thank you very much, gentlemen. We appreciate having you come and testify for us.

Mr. ROBISON. Thank you, Mr. Chairman.

Senator Moss. Our next witness will be Congressman Harold T. Johnson, who will also introduce Dr. James B. Kendrick, vice president of agricultural sciences, University of California.

We are always happy to have Congressman Johnson here who holds such an important position on the counterpart committee in the House of Representatives. He works on the House side on the same things that we work on on the Senate side. He is a great leader and we look forward to having him come before us.

**STATEMENT OF HON. HAROLD T. JOHNSON, A REPRESENTATIVE IN
CONGRESS FROM THE SECOND CONGRESSIONAL DISTRICT OF THE
STATE OF CALIFORNIA**

Mr. JOHNSON. Thank you, Mr. Chairman and members of the committee. I am very glad to have this opportunity to come here this morning and hear the people who are testifying as to S. 3553. There is a like measure on the House side. I happen to be a coauthor along with Congressmen Robison and Saylor. Our hearings are not scheduled yet so I thought I would come over here, I had the morning, and get a little education as to how to conduct our hearing over on our side. We have carried on a very active program under the Office of Water Research in California. It is headed up by the University of California at Los Angeles where the center is located. They have projects moving on several of their campuses. We have had the Stanford University

program and about 10 different private organizations. California has taken full advantage of the moneys that have been made available for the program, and we are in support of the contents of S. 3553, as far as funding is concerned.

Now, this morning I have with me here for the first time—I do want to stay and hear his testimony because he has gone into quite some detail on the program in the university—Dr. James B. Kendrick, who is vice president of agricultural sciences at the University of California. It is a very large institution—one that is carrying on a great research program. Dr. Kendrick has been with the university since 1947, and he is well acquainted with all aspects of the university program. He is now headquartered in Berkeley with the president of the university, and he is very active in the university's overall program. Dr. Kendrick and I met with all of the research center people carrying on their activities on the various campuses a month or so ago, and I told him I would accompany him here this morning to introduce him to your very fine subcommittee.

I will now turn you over to Dr. Kendrick.

Senator Moss. Thank you very much, Congressman Johnson. And, Dr. Kendrick, we are pleased indeed to have you come before us to testify on this matter. We know something of the work being carried on in the great State of California, which has so many water problems and is so large both in area and population. We are sure that you can give us testimony that will be most desirable for our record.

STATEMENT OF JAMES B. KENDRICK, JR., VICE PRESIDENT, AGRICULTURAL SCIENCES, UNIVERSITY OF CALIFORNIA

Mr. KENDRICK. Thank you, Mr. Chairman, members of the committee.

Let me first express my appreciation to Congressman Johnson for accompanying me to this hearing.

I am a fairly neophyte at this operation, but I am particularly pleased to give testimony largely from the effect of the legislation on the State of California.

I will submit to you my written testimony for the record, and I will attempt to highlight that testimony in the interest of time and reserve the rest of the time for questions if you have some.

Senator Moss. Thank you very much. The entire statement will go in as though given in full.

Mr. KENDRICK. Thank you.

As indicated, I am James B. Kendrick, vice president of the agricultural sciences for the University of California. I also serve as permanent chairman of the coordinating board of the university's statewide water resources center, and this is an appointment by the president of the university.

As vice president I administer the division of agricultural sciences, a multicampus organization, whose functions are teaching, research, and extension.

As chairman of this coordinating board I am responsible for the administrative supervision of the water resources center which is actually executed for me by a director.

The center is the officially designated research unit in California for dealing with the Office of Water Resources Research and for

carrying out the provisions of the Water Resources Research Act of 1964.

I am pleased to appear before this committee on behalf of my university and support the proposed legislation. And I will digress here to say that in the prepared text you will notice a typographical error, Senator Moss. I have your bill titled S. 3353; that should be 3553.

This amendment is particularly significant for California, a State which presently faces many critical problems of water supply and distribution, and which must resolve many conflicts among the water users and the public if a thriving economy and environmental well-being is to be assured. Not only would this legislation permit my university to undertake very vitally needed additional research upon some of the State's and region's urgent water problems, but it would enable us to develop a systematic program of citizen education and understanding which is necessary for the development and conservation of the State's limited water resources.

The passage of the Water Resources Act of 1964 proved to be of immense benefit to the University of California with its already established water center. The Federal annual allotment and matching grant programs enable the center to approximately double its fresh water research programs, and it made it possible to move into new fields of investigation of significance to the State.

Despite all of the excellent research that is being presently conducted by the water resources center, the university is falling behind in its water resources research efforts relative to the problems emerging. The dimensions of research have changed significantly in California since the 1964 act was passed. Water research has become enmeshed in the explosive aspects of improving the quality of urban living, preserving the desirable features of our environment, and it is involved in the strategies of economic and social change.

Because our board recognized that the research we had underway was not keeping pace with the needs of the State, I recently appointed a special faculty committee representing diverse disciplines and campuses to determine what needed to be done. The committee concluded, first, that the university's water resources research program had to be strengthened in order to meet the present critical problems of the State and Nation.

Second, we needed to broaden the range of our scientific disciplines involved in the research, particularly those in the behavioral sciences. And third, the research findings and results had to be disseminated much more effectively and understandably for the purpose of fostering well-informed private and public decisionmaking.

An important question before you as a committee considering this issue is what would the University of California and its water center do with the additional money which would be appropriated under the proposed legislation. Our research evaluation report provides guidelines for this answer.

And I don't mean to imply that the additional funding authorized in the amendment would supply all that I am going to give you as areas in which we feel we need to move, but they serve to identify the areas where we have in our committee report suggested that we need to strengthen our research. First of all, we would give more attention to the impact of man's needs and use of water on the State's coastlines, estuaries, lakes, and other water services.

Second, we wouldn't research on the efficiency of water use in agriculture, but with new emphasis upon California's total environment and economy.

Third, we would focus our research on the urban scene.

Fourth, we would place greater emphasis on the examination for water resources within the analytical systems framework.

Fifth, we would emphasize research dealing with the conservation of water use.

Sixth, we would intensify studies with respect to economic and financial considerations of water use and management.

Seventh. And we would direct more research toward the human behavioral and institutional aspects of water use and management.

In addition to the increased emphasis upon these research areas, funds provided by the proposed legislation would enable my university to develop an improved program to inform and educate the citizens of California concerning water resources needs and problems. And an expanded program is sorely needed in the State where divisive conflicts among groups and geographical areas are engendered and inflamed by information and communication gaps.

This we hope to accomplish by initiating a publication program to interpret research findings into relevant and comprehensive forms for the citizen layman. We would like to expand our cooperation with major associations and groups representing various segments of California's population and producing informational conferences, courses, and educational materials appropriate for respective audiences. We will work more consistently with the university's informational media and with nonuniversity media to develop informational programs of significant public issues.

This committee might ask how much of the additional appropriated money would be absorbed in administrative and overhead costs of the water center. Based upon my university's experience to date, the answer is very little. In recent years less than 10 percent of the Water Resources Research Act funds have gone into administrative overhead and for the current year over 97 percent of the allotment and matching funds are going directly to research.

In my opinion, our existing administrative setup is adequate to carry out the programs which could be initiated or expanded by the additional allotment.

California is now at the stage of development where it faces some major water decisions that will affect its entire economy and environment. These decisions must be buttressed by sound and adequate research if irreparable harm to the State and Nation is not to ensue. The proposed increase in funds will enable us to develop an expanded research and information program designed to meet critical public needs. Accordingly, I strongly urge this committee to approve this worthy amendment to the Water Resources Research Act.

I might add that I realize the testimony I have given is a very provincial view of what the amendment would do for California. Much of the research I must say has broad application, particularly when we are talking about peoples' attitudes, behavioral science attitudes, legal aspects in water development, and as you gentlemen realize, and the Congressman realizes, water in California has been I think even more important than the gold in California which started it all off in the first place.

Thank you, Senator.
(Dr. Kendrick's prepared statement follows:)

STATEMENT OF DR. JAMES B. KENDRICK, JR., VICE PRESIDENT, AGRICULTURAL SCIENCES, UNIVERSITY OF CALIFORNIA

I am James B. Kendrick, Jr., Vice President—Agricultural Sciences of the University of California. I also serve as the permanent chairman of the Coordinating Board of the University's Statewide Water Resources Center by appointment of the President of the University.

As Vice President, I administer the Division of Agricultural Sciences, a multi-campus organization whose functions are teaching, research and extension services. As Chairman of the Coordinating Board, I am responsible for the administrative supervision of the Water Resources Center which is the officially designated research unit in California for dealing with the Office of Water Resources Research and for carrying out the provisions of the Water Resources Research Act of 1964.

It gives me great pleasure to appear before this Committee on behalf of my University in support of the proposed legislation (S. 3353 and S. 3721) to broaden the program of and increase financial support for state water resources research institutes. These amendments are particularly significant for California, a State which presently faces many critical problems of water supply and distribution, and which must resolve many conflicts among water users and the public if a thriving economy and environmental well-being is to be assured. Not only would this legislation permit my University to undertake vitally needed research upon some of the State's urgent water problems, but it would enable us to embark upon a systematic program of citizen education and understanding for the purpose of fostering better policy decisions about the future development and conservation of the State's limited water resources.

As this Committee knows, California is a State with wide variations in water supplies, and with an uneven distribution of land valuable for urban and agricultural purposes, particularly between its northern and southern regions. To overcome disparate climatic and geographical conditions, the State has, since the turn of the century, been continuously involved in extensive planning and development of its water resources. As a result, most of the State's major agricultural areas such as the Central Valley and the Imperial Valley have been built upon technologically complex water storage, transfer, and distribution systems. Similarly, the major metropolitan regions, notably the entire San Francisco Bay area and the Los Angeles to San Diego complex have been fostered by elaborate water import schemes. Private and public enterprise, including the Federal, the State and the local governments, have all participated in constructing what is now the most intricate web of water relationships for any area in the world. Suffice it to say that the State of California would not have achieved its present population and economic growth without calculated utilization and management of its available water supplies.

Perhaps less visible than engineering features, but undergirding the whole California water development enterprise, has been an intensive program of research, a large part of which has emanated from educational institutions. A review of the historical evidence shows that the University of California through its Agricultural Experiment Stations and its Agricultural Extension Service worked closely with farmers in the study of plant-soil-water relationships, and the adaptation of improved irrigation practices. The University's hydrologists and engineers provided data and findings upon which water impoundment and conveyance systems were built. As the economy of the State became more complex and as the urban, industrial and recreational uses of water grew, the University sanitary engineer, the wildlife specialist, the economist, the recreational planner and representatives from many other disciplines became involved in water resources research activities. Presently, within the University of California, water-oriented research spans a broad spectrum of the natural and behavioral sciences. The degree to which the University research disciplines are now tied to the total economic and social well-being of not only California but the nation, is reflected in a table prepared by a Research Evaluation Committee of the Water Resources Center entitled "Program Areas in Water Resources Research Organized in Relation to Management Goals and Social Benefits," a copy of which is appended to this testimony. No one who studies this table carefully can fail to be impressed with the pivotal role that water resources research plays in the enhancement of the total environment.

Recognizing the need for an expanded and a more interrelated research pro-

gram, the University of California established in 1957 the Water Resources Center. This Statewide Center is charged with the responsibility for serving all campuses and divisions of the University in developing, coordinating and funding a research program, including the dissemination of results through publications and conferences. The Center is governed by a Board representing faculty of diverse disciplines and campuses, and an Advisory Council composed of distinguished water leaders and citizens of California provides vital information on research needs. The Center does not itself conduct research, but administers two separately funded programs—one dealing with "fresh water" and the other with water demineralization—which are undertaken by faculty in the regular teaching departments.

The passage of the Water Resources Research Act of 1964 proved to be of immense benefit to the University of California with its already established water center. The Federal Annual Allotment and Matching Grant programs enable the Center to approximately double its "fresh water" research programs, and it made it possible to move into new fields of investigation of significance to the State. Without attempting to be systematic in coverage in this brief presentation, let me cite a few examples of diverse research projects that have been funded by the Office of Water Resources Research, together with benefits that accrue. Research conducted at the Davis campus to develop a computer model of water flows in conveyance systems provided new design criteria for portions of the California Water Aqueduct. The construction of an input-output model on the Berkeley campus showing gross trade interdependencies among Western States in relation to water-dependent industries, has significance for resource pricing policies and water transfer schemes. Research is nearing completion on the Los Angeles campus involving improvements in rainfall forecasting on a seasonal basis for California and the West, information which will prove of incalculable benefit to many industries. A behavioral science study of the acceptability of mineral taste in domestic water conducted on the Berkeley campus, provides specific data for municipal water planners for the chemical design and treatment of urban water systems. Research on the Davis campus on the use of anti-transpirants to reduce evapotranspiration is providing significant insights into the reduction of water requirements of certain fruits and crops, as well as for highway ornamental and safety vegetation where tank truck watering is hazardous and costly. Research on the Riverside campus has revealed that watershed wildfires result in certain soils becoming nonwettable, greatly increasing the severity of flood flows and sediment production for which corrective measures are now being developed.

Despite all of the excellent research that is being presently conducted by the Water Resources Center, the University is falling behind in its water resources research efforts relative to the problems emerging. The dimensions of research have changed significantly in California since the 1964 Act was passed. Water research has become enmeshed in the explosive aspects of improving the quality of urban living, the preservation of the environment, and the strategies for economic and social change. Recognizing that research was not keeping pace with the needs of the State, some months ago I appointed a special faculty committee representing diverse disciplines and campuses to determine what needed to be done. In a report which was recently submitted, the Committee in essence concluded (1) that the University's water resources research program had to be reoriented to focus more effectively upon the critical problems of the State and the Nation; (2) that a broader range of scientific disciplines had to be involved in research particularly from the behavioral sciences; (3) and that research findings and results had to be more effectively disseminated for the purpose of fostering better private and public decision-making.

Drawing upon the findings of this Research Evaluation Report, brings me to the important question before this Committee, namely, what would my University and the Water Center do with the additional money which would be appropriated under this proposed legislation?

First, in terms of research we would broaden and intensify our efforts along the following lines:

—More attention will be directed to California's ecological and environmental complex with particular emphasis upon the impact of man and his facilities upon the State's natural amenities of coastlines, estuaries, lakes, and other water courses.

—Continued research effort will be given to the efficiency and productivity of agriculture, but with new emphasis upon its interrelationships to California's total environment and economy, since agriculture is the precursor of much urban development and provides greenbelts, open spaces and other amenities for urban populations.

—More of our research focus will be reoriented to the urban scene. In a state where 90 percent of the people will soon be living in metropolitan complexes and satellite urban communities, we recognize that the demands and values of the urban dweller will be increasingly shaping the patterns of water use and management.

—Greater emphasis will be placed upon the examination of water resources within an analytical systems framework. The various options and strategies for water utilization and development must be concurrently investigated including the interrelationships of conservation, reclamation, demineralization, water-basin transfers and waste disposal.

—Research dealing with the conservation of water use will be accelerated, including the systems for recycling and reuse, the alternatives for improving and maintaining water quality, and the economics and technology of water demineralization. Better knowledge concerning optimum water needs and standards of quality for different functions and purposes is extremely vital for California with its intensive water-using economy.

—Studies with respect to economic and financial considerations of water use and management will be intensified. Traditional concepts and practices of cost allocation, water pricing and benefit evaluations need to be reexamined within the framework of new technologies, and changing economic and social conditions.

—More research will be directed toward the human, behavioral and institutional aspects of water use and management. Existing research programs have emphasized the physical and engineering factors to the neglect of the study of social processes and arrangements that achieve public acceptability and support.

In addition to the increased emphasis upon research, funds provided in the proposed legislation would enable my University to systematically develop a program designed to inform and educate the citizens of California concerning water resources needs and problems. An expanded program is sorely needed in a State where divisive conflicts among groups and geographical areas are engendered and inflamed by information and communication gaps.

At his point let me note that our Water Center currently issues a good series of technical publications based upon research findings. It has also sponsored a few conferences on such topics as Water Quality Management, Groundwater Management and Water Pricing Policy. However, the Research Evaluation Committee found that, in general, both the publications and the Conferences reached only the professional water fraternity and not the broader segments of California's population. They concluded that the Center would have to provide a better linkage between research and policy-making if the findings of research were to have demonstrable impact upon both private and public decision-making.

If the money authorized in this proposed legislation were forthcoming our Center would propose to undertake the following:

—Initiate a publication program designed to interpret research findings into relevant and comprehensive form for the citizen-layman.

—Cooperate with major associations and groups representing various segments of California's population in producing informational conferences, courses, and educational materials appropriate for the respective audiences.

—Work through the University's informational media and with non-University media to develop informational programs on significant public issues.

—Adapt some of the educational techniques of the Agricultural Extension Service for the transmission of water resources knowledge to urban populations.

A question which members of this Committee might ask, is how much of the additionally appropriated money will be absorbed in administrative and overhead costs of the Water Center. Based upon my University's experience to date the answer is very little. In recent years less than 10% of the Water Resources Act funds have gone into administrative overhead and for the current year over 97% of the allotment and matching funds are going directly into research.

California is now at the stage of development where it faces some major water decisions that will affect its entire economy and environment. These decisions must be buttressed by sound and adequate research if irreparable harm to the State and Nation is not to ensue. The proposed increase in funds will enable us to develop an expanded research and information program designed to meet critical public needs. Accordingly, I strongly urge this Committee to approve this worthy amendment to the Water Resources Research Act.

TABLE 1.—PROGRAM AREAS IN WATER RESOURCES RESEARCH ORGANIZED IN RELATION TO MANAGEMENT GOALS AND SOCIAL BENEFITS

Object	Management goals	Programs for—				Program benefits	Social benefits
		Protected environments (1)	Agricultural environments (2)	Urban and industrial environments (3)	Combined environments (4)		
maximize water quantity.	Increase water supply at source. Control and retain flood waters. Increase use efficiency.	Watershed management. Upstream flood control, sediment control.	Weather modification; Studies of water cycle. Water harvesting. Contour plowing and other treatments to reduce sediment flow.	Water supply systems. Street drain systems.	Engineered systems. Flood control systems.	Increase water availability. Protect life and add to controlled release. Increase effectiveness as a resource.	Optimize income and regional development.
Water resources.	Maximize water quality.	Desalination. Reconditioning return flows after use.	Evaporation control. Irrigation system analysis. Conversion of sea water and brackish water to fresh water.	Methods of reducing water use in industry. Methods of reducing water use at home.	Coordinate use of surface and ground water. River development for navigation and power development. Recharge ground water. Maintain salt balance in soil zone, and ground water. Determination of environmental standards.	Assure water supplies for future growth policies. Maintain public health, augment water supplies close to demand site.	Optimize well-being.

TABLE 1.—PROGRAM AREAS IN WATER RESOURCES RESEARCH ORGANIZED IN RELATION TO MANAGEMENT GOALS AND SOCIAL BENEFITS—Continued

Object	Management goals	Program objectives	Programs for—				Program benefits	Social benefits
			Protected environments (1)	Agricultural environments (2)	Urban and industrial environments (3)	Combined environments (4)		
Promote ecological values.	Develop preferred ecosystems.	Improve natural fresh water. Preserve preferred ecosystems.	Desalination of natural water.	Removal of substances harmful to crops. Preservation of remnants of natural ecosystems and water they require.	Addition or removal of substances affecting health. Low water control in natural channels.	Control of thermal pollution.	Preserve natural values and augment health. Provide aesthetic and recreational uses of water in natural settings.	
			Fresh water requirements of natural ecosystems.					
Employment of water as an agent of beauty.	Develop preferred ecosystems.	Employment of water as an agent of beauty.	Salt water requirements of natural ecosystems.	Regulation of the beach zone, river channels, lake shores, for beauty.	Water policy for use of rivers, lakes, and beaches in cities.	Water policy for recreation.	Provide opportunities for recreation in new sites. Increase urban attractiveness.	Optimize environmental quality.
			Water requirements of controlled game and fish populations.					
					Consideration of water policy as a control of urban growth.	Land zoning.		

Improve economic social institutional aspects of policy planning and management:

- Development and implementation of public policy in relation to water and water-related problems.
- Development of technology for project and system planning.
- Determine human attitudes toward environment water quality and water cycling and reuse.

d. Extend knowledge with respect to all aspects of finance such as benefit-cost analysis pricing, cost-sharing allocation.

e. Economic analysis of alternative technologies and methods in water management. Environments that are 1) complex (large basins or regions) 2) multipurpose developments or 3) neutral problems (those pertaining to a region at large). Optimize effectiveness of social and governmental institutions.

Senator Moss. Well, thank you very much, Dr. Kendrick. I concur in your last statement and since all of the Senators who are sitting on this panel now come from very arid areas, I think all of us appreciate the extreme importance of water not only in agricultural use but in all other areas important to our States. All of us have been insisting for sometime now that we need to step up our efforts in research on all phases of water, not only on how it can be acquired, preserved, and distributed but on how it can be reused. Also how we can educate the public to properly address themselves to the uses of water and indeed where we are going to go when our population doubles and triples as it has done in California over the last couple of decades.

It seems to me you have concentrated in California nearly all of the problems associated with water—increasing population, a very arid area, some areas of surplus so you have distribution problems along with pollution, and so on.

We are very glad to hear from you and pleased with your testimony.

You answered one of the questions that I had turning in my mind near the end of your statement when you pointed out that the State itself contributed virtually all of the overhead on the research done in the institute with these funds. I think you used the figure about 97 percent, which means that the State certainly is matching the amount of money put out by the Federal Government and provides personnel and overhead that are not compensated. The Federal money therefore goes almost entirely directly into the research function, which was the congressional intent. That is part of the genius of this act. By bearing some of the burden it enables the States to get on with research. If the State had both the burden of research and overhead it would be more limited in what it might do.

You said that with the amount coming in now the water resources center at the university is falling behind. I think this is true in most States, and maybe all, which is one reason for supporting this fairly modest increase. After all, \$250,000 a year to each of the institutes is not an overwhelming amount of money considering the size of appropriations we deal with in this Congress. I don't mean to indicate that other appropriations aren't needed, but certainly there is sore need in the water resources and research field. So I appreciate having you testify, and telling us quite specifically as to the areas where you would be using these funds should the additional moneys be authorized by passage of this act.

Dr. KENDRICK. Thank you, Senator. I would like to add just one thing. You are quite right the increases are modest, and I want to emphasize that while I listed a lot of areas that indeed we need to go into, we don't belittle the \$150,000 increase to the allocation to the center if this should come by.

I would like to say one other thing.

One of the geniuses of the Congress on the early years was the passage of the Hatch Act. As you know in my full responsibility for administering the entire agricultural program for the University of California, the Hatch Act plays a very important part of the ongoing appropriation to the Agricultural Experiment Station. And it has been through that device and that foresightedness I think in this country that has done for agricultural research what I think is intended in this act, in developing water resource research in such a way

that you have this continuing appropriation. I don't say for a minute that it shouldn't be policed and accounted for in the sources that are appropriated, but the continuation of the annual allotment to the States allows a very much more efficient research program to continue.

Senator Moss. Thank you very much.

Senator Bible?

Senator BIBLE. I have wanted to commend Dr. Kendrick for an excellent statement. I am particularly glad that he was introduced by such a distinguished Congressman as the Congressman from the Second District of the State of California. Congressman Johnson is in a good deal the same position as Senator Allott of Colorado. He comes from the district that generates the water that goes into the Sacramento and American Rivers, and I don't know of anyone who has spent more time and has been more effective in water resource work in the State of California than Congressman Johnson. There is seldom a day or a week goes by that he doesn't ask for just a little bit more money to build another dam to stop the water from flooding out Sacramento and other areas in California, but he is dedicated to the wise and careful use of waters of his State. And I commend him for it. He has been an able workman in this field.

Mr. KENDRICK, what is the university's statewide water resources center?

Mr. KENDRICK. Senator Bible, the water resources center, the reason it is called statewide is—it is a redundant term. It is the University of California Water Resources Center. The reason that it is indicated here in this testimony as statewide is because the center carries on activities on I think about seven of our nine campuses.

Senator BIBLE. How large is that center in point of manpower? How many people do you have?

Mr. KENDRICK. The center itself has a director and an associate director and the usual staff. It has no in-house research staff at all. It calls upon the faculty members and the center acts largely as a University of California granting agency within the State and within the university.

Senator BIBLE. What is the usual staff, director and assistant director? I hope you don't pattern after the Federal bureaucracy because the usual staff might be rather large.

Mr. KENDRICK. I get your point. They are probably about—there is an administrative assistant and two or three secretaries.

Senator BIBLE. And you in turn are rather the clearinghouse for the various campuses that are University of California oriented or under the broad umbrella of the University of California?

Mr. KENDRICK. Yes. The University of California has nine campuses.

Senator BIBLE. Has nine campuses?

Mr. KENDRICK. And we have responsibility for all of those campuses that administer the funds from OWRR and other State-appropriated funds which exceed those that we get from OWRR.

Senator BIBLE. How many, if you know, are engaged in water resources work in the nine campuses total, not your overseeing clearing-house function?

Mr. KENDRICK. Senator, there are considerable, and I hesitate to

answer this because I do not know specifically. I can provide that for the record.

Senator BIBLE. You could provide it for the record. You might give us a range.

(Subsequent to the hearing Mr. Kendrick sent in the following clarifying data:)

UNIVERSITY OF CALIFORNIA,
OFFICE OF THE PRESIDENT,
Berkeley, Calif., July 24, 1970.

HON. FRANK E. MOSS,
Senate Office Building,
Washington, D.C.

DEAR SENATOR MOSS: When I appeared before the Subcommittee on Water and Power Resources on Monday, July 20, 1970, it was requested by Senator Bible that I forward information on the number of personnel in the various research projects administered by the University of California Water Resources Center. Attached is a table providing the information which is desired for the record.

My sincere thanks for the courteous reception of my testimony by you and the rest of the Committee.

Sincerely yours,

J. B. KENDRICK, Jr.

[Enclosure.]

NUMBERS OF PERSONS INVOLVED IN THE RESEARCH PROGRAMS OF THIS CENTER DURING FISCAL YEAR 1970¹

(All campuses)

	Under OWRR annual allot- ment program (all Federal funds)	Under OWRR matching grants program (Federal and State funds)	Under projects funded from State sources	Total
The fresh water research program:				
University faculty.....	10	24	31	65
Professional research personnel.....	2	15	12	29
Postdoctoral fellows.....			3	3
Graduate students.....	17	41	27	85
Undergraduate students.....	6	11	23	40
Technicians, clerical, etc. ²	4	13	26	43
Total.....	39	104	122	265
The water demineralization research program: ³				
University faculty.....			17	17
Professional research personnel.....			6	6
Post doctoral fellows.....			6	6
Graduate students.....			37	37
Undergraduate students.....			4	4
Technicians, clerical, etc. ²			16	16
Total.....			86	86
Grand total ¹	39	104	208	351

¹Does not include personnel of Water Resources Center and its Archives (3 faculty, 3 librarians, 8 undergraduate students).

²Services of accounting, shop, and report preparation by contract are not included.

³There are Federal grants made by Officer of Saline Water, U.S.D.I. to this program, but these grants are not administered by this Center, and therefore not included. There are many fresh water research programs on individual campuses, also, that the Center does not administrate, and are therefore not included. The Center performs only a coordination function with these.

Mr. KENDRICK. Several hundred.

Senator BIBLE. Several hundred professors and supporting staff?

Mr. KENDRICK. Yes; including students.

Senator BIBLE. Student included. This is a little afield of the subject we are examining but curiosity prompts it. What is the total student enrollment in the nine campuses of the University of California?

Mr. KENDRICK. About 107,000.

Senator BIBLE. 107,000. And the nine campuses employ how many professors and teachers that are engaged in actual teaching, not administrative?

Mr. KENDRICK. About 6,500.

Senator BIBLE. 6,500.

Well, I think you have made a fine statement, and I think certainly those of us who have worked in waterfields for many, many years know some of the problems that California has that are even more complicated than those of Colorado, if I might just use an example that comes handy now.

One of Senator Allott's main problems has always been that he takes credit for furnishing all of the water that generates all the power that comes to the Lower Basin States and California and he wants a better deal, and he usually gets it because he says they are creating electrical energy that ultimately gets to the city of Los Angeles and other areas in the State. So there is some validity in comparing his role in this water picture with that of Congressman Johnson.

Thank you very much.

Mr. KENDRICK. Even within our own States water generates in areas where most of the people are not living.

Senator BIBLE. I am very well aware of this and that is why I alluded to Congressman Johnson. You have a bit of an intrastate problem of Oregon. But I am not going to get into that now. It would probably take a few minutes more than we have remaining before lunch.

Thank you, Mr. Chairman.

Senator Moss. Thank you, Senator Bible.

Senator Allott, you are allotted your rebuttal time.

Senator ALLOTT. Well, this is all in good spirit because we all represent our own States in the way we think they should be. I don't want to embarrass Congressman Johnson in any way by saying the good things that I would like to say about him. I only say this, the superlatives that have been used by my colleagues are not too superlative concerning his contributions to the Interior Committee in the House and Interior Committees in Congress. And I want to say that for the record. I sat with him on many, many bills in conferences between the House and the Senate, and he is one of the great knowledgeable people on the House side and in fact in the entire Congress. I couldn't say too much in behalf of his work.

I would like to say this first of all about your statement, Mr. Kendrick. It is the kind of a statement I like to see. And it makes a great deal of sense to me. I like to see statements that have more than just a bunch of words in them, people who have given enough thought to it to be able to set out in apple pie order where they have been and where they want to go. And from that point of view I think you have a very, very excellent statement.

Mr. KENDRICK. Thank you, Senator.

Senator ALLOTT. Particularly on page seven where you have said specifically what you hope to accomplish with additional resources for your centers.

I don't want to be misunderstood in this area at all. Having been engaged as a practicing lawyer and spending almost two-thirds of my

time with water and water problems, I can hardly help but have a great interest in water. At the same time, as the chairman has suggested, I don't know of any water problem that I can think of offhand that the State of California has not faced. And through the advocacy of your Representatives in Congress you have been very well taken care of. California is a big State and it has a lot of people, and it does take vast sums. But at the same time while California has received a lot of Federal money, California has also placed a great financial burden on itself to try to take care of its own problems. For this I think she deserves a great deal of credit, if I may say so, and this despite the antagonistic positions at times that we in upper basin States have had with the State of California.

My concern about this whole proposal really comes in two areas. This is a modest program that Congress has initiated and the additions here are not immodest, but I am concerned about that area in connection with the quality of research.

One thing that I think sometimes tends to happen where you have research emanating from a Federal source entirely is that you do not have necessarily the selection of the best researchers in a given field, nor do you necessarily have the research in the specific areas which will be of most value to that particular area or to the country. It sometimes also depends upon who knows who and who is working under who. And my only concern about research in this particular area is that it be of the highest and the very best quality and that it go to those areas which are most pertinent to what we regard generally now as the supply and the quality of water for our use.

And then the second great concern to me is the question of dissemination. And that problem is a very recurring one. We have thousands, perhaps hundreds of thousands, of pages of reports through commissions of the government and boards of the government which are printed and promptly placed on the shelf where no one ever refers to them. So that if the quality of research in your State or mine or Senator Bible's or Senator Moss' is very high and it reflects the needs of those States—and as I said yours gets almost into the whole wide area of anything touching water—then this will serve its purpose and serve it well. And then if it is disseminated—and this is why I was impressed by your last points, not the previous ones you mentioned but the last ones, where you place so much emphasis on distributing data and making it available to the layman who may be the mayor of a town and know nothing about water except that you turn a tap—it seems to me that then the research we are doing becomes significant.

I don't think you have to have apologies for being parochial at all because the problems of each State do vary, and you can probably do your best work in California or in Nevada or in Utah or in Colorado or in New York by devoting yourself to the problems that affect that State, thus producing the sum total of knowledge which will enable us to deal with our water problems. I would like to ask you one question.

In this whole area, we realize that water is just not a question of biology or microbiology or a question of pollution or a question of soil conservation. And soil conservation does come in very heavily. We get into all kinds of disciplines. What means do you use as administrator of this program to effect interdisciplinary action to the solution of your problems?

Mr. KENDRICK. Senator, you have touched on something that we spend a lot of time talking about. It is sort of related to you can lead the horses to the trough and hope they will drink from it if you provide the atmosphere.

I think that the way we accomplish this best is through the actions of our coordinating board, the board that I chair. The coordinating board is in essence the board of directors for the Water Resources Center, and it meets actively three or four times a year to study and decide what areas of research we want to go into. It has the power—

Senator ALLOTT. May I interrupt you?

Mr. KENDRICK. Yes, you may.

Senator ALLOTT. Before you proceed, you then have representatives from all nine universities?

Mr. KENDRICK. Yes. The coordinating board has representation from all campuses with the exception of the San Francisco campus which is the medical campus. We have stipulated in our organizational plan that we have representation from the social sciences, from engineering, from agriculture, from political sciences and marine sciences and biology so that we purposely structured our coordinating board so that it has wide range of disciplines represented. We have professors of law also serving on that board. This board then reviews the recommendations of the director and will encourage—it approves actually—the grants within the university for applications for funds for programs. It is by this means that we encourage the interdisciplinary approach to these problems. We also set up task forces and appoint committees composed of representatives from the social sciences or from any appropriate area that provides the kind of interdisciplinary mix that we think is important.

An example of the kinds of things we have done antedating my particular responsibility with this committee, the water resources center coordinating board felt that the impact of water and the highway development system, the Federal highway system going down the east side of the San Joaquin Valley in the virtual virgin areas was such that we should begin to study what the water and transportation development in the area would be. So we established a steering committee composed of many representatives from the faculty to devise a plan of study whereby the university's expertise could be helpful in providing alternatives. We weren't trying to plan the whole future of the San Joaquin Valley but to face some alternatives of what would happen with the location of cities and roads, total economic development.

This has developed into a major project of its own under the auspices of the Water Resources Center.

Senator ALLOTT. Well, then, the interdisciplinary aspect of your work takes place basically at your level, or at the level of the Center itself through the coordinating committee.

Mr. KENDRICK. We are the major area that encourages it—we have actual working arrangements in the projects. We have interdisciplinary approaches to the programs.

Senator ALLOTT. At the individual colleges you do have efforts also to have interdisciplinary action with each research project?

Mr. KENDRICK. That is correct.

Senator ALLOTT. Thank you very much, sir.

Senator Moss. Well, thank you very much, Mr. Kendrick and Congressman Johnson. We are most pleased that you came here and your testimony has been valuable to this subcommittee.

Mr. JOHNSON. Thank you, Mr. Chairman.

Senator Moss. We will hear one more witness before we break for the noon recess, and I am going to call on my colleague Senator Bible to introduce Dr. George B. Maxey, director of the center for water resources research at the desert research institute. Will you come forward, Dr. Maxey, and I recognize Senator Bible.

Senator BIBLE. Thank you very much, Mr. Chairman.

Mr. Chairman, it is my distinct pleasure and honor and privilege to introduce to you and to Senator Allott, George Maxey, who is the director of our center for water resources research at the University of Nevada operating through the Desert Research Institute.

Mr. Maxey is an unusually well-qualified water research man, having spent many years with the U.S. Geological Survey. He has been a leader in our State of Nevada in this field and has prepared many papers under his own name particularly in the field of underground water.

He has, I think, a very fine statement. I have read it, I have discussed it with him. I am going to suggest to him that he, in the interest of time, incorporate the full statement in the record and then highlight the points that he cares to make in support of your particular bill which is before this committee for consideration at this time.

And I now introduce George Maxey to the other members of the committee.

Senator Moss. Thank you, Senator Bible.

And Dr. Maxey, we are very glad to have you, sir.

STATEMENT OF GEORGE MAXEY, DIRECTOR, CENTER FOR WATER RESOURCES RESEARCH, UNIVERSITY OF NEVADA

Mr. MAXEY. Thank you.

Thank you, Senator Bible. And since you have introduced me I will not waste time in talking about who I am. I would like to add to the record that I am representing Chancellor Neil Humphrey of the university system which takes care of both of our campuses and the desert research institute, and he joins me in making this statement.

Senator Moss. Thank you.

Mr. MAXEY. Mr. Chairman, the former Secretary of the Interior at the time that this bill, the Water Resources Research Act of 1964, was being considered made a statement that in my opinion covers essentially the aims and objectives that this committee and the Senate and the House of Representatives meant the bill to accomplish.

It enlisted—the statement of Senator Udall enlisted the scientific and engineering competence of university research in water resources problem solving, and I also suggested that the critically inadequate program of scientists and engineers being trained in the sciences would be greatly increased as a result of the passage of the bill.

These two benefits are to me the most important of the program. In my statement I have pointed out that in the past 6 years there was a development in the first 3 years which was a consistent climb in training of graduate students and young people in the water resources

field. And if you look at the numbers of page 2 you will see that starting in 1968 a decline, consistent decline, has occurred, which we in the Nevada Water Resources Center attribute to the diminishing value of the dollar—in other words, to increased costs which resulted ultimately in the graduate student as well as the rest of the program being neglected.

I do not have nationwide figures, but qualitative estimates and conversations with other directors indicate that this same trend is true.

This point I want to make because I think that training of water resources research specialists is one of our big aims in the OWRR program.

In looking at verification of this concept, I studied the literature and came across a very recent study that came about 3 weeks ago by Dr. James E. Lewis of the Louisiana Water Resources Research Institute who points out the need for immediate action to increase the supply of water resources research manpower to reach our own national goals.

Dr. Lewis points out that by 1975 there will be a deficit in water resources manpower of over 50,000 and by 1980 this deficit may well increase to a hundred thousand. And that statement is referred to in my statement.

I might point out also looking at the national benefits of the manpower training program, of the people who have been trained in Nevada only one has been retained there, and in effect we have had sort of a loss of brainpower from the State in our training.

Our people are teaching in such faraway places as Israel, in Florida, in Illinois, and are working with consulting companies around the world. We are contributing nationally to the manpower shortage, even though we are a very small effort in the overall picture from the point of view of the Nation.

A second point I would like to make, and if I may, Mr. Chairman, introduce four corrections in my statement for the record.

On page 4 in the columns of figures under fiscal 1965 through fiscal 1971 under "Allotment authorized," the figure \$28,051,000 should be changed to \$33,151,000, and this changes the total then to \$95,151,000.

And under the "Appropriated" column the first figure instead of being \$27,211,000 should be \$32,311,000, and the total should be \$57,561,000.

The reason for this happening is a matter of typographical error. It proves that college professors also are not completely infallible.

Now, a second point that I would like to make is the way that inflation in other areas has eaten into our hundred thousand dollar allotment. It is reflected in higher salary costs. In Nevada alone the salary schedule reflects an increase in salary costs of 25 percent during the period 1965-70.

Small items of equipment that may seem insignificant in view of the astronomical terms that the U.S. Government budget reflects, but still which are extremely significant to a college professor trying to run a water resources research program, includes such things as 40 percent rises in water level recorders, and pH meters have increased 30 percent, conductivity meters have increased 50 percent.

We have to have the equipment in order to do the work, so we buy the equipment at the expense of the graduate student quite often.

We have had to drop support for the students in favor of equipment and operations.

Another item that has concerned us very much in the water resources research business is that there is available as a result of the space effort and as a result of developments in the nuclear energy field a tremendous array of equipment of high accuracy and of sophisticated development that is not being adopted in the water research business because we do not have money to support the adoption of it.

I would suggest, for example, sensing tools for temperature potential, chemical constituents, and the like. And as Dr. Lewis in the same report I quoted before said—

A qualitative shift in manpower requirements, if not a quantitative reduction, could be achieved through the encouragement of the OWRR and other agencies toward more intensive research in the application of remote sensing system to water resources.

This applies not only in remote sensing systems but in other measuring devices.

Now, some questions have been raised as to the practical results of research efforts, practical not only from the regional and local point of view but also from the national point of view.

And I have selected in my statement, and I do not certainly intend to go into these projects in detail, but I have selected three projects which have significantly affected both State, regional, and local thinking in terms of ground water resources in recent years.

The first of these is a title II project which developed a simulation theory model of the Truckee-Carson River Basin. Almost upon the—really before this was completely developed, a critical condition developed on the pyramid-like question in Nevada, and a Federal task force was appointed to look into this. That Federal task force, Federal and State task force has looked at our simulation theory model and is planning its utilization in analysis of such things as appropriation problems, water use problems in the Pyramid-Tahoe region.

We have also developed chemical and flow regimes of Great Basin springs. These are tremendously important to us in the Great Basin, and this of course involves Utah, small parts of Oregon, and Idaho as well.

We have obtained some very practical results. Some of these are being used by the U.S. Bureau of Sport Fisheries and Wildlife, and other agencies.

Again, early in our program we recognized the need for an analytical tool that would be extremely useful in basin studies and in ground water studies. We selected the electrical analog for this work. Our electrical analog as far as we know is the first one that was used for the actual management of a ground water basin anywhere in the world.

All the other analogs were utilized purely for research purposes, and that tool is still being used by our State engineer in his development of appropriations in his judgment on appropriation of water in Las Vegas Valley.

We have used the analog for other purposes, analysis of power output at Boulder Dam, for example.

Senator Allott may be interested in this problem. We might have been on the other side, Senator. I don't know.

And we have the analog in analyzing a river basin for the development of dams and recreational facilities.

Now, this I do not consider to be a complete statement. I hoped to cover some points that were extremely interesting to us in Nevada and in our program. And I hope that the other witnesses have developed other points that I have missed. And I appreciate very much the opportunity to testify here, and I hope that the Senate sees fit to act favorably on Senate bill 3553.

Thank you very much.

Senator Moss. Thank you very much, Dr. Maxey.

(The prepared statement of Mr. Maxey for inclusion in the record follows:)

STATEMENT OF DR. GEORGE B. MAXEY, DIRECTOR, CENTER FOR WATER RESOURCES RESEARCH, DESERT RESEARCH INSTITUTE, UNIVERSITY OF NEVADA SYSTEM, RENO, NEV.

Mr. Chairman, I am George B. Maxey, Director of the Center for Water Resources Research of the Desert Research Institute, a unit of the University of Nevada System. As such I have been completely involved with the implementation of OWRR programs, both in the State of Nevada and through close association with other state directors at the national level. In making this statement, I am also representing Mr. Neil D. Humphrey, Chancellor of the University of Nevada System and a member of the Committee on Water Resources of the National Association of State Universities and Land Grant Colleges. I am here to testify in support of the pending bills introduced by Senator Moss and Senator Hansen to amend the Water Resources Research Act of 1964.

Mr. Chairman, during the 1963 hearing before this Committee, a statement by the then Secretary of the Interior was included in the hearing record that I would like to quote in part:

"Legislation to assist water resources research at universities will have two beneficial results. It enlists the scientific and engineering competence of university research in water resources problem-solving, and it will also result in augmenting the critically inadequate numbers of scientists and engineers trained in the sciences related to water resources."

These benefits, gentlemen, are to me among the most important of the program.

To cite a few statistics that apply to the Nevada Center, I would point out that, in the field of training scientists, eight Ph.D. and twenty-four M.S. graduates of the University of Nevada have received support under the Water Resources Research Act. Currently eight Ph.D. candidates and seven M.S. candidates are receiving support and being trained under this program. Five of the Ph.D. graduates are now engaged in teaching and research programs at various universities throughout the United States. The other three Ph.D. graduates are actively engaged in water resources programs with the U.S. Corps of Engineers, the U.S. Geological Survey, and at our Center. Of the M.S. graduates, six are continuing their training as Ph.D. candidates, six are engaged in research, seven are working for resource agencies or consulting firms and the remainder are completing military obligation or their status is unknown.

NUMBER OF GRADUATES WHO RECEIVED SUPPORT UNDER THE WATER RESOURCES RESEARCH ACT OF 1964

	M.S.	Ph. D.	Total
1965.....	1	0	1
1966.....	2	0	2
1967.....	7	3	10
1968.....	7	1	8
1969.....	5	2	7
1970.....	2	2	4
Total.....	24	8	32

I do not have the information nation-wide, but qualitative estimates suggest that our experience is representative of the experience of the other 50 participants covered in allotment program. However, it is disturbing to me that the 1969 report of the Office of Water Resources Research indicates a leveling or dropping

eff in student enrollment after the 1966-67 school year. In Nevada we have experienced this trend. In 1967 ten graduate students completed their program. This number dropped to eight in 1968, seven in 1969, and to only four in 1970. This reduction, in our case, has not been because of the lack of qualified candidates, but rather the result of continued inflation and increased competition for research support. This reduction in available student support is particularly disturbing in view of recent studies such as the one recently completed by Dr. James E. Lewis of the Louisiana Water Resources Research Institute which points out the need for immediate action to increase the supply of water resources research manpower to reach national goals. Dr. Lewis points out that by 1975 there will be a deficit in water resources manpower of over 50,000 and by 1980 this deficit will increase to well over 100,000 (Louisiana Water Resources Research Institute, Bulletin 4, 1970).

The Committee undoubtedly recognizes that since 1965, the Congress has authorized the expenditure of \$90,051,000 for the three programs. Of this amount, \$52,461,000 was recommended for appropriation by the administration and has been appropriated by the Congress. In other words, during the seven year period from fiscal 1965 through fiscal 1971, the appropriations recommended in the administration budget have been about 58 percent of the authorization and \$37,590,000 less than the amount authorized by this Committee and the Congress.

FISCAL 1965 THROUGH FISCAL 1971

	Authorized	Appropriated
Allotment.....	\$28,051,000	\$27,211,000
Matching.....	25,000,000	15,750,000
Title II.....	37,000,000	9,500,000
Total.....	90,051,000	52,461,000

A rather unique situation involved in the requests and appropriations is that while the allotment program, the one now suggested to be amended, has been fully funded during the last six years, support for the matching grant program under Title I and the Title II program of additional water resources research has been only a fraction of the authorization.

It would appear from this history that the allotment program may have been considered mandatory by the Bureau of the Budget and the Department of the Interior in both administrations and that the amount the Congress sees fit to authorize for this program can be reasonably assured of being funded. Adoption of the amendment to Section 100 of the Act increasing the authorization for the allotment program from its present \$100,000 per annum for each state institution to the proposed figure of \$250,000 could very well relieve the financial strain and permit a restoration of the program to its earlier effectiveness before the respective Center's activities are progressively hampered by the results of general inflation.

This inflation is reflected in higher salary costs and in substantial increases in costs of supplies and materials required in our research effort. The University of Nevada System salary schedule reflects an increase in salary costs of twenty-five percent during the period 1965 to 1970.

A water level recorder which cost \$182 in 1965 has increased in costs to \$252 or nearly 40 percent, a pH meter has increased 30 percent and a conductivity meter, 50 percent.

Another item that has concerned those of us in the research field is the lack of funds to acquire and use in the water research field the sophisticated types of equipment recently developed for and now used so successfully in the space effort. Examples would include the adoption of various sensing tools for temperature, potential, chemical constituents, and the like.

For example, Dr. Lewis points out:

"A qualitative shift in manpower requirements, if not a quantitative reduction, could be achieved through the encouragement by the OWRR and other agencies toward more intensive research in the application of remote-sensing systems (airborne sensors and satellites) to water resources."

Some questions have also been raised as to the practical results of the research efforts of the various Centers funded under the program. We at the Desert Research Institute have continually attempted to direct our efforts toward

projects that directly affect the well being of our people and result in practical use of our research activities.

I have selected three of the many projects of our Center as examples of our efforts. They are summarized herewith:

"APPLICATION OF SIMULATION THEORY TO WATER RESOURCES PLANNING AND
MANAGEMENT

"The purpose of this study was to develop a method by which various types of management decisions affecting the optimal operation of a complex river system can be analyzed and evaluated. The Truckee-Carson River system was chosen to evaluate a number of newly-developed tools in water resource planning under a realistic situation. A method of combining the hydrology of the system, stream-flow synthesis, and an optimization technique into a system model was developed. State and federal agencies are currently involved in the resolution of some serious water management problems on the Truckee-Carson River System. The management model developed under this project has drawn wide interest from all concerned agencies in the direct application of this model to evaluate proposed changes in water management practices.

"The Pyramid Lake Task Force appointed by the governors of Nevada and California and the Secretary of the Interior to find a solution to the problem facing the Pyramid Lake Indian Tribe, that of an inadequate water supply to stabilize Pyramid Lake, has shown special interest in the model. Members of the Task Force have seen the capabilities of the model demonstrated and intend to utilize the model to evaluate various management policies for Lake Tahoe and other upstream reservoirs and the effects of water use change on the supply available to Pyramid Lake."

"CHEMICAL AND FLOW REGIMES OF GREAT BASIN SPRINGS

"Springs are a major water resource of the Great Basin; many communities and enterprises are wholly or partly dependent on this source of water. This project investigated the variability, within the year and from year-to-year, of flow and quality of water of typical springs. Results are related to geology, hydrology, precipitation, and air temperature. From this, methods are developed for determining long-term limits within which flow and quality may vary and for predicting yearly flow and quality based on previous winter snowpack. The methods are applicable to any spring.

"Practical results have already been achieved. Using our data and approach, users at one group of springs (Martis Creek Springs, Truckee Basin, California) have established long-term assured yield and quality. This has permitted them to proceed on a rational basis with a major development which will have important favorable consequences to the local economy. In another case, our records and predictive approach have been used in evaluating the availability and quality of water at the fish hatchery of the U.S. Bureau of Sport Fisheries and Wildlife, Ruby Marsh area, Elko County, Nevada.

"The methods parallel on a smaller scale the case of river basin studies where allocation of water and economic development are based on knowledge and prediction of the variable yield and quality of the water resource."

"ANALOG COMPUTER FOR HYDROLOGIC RESEARCH

"An electric analog model of the Las Vegas Valley, Nevada ground-water basin was developed and used to determine the effect of a selected pattern of development of ground water and as a tool to assist State Administrative Agencies in the determination of water availability in an extremely short water area. Its utilization by the State Engineer of the State of Nevada in issuing or denying applications for underground waters has resulted in a comprehensive use of the resource.

"Another analog was developed for a study to determine an operational plan to obtain maximum annual power production from Glen Canyon and Hoover power plants. This study aided the Colorado River Commission of Nevada in its analysis of the operations of the two plants.

"The same analog was utilized on a Corps of Engineers upstream reservoir study on the Humboldt River. The study demonstrated that the downstream users would not be adversely affected by the upstream storage. The Elko Fair

and Recreation Board has utilized information obtained from the model to assist them in securing local support for construction of the facility."

In conclusion, and on behalf of the Desert Research Institute of Nevada, I would like to express our appreciation of the action of the Committee in considering this legislation and to urge favorable consideration by both the Committee and the Senate so this successful program can continue on the scale anticipated when the Congress approved the original proposal in 1964.

Senator Moss. Your statement is a very excellent one and gets down to some of the practical things that have been developed by the research program. This is something we always would like to look at. We want to know what is really happening, and you have been very specific on that.

Two of the things you have mentioned have impressed me particularly. Your table on page 2 shows the number of graduates who are being supported in part by these research funds has turned down in the last 3 years, indicating that we are not reaching as many, or at least not training as many scientists. This is a very important aspect. Then you have pointed out how inflation has caught up with water research like everything else in this country, just by computing the cost of specific items that you have to buy. The fact that they are up 30 to 50 percent in cost translates through to us that it is time to increase the authorizations because we cannot get the same results if we are trying to work on a 1964 level of funding in 1971 and on ahead.

Those are very practical things. And we are pleased also to have you appear immediately after California, which is a vast State with both a lot of water and dry area, and tell us about a desert State much like mine, smaller, much smaller in population but with problems that are just as vexing and need solving just as much as those in the huge State of California. We are very pleased that you could do this.

The introduction by Senator Bible gave us a good background of the work that you have done over the years, and I am sure you are very effectively operating the program now in the Water Resources Research Center in Nevada.

Senator Bible, do you have any questions?

Senator BIBLE. I have no questions. I want to commend Dr. Maxey for his usual fine workmanlike job in presenting his comments to this committee. I would only add, based on my own knowledge, that comments have come to me from various agencies in the State. This is a program in our State that is supported on a broad base by the State legislature, by the county commissioners, by the farm organizations, and by the stockmen. That shows to me great local interest and participation and enthusiasm over this program. For those who actually end up having to pay the bill, the tax bills, to have such enthusiasm for this type of a program, it must be very well worthwhile.

I can testify to the broad based support that this program receives throughout practically the entire State of Nevada. And I add that to show that it does bring results and does bear fruit.

Thank you very much for a fine statement.

Thank you, Mr. Chairman.

Senator Moss. Senator Allott?

Senator ALLOTT. Just a very brief one. I recently in relation to another bill here tried to bring out the importance of university-oriented research vis-a-vis private contract research with respect to the develop-

ment of graduate students, which is very much in accord with a part of your statement.

I think that this is a distinction that has to be made. I have here some material from the Department of Interior which shows that the number of students in this program has increased from 561 in 1965 to 1,361 in 1966, and to 1,900 in 1970, throughout the United States. These figures, I must also say, include upper class undergraduate students, so this is not a challenge to your statement. It does appear that we have been able to increase the total number of students, but I would imagine that perhaps your experience with the graduate students might be reflected in other universities also.

Mr. MAXEY. Ours is a purely graduate student program. And as I made quite plain I did not want to be the judge for the Nation, but I got this impression from discussing this with other directors.

Senator ALLOTT. I think the important thing is that the value that is received from a university-oriented program is the development of graduate students in the various areas of research which you certainly cannot get out of private industry or somewhere else. It has to occur within the university.

Mr. MAXEY. Yes, sir.

Senator ALLOTT. A very fine statement.

Senator MOSS. Thank you very much, Dr. Maxey.

Mr. MAXEY. Thank you.

Senator MOSS. We will now have to adjourn for lunch and we will reconvene promptly at 2 o'clock.

(Whereupon, at 12:20 p.m., the committee recessed, to reconvene at 2 p.m. on the same day.)

AFTERNOON SESSION

Senator MOSS. The hearing will now resume, and I am going to call on Dr. Norman A. Evans, the director of Natural Resources Center at Colorado State University, and ask my colleague, Senator Allott of Colorado, if he would like to introduce Dr. Evans.

Senator ALLOTT. I am very happy to, Mr. Chairman.

Mr. Evans is the director of general research at Colorado State University. We are very proud of our State university because of the amount of research and quality of research in almost every area, particularly concerning our natural resources and the natural sciences. And for that particular reason I am happy to have him here today and give us some idea of what has been done in Colorado. I might say that we do have in Colorado a Colorado State Water Conservation Board which is charged officially with the conservation and use of the water. So that there is the opportunity there to correlate the research work of the university, which has gone on for many, many years, directly with the actual use and application and conservation of water in the State.

Senator MOSS. Thank you, Senator Allott.

And, Dr. Evans, we are pleased to have you before the committee. You may proceed, sir.

Mr. EVANS. Thank you, Mr. Chairman.

STATEMENT OF DR. NORMAN A. EVANS, DIRECTOR, OFFICE OF
GENERAL UNIVERSITY RESEARCH, COLORADO STATE UNIVER-
SITY

Mr. EVANS. Mr. Chairman, thank you very much, Senator Allott, for that introduction.

As you have stated, I am director of the Office of General University Research which includes responsibilities for administering the Office of Water Resource research program in Colorado.

My duties include research development, coordination among research institutions of the State, and coordination with both State and Federal agencies working on water problems in Colorado.

In the latter regard, I am privileged to have an opportunity to serve as vice chairman of the Colorado Water Pollution Control Commission with an opportunity to relate our research program directly to that State agency and the other State agencies. And we take a great deal of pride in the degree to which we do relate the research to the needs of the State. I also serve as chairman of the water board for the city of Fort Collins, and so I feel that I am very actively engaged on the firing line so far as water resource management, development is concerned.

I feel it a very good advantage to me in performing my duties as director of the water research program in Colorado under this Federal act.

When that act was implemented in 1964, Colorado was already a leader in many aspects of water resources research. Four universities have long been involved in this kind of work. Colorado State University, of course, well known for a long history of leadership in irrigation and other aspects of water resources, especially hydraulic engineering; the University of Colorado also points to a long history of competence in many aspects of water resources, as does the Colorado School of Mines and the University of Denver.

Although this history is a long one, the volume of research was small prior to the 1964 act. That act increased the volume of research and stimulated research in new important fields that had previously not received very much research funding attention.

I think this is one of the outstanding results of that act, certainly for Colorado I feel this to be true.

According to the 1964 report from my office to the Office of Water Resources Research, there were 27 faculty members in 11 disciplines working in water resources research. My report for fiscal 1970 indicates there are 54 professors in 20 disciplines engaged today.

This impressive increase in scientific and professional effort is due in large measure to the stimulation of supporting funds through the Office of Water Resources Research.

During the course of the program today, which is about 5 years, there have been 280 students supported fully or in part in their graduate work on water problems. These men and women have subsequently entered the professional world prepared to bring new knowledge, new techniques, new enthusiasms and new dedications to these problems. Without that support many would have entered other fields leaving us even further behind inadequately trained manpower today.

Other testimony has touched upon the position with respect to trained manpower in the water field.

The section 100 allotment program with which S. 3553 deals provides a stable base for planning a head for both graduate students and faculty. And this is very important in maintaining a stable and productive program both with respect to trained manpower and with respect to research.

The research and graduate training institutions in Colorado have in fact more capability for water research in terms of faculty and facilities than they have fiscal resources with which to sustain them. The increase of S. 3553 would help us make fuller use of that capability.

Now, although I am attempting to review the problems of Colorado I will not do so because I am certain that your committee is well aware of them, and that the Honorable Senator Gordon Allott has probably made you very well acquainted with them. Instead I want to show you four illustrations which show the vitally important role which the OWRR research program has played in the development and management of Colorado water resources.

Without that program, each of these problems would still be waiting for answers.

The first one, Senator Allott referred to the Colorado Water Conservation Board as our leadership in planning. This board together with the U.S. Bureau of Reclamation is engaged in a long-range water program development, and the first step in that plan development is a look at the role of water in the total State economy.

This is called by the economists an input-output model. These two agencies, Colorado Water Board and the Bureau of Reclamation have asked us to develop that model, that input-output model which will form the foundation in the future development of the long-range water plan.

We are doing this in very close cooperation with them and with the active participation of members of the staffs of both of those agencies in the project.

So not only are we developing a need, answering a need there, but I think interestingly we are providing some important training for some of the staff members of both agencies. I think this is an incidental but rather important feature.

The second example, in pollution control our program is moving along from the period of setting of standards and classification of streams and water bodies into programs of heavier emphasis upon surveillance and enforcement.

One of our projects has been developed jointly with the Colorado Water Pollution Control Commission to make an analytical review of the current procedures, organization and policies of that program. This will analyze the technical adequacy of monitoring networks, for example, and provide us other inputs from a, you might call it an academic critique if you like, from the outside, from an objective third party so to speak on how that program is going, what the response to it is among the people of the State and where in the technical and management sense we can improve it.

I think this has been very valuable. Some recommendations already submitted will be adopted, and more recommendations are to come.

For example, No. 3, our grand transportation routes, in Colorado

necessarily follow generally the river systems because of the topography. Highway embankments often form one bank of a river channel crossing and recrossing many times.

These embankments suffer severe water erosion as do the abutments of bridges along those water courses. This serious problem has been studied within the OWRR program to devise and design, develop new ways of stabilizing and controlling that erosion.

These procedures, design recommendations have been given to the State highway department engineers, to the public roads people and have been applied along the Colorado River in the design of the Interstate Highway coming through Colorado.

The Denver Water Board has also used those procedures in stabilizing rivers which are used to transport water to the city of Denver.

The last case, flood runoffs from small watersheds in the mountain region has always been very difficult to forecast, virtually impossible, partly because of lack of historical runoff data but more importantly because of the complex nature of rainfall in that mountain area.

Public agencies such as the Highway Department, Soil Conservation Service and Bureau of Reclamation as well as municipalities, all concerned with drainage, with runoff, with runoff control, with flood control, have requested assistance in improving the ability to forecast flood runoffs. And this we have done under several projects of the OWRR program and have produced new analytical techniques and procedures for making better floodflow estimates.

In conclusion, the vision of Congress in initiating the OWRR program has been confirmed. It has provided Colorado with research answers on urgent problems which otherwise would not yet be available. It has been so successful in stimulating water research and training that it should now be expanded to provide for more rapid use of results.

Public decisions are increasingly dependent upon new knowledge. Too often the decisionmaking stage is reached before the new knowledge is available. It is vitally important that the Congress provide for a viable, forward-looking water research program.

That concludes my statement. I will have the full statement for the record. I have summarized it, and I thank you very much.

Senator Moss. Well, thank you very much, Dr. Evans.

We will place your full statement in the record at this point.

(The prepared statement of Dr. Evans for inclusion in the record follows:)

STATEMENT OF DR. NORMAN A. EVANS, DIRECTOR, OFFICE OF GENERAL UNIVERSITY RESEARCH, COLORADO STATE UNIVERSITY

My name is Norman A. Evans. I am Director of the Office of General University Research at Colorado State University in Fort Collins, Colorado. My responsibilities include supervision of the program of the Office of Water Resources Research, U.S. Department of Interior, in Colorado. My duties are research program development, coordination with both state and federal water agencies in Colorado, and coordination among the research institutions of the state.

When the Water Resources Research Act was implemented in 1964, Colorado was already a leader in various aspects of water resources research. Four universities have been involved. Colorado State University traces a history of national and international service in irrigation and hydraulic engineering back to the date of its founding in 1870. The University of Colorado points likewise to a long history of competence in the economic aspects of water resource develop-

ment. The Colorado School of Mines, recognized as the outstanding school of its kind in the country with regard to mineral and petroleum engineering and geology, has also devoted much academic and scientific attention to water as a mineral resource. The University of Denver has focused upon the economic and social implications of water resources, particularly as they relate to water-based recreation and water pollution control. Although the history is a long one, the volume of research was small. The Act increased the volume and stimulated research in other new and important disciplines.

According to the 1964 OWRR Report for Colorado, there were 27 faculty members in 11 disciplines working in water resources research, while my 1970 Annual Report shows that there are 54 professors in 20 disciplines so engaged today. This impressive increase in scientific and professional effort is due in large measure to the stimulation of supporting funds through the Office of Water Resources Research.

During the course of the program to date, there have been 280 students supported fully or in part in their graduate work on water problems. These men and women have subsequently entered the professional world prepared to bring new knowledge, new techniques, new enthusiasms and new dedication to those problems. Without that support, many would have entered other fields leaving us even further behind in adequately trained manpower today.

The research and graduate training institutions of Colorado have, in fact, more capability for water research in terms of faculty and facilities than they have fiscal support with which to sustain it. The increase proposed by S. 3553 would help us make fuller use of that capability.

I am tempted to review all the water problems of Colorado for you in support of legislation now being considered to increase financial support to water research. However, I will not do so because, in the first place, this committee is fully knowledgeable about water problems in the various regions of the country today, and in the second place, I would venture to guess that the distinguished Senator from Colorado, the Honorable Gordon Allott, has already oriented you to our problems. I will, instead, show you by means of four illustrations the vitally important role which the OWRR research program is playing in the development and management of Colorado's water resources. Without this program, each of these problems would still be waiting for answers.

Case No. 1

Long range plans and priorities for state water resource development are being formulated by the Colorado Water Conservation Board with the help of the U.S. Bureau of Reclamation. At the request of these agencies a study was initiated which will measure the role of water in the total state economy. The result will be an input-output model which will become the foundation for the State Water Plan. Personnel of the two governmental agencies are getting valuable training by actively participating in every stage of the project (B-059-COLO).

Case No. 2

Colorado's water pollution control program is now moving from the standards setting and stream classification stage into one of refinement in the surveillance and enforcement program along with greater attention to forward planning and operational efficiency. Project A-010-COLO was initiated jointly with the Colorado Water Pollution Control Commission to make an analytical review of current organization, procedures, and policies. Useful recommendations have been made to the Commission concerning: (a) technical staff reorganization for better management efficiency; (b) development of a long-range planning function within the staff, and (c) greater utilization of federal funds to augment state funds in water pollution control, especially pertaining to planning. This critique from an external position gives timely guidance to the state agency as it moves ahead in its important work.

Case No. 3

Ground transportation routes in the intermountain West, because of topography, coincide with river and stream systems. Highway embankments often form one bank of a river channel, crossing and recrossing many times. Water erosion of embankments and at bridge abutments is a serious problem for which solutions have been found in Project A-002-COLO and Project B-014-COLO. Through laboratory models, erosion control design procedures were developed and provided to Highway engineers for use along the Colorado River. The Denver

Water Board also uses the results in stabilizing banks of streams being used to transport water for the city of Denver.

Case No. 4

Flood runoff from watersheds in the mountain region has been difficult to estimate because of lack of historical records and the extreme complexity of precipitation events. Public agencies such as the Highway Department, the Soil Conservation Service, and the Bureau of Reclamation, along with municipalities concerned with urban drainage, having requested research to improve flood flow estimates for use in design of highway drainage, dams, canal protection floodways, and other facilities. Projects A-002-COLO, B-005-COLO, B-030-COLO, and B-054-COLO have provided new analytical techniques and procedures for making better flood flow estimates in the mountain watersheds of Colorado. The new technology applies equally well in any similar geographic region.

In conclusion: the vision of Congress in initiating the OWRR program has been confirmed. It has provided Colorado with research answers on urgent problems which otherwise would not yet be available. It has been so successful in stimulating water research and training that it should now be expanded to provide for more rapid use of results.

Public decisions are increasingly dependent upon new knowledge. Too often the decision-making stage is reached before the new knowledge is available. It is vitally important that the Congress provide for a viable, forward-looking water research program.

Senator Moss. I notice in referring to various projects you have given a code number. Is that the number that you apply to a specific project when it is undertaken?

Mr. EVANS. Those are the numbers by which the Office of Water Resources Research identifies projects.

Senator Moss. I see. So in giving us these four examples you were in every instance pointing to a specific project that was funded out of these moneys?

Mr. EVANS. That is correct.

Senator Moss. Well, that of course makes the point very well to show the practical use that has come already from these funds and I think is quite persuasive in arguing for an increased amount. I suppose you suffer from the inflationary problems that we heard about earlier. It is harder to make that money stretch.

Mr. EVANS. Yes, sir. We certainly have all those problems. I did not include in my statement a great many things which I knew others would include. So I tried to focus my statement rather narrowly upon particular, four particular outputs to the State of Colorado.

Senator Moss. That was directly within your own experience in Colorado?

Mr. EVANS. Yes, sir.

Senator Moss. Thank you, Dr. Evans.

Are there any questions, Senator Allott?

Senator ALLOTT. Yes.

Dr. Evans, you have mentioned that you have had 280 students participate in this. Can you give us the number of doctorships that have been awarded as a result of that CSU program?

Mr. EVANS. I could not be accurate with that, Senator Allott, but something on the order, I think, of about 25 as a—I will have to say a guess.

Senator ALLOTT. That would be an average of about five a year?

Mr. EVANS. I think that is probably a fair guess. I would like to add that in terms of numbers of students—and this has been brought up before. I wish to reenforce it—we have had roughly in the last 3 years a very sharp decline in number. And this was mentioned by Dr. Agnew

and others. The inflationary inroads have caused us to reduce, I am sure, the number of students supported here in favor of other causes.

Senator ALLOTT. Now, specifically, could you give us some idea of what the university would do with respect to the additional moneys which are promulgated in this bill?

Mr. EVANS. Yes, sir. In addition to taking up the gap of the inflationary problem, the new program which is suggested for this program, upon which this increase is in part based would be the provision of the research results to those who apply it in a form which they can easily use and apply. And this is a very important problem in the whole research process. It is one which the land-grant system solved by establishing an Agricultural Extension Service to do. But we have not a comparable process in our water research program. We very badly need it.

For example, a research report will come out. It will be in the scientific technical jargon. Most of those who apply it are less well trained than those who create it. It is very difficult for them to understand both, not only the language but especially the mathematics and the technology behind the research.

Although the results are there they are very difficult to extract and use by those practicing the arts of engineering and so on.

And it is that step in the process between the production of research and its final application that is missing, and it is that step for which some of the funds of this proposed new bill would go.

Senator ALLOTT. You think this dissemination work should be done by the university, and you propose to do it basically through your agricultural services now existing?

Mr. EVANS. Lacking firmer, say, guidelines from the Department of Interior, if we had the additional money, I think we would probably use the framework we already have, yes; so far as the dissemination and the putting out of information into the hands of users.

Senator ALLOTT. Of course, I was thinking particularly of the extension service.

Mr. EVANS. Yes. I personally, if I had no constraints upon how I managed it, would do it that way. I am certain I would. There is one—well, I think that would be my answer.

Thank you.

Senator ALLOTT. Has the Colorado Legislature taken any steps or action to support or indicate a need for expanded water research programs?

Mr. EVANS. I could not say—I could not point to any particular legislation that would indicate that. Every year, of course, the legislature in examining budget requests reacts very favorably to the water research requests before it. Some of the legislators have recognized this information interpretation problems which I have just outlined.

There have been some discussions with me initiated by legislators about the method of attack on that problem, how could we go about getting into interpretation of the research results. This has been expressed privately to me by legislators. There has been some thought of introducing into the Colorado Assembly a bill which might seek to accomplish that purpose. The need has been recognized, in other words.

Senator ALLOTT. Well, I have a list of projects before me which have been in progress at the Colorado State University and you have

mentioned three or four in your statement. Let us take one specifically with respect to the control of water along highways and our mountain valleys and canyons and bridge abutments.

Now, did you find that it was difficult to get through to the highway department the results of your research so that it could be utilized in the network?

Mr. EVANS. Yes. The research there was transposed in the form of a handbook, and this took a very large effort on the part of the research developers, to translate that work into the form of a handbook but it ultimately was done to provide those engineers of the highway department with the handbook type of information which they needed.

Senator ALLOTT. Another case that I am interested in is case No. 4, which the chairman can understand very well because he faces the same problems that we all do in arid regions where you get cloud-bursts and you get these very extreme amounts of water.

As a typical example the 1965 floods in Colorado which I am sure you remember caused a greater discharge from Bijou Creek into the Platte than normally passes Omaha in the Missouri River, and normally Bijou Creek is dry, of course.

Now, are you going to pursue the same methods in attempting to relay the information you get from this type of research to all of our towns—and there are so many of them at the lower reaches of streams and creeks and rivers—to get that research into the hands of the people who need to use it?

Mr. EVANS. I am glad you pick that one, Senator Allott, because it is one of the best examples of my point. That kind of research is what I could call very sophisticated in that it applies to the kind of mathematics that are not normally understood at all by the average graduate at a B.S. degree level or even generally at an M.S. degree level.

In other words, quite sophisticated data, the precipitation data and the runoff data. But the analytical techniques have been applied and in this case the guidebook, handbook translations have not.

So in order to make them fully useful we are going to have those guidebooks or handbooks. And they are not available.

Senator ALLOTT. They are not?

Mr. EVANS. They are not now available.

Senator ALLOTT. But they would be under this program?

Mr. EVANS. That is correct.

Senator ALLOTT. Now, you mentioned that you had 54 faculty members working in water research now. What percent of the salaries of those faculty members are supported by this program?

Mr. EVANS. I think probably 30 percent as a guess, an average around 30 percent.

Senator ALLOTT. How many professors are supported in whole by this program?

Mr. EVANS. I do not know of any professors at all who are supported 100 percent by the program.

Senator ALLOTT. So that the program does extend in part over the 54 members of the faculty?

Mr. EVANS. Yes, sir. That is correct.

Senator ALLOTT. Do you think, and I am asking for your opinion, that the State-by-State method is the most practical way of disseminating the results of research under this program, Dr. Evans?

Mr. EVANS. Yes, sir. I do. I think that the point of production of research should be the point where it is translated into usable forms. The dissemination which is in my view a slightly different issue, simply the spreading out of the information widely across society, could be done otherwise. But the interpretation and the translation, the putting of the research into the form most conveniently easily applied should be done at the point where it is created.

Senator ALLOTT. Thank you very much, Dr. Evans for a very fine statement. It will help us considerably in the consideration of this legislation.

Senator MOSS. I do thank you, Dr. Evans. It has been a fine statement and we appreciate your coming to testify for us.

Mr. EVANS. Thank you very much.

Senator MOSS. Mr. Eric Johnson, Executive Secretary of the American Water Works Association.

We will be glad to hear from you, Mr. Johnson.

STATEMENT OF ERIC F. JOHNSON, EXECUTIVE DIRECTOR, AMERICAN WATER WORKS ASSOCIATION

Mr. JOHNSON. Thank you very much, Mr. Chairman.

I am happy to be here as one of the users of the research that is being done by the Office of Water Resources Research.

I have a prepared statement, together with some of the policy statements and public statements that have been made by the Association concerning research, and I would like to file that with you and merely talk to some of the high points of this testimony.

Senator MOSS. We thank you for that. The entire text will go into the record.

Mr. JOHNSON. The American Water Works Association is an association that represents the water utilities, the people who supply the drinking water to the public, and because we feel that the augmented program that is proposed in S. 3553 will have a beneficial effect on our water utility people—that is, their efforts—and upon the public that they serve, we are very anxious to see it pass.

There are some 23,000 water utilities in the United States serving approximately 170 million people. Most of these water utilities are small unit operations—that is, they serve—I believe it is 85 percent of them serve 5,000 or fewer people. This means that they generally hire five or fewer people to staff them.

Operations such as this are too small to carry on the research or training operations on a scale to take care of the problems that we are facing today and that we look to face in the future, the kind of research that will provide the technology to meet the problems of tomorrow and the technologists who are well trained. These problems are a consequence of the burgeoning population, of the urbanization and of the pollution that is caused by these forces.

Although the industry is convinced that the current technology is adequate to the known problems that now exist, what it fears is the problems of tomorrow, of 10 years from now, of 15 years from now.

We feel that the technology to meet those problems must be researched today, and we must train our people in handling the more sophisticated equipment that will be needed to treat water when it is contaminated by some of the new exotic contaminants that we face in the future.

It has been reported that some 90,000 new chemicals were introduced during the past decade. Perhaps we can look forward to 150,000 in the next decade, and although many of these chemicals may have no significance as far as the safety of our drinking water supply is concerned, we are worried that some of them will have an impact. And we are looking now to facing, or to having the research done and the training done to face those problems.

One of the steps to avert a crisis in the future, we feel, is the increased research effort that is proposed under S. 3553, and we feel this way particularly because it focuses on an effort to promote application of the results of research, research that is undertaken under this program.

In the past the Association has felt, at least sometimes, that some of the research that was carried on in the basic act was of rather remote value to the water supply man who was trying to improve his service to the public. So this proposed new emphasis on technical information transferred—that is, the process of making useful the results of research—is a most gratifying provision as far as we are concerned.

It is our hope, too, that the new interest in application of research will permit the Office of Water Resources Research to give direct assistance to research concerned with the production of high quality drinking waters from the constantly degrading sources of supply. No other Federal agency is at the present time rendering support to university or independent organizations for such research. And such research, as we have pointed out before, is badly needed if the industry is to meet its demands of the future.

Out of the water resources research program to date have come an interest in, an appreciation of the problems of public water supply by a variety of professional workers in many disciplines, thereby extending and strengthening the interest in and the attack upon the problems of the field.

Out of the program, too, has come a considerable amount of training of capable researchers in special needs of the field.

We have been in contact with some of this through our own thesis awards program in the association wherein we have tried to encourage students in the field to do their research in water supply related subjects.

But out of the program to date has come too little information of practical and applicable value to the water utility man, and this is the important potential benefit that we see in the emphasis on technical information transfer as proposed in S. 3553, and we therefore urge its passage.

(The complete prepared statement of Mr. Johnson, above-referred to, follows:)

STATEMENT OF ERIC F. JOHNSON ON BEHALF OF THE AMERICAN WATER WORKS ASSOCIATION CONCERNING S. 3553

My name is Eric F. Johnson. I am Executive Director of the American Water Works Association. The Association is a scientific and educational society dedi-

cated to improving water service to the public through advancing the technology and the management capability of water utilities and their employees. The Association's 21,000 members are principally managers and engineers concerned with supplying water service to the public, but many other disciplines interested in the problems of water supply are also participants in its program.

The Association is happy to accept your invitation of July 10 to comment on S. 3553 which proposes to increase the appropriation under Section 100 of the Water Resources Research Act from \$100,000 to \$250,000 per state, for it feels that the water supply industry and the public it serves can benefit from the augmented program proposed under the bill.

There are some 23,000 water utilities in the United States today supplying drinking water to approximately 170,000,000 Americans. Because most of these utilities are small-unit operations—85 per cent of them serving 5,000 or less population—they are on the whole too small to carry on the basic research and training programs required to keep the technology and the technologists involved abreast of the growing problems that are a consequence of burgeoning population, urbanization, and pollution.

Although the industry is convinced that current technology is capable of meeting the known problems of today, it is concerned now with the problems that it will have to face tomorrow with the same technology and the same technologists unless action is taken now to fortify the federal research and training effort in the field. It has been reported that 90,000 new chemicals have been developed over the last decade, and these have found their way into our surface supplies. Viruses have entered more and more into the epidemiological picture of late and their fate in the process of water treatment is not well enough known. And as more and more exotic contaminants are introduced into our water sources without research to understand them and technology to combat them, we are, we fear, building up to a crisis in public water supply—a crisis that need not occur if we take steps now to avert it.

One of those steps, the Association feels, is the increased research effort proposed by S. 3553, particularly because it focuses upon an effort to promote application of the results of research undertaken as part of the program. In the past, the Association has felt that some of the research carried on under the basic act has been rather remote in the benefits promised to the water using public. Thus the proposed new emphasis on information transfer—that is, the process of making useful the results of research—is a most gratifying provision of the bill.

It is our hope that the new interest in application of research will permit the Office of Water Resources Research to give direct assistance to research concerned with the production of high quality drinking waters from the degrading sources of supply that now provide the nation's water sources. No other federal agency is rendering support to university or independent organizations for such research. And such research, as we have pointed out before, is badly needed if the water industry is to meet its responsibilities in the future as it has in the past.

Out of the Water Resources Research program to date have come an interest in and appreciation of the problems of water supply by a variety of professional workers from many disciplines, thereby extending and strengthening the interest in and attack upon the problems of the field. Out of the program, too, has come a considerable amount of training of capable researchers into the special needs of the field. But out of the program to date has come too little information of practical, applicable value to the water utility man anxious to give better service to his public. This is the important potential benefit we see in the emphasis on technical information transfer proposed in S. 3553 and we, therefore, urge its passage.

To give your committee some background on the activities of the Association directly in line with the purpose of this bill, I am enclosing copies of a number of recent policy and public statements that are pertinent.

STATEMENTS OF POLICY ON PUBLIC WATER SUPPLY MATTERS

AWWA PRINCIPLES OF NATIONAL WATER POLICY

In the fulfillment of its daily task, the public water supply industry in 1966 processed and served about 25 billion gallons of potable water to some 157,000,000 persons in the United States alone. The service has long been performed largely on a self-supporting basis. The industry also deals with the additional

problems of growing per capita water use, increasing population, urbanization, pollution, and growing competition for available water by other users.

The American Water Works Association, a scientific and educational organization with a membership of more than 19,000, represents the field of public water supply. Since its organization in 1881, the Association has been concerned with the proper development, conservation, and management of the nation's streams, lakes, and ground water, upon which more than 20,000 utilities currently depend for water supplies.

A sound water resources policy must have as its primary objective the provision of an adequate supply of water for our people, carefully planned and properly managed. Among the many other related considerations, planning and management must include the prevention of waste, the reduction of pollution to its lowest practicable level, the provision of means for the best and most effective distribution of water, the encouragement of effective water reclamation and reuse when economically feasible, and the taking of further steps to protect life, property, and land from the destructive forces of water. In addition, a sound policy must provide basic guidelines which clearly define areas of responsibility.

The responsibility for water resources projects, of which public and industrial water supplies are a primary consideration, should rest with that echelon of government or of private interests closest to those people benefited. This broad management responsibility includes sponsoring, planning, development, financing, ownership, operation, and maintenance. The cost of such projects should be borne proportionately by those who are benefited.

The majority of water crises may be traced to insufficient and delayed action rather than actual shortages of usable water. To establish appropriate water policies for regional and local areas within the framework of national needs, comprehensive studies should be made by competent people to assure that planning will result in the most economical use of water for domestic, industrial and other uses and to prevent waste. Since comprehensive planning is a dynamic process, it is imperative that the plans evolved be subjected to continual updating, and that this continual appraisal become a tool for the evolution of policies.

It is with this background that the American Water Works Association sets forth the following principles by which the water supply industry can best meet its responsibilities to the public. These principles are consistent with the best processes of intergovernmental action in a free economy and are based on a long history of demonstrated ability of the public water supply industry to support and finance itself with a minimum of public assistance.

PRIORITIES

Priorities for water, where competition among water users occurs, should be measured by the degree to which the use is vital to human needs and the contribution it will make to the economic and social welfare of the region concerned.

WATER SUPPLY SOURCES

Each water source should be developed and managed with careful attention to the hydrologic and ecologic systems of which the particular source is a part. Political boundaries should not become barriers to most effective utilization for public supply. Although stream systems provide most of the water used for public supplies, ground water sources, developed and undeveloped, are among the nation's most valuable natural resources. The utilization and management of ground water must be based on evaluation of its role in the hydrologic system.

Withdrawals from ground water sources should be based on knowledge of aquifer capabilities and recharge rates. Saline water intrusion should be avoided by careful individual well location, controlled pumping, and, where necessary, by protective barriers of induced fresh water. Withdrawals of ground water to levels of near depletion should be resorted to only after all other water supply alternatives have been explored and with full public realization that eventually other sources will be required. Artificial recharge of ground water formations is increasingly vital in sustaining ground water supplies, and the use of adequately reclaimed waters for recharge should be considered.

The growing value of desalted ocean water or inland saline waters as public and industrial water sources must be recognized. Such sources should be utilized where natural water supplies are unavailable or inadequate or where study finds such converted water economically advantageous.

WATER QUALITY MANAGEMENT

The pollution or degradation of the quality of water supply sources has damaging effects on the health, welfare, and economy of local, state, and regional sectors and the nation. The public water supply industry, as an important factor in our economy, is entitled to a good-quality raw water. The responsibility for assuring good water quality through pollution control and abatement rests with those who return waste products to our streams, lakes, and underground sources. All levels of government, federal, interstate, state, and local, must take effective action to identify and reduce to the lowest practical minimum the pollution of our waters.

WATER CONSERVATION

Water as a vital element in our economic and social well being is a renewable natural resource. It must be managed to best meet all the many needs of man. Every effective means to prevent and minimize waste and promote wise use should be employed by all entities, public and private, engaged in water resource activities.

BASIC DATA

Hydrologic and other basic data continue to provide a vital base for water resources planning, development, and management. Data acquisition should be a responsibility of each level of government and each water producer, whether public or private. Water facts should be documented, expressed clearly, and made available to all on a current basis. Better coordination of data acquisition and publication should be supported and encouraged.

Federal data acquisition programs should be designed and conducted with attention to the full range of current and future uses by all entities, public and private. State agencies should participate in the acquisition and study of basic data to meet the needs within the state and should encourage municipalities, water departments, and other public and private entities in data collection. Federal programs should be a support function to the activities and responsibilities of state and local agencies whenever possible.

ROLE OF FEDERAL GOVERNMENT

The role of the federal government in water resource programs and projects should be supportive and cooperative, not preemptive. The federal government should provide:

1. Continuing cooperation with the states and local public and private agencies for the preparation of general plans for the unified development and management of river basins in accordance with sound hydrologic, engineering, and economic principles.

2. Systematic and effective coordination among federal agencies engaged in water resources activities to eliminate competition and duplication of effort by these agencies.

3. Research in those aspects of water problems of the nation which are beyond the capabilities of state and local groups, with close coordination and support, wherever possible, with state and local efforts.

Successful planning and implementation of water resources and related developments require that the following principles be recognized in federal actions:

1. The development and management of water resources of interstate watersheds through compacts should be encouraged.

2. State and local agencies should be encouraged to assume greater responsibility for planning, constructing, operating, financing, and managing water resources projects.

3. The right of each state in interstate basins to control the use of its water and associated land resources should be recognized and respected by the federal government, provided that management of the resources is responsive to clearly defined national needs and established interstate responsibilities.

4. Regulations should not necessarily be uniform for the entire nation but should be consistent with regional circumstances and requirements.

The federal government should assume the initiative in development only when:

1. An economically justifiable project is of such magnitude as to be definitely beyond the capacity of local groups.

2. A project is so complex that no clearly defined local or state group or groups can be identified as principal beneficiaries.

3. The participation of the federal government is necessary to assure the maximum feasible development in keeping with a comprehensive, regional or basin plan.

4. Programs and projects are not competitive with alternative means of developing the necessary water resources by state, local, or private initiative.

ROLE OF THE STATES

The states should fully exercise their constitutional rights and responsibilities in the control and management of water resources. They should take the initiative in carrying forward water resources and related developments on a cooperative basis with the agencies of local and federal governments. To carry out these responsibilities, a single appropriate agency should be established in each state to provide unified policy and coordinate the water resources activities of the various agencies in each state. The states must:

1. Provide water quality management, including pollution abatement and control.

2. Undertake flood plain management to reduce flood damage, reduce need for flood control projects and make it possible to open flood plain property for public recreational and other uses.

3. Encourage suitable land use practices, including forest and tree farm management to reduce erosion, floods, siltation of reservoirs, and wasteful use of water, and to enhance the maintenance of stream flow.

4. Provide for the acquisition and holding of sites for storage reservoirs for future use where need for the construction of such reservoirs for water resources needs is demonstrated.

5. Permit and encourage the formation of water districts, or similar organizations, for the planning and management of public water supply systems, privately and publicly owned, to meet the public and industrial water supply demands. The state should establish through its appropriate central agency, regulations necessary to assure the reasonable adequacy of the system proposed by these organizations.

6. Participate in the planning and management of water and related resource developments on interstate streams on a continuing cooperative basis with representatives of all federal, state and local agencies involved. This joint participation should be continuous in order that the plans and project development assure the best and most effective management of water to meet both the current and long range needs of the people of a region, state, or locality with consideration of national needs.

7. Through its planning and management policies, appropriately regulate water use at the supplier level to minimize waste and to provide for wise use and conservation of water.

8. Be responsible for developing, publishing, and keeping current studies of its water resources, and the demands that will be placed upon them as a sound basis for comprehensive plans by which its water resources may be managed. It is of vital importance that water resource plans be periodically reviewed and updated.

9. Regulate through its appropriate state agency the multiple use of streams and water bodies which are parts of public water supply systems.

10. Establish the practice of utilizing basic data for making decisions in the water resources field.

ROLE OF LOCAL AGENCIES

Historically, local entities have served the population with public water supplies, efficiently and economically. Agencies, public or private, such as water districts, cities, towns, villages, investor owned water companies, commissions, and authorities should be responsible under state law for:

1. Planning, financing, constructing, and operating system for public and industrial water supplies for all uses.

2. Managing the systems as self-sustained, utility-type enterprises.

3. Participating in multipurpose water resources planning and management ventures to the end that public water supply needs receive due attention.

4. Considering the feasibility of including recreational facilities which may be associated with water supply utilities. The cost of recreational facilities, if provided, must be assumed by the sponsoring entity or be self-supporting and must not be imposed on the water utility.

5. Staffing the water system operation with adequately qualified personnel. Water department officials should be selected on the basis of experience and competence. Because of the responsibilities to the welfare and health of the community, they should be given latitude in management and promise of continuity of service with salaries commensurate with their responsibilities.

6. Recognizing the contributions of local entities, such as the soil and water conservation districts, irrigation districts, conservancy districts, and other similar local organizations, not only to water resources but to public water supply ventures. They should provide for the coordination of activities with these organizations and participate cooperatively with them for better development and management of water resources.

7. The collection and preservation of water source and operating data useful to planning and management activities. They should seek reliable data collected by other public agencies as a basis for defining realistically safe yields.

"SAFE WATER—OR IS IT?" ASKS JOHNSON

In a keynote address to the Indiana Section of AWWA in Indianapolis, Eric F. Johnson, AWWA Executive Director, made some points of interest to all who are concerned with administering public water supplies. The text follows:

"Safe water—or it is it?" is a question being asked with increasing frequency as the Department of Health, Education, and Welfare seeks to pump new life into its water supply program by scaring people into worrying about what they have always taken for granted.

"Actually, HEW spokesmen have not said that water is unsafe—they have merely insinuated that it is. They have pointed out that one-third of the nation is drinking water of questionable or unknown quality—questionable because HEW procedures have not been followed to the letter, unknown because neither they nor the state have had the personnel to conduct the inspections for which they are responsible. In all this their objective, in common with AWWA's, has been the improvement of water quality and water service. And for this reason AWWA has been supporting the idea of a greatly fortified Public Health Service water supply program although it has taken strong exception to the tactics that have been adopted by those now in command.

"In giving support to HEW's Bureau of Water Hygiene, AWWA's Government Affairs Committee has been working hard to convince legislators of the need for a greatly expanded program of research and training and support for state health departments to avoid the crisis in water quality that is now being insinuated as imminent and to avoid the consequent inefficiency of a crash program to combat such a crisis.

"Most legislators, as well as most of the public, today are completely unaware of the fact that there is a \$50 billion industry between the polluted river and the kitchen tap. They believe that the Department of the Interior has full responsibility for their drinking water safety as part of their responsibility for the water pollution program—and, of course, they are wrong. But lately, from the Administration, there have been signs that a single department—of the Environment—may in the end have responsibility for both water and water pollution and every other aspect of our use of our resources.

"If this does eventuate, it is difficult to say what effect it will have on the status of the water supply program, but it is hard to believe that the situation can be any worse than it now is—with only \$2.5 million allocated to not only public drinking water but shellfish as well, compared with a water pollution program more than 400 times as big.

"Safe water from public supplies in the United States and Canada has long been taken for granted, not only by the public but by some of the people responsible for supplying it. The history of that confidence is based in the technological explosion that started almost 100 years ago and was capped by the discovery of the effectiveness of chlorination, in the dedication of two or three generations of water supply engineers, chemists, bacteriologists, and managers, and in the assistance given them by state health departments and a Public Health Service that was outstanding in its willingness to support the effort to guarantee safe water to the public. Through this combined effort American water utilities have been able to achieve a reputation as supplying the best water service in the world. It is a reputation that they have earned with hard work and dedication; it is a reputation that they have deserved.

"Today, however, the water industry finds itself in a new world—a world of burgeoning population, of uncontrolled urbanization, industrialization, and of consequently mounting pollution of the sources of its supply. Furthermore, the problems with which it is faced in supplying safe water are growing not only in quantity but in quality as exotic chemicals, the toxic effects of which are still unknown, and other contaminants resulting from our expanding technology present themselves as new problems beyond the ability of most water utilities to tackle. Thus the question 'Safe water—or is it?' becomes less certainly answerable.

"We may be tempted to sit back on hard-earned reputations and say 'of course,' but we must recognize it is no longer a matter of course. New problems, or new possibilities of problems, are impinging. To come up with solutions or answers, we need research—and then to apply the results of that research we will need training. That is why AWWA is now seeking assistance for research and training—at the federal level through research and training grants and at the utility level through research support and training program participation.

"The provision of safe drinking water from constantly degrading sources of supply is a problem that requires a constantly increasing level of technological expertise which can be gained only through research and the application of research findings. As an industry we need to realize that our achievements to date are only the first step in giving the public the kind of water quality and the kind of water service it deserves now and will demand in the future. We must take action now to plan and promote and put into effect 'Better Water for Americans.'"

SET ASIDE 5 PERCENT FOR EDUCATION—AWWA

Despite increased education activities by AWWA, training of water utility managers, supervisors, and operating personnel reaches only about 1 percent of those it might benefit.

Recognizing that it has failed to give managers the help they need in selling training to their superiors, AWWA in January drew up a policy statement on training for the use of managers in promoting training for themselves and their subordinates.

The capital investment in water utilities is more than \$50 billion, with an annual additional construction cost approaching \$5 billion. Because an industry of such magnitude and importance deserves highly skilled people, AWWA is now supporting a program calling for each water utility to clearly earmark as educational funds in its budget amounting to at least 5 percent of management and operator salaries. This money would support an adequate training program.

Trained men are now almost impossible to hire. The field is so highly specialized that understanding of it outside the industry is rare.

Here is how the training money might be spent: Most existing managerial and operator training courses run for one or two weeks annually. Attendance at a formal course each year for one week amounts to about 2 percent of a man's time, and 2 percent of the allocated funds would take care of it. The rest could finance other training, including attendance at specialized schools such as vocational schools, and the establishment of in-house programs.

STATEMENT OF JOSEPH H. KURANZ ON BEHALF OF THE AMERICAN WATER WORKS ASSOCIATION

My name is Joseph H. Kuranz. I am President of the American Water Works Association, a scientific and educational organization with a membership of more than 20,000 individuals and organizations in the water supply field. Since 1957 I have been Manager and Chief Engineer of the Waukesha Water Utility, Waukesha, Wisconsin. On behalf of the Association, I am pleased to accept your invitation of May 26 to present our views on the proposed budget appropriation for the Bureau of Water Hygiene in the coming fiscal year.

The American Water Works Association represents an industry that provides public water service to 170,000,000 Americans through 23,000 water systems with facilities valued at more than \$50 billion. Its purpose, since it was founded in 1881, has been to improve the service that the water supply industry provides to the public, by advancing knowledge of the design, construction operation, and management of the water systems providing that service. And throughout most

of its life, a strong ally in helping the Association to build and to teach the technology of the field has been the U.S. Public Health Service.

That the industry has been successful in doing its job is evidenced by the fact that the public can and does take for granted the safety of its drinking water. The United States is now recognized as having the best and most dependable water service in the world. But the team that has achieved this end has been broken up.

Although the water supply industry itself is still working toward better water service—and has, in fact, established much higher goals of quality than just safety—the Public Health Service members of the team have been virtually wiped out in the current emphasis on the water pollution control effort. What this means is that the facilities traditionally required to provide water to the public will continue to be provided, paid for on a self-sustaining basis by water supply rates, but that the basic research required to keep water supply technology not only up to but ahead of the problems created by population growth, urbanization, and pollution, and the training required to implement this technology are falling behind. And such falling behind is bound to create a crisis in water supply quality in ten to fifteen years.

To avoid such a crisis—and the waste of federal funds required for any crash program required to meet it—it is highly important that the research and training capabilities of the Public Health Service and its allies in the universities and training facilities of the nation be brought to bear on this problem now. Water supply facilities take a long time to build, but even before they can be built to meet the treatment problems of tomorrow, the technology of their design must be developed and, then, before they can be operated, the technical knowhow must be taught.

Because the very large majority of water utilities consists of small-unit operations, employing ten or fewer workers, it has been impossible for them to develop internally the type of basic training or research effort needed. And now that federal assistance in these fields has been virtually discontinued, the Association is worried that a crisis in water quality is being made inevitable.

With the growth of population, with its growing concentration in urban areas, and with the consequent growth of the pollution problem, the water industry is being faced with many new challenges in maintaining and improving the quality of the water delivered at the tap. These challenges are growing in magnitude and complexity at the same time as federal support in meeting them has been disappearing. And though the Association, through its own Research Foundation, through its policies and programs (see attached) and the larger utilities through their own staff efforts, have been trying to tackle the priority problems involved, it is obvious that, without federal help, their efforts will be woefully inadequate.

The Bureau of Water Hygiene at one time had the capability to handle this kind of effort both through its in-house research and training and through its grants to universities and other training facilities. The new budget of \$2,300,000 for this agency that now comprises ten regional offices, four laboratories, and a Washington headquarters makes possible only a minimum of in-house activity along these lines and absolutely no research or training grants to enlist the assistance of private agencies in tackling this vital problem. So we are worried as to how we are to answer such questions as:

1. Are the present Public Health Service Drinking Water Standards applicable to waters derived directly from treated sewage?
2. What are the long-term toxic and carcinogenic implications of repeated exposure through drinking water to organic contaminants of industrial origin?
3. What are the long-term toxic effects of trace metals in drinking water?
4. How can water treatment plants reliably destroy viruses in their sources of supply?
5. What are the public health implications of deterioration of distribution systems at a time when they are being subjected to increasing use?

And even when they are answered, we are concerned about having personnel trained to handle the treatment methods required to combat the contaminants involved.

We need federal help in these respects. We feel that the Bureau of Water Hygiene is best prepared, by past experience, to give us this help now when we need it. To permit the Bureau to do so, we feel that it needs twice the personnel and three times the appropriations now allotted to it. And we are certain from the history of our cooperation with the Public Health Service that such an augmentation of its effort in the coming year is entirely practicable.

We therefore urge a recognition of the vital importance of the developing problem in the quality of the nation's drinking water supplies through a significant increase in the Bureau of Water Hygiene budget to permit a fortified in-house program of research and training and to provide for research and training grants to outside agencies in support of the effort to assure quality water and quality water service to the public.

POLLUTION OF WATER SUPPLY SOURCES

DETERMINED THAT THE EVER-INCREASING WATER NEEDS OF THE PUBLIC SHALL BE MET, AWWA VIGOROUSLY SUPPORTS EFFORTS TO: (1) PRESERVE HIGH-QUALITY WATER SUPPLY SOURCES AND (2) RESTORE TO REASONABLE STANDARDS THE QUALITY OF PRESENTLY POLLUTED WATER SUPPLY SOURCES

For this statement, pollution of water may be defined as degradation of quality by anything added to the normal constituents of a water source, that tends to make the water less desirable as a source of water supply.

The American Water Works Association believes that the most desirable source of water for domestic supply is one that is unpolluted and urges that such waters be kept free from pollution.

To permit efficient and economical utilization of water sources already polluted or threatened with pollution the Association urges control over waste discharges and land uses that affect water sources; accelerated programs of basic and applied research; continuing education for water and waste water utility employees; and public information to develop public awareness of the pollution problem as it relates to water supplies.

A primary objective of the Association is "to consider and deal with the problems involved in the production and distribution of safe and adequate water supplies." These problems are to a large extent dependent on the quality and quantity of the water source. Therefore, close control of waste discharges is absolutely essential to the economical production of safe and aesthetically acceptable water for the consumer.

Progress is being made in the control of water pollution by many municipalities and industries. Many water resources that are or will be required for drinking water supply purposes, however, are still being degraded by waste discharges. As a result of technologic advances made by industry and the growth in population, many sources are being increasingly degraded by wastes of widening variety and of possible significance to health. Thus the availability of water of good quality is being reduced.

Continuation of efforts to improve public water supply sources toward the goal of no pollution is a major objective of the Association. To further the goal of conservation and protection of water resources for public supply, it is the policy of AWWA to promote actively the support of the following positive objectives:

1. Close control over waste discharges and land uses that would have degrading effects on water resources, including precipitation, surface waters, and ground water. AWWA strongly supports legislation at the local, state, and federal levels to implement the control.

2. An accelerated program of basic and applied research to include the determination of what components of waste are harmful, in what concentrations they are harmful, and how these harmful components can be counteracted or removed.

3. An accelerated program of continuing education for water and waste water utility employees to keep them aware of, and capable of coping with, the ever-widening spectrum of pollutants.

4. An accelerated public information program to develop public awareness of the pollution problem as it relates to public water supplies, the measures being taken for its solution, and the need for public support of these measures.

The Association endorses the principle that no individual, organization, industry, or government unit has the right to add anything to a source of water supply that will cause any other individual, organization, industry, or government unit to spend an unreasonable amount of money for its removal to provide a usable water supply.

ALLOCATION OF WATER FOR WATER QUALITY CONTROL

The American Water Works Association supports firmly the position that the quality of the nation's water resources must be upgraded and maintained at

levels as high as are technically and economically possible. This level of quality must be achieved and maintained in order to satisfy the rapidly growing municipal, industrial, and other demands for high quality water. The Association recognizes, however, the engineering difficulties and the costs involved in providing the very high degree of treatment for all municipal sewage, industrial wastes, and agricultural return flows required to assure that these high standards will be met. In addition, the Association recognizes that substantial quantities of pollutants are derived from sources presently uncontrollable such as runoff from urban and agricultural areas.

The Congress of the United States has accepted the premise that waste treatment alone may not be sufficient invariably to maintain proper quality levels in streams, by providing¹ that storage for regulation of streamflow for the purpose of water quality control may be included in federal reservoirs. The Congress has stated, however, that such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source.

The Secretary of the Interior has recommended that Congress enact legislation that would require the states to pay one-half of the separable costs and the annual operation and maintenance costs allocated to water quality control for federal projects. He has recommended further that the states be required to pass legislation and take other measures to assure that the minimum flows in rivers necessary for quality control purposes will be protected against adverse diversions and depletion.

For several federal projects now under consideration, the Bureau of Reclamation and Corps of Engineers have proposed the inclusion of storage to provide water releases for low flow augmentation. The Federal Water Pollution Control Administration has indicated that in some instances such storage and the water made available thereby should now be irrevocably committed to water quality control. In these instances the low flow augmentation requirements are predicted upon the FWPCA's projections of urban, industrial and agricultural development and of the resultant waste loadings upon the streams for 100 years or more in the future, assuming no increase in efficiency of waste control and treatment. Such commitment of storage and water may conflict in the future with water supply for other higher uses, such as municipal, industrial and agricultural development. These uses of available water supplies may show a greater economic return than the continued allocation of water to low flow augmentation.

Waste control and treatment technology is improving. The Association believes that it will be possible in the future to control and treat wastes from all sources to a much higher degree than at present and at the same or lower costs. Furthermore, the actual pattern of economic development may be substantially different from the pattern foreseen in long-range projections made now.

The Association recognizes that it may be necessary and economically advantageous in certain situations to release water from storage now and for some years in the future for low flow augmentation, rather than provide the extremely high degree of waste treatment that would otherwise be required for maintenance of acceptable stream quality levels. The Association believes that this must be regarded as an interim measure subject to periodic review, with possible reallocation of the storage and water involved as technical and economic conditions change. It is recognized that the reimbursable federal costs may be increased by such reallocation.

The Association is opposed to any policy or plan that would permanently and irrevocably commit reservoir storage space and water for purposes of control of or prevention of deterioration in water quality caused by the discharge of municipal and industrial waste effluents or of agricultural return flows. Such allocations of storage and water for waste quality control purposes should be subjected to reviews carried out jointly by the federal and state agencies concerned, at intervals of not more than 10 years. The allocations should be examined in the light of conditions then prevailing as to: (a) advances in the technology and economics of waste control and treatment, (b) projections of urban, industrial and agricultural development and resultant waste loadings, (c) demands for, and relative economies of, use for other purposes of the storage and water previously allocated to water quality control, and (d) uncontrollable sources of quality impairment. Storage and water allocated to water quality control should be reallocated, in whole or in part, to other purposes at such time as it is found necessary or economically advantageous.

¹ Sec. 3(b)(1), Federal Water Pollution Control Act, as amended.

RETURN OF WATER TO DISTRIBUTION SYSTEM

THE AMERICAN WATER WORKS ASSOCIATION IS OPPOSED TO THE RETURN OF WATER FROM THE CUSTOMER'S SYSTEM TO THE DISTRIBUTION MAINS OF A PUBLIC POTABLE WATER SYSTEM

When water enters a customer's system, it is no longer under the control of the water utility. To support the water utility in carrying out its responsibility to provide its customers with a water that is safe, the Officers and Directors of the American Water Works Association reaffirm the position previously taken that customer use of water from the public supply system for cooling or other purposes within the customer's system and later return of the water to the distribution system of the water utility is not acceptable practice and cannot be approved.

Water remaining under the control of the water utility, such as finished water that the utility has used in air-to-water heat exchangers for cooling motors, may, with the approval of the regulatory agency having jurisdiction, be put into the utility's distribution system.

 QUALITY GOALS FOR POTABLE WATER

At the 1965 Annual Conference, the Water Quality Division voted to set up quality goals for potable water, and guidelines for the goals to be established were derived. These actions subsequently were approved by the Executive Committee of the Association. An eleven-member task group [now the Committee on Water Quality Goals] was appointed, expanding the group of four that had previously been working in this area and had published a set of ideal criteria for water quality in the November 1962 Journal.¹

GUIDELINES

The Committee on Water Quality Goals was directed to set up realistic quality goals for the water industry—goals that would tend to raise the quality of the water delivered to the consumer by being at once in accordance with advanced thinking and amenable to being grasped by nontechnical personnel. They were not to be impractical objectives, even though they were to be substantially more exacting than existing USPHS Drinking Water Standards with respect to aesthetic qualities. They were to be generally attainable by correct application of known treatment processes and methods.

It was recognized that the goals should not be static, but should be reviewed, and revised if warranted, perhaps every 3 years. The water industry is constantly being faced with the problem of meeting rising esthetic demands. At the same time, because of increasing population and industrialization, the quality of water sources has deteriorated.

Responsibility for application

Public water utilities should adopt quality criteria against which they can gage the effectiveness of their day-to-day operations. Managers of a given system must decide whether the cost of furnishing quality water is warranted. The expense of approaching or meeting the goals may be very high for some systems. For instance, removal of high dissolved-solids content or color may prove inordinately expensive. Management, then, has to weigh the value of the benefits to be derived against the cost of producing the finer quality water. It may conclude that consumers are satisfied with water meeting goals less rigorous than those recommended here.

The industry has accomplished much in the area of water treatment, control, pumping, and delivery, but consumers judge quality at the tap, not at the source. Therefore, good consumer relations depend on maintaining high quality to the point of delivery. The goals stated herein are not merely for water entering the distribution system.

The definition of a functionally ideal water is as follows:

Ideally, water delivered to the consumer should be clear, colorless, tasteless, and odorless. It should contain no pathogenic organisms and be free from biological

¹ Bean, E. L. Progress Report on Water Quality Criteria. *Jour. AWWA*, 54: 1313 (Nov. 1962).

forms which may be harmful to human health or esthetically objectionable. It should not contain concentrations of chemicals which may be physiologically harmful, esthetically objectionable, or economically damaging. The water should not be corrosive or incrusting to, or leave deposits on, water-conveying structures through which it passes, or in which it may be retained, including pipes, tanks, water heaters, and plumbing fixtures. The water should be adequately protected by natural processes, or by treatment processes, which insure consistency in quality.

The Committee on Water Quality Goals believes it should not set goals for items that primarily and principally concern health, but should defer to USPHS and the medical profession. With respect to toxic substances, the USPHS Drinking Water Standards provide very broad safety factors, and the committee generally accepts these standards. This eliminated from consideration such items as the following: Lead, barium, fluoride, arsenic, cyanide, silver, selenium, cadmium, chromium, nitrates and nitrites, radium, strontium, polynuclear compounds, organic phosphorus, chlorinated hydrocarbons, boron, and uranyl ion.

RATIONALE OF GOALS

Turbidity

Today's consumer expects a sparkling, clear water. The goal of less than 0.1 unit of turbidity insures satisfaction in this respect. There is evidence that freedom from disease organisms is associated with freedom from turbidity, and that complete freedom from taste and odor requires no less than such clarity. Improved technology in the modern treatment processes make this a completely practical goal.

Nonfilterable residue

Water should be free of observable suspended particles or residue after settling. The goal indicates a virtually suspension-free state.

Macroscopic and nuisance organisms

It is obvious that macroscopic organisms such as larvae, crustacea, and numerous algae that may affect appearance should not be present. Nuisance organisms may affect appearance, taste, or odor, perhaps only after standing, heating, or freezing. They include, among others, the iron bacteria, sulfur bacteria, and slime growths.

Color

Because of difficulty in matching the colors of natural waters to the colors of standards, it is suggested that, when difficulty is encountered, a photometric transmittancy method should be employed. Color of less than 3 units will not be noticed, even in a filled bathtub, whereas color of 5 units may be noted by many. Fifty-five per cent of 102 interstate waters in 1961 showed color of less than 3 units.² For the 100 largest cities in 1962, the median color was reported as 2 units.³

Odor

Odor is a nebulous characteristic, difficult to quantify; agreement is seldom obtainable, as to the presence of odor or its character in a given potable water. The goal of water utilities should be elimination of all odor. The presence of odor is to be evaluated by difference before and after contact with carbon. Some materials may be removed by carbon only after treatment with a strong oxidant, which should be utilized when required to demonstrate the difference.

Taste

Taste is also a nebulous characteristic whose determination is complicated by the variability of perception of individuals from day to day. It is generally agreed that all potable waters do have some taste. If the taste is mild and not offensive in character, most individuals become accustomed to it. But water should be palatable to all; individuals first tasting any water should not be offended, and it should not be necessary that one become acclimated to the taste to regard it as characteristic of a good-quality water.

²TAYLOR, F. B. Effectiveness of Water Utility Control Practices. *Jour. AWWA*, 54: 1257 (Oct. 1962).

³DURFOR, C. N. & BECKER, E. Selected Data on Public Supplies of the 100 Largest Cities in the United States, 1962. *Jour. AWWA*, 56: 236 (Mar. 1964).

Aluminum

At levels exceeding 0.05 mg/l, precipitation may take place on standing, or in the distribution system. Turbidity and nonfilterable residue will be affected.

Iron

With an iron content exceeding 0.05 mg/l, some color may develop, staining of fixtures may occur, and precipitates may form. The magnitude of such phenomena are directly proportional to the concentration of iron in the water.

Manganese

In concentrations of only a few hundredths milligrams per liter, manganese will cause buildup of coatings in distribution piping, which slough off. It causes staining of laundry items in brown blotches and forms black precipitates objectionable to consumers.

Copper

Copper content of 0.5 mg/l, or less, in some soft waters, will cause staining of porcelain. In 1961, of 163 interstate supplies, 70 per cent contained less than 0.2 mg/l;² of the 100 largest cities, 94 contained less than 0.1 mg/l.⁴

Zinc

In concentrations of 5 mg/l, a disagreeable taste may be noted. Zinc is undesirable in water passing through piping systems, as it may aid corrosion. The states of Ohio and North Dakota now limit zinc content to 1.0 mg/l. In 1961, of 163 interstate supplies, 45 per cent contained less than 1.0 mg/l.⁴

Filterable residue

Low dissolved-solids content is desirable, if one is to avoid precipitations in boilers or other heating units, to reduce sludge in freezing processes, and to reduce rings on utensils and precipitations on foods being cooked. The stated limit of 200.0 mg/l is in line with other goals stated herein.

Carbon-chloroform extract (CCE)

This goal is based on equipment design and procedures utilized by USPHS throughout the early 1960's. Other designs need correlation with such units to determine relative adsorption efficiency to determine equivalent goal values. Materials adsorbed on activated carbon are organic. Toxic substances recovered may include chlorinated insecticides, nitrates, nitrobenzenes, aromatic ethers, and many others. Tastes and odors often may be correlated with the amounts of chloroform-soluble materials present, these materials having excessive odor thresholds. Most of the chloroform-soluble materials derive from manmade wastes. Waters from sources remote from concentrated industrial activities or human populations usually show CCF concentrations less than 0.04 mg/l. Where concentrations of CCE of 0.2 mg/l are found, the taste and odor of the water is always poor.⁵ In 1961, USPHS found the average CCE in 139 cities to be 0.066 mg./l. In 1962-63 the average was 0.065 mg./l.⁶ In 1961, of 172 supplies, 48 showed less than 0.05mg./l.¹

Carbon-alcohol extract (CAE)

This requirement is supplementary to the preceding CCE. The proportion of materials most commonly found is roughly in the proportion indicated by the limits stated for the CCE and CAE. (See the comments on CCE.)

Methylene-blue-active substances

This classification replaces the designation of ABS previously in use. The change is required because of changes in composition of the new detergents. The analytic technique used determines not only ABS but also alkyl sulfates and related materials that react with methylene blue.

Hardness

It is not intended to imply that hardness of waters below 80 mg/l should be increased to that content when corrosion can be otherwise controlled. To the average water consumer, hardness of 80-100 mg/l is not objectionable. It is important that, whatever the goal chosen, the hardness should be maintained at a uniform level. Most important is the degree of stability attained. It has been fairly stand-

⁴ *Public Water Supplies of the 100 Largest Cities in the United States*. USGS Water Supply Paper No. 1918. US Govt. Printing Office, Washington, D.C. (1962).

⁵ Tentative Methods for Carbon Chloroform Extract (CCE) in Water. *Jour. AWWA*, 54: 223 (Feb. 1962).

⁶ Minutes of Advisory Committee on Use of USPHS Drinking Water Standards. Sep. 24-25, 1965.

ard practice, for many years, to soften to roughly 5 grains of 85 mg/l hardness. The individual management, in choosing a standard, must consider that, the higher the hardness, the greater the cost to individual consumers; the less the hardness unless corrected, the greater the corrosion tendencies, and the greater the relative cost for treatment.

Alkalinity

This goal is a measure of alkalinity decrease or increase in the distribution system, and also after 12 hr at 130°F in a closed plastic bottle, followed by filtration. This goal is a simple determination, indicating in a practical way that the alkalinity is stable. The maintenance of calcium carbonate stability is the most effective method of preventing corrosive action on iron water mains. Undersaturation will result in reactions causing iron pickup and development of red water. Oversaturation will result in carbonate deposition in utensils, water heaters, household piping, and even in water mains. The point of stability is quite variable in different waters, and even in water from a single source. Various methods have been utilized to determine the point of stability, including the Enslow stability indicator, the Langelier index, the Ryznar index, and Oxygen Depletion, the latter three covering only a few of the many chemical factors involved, none of which suffice in practice, being only hypothetical indicators.

Coupon tests

Coupon insertion in pipelines is now the recognized method for checking on corrosion properties of vapors and gases. It has been used to a very limited extent in the field of water supply, where at least fifteen factors affect corrosivity. Coupons measure the combined effects both additive and neutralizing, of all the factors of corrosion, both known and unknown, including the physical factors of velocity and turbulence. Thus, coupons can provide valuable standards of comparison. Data on the use of coupons are still limited. Present data indicate levels should be those stated in Table 1 as goals. One design of coupon test equipment for water mains has been published.¹

Coliform organisms

Many water utilities have adopted high standards of operation and their water supplies have shown only a fraction of one coliform per liter over periods of many years. Municipalities that have so raised their bacteriologic quality far above the existing standards have established much improved health conditions with respect to certain significant illnesses, such as intestinal disturbances. Modern disinfection control procedures are such that a practical goal can be the destruction of all coliform organisms.

Gross beta activity

All evidence indicates the effects of radioactivity to be entirely harmful rather than beneficial. Therefore, it appears desirable to limit the intake of radioactivity as much as possible. A goal of 100 pc/l is well below the existing standards, yet it is several degrees above present-day general levels. In 1961, of 136 potable water supplies tested, 132 showed no more than 16 pc/l.² Of 100 largest cities, 92 showed less than 20 pc/l in 1961.⁴ In periods of bomb testing, natural waters have shown double this content; however, in periods free of bomb detonations, the natural background in most areas is only about 10 pc/l, or one-tenth this goal.

TABLE 1.—Potable Water Quality Goals¹

[Not a standard]

<i>Characteristic</i>	<i>Goal</i>
Physical factors:	
Turbidity.....	less than 0.1 unit.
Nonfilterable residue.....	less than 0.1 mg/l.
Macroscopic and nuisance organisms.....	no such organisms.
Color.....	less than 3 units.
Odor.....	no odor.
Taste.....	no taste, objectionable.

¹ For all health-related constituents not stated herein, these goals shall require complete compliance with all recommended and mandatory limits contained in current USPHS Drinking Water Standards. Unless other methods are indicated, analyses shall be made in conformance with the latest edition of *Standard Methods of Examination of Water and Wastewater*.

Chemical factors (measured in mg/l) :

Aluminum (Al)-----	less than 0.05.
Iron (Fe)-----	less than 0.05.
Manganese (Mn)-----	less than 0.01.
Copper (Cu)-----	less than 0.2.
Zinc (Zn)-----	less than 1.0.
Filterable residue-----	less than 200.0.
Carbon-chloroform extract (CCE)-----	less than 0.04.
Carbon-alcohol extract (CAE)-----	less than 0.10.
Methylene-blue-active substances (MBAS)---	less than 0.20.

Corrosion and scaling factors:

Hardness (as CaCO₃)----- 80 mg/l; a balance between deposition and corrosion characteristics is necessary; a level of 80 mg/l seems best, generally, considering all the quality factors; however, for some supplies, a goal of 90 or 100 mg/l may be deemed desirable.

Alkalinity (as CaCO₃)---- change of not more than 1 mg/l (decrease or increase in distribution system, or after 12 hr at 130° F. in a closed plastic bottle, followed by filtration).

Coupon tests (incrustation and loss by corrosion). 90-day tests (incrustation on stainless steel not to exceed 0.05 mg/sq cm; loss by corrosion of galvanized iron not to exceed 5.00 mg/sq cm).

Bacteriologic factors:

Coliform organisms (by multiple-fermentation techniques)----- no coliform organisms.

Coliform organisms (by membrane filter techniques)----- no coliform organisms.

Radiologic factors:

Gross beta activity----- less than 100 pc/l.

Senator Moss. Well, thank you very much, Mr. Johnson, for a fine statement and for the attached data which you brought with your testimony.

Speaking in terms of the users of water, you certainly bring your point of view that we want in our record. You have a conviction that out of this research done in the various water resource centers in the universities in this country can come much of the information we need for the improvement of our water supply, so we can provide for our population. We do appreciate it. Glad to have you with us, sir.

Mr. JOHNSON. Thank you very much.

Senator Moss. Dr. Allen F. Agnew.

Congressman Foley introduced you earlier, sir, and we have kept you waiting quite a long time. We are anxious to hear from you.

STATEMENT OF ALLEN AGNEW, DIRECTOR, STATE OF WASHINGTON WATER RESEARCH CENTER, AND CHAIRMAN, WATER RESOURCES COMMITTEE, NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES

Mr. AGNEW. Thank you, Mr. Chairman.

Mr. Chairman, I am pleased to represent the National Association of State Universities and Land-Grant Colleges in this presentation today. And in addition, I am representing the State of Washington Water Research Center, which is the other hat that I wear.

Senator Moss. Very good.

Mr. AGNEW. I have two written statements, Mr. Chairman, both of which I should like to ask to have introduced into the record.

Senator Moss. That will be done. Thank you.

Mr. AGNEW. And with your permission, I would like to speak about some of the highlights in those two statements.

Senator Moss. Very good.

Mr. AGNEW. Well, sir, several years ago you sat in here as we considered S. 2, and the association that I am representing today, which now represents 111 State universities in the 50 States and the District of Columbia and Puerto Rico—and I believe that President Harland Randolph of the D.C. Land-Grant School is here—this association presented a team of five men, as you will recall, who discussed various aspects of the needs for water research, and they included Dean Peterson, you remember, who talked about science and engineering, and President Elkins of the University of Maryland, who talked about the manpower training which we have heard about earlier again today; President Reitz of Florida who talked about the economic resource, water as an economic resource, and Chairman, or Chancellor Aldrich, Daniel Aldrich of the Irvine Campus of the University of California, who talked about the Federal-State relations, and then President Bill Morgan of Colorado State University wrapped it up by talking about water and a public resource.

Senator Moss. I remember very well.

Mr. AGNEW. And in my testimony, you will remember a statement that President Morgan made in concluding. This is on page 3. I would like to repeat it here, because sometimes these days this particular philosophy is being lost sight of.

He said:

Research today is a base for our general welfare. Research is the key to the most productive agriculture of all times; to greatly improved health; to a viable, productive, modern industry; to national security; to an extension of our environment beyond the earth atmosphere, and to many other desirable objectives. Thus, it is only proper that we should turn to research for assistance in stretching our limited water resources to the limit.

And that, Mr. Chairman, 7 years ago, I believe, is still appropriate today. And he went on then to talk about the breadth of water research needs, touching on water quality, recreation, navigation, river system planning, economic growth, legal problems, et cetera.

Well, I would like to move from 7 years ago then to where we stand today. We have had 5 years to take a look at those programs, those of us in the universities who are operating from that standpoint and those of us, our friends in the Federal agency operating from their standpoint, and this is, as you recognize, a very unique program tying the university community and the executive, the Federal agency, together, and a program that encompasses all of water resources, not just water quality but any aspect of water resources. It is not mission-oriented the way missions of special Federal agencies are defined, but the missions of the total water resource for the total Nation and functioning through the individual States.

I think that we in the universities and in the Federal Establishment, and if I could include the Senate and House committees as "we" also, we all can feel very proud of what has been accomplished by this legislation.

The fact that we recognize a few things that we feel need to be enhanced, as witnessed by your legislation S. 3553, points out that we have learned something in 5 years, and we therefore appreciate and we support this legislation, the national association does.

Well, this unique partnership has permitted the individual States to establish their own water research centers.

Now, admittedly, there was water research going on in these States before the act was created, but we established a communication mechanism through the establishment of these centers. We were able to gather together on the university campuses and between the universities and the States these people who are interested in working in water, and therefore I feel this is one of the major accomplishments of this act of 1964. This has permitted the States to focus on their own water problems through providing State funds, either through the universities or through direct legislative appropriations or in other ways.

And as you know in your own State this can be very substantial. In our State it is almost \$2 for every \$1 of Federal money.

Well, this unique partnership in our State and many other States has worked through the allotment program, this section 100 program, to grant seed grants, rather small amounts of money to individual projects. And these seed grants that permit a researcher to put a graduate student on a job to take a look at this particular task, and possibly if it is a small one, to solve it. On the other hand, by identifying it, if it turns out to be a larger task or a multidiscipline task, then other resources can be brought to bear outside the allotment program. But the allotment program permitted it to jump off the springboard, get started.

I would like to remind you that our goals and our objectives are changing. They are not exactly what they were 7 years ago. These are human decisions. Our changing desires, the way we do things to water has created new problems that we could not anticipate 7 years ago. And so I feel that we must be flexible in our programs, and I believe that the act has this kind of flexibility and that your legislation, companion legislation, recognizes the need for enhancing this flexibility to provide the communication mechanism.

Now, I would like to speak just briefly about the allotment program itself. We recognize the advantages of the matching grant, the section 101 and the section 200, title II programs.

The allotment program not only receives review back in the States where we have our State agencies helping us, university people identify problems and then working out a research proposal that will tackle that problem, but our university advisory committees, whatever they are called, review, screen them and select those that seem to be most meritorious. Then these are sent in to Washington to the Office of Water Resources Research, where they review, they screen these projects, and they suggest that we alter them; they can deny them, which they have done.

It seems to me that this provides the Office of Water Resources Research with a management tool for programs that originate in the States. So again, it is coupling this team of university and Federal agency people together in a decision here on what kind of research is to be done.

If I could step just briefly into my other hat now, the hat of the State of Washington, that is the second statement that you have

before you, in our State we have two universities participate through the center, the University of Washington at Seattle, and Washington State University at Pullman. We have a joint scientific committee consisting of three faculty people from each university. These men represent varying disciplines related to water.

These six men, then, the six colleagues screen our projects. We send the projects in to Washington, the allotment project. And to date we have funded 36, in 5 years 36 of these projects.

Now, that is up until this past July 1. We have had 194 students involved in the program in these 5 years, and our purposes are five, really. First, of course, is research, to perform the research.

But the second one would be to pinpoint gaps in our knowledge, to identify research needs.

The third would be to create public awareness of the complex nature of water resources.

And the fourth would be to create a desire on the part of the faculty members to get involved in water studies.

And the fifth would be to produce graduates with solid backgrounds—we heard about this earlier—solid backgrounds in training and modern techniques of solving water resource problems. We in the State of Washington have been able to maintain fairly good communications with our State water agency. I say fairly good, because we have not put as much effort into this communication mechanism as we should, and their people, though, they are very competent, are covered up with brush fires they must put out continually. Therefore, they don't have time to sit down and read a 200- or a 400- or a 700-page set of volumes. So we must enhance our communication mechanism both by preparing readable, digestible summaries in layman's language for the city fathers and others who are not technically trained, and then also a mechanism of sitting down across the table in skull sessions, seminars, workshops, this sort of thing.

And we in our State hope to use, through the existing—hope to work through the existing communication mechanism the co-op extension service of the agricultural college and also a technical extension service in our engineering college.

So we already have the kind of structure, and we must devise means of working with that structure so we don't have to duplicate it.

In our State because of the existence of the center we have been able to perform two major studies for the State department of water resources, and one of these was turned in in 1967, and the other has just been turned in in the last several months to the State department of water resources, and four of these five studies resulting from this last one have been published. The fifth one is due to come out. It is in review right now by the State department of water resources and it is due to come out this fall.

These studies are multidisciplined. They are studies of 20 to 24 faculty people from the two universities and from two other colleges in the State, Western Washington State College and Central Washington State College.

We would expect that this increased allotment program would permit us to enhance the communication mechanism to augment the allotment program of research funding so that we could include more professionals than we are able to fund now.

For instance this year we were able to fund only 65 percent of the meritorious proposals, the good ones that remained after screening. Those that we could not fund this year we took to the State agency hoping that they could get funding there. And in our State, as in the Federal Establishment, there is a review by other State agencies that have missions that might lean or depend upon a particular proposal that we turn in, just as the Office of Water Resources Research calls upon review from Agriculture or from the Geological Survey or from other agencies here.

Well, I think, sir, this is in essence what I wanted to say except for a conclusion, and the concluding remark that I wanted to refer to is found on pages 6 and 7 of the first statement—that is, the National Association of State Universities.

These water research centers serve as a focal point for water research activity. By scanning the water resources research catalog of the Department of the Interior, 5,000 research topics, we can assure that unwarranted duplication does not exist.

The university water research center thus has an influence through the State agency that is far wider than just the projects which the Federal agency helps fund, far wider. These seed grants permit us to gather in other talents that exist at the university that are currently working on problems. And because your bill, Senate bill 3553, and 3721 will enable a partnership that we referred to earlier, this partnership of the governmental agency and the university community and private industry to do a better job of solving society's water problems, the National Association of State Universities and Land-Grant Colleges supports the provisions and urges favorable action on this legislation.

Thank you, sir.

(The complete prepared statements of Mr. Agnew follows:)

PREPARED STATEMENT OF ALLEN F. AGNEW, DIRECTOR, STATE OF WASHINGTON WATER RESEARCH CENTER, AND CHAIRMAN, WATER RESOURCES COMMITTEE, NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES

My name is Allen F. Agnew, I am Director of the State of Washington Water Research Center and Professor of Geology at Washington State University. My appearance today is in the capacity of Chairman of the Water Resources Committee of the National Association of State Universities and Land-Grant Colleges. I wish to thank the Committee on behalf of the 111 major State universities and land-grant institutions comprising the membership of the Association for this opportunity to speak in their behalf in favor of S. 3553 and S. 3721 which would amend P.L. 88-379, the Water Resources Research Act.

We should have preferred the opportunity to present a more comprehensive oral statement by several representatives of the Association. However, in heeding the suggestion of the Chairman of the full Committee that the hearing be limited to half a day if possible, we have settled on my single oral presentation of the Association's views, accompanied by this written statement and those of other representatives of the Association.

THE ACT

The National Association of State Universities and Land-Grant Colleges in the early 1960's became concerned that too little attention was being given to the broad range of water-resource problems confronting the Nation. The Association recognized that much research was needed to provide the information necessary for the resolution of these problems, and that good solutions were of little value without properly trained personnel to implement them. The result of this concern, expressed through the activities of the Association's Committee on Water Resources, was the passage of the Water Resources Research Act in

1964. This act provided for the establishment of an Institute in each State at the land grant university and/or State university, which in cooperation with State and Federal agencies would mount an attack on water-resource problems.

The Act was signed by President Johnson on July 17, 1964, and on that same date the Secretary of the Interior established the Office of Water Resources Research to aid in administering the Act. The research and training activities authorized under the Act are broad in scope, including studies in the physical and biological sciences, engineering, and a number of the social sciences. Two types of financial support were made available under Title I of the Act—(1) an annual allotment to an approved water research institute or center in each of the 50 States and Puerto Rico, and (2) matching grants for projects selected and approved by the OWRR on a competitive basis by the 51 institutes, with non-Federal support equal to or more than the Federal grant.

Title II permitted proposals to be funded under grants, contracts, matching or other arrangements with educational institutions, private foundations or other institutions, with private firms and qualified individuals, and with local, State, and Federal governmental agencies, to undertake research into any aspects of water problems related to the mission of the Department of the Interior. However, because President Johnson objected to the provision for Congressional clearance of specific Title II research projects, no funding was requested during Fiscal Years 1965 and 1966. These objectives were met by Public Law 89-404, which was signed on April 19, 1966.

THE PROBLEM, AS SEEN TEN YEARS AGO

We do not need to develop here the thorough and comprehensive background statements of justification and support for a coordinated water-research program at the universities, in partnership with the Federal government, for this was admirably done in hearings on S. 2 before this Committee on February 19-20, 1963, sponsored by Senators Anderson, Jackson, Moss, Burdick, and Metcalf of the Committee who are still actively interested in the results of this legislation, seven years later. That record speaks for itself. In this interest you five Senators have been joined on the Committee during the intervening period by a dozen others, all of whom represent States with water problems.

The Association's statement before the Committee in 1963 was most ably presented by a team of five, guided by Dr. William E. Morgan, then President of Colorado State University. These five included Dr. D. F. Peterson, Dean of the College of Engineering of Utah State University, who discussed the science and engineering aspects; President Wilson H. Elkins of the University of Maryland, who touched on the critical manpower-training issue; President J. Wayne Reitz of the University of Florida, who talked about water as an economic resource; and Chancellor Daniel G. Aldrich of the University of California at Irvine, who dealt with the Federal-State relationships involved. President Morgan's concluding statement on water as a public resource neatly wrapped up the package.

I do not intend to redevelop those five points, although they are just as valid today, after 5½ years of operation of the program, as they were then when it was being conceived. I should, however, like to stress one of the introductory remarks of President Morgan, which most of us who operate in the governmental, university, or private industry spheres are all too aware of, but which surprisingly is not being heeded by some persons in policy-making positions today. Dr. Morgan said: Research is today a base for our general welfare . . . Research . . . is the key to the most productive agriculture of all time; to greatly improved health; to a viable, productive, modern industry; to national security; to an extension of our environment beyond the earth's atmosphere, and to many other desirable objectives. Thus, it is only proper that we should turn to research for assistance in stretching our limited water resources to the limit.

Dr. Morgan's written statement discussed the broad and diversified basis of water as a public resource, citing water quality, recreation, navigation, flood control, river-system planning, economic growth, and the legal-administrative-organizational aspects of water management.

Those same facets have continued to be important during the past 5½ years because the report, "A Ten-Year Program of Federal Water Resources Research" (FCST/COWRR, Feb. 1966, 88 p.), which is used as the basis whereby our State-submitted water-research proposals are judged, has carried those topics forward in the form of fourteen major problem areas which it recognized in 1965 when the report was being prepared, as follows:

1. Water Resources Planning.

2. Water Pollution Control.
3. Water Conservation.
4. Ecologic Impact of Water Development.
5. Effects of Man's Activities on Water.
6. Cost of Water-Resource Development.
7. "Far-Out" Ideas.
8. Climatic Changes.
9. Information Storage and Dissemination.
10. Problem Assessment.
11. Water Resources Research Laboratories.
12. Experimental Watershed.
13. Coordination of Research.
14. Manpower.

THE PROBLEM, AS SEEN TODAY

Today, five years later, the multiple author of this Ten-Year Program, the Committee on Water Resources of the Federal Council for Science and Technology, has taken a mid-term look at it and has recognized (Report, p. 5) that new problems have emerged, that existing research requirements have to some extent been satisfied or require different emphasis, and that research needs must be presented in terms of major problem areas. Further, the FCST/COWRR has recently identified in a report entitled "Federal Water Resources Research Program for Fiscal Year 1970" (1969, 47 p.) the following five specific problems that warrant immediate increased research support:

1. Managing metropolitan area water systems.
2. Improving regional water-resource planning and management.
3. Controlling pollution due to thermal discharge, oil and sediment.
4. Protecting public health.
5. Predicting ecologic changes.

The performance of the 51 Institutes or Centers over 5 years of operation amply sustains the wisdom of the enabling legislation. The annual reports by the Office of Water Resources Research to the Congress provide continuing tangible proof of the effective Federal-State partnership that has been established thereby.

The original act, providing \$100,000 annually to each Water Resource Research Center, was thought by the sponsors of the legislation to be adequate to initiate the program. It has become evident that inflation has drastically eroded the purchasing power of the amount originally authorized. In addition, the original authorization was predicated on known problems. Even the most knowledgeable scientist in 1964 did not anticipate the multitude of problems associated with the rapidly changing environment or the magnitude of the task and the cost of disseminating and interpreting the results of scientific and engineering research deemed significant for the solution of water-resource problems. Even with the existing substantial non-Federal contributions, the present authorized Federal appropriation is no longer adequate to support these responsibilities of the Water Resource Research Centers.

The Association therefore supports S. 3553 and S. 3721, which would amend the Water Resources Research Act of 1964 to increase the allotment for each State under Section 100a of Title I to \$250,000 per year. The legislation also amends Section 100b of Title I to reflect the responsibility of the Water Resources Research Centers to communicate the results of water research to the user.

Senate Bills S. 3553 and S. 3721 will enable this unique Federal-State partnership to come more closely to realizing the goals that were envisioned in 1963—(1) to do research that will solve existing problems and will anticipate others, in a framework of planning for the wise use of the resource; (2) to educate and train the people who are now and who will be in the future involved in the implementation of these planning and management decisions; and (3) to communicate the results of these searches for new knowledge and for new applications of old knowledge from the generator of the ideas, or researcher, to the recipient, or user.

In our re-examination of the water resources research program, we have noted that it must be national in scope, or at least regional. Nevertheless, many projects that may seem to have only local application are seen to possess, on further examination, regional and national application. One of the major side-benefits of the program—in fact, it is an overriding benefit in the case of some States—is the fact that the establishment of the Center under the OWRR program has permitted a large and coordinated State-funded program to be devel-

oped. This point is emphasized in my accompanying statement for the State of Washington, and I am sure that many others who will communicate with this Senate Committee will likewise stress its importance.

The Water Research Centers in such States serve as the focal point for water-research activity in the many subdivisions of the university, and thus provide a communication mechanism that previously did not exist on the campus. Coupled with the massive annual compilation of the Water Resources Research Catalog by the Office of Water Resources Research (5,000 active research projects inventories and cross-referenced), this communication mechanism enables the researcher to undertake and pursue his study not in a partial vacuum but in an environment of complete awareness of related ongoing research in governmental agencies, universities, and private organizations.

The dollar value of non-Federal money invested in water research by the universities has been estimated by the OWRR as about 67 cents for every Federal dollar. Many States, including my State of Washington, have been able to do more—our ratio is about \$1.84 non-Federal for every Federal dollar. This and other matters are amplified in my separate statement, submitted in the capacity as Director of the State of Washington Water Research Center.

The university water research center thus has an influence that is far wider than just the projects which the Federal agency helps fund. The Center's seed grants enable experts in many disciplines to put together large and comprehensive research projects in which water is only one segment. Such projects, in fields of agriculture or engineering for example, have the multiplier effect of causing the application of much larger reservoirs of money and talent to problems whose thrust is mainly in another area.

For example, the water research center might fund a series of seminars that bring together a group of experts on a problem that involves pollution. Having confronted the issue in this concrete fashion, these people might then be able to (1) prepare the framework and the body of a research proposal that could be sent to another Federal agency—say the Federal Water Quality Administration—for funding; or, in a larger context, (2) prepare an environmental program of curriculum and research that could result in financial support from the Department of Health, Education, and Welfare or the newly-announced Environmental Protection Agency.

The other side of the coin is the fact that ongoing research at a university in soil science or fisheries or economics or electrical engineering can generate information that is useful to a water-research project also. Thus, many more ideas and sources of funds are contributed to a particular water project than may be evident at first glance or than may appear on paper.

CONCLUSION

In these times of massive problems dealing with both our natural resources and our human resources, we are concerned with limiting our expenditures and establishing priorities for these funds, which are admittedly less than adequate to accomplish what we feel must be done. Therefore, we must examine existing programs closely to determine whether they are doing the job expected of them. In the process, we must take a thorough look at what should be done, and then determine the steps that we can take to assure that this can be accomplished.

In the Water Resources Research program we see a program that has been surprisingly successful and has accomplished much of what was expected of it seven years ago by the framers of the legislation. We also see areas in which the program could be improved so that it can be of even greater service to the citizens of our Nation.

Because S. 3553 and S. 3721 will enable this partnership of governmental agency/university community/private industry to do a better job of solving society's water problems, the National Association of State Universities and Land-Grant Colleges supports their provisions and urges favorable action on this legislation.

PREPARED STATEMENT OF ALLEN F. AGNEW, DIRECTOR, STATE OF WASHINGTON WATER RESEARCH CENTER, WASHINGTON STATE UNIVERSITY

My name is Allen F. Agnew. I am Director of the State of Washington Water Research Center and Professor of Geology at Washington State University. My appearance today is in this capacity and also as Chairman of the Water

Resources Committee of the National Association of State Universities and Land-Grant Colleges, and I am presenting separately the written statement of that organization. The statement that follows represents the thinking and position of the State of Washington Water Research Center.

I wish to thank the Committee for the opportunity to present our views on S. 3553 and S. 3721, which would amend P.L. 88-379, the Water Resources Research Act.

THE CENTER

The State of Washington Water Research Center was formed on November 17, 1964, in response to the enactment of P.L. 88-379, through a Memorandum of Agreement signed by the Presidents of Washington State University and the University of Washington. The purpose of the Center is to search for new knowledge that will solve water problems and will provide for better management of this most critical natural resource.

A Joint Scientific Committee of six members, three from each university selected because of their competence in water research and their academic disciplines, provides guidance and advice to the Director of the Center. Appointed by their respective Presidents for overlapping three-year terms, the Joint Scientific Committee includes: Professor Milo C. Bell, UW—Fisheries; Dr. Walter R. Butcher, WSU—Agricultural Economics; Dr. James A. Crutchfield, UW—Economics/Public Affairs; Dr. John F. Osborn, WSU—Civil Engineering/Hydraulics; Professor Warren A. Starr, WSU—Soils; and Dr. Robert O. Sylvester, UW—Civil Engineering/Sanitary Engineering. The chairmanship rotates annually between the two universities.

The Center's research projects support the graduate studies of numerous students through their specific Departments, thus contributing to their education and training—194 students have been so supported during the five years of the Center's existence.

This cooperative venture between the two universities is unique, and this relationship has proved to be extremely viable, with the capability of drawing upon experts in almost every field of water and related resources. In addition, an examination of the operation of the Center's program in the past five years has shown considerable interest on the part of faculty people at the State Colleges who wish to participate in the investigations. To date, only two persons from two of the State Colleges have been so involved, through the matching-grant program, but the opportunity for this involvement could be increased substantially if the provisions of S. 3553 and S. 3721 were enacted.

THE CENTER'S PROGRAM

The program of the State of Washington Water Research Center is very broad. Although the performance of research and the completion of research reports dealing with specific topics or problems are the primary knowledge products of the Center, other major functions and results have been:

1. To pinpoint gaps in the knowledge of water resources and thus identify the research needs of the State of Washington, the region, and the Nation.
2. To create a public awareness of the complex nature of water resources.
3. To create a desire on the part of the faculties of the Universities and Colleges in the State to become involved in these studies, and
4. To produce graduates with substantive backgrounds and training in the modern techniques of solving water-resource problems.

The Center is supported financially by the Federal Office of Water Resources Research and by Washington State University; in addition, funds for large multi-discipline studies and specific projects have been provided by the Washington Department of Water Resources.

The Center has participated in programs of research through the Office of Water Resources Research under two sections of P.L. 88-379—Allotment (Sec. 100) and Matching Grant (Sec. 101).

Approximately three-quarters of the Allotment money has been used to fund specific research projects. These seed grants, though small, (averaging \$4750 per year) are sufficient to permit a project to be examined and, in many cases, solved in one or two years; other projects have developed sufficient information and challenges to warrant support for a number of years. Although non-Federal funds are not required, the amount of university and other non-Federal money thus applied to these Allotment projects is essentially equal to the Federal

money—averaging \$4,800 per year for the 36 projects funded thus far. A list of Allotment projects funded through fiscal year 1970 is included as Appendix A.

Before an Allotment project is funded by the State of Washington Water Research Center, it must pass through two thorough reviews. First, it is scrutinized by the six-man Joint Scientific Committee of the Center and an equal number of professional colleagues at the two universities. Then, those selected for funding are forwarded to the Office of Water Resources Research where they are again reviewed. Upon receiving a favorable statement from OWRR, the project is then funded. The reviewers pay particular attention not only to the nature of the proposed research, the plan of attack, and the competence of the investigators, but also to the relevance of the research. Although this insistence of relevance does not preclude "far-out" ideas recognized as needing attention by the FCST/COWRR report, "A Ten-Year Program of Federal Water Resources Research, Feb., 1966," it does insure that most of the work will be directed toward problem solving; this relevance has another form of significance, for many of these project ideas were first identified by State agency personnel as needing research.

The Allotment program of the Center has been concentrated in four of the FCST/COWRR areas—water resources planning, water cycle, water-quality management and protection, and water-supply augmentation and conservation. It is interesting to note that these constitute four of the five categories which have received the major part of Federal Agency research activity as well—only the category of water quantity management and control received minimal attention through the Center's allotment program. One of the strengths of the Allotment (Sec. 100) program is the fact that the high-priority Federal research categories are not applied by the OWRR as rigidly as they are in selecting the Matching Grant (Sec. 101) and Title II (Sec. 200) programs; this provides for the recognized need for breadth and flexibility in the total OWRR program, and enables each Center to be more responsive to needs and priorities in its State and region.

We have come to realize that funds for the Allotment program are inadequate, because the State of Washington Water Research Center is receiving nearly twice the number and dollar amount of meritorious project proposals that can be funded with the existing level of OWRR funds.

With regard to the Matching Grant (Sec. 101) program, the Center has been able to receive funding for only a small portion of the meritorious proposals submitted (See Appendix B). Because of the intensity of the national competition, however, this problem faces most of the Centers. It is unfortunate that, when State agencies identify problems that need to be solved and offer the matching funds, and the university researchers are able to devise research proposals that will lead to their solution, these problems cannot be tackled because of the inadequacy of the moneys appropriated under Section 101.

The same problem of inadequate funding for Title II (Sec. 200) proposals exists, and it is magnified because matching non-Federal money is not required and thus more and larger projects are proposed, so fewer can be funded by OWRR.

Though Federal money is unquestionably the backbone of the Center's operations, such funds are actually considerably less on a year-to-year basis than the non-Federal funds. During the past year the Center has been working on several studies supported by the Washington State Department of Water Resources; one of these leads into an OWRR matching-grant project in Fiscal Year 1971, which deals with low-flow criteria.

The most recent major study performed for the Washington Department of Water Resources consists of a set of five reports that are answering questions raised by an earlier major study for the DWR in 1967, entitled "An Initial Study of the Water Resources of the State of Washington." These five reports cover such subjects as future requirements for agriculture, industry, and fisheries; manipulation of runoff by forest practices; water-quality; flood-management criteria; and several aspects of the Columbia River as a resource (See Appendix C).

Perhaps the most significant study performed by the Center for the State is the current "Conceptual Study of a State Water Plan," which provides guidance to the Washington Department of Water Resources in the preparation of a State water plan.

TO ENHANCE THE PROGRAM

In conclusion, the establishment of the State of Washington Water Research Center was brought about by the enactment of P.L. 88-379, so the previously mentioned advantages to the State have resulted directly because of the legislation, S. 2 of the 88th Congress.

The Water Resources Research Act has also enhanced the opportunity for university people to tackle controversial matters, as I discussed several months ago in a speech entitled, "Water Research—A Third Approximation," which is appended to this statement (Appendix D). Such research opportunities, not bound by tradition nor restricted by agency mission, permit the Center to fulfill its obligation to society.

The need for a more substantial effort to get the results of the research to the user, whether a State agency or a segment of the industrial community, is widely recognized and is certainly germane to the State of Washington. A greatly expanded State-wide communication program is one of the ways in which this could be achieved.

The legislation before the Subcommittee, S. 3553 and S. 3721, would authorize the mechanism and funding for accomplishing those aspects of the Water Resources Research program which we all recognize are in need of bolstering—an improved communication mechanism for transferring research results to the user, and an enhanced program of seed-grant research money which will enable additional colleges and universities in the State to participate through the increased allotment.

The State of Washington Water Research Center urges favorable action on this legislation.

MEMBERS OF THE NASULGC WATER RESOURCES COMMITTEE, NOVEMBER 12, 1969

1970

- Dr. John C. Calhoun, Vice President for Programs, Texas A & M University.
 Dr. Ernest W. Hartung, President, University of Idaho.
 Dr. Roy E. Huffman, Vice President for Research, Montana State University.
 Professor Robert L. Smith, Chairman, Department of Civil Engineering, The University of Kansas.
 Dr. George Worrilaw, Vice President for University Relations, University of Delaware.

1971

- Dr. Allen F. Agnew, Director, State of Washington Water Research Center, Washington State University.
 Dr. George P. Hanna, Jr., Chairman, Department of Civil Engineering, University of Nebraska.
 Dr. Neil D. Humphrey, Chancellor, University of Nevada System.
 Dr. Elbert F. Osborn, Vice President for Research, Pennsylvania State University.
 Dr. Charles A. Palm, Dean, College of Agriculture, Cornell University.
 Dr. E. T. York, Jr., Provost, University of Florida.

1972

- Dr. Daniel G. Aldrich, Chancellor, University of California.
 Dr. A. Ray Chamberlain, President, Colorado State University.
 Dr. Ferrel Heady, President, University of New Mexico.
 Dr. Richard Kassander, Director, Water Resources Research Center, University of Arizona.
 Dr. John F. Kennedy, Director, Institute of Hydraulic Research, University of Iowa.

APPENDIX A

ALLOTMENT PROJECTS OF THE STATE OF WASHINGTON WATER RESEARCH CENTER, THROUGH FISCAL YEAR 1970

A-001-Wash.—Campbell, Professor Thomas H. (University of Washington, Civil Engineering). Infiltration Beneath a Forest Floor. January 1, 1965–June 30, 1966.

A-002-Wash.—Johnson, Dr. Ralph W. (University of Washington, Law). Defects in the Water Law in the State of Washington. February 8, 1965–August 30, 1965.

A-003-Wash.—Bevan, Dr. Donald E. and Paulik, Gerald J. (University of Washington, Fisheries). Simulation of a Water Resource System. January 1, 1965-June 30, 1968.

A-004-Wash.—Richey, Dr. Eugene P. (University of Washington, Civil Engineering). Fluid Mechanics of Downstream Migrant Fish Passage Structures. July 1, 1965-October 31, 1967.

A-005-Wash.—Buss, Dr. Irvan O. (Washington State University, Wildlife Biology). Some Effects of Water Impoundments on Waterfowl Populations and Reproduction on the Snake River, Washington. February 8, 1965-June 30, 1970.

A-006-Wash.—Jensen, Professor Max C. (Washington State University, Agricultural Engineering). Drainage Theory for Removal of Excess Water from Irrigated Lands. June, 1965-June 30, 1968.

A-007-Wash.—Crosby, Professor James W., III. (Washington State University, Geology). Methods of Estimating Ground-water Recharge Near the Margins of Plateau Basalts. January 1, 1965-June 30, 1967.

A-008-Wash.—Proctor, Dr. Donald E. (Washington State University, Civil Engineering). Evaluation of Factors Affecting Stream Self-purification. February 8, 1965-June 30, 1968.

A-009-Wash.—Bender, Dr. Donald L. (Washington State University, Civil Engineering). Determination of Flows for Ungaged Streams. July 1, 1965-December 31, 1968.

A-010-Wash.—Withdrawn.

A-011-Wash.—Faulkner, Dr. Lindsey R. (Washington State University, Plant Pathology). Distribution and Ecology of Nematodes in Irrigation Water. July 1, 1965-June 30, 1966.

A-012-Wash.—Nece, Dr. Ronald E. (University of Washington, Civil Engineering). Effect of Dam construction on Downstream Water Temperature. July 1, 1965-June 30, 1968.

A-013-Wash.—Iulo, Dr. William (Washington State University, Economics). The Role of Industrial Process Changes in Affecting Water Requirement. July 1, 1965-June 30, 1968.

A-014-Wash.—Tinney, Dr. E. Roy and Crutchfield, Dr. James A. (Washington State University, Civil Engineering; University of Washington, Economics). Planning and Evaluation. 1965-1966.

A-015-Wash.—Brown, Dr. Gardner (University of Washington, Economics). Selection of the Optimum Method for Estimating the Demand for Nonmarket Water Resources with Incomplete Information. February 25, 1966-June 30, 1967.

A-016-Wash.—Carlson, Dr. Dale A. (University of Washington, Civil Engineering). Improvements in Treatment Design for Enhancing Wastewater Quality. July 1, 1966-June 30, 1968.

A-017-Wash.—Campbell, Professor Thomas H. (University of Washington, Civil Engineering). Computer Generation of Stochastic Streamflow. June 15-September 15, 1966.

A-018-Wash. Drake, Dr. Charles H. (Washington State University, Bacteriology). Ecology of Selected Aquatic Bacteria in the Snake River, July 1, 1966-December 31, 1968.

A-019-Wash.—Allen, Dr. G. Graham (University of Washington, Forestry). Enhancement of Water Quality Using Forest-derived Coagulating System. July 1, 1967-June 30, 1970.

A-020-Wash. Campbell, Professor Thomas H. (University of Washington, Civil Engineering). A Study of Serial Correlation in Annual Stream Runoff. July 1, 1967-June 30, 1969.

A-021-Wash. Crosby, Professor James W., III. (Washington State University, Geology). Physical Characteristics of Basalt Aquifers. July 1, 1967-June 30, 1971.

A-022-Wash.—Gessel, Dr. Stanley P. (University of Washington, Forestry). Methods of Analysis and Determination of Effects of Alternative Uses of Forested Lands on Streamflow. July 1, 1967-June 30, 1969.

A-023-Wash.—Nece, Dr. Ronald E. (University of Washington, Civil Engineering). Internal Currents Resulting from Intermediate Density Inflows into Stratified Reservoirs. October 1, 1967-June 30, 1970.

A-024-Wash.—Seabloom, Professor Robert W. (University of Washington, Engineering). Bacteriological and Esthetic Effect of Pleasure-Boat Waste Discharge on Small Harbors. July 1, 1967-June 30, 1969.

A-025-Wash.—Whittlesey, Dr. Norman K. and Butcher, Dr. Walter R. (Washington State University, Agricultural Economics). Maximizing Productivity of Water Used for Irrigation of Agricultural Lands). July 1, 1967-June 30, 1970.

A-026-Wash.—Carlson, Dr. Dale A. (University of Washington, Civil Engineering). Nitrate Removal from Activated Sludge System. July 1, 1968-June 30, 1970.

A-027-Wash. Gessel, Dr. Stanley P. and Wooldridge, Dr. David D. (University of Washington, Forestry). Effects of Forest Cover Manipulation on Water as Studied by An Electric Analog. July 1, 1968-June 30, 1969.

A-028-Wash.—Gladwell, Professor John S. (Washington State University, Civil Engineering). Runoff Generation as a Function of Precipitation and Watershed Characteristics. July 1, 1968-June 30, 1970.

O-029-Wash.—Higgins, Dr. David T. (Washington State University, Civil Engineering). The Storage Coefficient as a Function of Water Table Celerity. July 1, 1967-June 30, 1970.

O-030-Wash.—Johnson, Dr. Ralph D. and Rosenow, Dr. Beverly J. (University of Washington, Law). Analysis of the Water Rights Registration Act and Associated Legislation of the 1967 Washington Session Law, with Special Reference to Water-Management Districts. July 1, 1968-June 30, 1970.

A-031-Wash.—Warren, Dr. Robert (University of Washington, Political Science). A Comparative Analysis of American and Canadian Governmental Arrangements for the Development of Regional Water Policy in the Columbia River Basin. July 1, 1968-June 30, 1970.

A-032-Wash.—Fritschen, Dr. Leo J. (University of Washington, Forestry). Hydrologic and Energy Balance of Stocked and Nonstocked Douglas Fir Sites as Calculated by Meteorological Methods. July 1, 1969-June 30, 1972.

A-033-Wash.—Funk, Dr. William H. (Washington State University, Civil Engineering). Bioassays to Determine Algal Growth Potential of Micronutrients. July 1, 1969-June 30, 1972.

A-034-Wash.—Welch, Dr. Eugene B. (University of Washington, Civil Engineering). Nuisance Algal Growth Related to Environmental Factors. July 1, 1969-June 30, 1971.

A-036-Wash.—Lomax, Professor Claude C. (Washington State University, Civil Engineering). Controlling the Location and Dispersion of Thermal Polluting Effluents. July 1, 1969-June 30, 1971.

A-037-Wash.—Wooldridge, Dr. David D. (University of Washington, Forestry). Quantitative Assessment of Disposition of Precipitation in Relation to Streamflow. July 1, 1969-June 30, 1970.

APPENDIX B

MATCHING-GRANT PROJECTS OF THE STATE OF WASHINGTON WATER RESEARCH CENTER, THROUGH FISCAL YEAR 1970

B-003-Wash.—Bevan, Dr. Donald E. and Salo, Dr. Ernest O. (University of Washington, Fisheries). Estuarine Water Quality and Fish Distribution. January 1, 1966-June 30, 1967. Source of Matching Funds: Georgia-Pacific Corporation; University of Washington.

B-004-Wash.—Bevan, Dr. Donald E. and Salo, Dr. Ernest O. (University of Washington, Fisheries). Water Quality as Related to Survival of Salmon Eggs and Larvae. July 1, 1965-September 15, 1966. Source of Matching Funds: Everrett Mills Technical Committee.

B-005-Wash.—Crosby, Professor James W., III. (Washington State University, Geology). Investigation of Techniques to Provide Advance Warning of Ground-water Pollution Hazards, with Special Reference to Aquifers in Glacial Outwash. June 1, 1966-August 31, 1971. Source of Matching Funds: City of Spokane.

B-011-Wash.—Kraft, Dr. Gerald F. (Western Washington State College, Biology). Factors Affecting the Movement of Water and Organisms Within a Regulated Multipurpose Lake. July 1, 1966-June 30, 1969. Source of Matching Funds: City of Bellingham, Whatcom County Commissioners, Western Washington State College.

B-018-Wash.—Faulkner, Dr. Lindsey R. (Washington State University, Plant Pathology). Ecology of Nematodes in Irrigation Water. July 1, 1966-June 30, 1969. Source of Matching Funds: Washington State University.

B-019-Wash.—Hammond, Dr. Kenneth A. (Central Washington State College, Geography). The Impact of Federal Water Legislation at the State and Local Level. January 1, 1968-March 31, 1970. Source of Matching Funds: Central Washington State College.

B-023-Wash.—Mar, Dr. Brian W. (University of Washington, Civil Engineering). Verification of Models and Basic Data Used in the Management and

Control of Water Quality, July 1, 1968–June 30, 1971. Source of Matching Funds: Washington Department of Water Resources.

B-035-Wash.—Woodriddle, Dr. David D. (University of Washington, Forestry). Objectives and Comprehensive Planning for Urban Storm Water Removal. July 1, 1969–June 30, 1970. Source of Matching Funds: King County, Washington; Washington Department of Water Resources.

APPENDIX C

TWO MAJOR STUDIES BY THE STATE OF WASHINGTON WATER RESEARCH CENTER FOR THE WASHINGTON DEPARTMENT OF WATER RESOURCES

1966–67. First group of studies published as:

1967.—An Initial Study of the Water Resources of the State of Washington by Director E. Roy Tinney of the Center and 15 faculty members at both universities. Four volumes, approximately 1000 pages.

Volume 1—A First Estimate of Future Demands for Water in the State of Washington, by John A. Adams (Washington State University); Milo C. Bell (University of Washington); Gardner Brown Jr. (University of Washington); Walter R. Butcher (Washington State University); Thomas H. Campbell (University of Washington); James A. Crutchfield (University of Washington); John S. Gladwell (Washington State University); Sherman B. Green (University of Washington); Robert A. Sutherland (Washington State University); and E. Roy Tinney (Washington State University), approximately 300 pages, 95 tables, 14 figures.

Volume 2—Water Resources Atlas of the State of Washington, by J. S. Gladwell and August Mueller, approximately 325 pages, 13 tables, 75 figures and small maps, 51 charts and large maps.

Volume 3—Irrigation Atlas of the State of Washington, by Walter R. Butcher, Ray Gilkeson, and Max C. Jensen, approximately 100 pages, 14 tables, 7 figures.

Volume 4—Water Quality of the State of Washington, by Carl A. Rambow and Robert O. Syvester, approximately 270 pages, 11 tables.

1969–70. Second group of studies, including:

1970.—Water Research Center Report No. 3, A—Miscellaneous Studies of Economic, Agriculture, Fishery, and Forestry Aspects Affecting the Water Resources of the State of Washington, by Milo C. Bell (University of Washington); Walter S. Butcher (Washington State University); Millard Hastay (Washington State University); and David D. Woodriddle (University of Washington), approximately 450 pages.

1970.—Water Research Center Report No. 3, B—Water Quality Aspects of the State of Washington, by Brian W. Mar (University of Washington); W. Mason (University of Washington); David A. Nunnallee (University of Washington); and M. Rapp (University of Washington), 207 pages plus numerous figures.

1970.—Water Research Center Report No. 4, A—Commentary on Improving the Flood-associated Activities of the State of Washington Department of Water Resources; Guidelines for Establishing Economic and Engineering Flood Criteria, by P. W. Barkley (Washington State University); D. L. Bender (Washington University); H. D. Copp (Washington State University); J. G. Hattersley (Washington State University); and J. F. Orsborn (Washington State University), 103 pages, 8 tables, 18 figures.

1970.—Water Research Center Report No. 4, B—Commentary on Improving the Flood-associated Activities of the State of Washington Department of Water Resources; An Analysis of the Law Governing Six Selected Washington Water-oriented Districts, by M. D. Garvey, J. D. Morgan, and K. L. Schubert, Attorneys, Seattle, 364 pages.

(1970).—Water Research Center Report No. 5—The Columbia River as a Resource (A Preliminary Evaluation of the Consequence of a Diversion), by Milo C. Bell (University of Washington); Gardner Brown (University of Washington); James A. Crutchfield (University of Washington); Millard Hastay (Washington State University); Ralph M. Johnson (University of Washington); and Brian W. Mar (University of Washington). Manuscript being reviewed for publication, approximately 330 pages.

APPENDIX D

Address by Allen F. Agnew, Director, State of Washington Water Research Center, Washington State University, Pullman, Washington, before the 36th

Annual Meeting of the Inland Empire Waterways Association, in Richland, Washington, on October 14, 1969.

WATER RESEARCH—A THIRD APPROXIMATION—INTRODUCTION

Mr. Chairman, Ladies and Gentlemen: I am here to talk with you about water research. Now, we know that *doing* research can be pretty exciting, but we also know that *talking* about it can be pretty dull sometimes. So, in order for me to talk about such a dry subject as water research and at the same time entice you to *listen* to what I have to say, I decided to use an attention-getter.

This technique, as you Thespians all know, is old as the hills and has been used with varying degrees of success by speakers as well as by persons engaged in other pursuits. It is employed in different ways such as by the person who wants to intrude upon conversation that is being monopolized, through the clearing of his throat; by the emergency vehicle that announces its approach through the wailing of its siren; or by the husband just sitting in his easy chair with pipe, slippers, the evening paper, and his TV set or radio turned on. If you don't think that last one is a marvelous attention getter, you husbands should just think back to the last time you were resting comfortably in such a setting. Then it is that the wife, God bless her, thinks of all the things that need to be done around the house, right now!

All right, so my attention getter is the "Third Approximation." Why did I pick this expression? Well, a few years ago I heard a lot of my soils friends talking about the Seventh Approximation. And as I inquired I learned that this represented a seventh attempt at a classification of soils, each one more refined or more comprehensive than the last. Thus the 6 preceding classifications, and this 7th one also, were trying to achieve *the* classification of soils that would do everything that could be done in categorizing this most important physical blanket of our earth.

Now, my use of Third Approximation is not merely an attempt to describe the increasing sophistication of water-research effort in the United States, but rather is aimed at a consideration of water research in three stages of its historical development. These stages I have chosen to designate as Pre-Sixties, the Sixties, and Post Sixties.

In discussing water research with you today, I have deliberately restricted myself to the United States. This does not mean that we think the studies of our friends in Canada are inconsequential—far from it, for the Canadian government and the Provincial governments are likewise assessing their water resources and research needs, and excellent contributions to our knowledge are being made in Canadian universities and other Canadian research institutions. It is just that I am more familiar with our situation in the United States and so I apologize to our Canadian friends who may be attending this meeting, for this apparent neglect.

PRE-SIXTIES

The dates 1959-61 mark the signal study and hearings in 1959, and the report in 1961 of the Senate Select Committee on National Water Resources. Before 1959 the water problems of the Nation were certainly being examined, and research was certainly being carried on in a great number of areas.

Numerous *Federal* agencies had been conducting research on water matters appropriate to their individual missions. At least one agency in each of the *States*, and sometimes more, were cognizant of the need for research answers to specific water problems. And *Universities* and to a smaller degree other institutions such as Battelle-Northwest were attempting to learn answers to some of the obvious problems in the field of water—problems that fell within traditional academic disciplines such as hydraulics or zoology or my own field of geology.

During these pre-1959 years we had see Federal agencies begin their missions in the early 1800's (Corps of Engineers), in the mid and later 1800's (Department of Agriculture and the Geological Survey), and in the early 1900's (Bureau of Reclamation). Also commencing in the early 1800's State Geological Surveys and subsequently some State Water Surveys began to examine the occurrence, character, and movement of ground water and surface water.

And all the while the universities were training students in water-related disciplines, one of which used the basic term for water—hydrology. Housed in the area of civil engineering, hydrology found hand maidens not only in geologists who were interested principally in ground water but, in an equally important way,

agricultural scientists and engineers who were interested in water and soil relations, other engineers who dealt with water and forest products or grains, and water in relation to industries and municipalities. The *interdisciplinary* focus was to be provided later, as we came to realize more fully the interrelations of the many areas of interest and concern in water matters.

Most of you who are attending this IEWA Annual Meeting know, better than I, the significance of the many attempts to review the Nation's water resources in the first 50 years of the 20th century. The Inland Waterways Commission of 1907, the National Waterways Commission of 1909, and the Waterways Commission of 1919 all attempted to formulate comprehensive plans for the improvement and control of the river systems of the United States.

President Theodore Roosevelt charged the National Conservation Commission of 1908 to make an inventory of the natural resources of the United States, specifying water as one of the four categories to be inventoried. Beginning in 1920 with the Committee on Reorganization of the Executive Department, subsequently in 1932 and again in 1947 and 1953 with the First and Second Hoover Commission, we have attempted time and again to establish closer liaison and coordination among the several departments of the Executive Branch, and their overlapping authorities and programs.

Numerous other Commissions, Committees, and Boards all looked at our water resources during the critical 1930's, 1940's and 1950's. The last of these, in 1954, laid stress on the gathering of basic data, the planning of water-resource developments, the study of water rights, and the benefit-cost evaluation of water projects, and the principle of cost sharing among all participating interests was enunciated.

However, no specific mention was made of the need for continuing and expanded research efforts to provide new tools or to modify old ones that were being applied to our Nation's water resource, despite the fact that such new tools or modifications of old ones were continually being provided by staff members of governmental agencies and by university and other research people through professional publications or contract work.

So this First Approximation of the Pre-Sixties was certainly not a period of water-research *drought*. Nevertheless, the peculiar circumstances of shortages of supply, pressures of demand, and concern over pollution, all set in the frame of reference of our phenomenally growing population and our developing concern for the future during the years after World War II, finally provided the setting for the Senate Select (Kerr) Committee on National Water Resources of 1959.

That Committee's study, one of whose recommendations recognized the great need for research in water problems, marks the beginning of the Second Approximation of our discussion today, The Sixties.

THE SIXTIES

As the hearings of the Senate Select Committee on National Water Resources were being held throughout the Country in 1959, one of the six or seven thoughts that was emphasized repeatedly was that "research on all phases of water-resource development should be stepped up" (Theodore M. Schad, Staff Director of the Senate Select Committee, report on the status of the Committee, before the American Society of Civil Engineers, January 6, 1960).

The Senate Select Committee report was surely a massive one, consisting of 32 Committee Prints and 23 volumes of hearings, totaling 3,920 pages. The report considered, as you are aware, the several important elements of the Nation's water resources—supply and demand, water quality and pollution, damages due to floods and droughts, and action areas and roadblocks.

In reviewing these reams of words, data, and recommendations, C. L. McGuinness (1962, p. 200) of the U.S. Geological Survey asked the question, "What do we do now?" (McGuinness, C. L., 1962, "Water for the United States": *Natural Resources Journal*, v. 2, p. 187-225). He then proceeded to consider answers to his question, under the following categories (1962, p. 203-222):

1. Improving public understanding of water problems
2. Comprehensive planning
3. Improving State and local planning and decision making
4. New technical methods
5. Research in economics and the social sciences
6. Importance of increased basic and applied research
7. Collection, analysis, and interpretation of basic data
8. Federal water-resources activities.

McGuinness drew five conclusions from all of this (1962, p. 223-224), two of which are particularly germane to my talk and thus deserve restating today. One is that research and investigation are the prime need to enable us to make better use of our limited supply of water as the demand increases. The other is that the key to the whole situation is public education and support.

I certainly don't have to explain to you members and friends of the IEWA the significance of that latter statement, because the IEWA and other organizations with similar goals are prime examples of the recognition of the value of public education and support, and of the means to achieve this element, without which any resource program cannot succeed.

Many of the recommendations of the Senate Select Committee on National Water Resources have been put into effect, showing that members of both of our great political parties recognize the enormous value and significance to our Nation of the development and wise use of this most important natural resource, water, as was stated yesterday at lunch by Congressman Foley.

Accordingly in the past five years the Congress and the Presidents have enacted several major pieces of legislation that resulted from recommendations of the Senate Select Committee—three that I wish to mention today are the Water Resources Research Act of 1964, the Water Resources Planning Act of 1965, and the creation of the National Water Commission of 1968.

The youngest of these, the National Water Commission, is just beginning its studies and hearings regarding national water goals and policies, as was mentioned yesterday by Congresswoman May and General Groves.

The middle of these children of the Senate Select Committee, acting through the Water Resources Council, is planning for the development of the Nation's water resources on the basis of river-basin units.

Furthermore, the Council issued late in 1968 the First Assessment of the Nation's Water Resources which was referred to yesterday by Mrs. May. This document, whose guidelines and data are now being re-studied in preparation for the Second Assessment, comes near the end of the second period (or Second Approximation) that we have been discussing, and so its major use will be in the third period (or Third Approximation), which we are just entering.

But I have said that our three approximations deal with water *research*, not water *resources*. So, let's talk about water research in the Sixties that resulted from the Act of 1964.

This act created the *Office of Water Resources Research* in the U.S. Department of the Interior, and the charge given to that office was a threefold one:

1—To provide basic allotments of Federal funds (currently \$100,000 each year) to the water research Center or Institute established at the land-grant university (in our case, Washington State University) in each of the 50 states plus Puerto Rico:

2—To provide Federal matching funds for specific research proposals presented by the center or Institute in the State, judged on the basis of priority of subject matter and research need.

In implementing each of these two categories of the Act—allotment and matching grant—the designated Water Research Center or Institute in a State can make agreements with other universities in the State, which will permit them to share in this program. Thus my university, Washington State, has such an agreement with the University of Washington in Seattle, which permits these two universities to share in the allotment funds.

Furthermore, the State of Washington Water Research Center solicits matching grant research proposals from *other* universities; these proposals are judged by the Joint Scientific Committee of six faculty members highly esteemed by their colleagues for their work in water resources, three each from Washington State and from the University of Washington. During the current fiscal year our Center is supporting several water research projects at these two universities, and also projects at Western Washington State College and Central Washington State College.

3—The third part of the charge given to the Office of Water Resources Research deals with Title II research projects. Now these projects require no non-federal funds, and are funded on the basis of priorities established by the OWRR. However, these Title II projects are different in that the proposals do not have to be submitted through the State Center or Institute, but can be submitted directly to the OWRR by any university or college, or private research institute (such as Battelle-Northwest).

The OWRR program is in its fifth year, as its initial funds were distributed in the middle of Fiscal Year 1964-5 to 14 selected institutes, and the first work got under way in the Summer of 1965. In the Pacific Northwest, institutes in the States of Idaho, Montana, and Washington made this First Fourteen.

However, the program that began in 1965 has suffered from malnutrition of money, as only the allotment part of the work has been funded up to the amounts authorized in the Act. The matching-grant funds are lagging behind at only 60 per cent of the authorized amount of \$5 million, and the Title II funds at only 28 per cent of the authorized \$7 million, in the fiscal year just past (1968-69).

In establishing its priorities for research projects, the OWRR has used as a basis the Ten-Year Program of Federal Water Resources Research, published by the President's Office of Science and Technology in 1966. This report was prepared by the Committee on Water Resources Research of the Federal Council for Science and Technology, which consists of representatives of nine Federal agencies; the program is based on the water-research activities of these Federal agencies, and thus has been criticized by many of us university people as not being completely applicable to water research priorities as seen through non-Federal eyes.

The Office of Water Resources Research, the oldest child of the Senate Select Committee recommendations of 1961, is now five years old. Its first Director resigned a few months ago to return to university life, and its second Director, Dr. H. Garland Hershey, reported for duty on September 29, just 3 weeks ago. In addition, a reorganization within the Department of the Interior a year ago established an Assistant Secretary for Water Quality and Research. This new Assistant Secretary Carl Klein, has stated that he is aware of the need for greater funding of water research. This, together with indications of possible changes in the OWRR program suggested by the fact that the OWRR has a new Director and is now five years old, indicates that we are ready to consider a new era in water research, which I have termed the Third Approximation.

POST-SIXTIES

What is this Third Approximation of water research that we are looking toward, in this period that we are just entering? Well, for one thing, it is a period when we need to re-examine the program of the Office of Water Resources Research and the State water research centers, to see if they are doing the job that was expected of them by those who were responsible for the passage of the Water Resources Research Act of 1964.

At the Federal funding level, the concern is that the research must be *national* in scope, or at the least, regional; the Federal people are just not interested in funding research that they consider has only a statewide or more limited application. On the other hand, the State funding agencies are just as concerned that the research be directed toward the latter types of problems—that is, *State and local*, and that the Federal government should support the wider ranging programs.

We understand the positions of both of these types of funding-agencies. However, the Federal agency should realize that the University water research centers apply a substantial amount of State funds to their operations. This figure has been estimated as about 67 cents of State money for every dollar of Federal money for all of the Centers in 1968; the State of Washington is one of 10-12 States that has done more—we have put up about \$1.84 of State funds for every Federal dollar.

Two even more important points should be made. One is that *any* project, no matter how local its title may make it seem, provides knowledge that is useful in another geographic region, or in a different discipline, and thus provides one more piece in the solution to the very complex puzzle that is the management and wise use of our Nation's water resource.

The other point is that the water research center at a university has a far wider influence than just the primary benefits—projects that the Federal agency helps fund. The secondary benefits are that its seed grants enable experts in many disciplines to put together large and comprehensive research projects in which water is only one segment. Such projects, in fields of agriculture or engineering, have the multiplier effect of causing the application of much larger reservoirs of money and talent to problems whose thrust is mainly in another area. For example, the Water Research Center might fund a series of seminars or "skull sessions" that bring together a group of experts on a problem that in-

volves pollution. These people might prepare the framework and body of a research proposal that goes to the FWPCA for funding, or in its larger context, an environmental program of curriculum and research that would result in even greater support from the Department of H.E.W.

The other secondary benefit is that ongoing research work at a university in, say, soil science or fisheries or economics or electrical engineering, would have generated information that is useful also to a water-research project, so that many more ideas and funds are contributed to the particular water project than may appear on paper.

All right, now let's take a look at the *kind* of research. The old flap about basic (or academic) versus applied (or mission oriented) research is with us again. For a stimulating editorial on this subject, I want to call your attention to the new Annual Report of the WSU Engineering Research Division's Director Dr. Eugene Greenfield.

Some persons (many Congressmen, news-media people, and other concerned but not completely informed citizens) poke fun at titles of certain research projects, pointing out how foolish it is to study something like, say, the third lumbar vertebra of a left-handed red-haired baboon in Central Africa. Although part of the problem is that the researcher may not have been too careful in selecting the title of his project, his major fault was in not showing the *relevance* of this research to the solution of problems that we can understand and appreciate, problems that seem much more important to us. It may be very difficult for the researcher to detect *any* potential application of such a research project, but then he should have had *some* reason for pursuing it. Certainly those of us who suffer from the constant pain of lower-back trouble would relate immediately to the aforementioned bit of baboon-ery.

On the other hand, what is the relevance of such an innocuous title as "Ecology of Selected Aquatic Bacteria in the Snake River?" At first glance this may look like just another piece of academic research, with no obvious application other than the joy it gives to a bacteriologist who studies these little buzzards. Far from it. Professor Charles Drake of W.S.U., in his relevancy statement that he submitted in justification of his proposed project, pointed out the application of this study to the proposed construction of a dam downstream and the effect that the changed stream regimen might have on the growth of these microscopic creatures, and their consequent effect on the proposed uses of the reservoir created by the dam. As many of you know, the applied nature of this particular project is causing us to sit up and take notice.

Our own Senator Jackson has made quite a point of the need for basic research *as well as* applied research, in the recently issued Committee Print of the Senate Committee on Interior and Insular Affairs of which the Senator is chairman. In this report, Ted Schad discussed the history of the implementation of the recommendations of the Senate Select (Kerr) Committee of 1959, and pointed out repeatedly the value of basic research, and the Committee recommended that greater emphasis be given to it.

(Ted Schad, as most of you are well aware, is the very capable Executive Director of the National Water Commission, and at that time was Deputy Director of the Legislative Reference Service of the Library of Congress.)

Specifically now, let's turn to the State of Washington Water Research Center. Since its inception in 1965 we have sponsored 45 separate research proposals that have been funded jointly by the OWRR and the State. These 45 proposals have been cross-indexed according to approximately 125 key words, so that potential users can retrieve this information readily. This key-word index will be made available shortly and distributed widely among potential users and other interested persons. The index enables us to know such things as the fact that three of our projects deal with algae, and that one project may be cited under as many as five key words and thus gives valuable information on those five subjects.

Specific research projects currently underway by the Water Research Center include 19 titles (8 WSU, 10 UW, 1 CWSC).

In addition to these 45 specific research projects, the State of Washington Water Research Center has been involved since its beginning in a rather comprehensive assessment of the water situation in the State, the supply and demand, the different uses, the pollution problems, the "people decisions" as to what they want to do in the way of recreational use of the waters, the management decisions needed to accomplish these objectives, and the legal and administrative framework in which these decisions are made. Funded by the State Department of Water Resources with solely State funds, these studies are at-

tempting to provide alternatives for management decisions that must be made by that Department's Director Maurice Ahlquist, by other State agency executives, and by Governor Evans.

I want here to express our debt to the many Federal agencies whose data we use and whose current studies are a great help to us—for example, Interior's Geological Survey, ESSA's Weather Bureau, and Agriculture's Economic Research Service and Agricultural Research Service; and to the State agencies such as the Department of Commerce and Economic Development for other data and interpretations that are important bases for our studies.

I want to stress right now that these studies involve many controversial policy matters. Some of you may feel that university types or research types should stay away from such critical topics. With this view I have to disagree most forcefully.

The university is certainly not the fountainhead of *all* knowledge, nor can it be said that university people are without the sin of making wrong decisions or drawing conclusions that have to be modified as a result of subsequent knowledge. Nevertheless, if it is to fulfill its responsibility, the university is traditionally at the forefront of new knowledge—in developing it and testing it, and in providing the students, those who will be making the policy decisions after us, with part of the background that will enable them to make these decisions wisely.

Accordingly, as part of its educational and training process, as part of its service to the citizens who support higher education, we university people must continue to do research on matters controversial. Such research must not be bound by tradition. Rather, in order to fulfill its obligation to society, university thinking must be innovative and imaginative; as such it will disturb us complacent ones, and it will examine questions rubbed raw by emotionalism that results from our own personal, social desires.

Who does not know the controversy in managing a multi-purpose reservoir? If the manager drops the water level in order to generate power or to provide anticipated flood-water storage, the shoreline recreationists will howl. But the manager has to make his decision (and absorb the howls) on the basis of guidelines established by many elements of society for this reservoir, to the best of his ability. These are "people decisions" and fit beautifully into your theme for this IEWA Annual Meeting, "Building for People."

Some of our research is an attempt to refine the manager's guidelines through the consideration of the total interests and pressures involved—local, State, regional, and national. This is sometimes exceedingly difficult to accomplish because our social goals are changing, and because we as human beings are considerably less than objective. Nevertheless, we are trying, and we want you as individuals and as groups with missions to realize the scope of the problem and urge you to take another look at your goals in the framework of these multiple, yet integrated pieces.

In these times of massive problems dealing with both our natural resources and our human resources, we are concerned with limiting expenditures and establishing priorities for these funds that are admittedly less than adequate to do the jobs that we feel *must* be done, as was pointed out so well yesterday by Congressman Foley and Mrs. May; therefore we must re-examine our thinking and our programs to decide if we as individuals possess strong enough character to face these problems honestly and to be willing to put our effort (and our money) where our month is, and thus pay our share of the cost without complaining.

Lest you think that this is just another plea for additional funds for a program that I am pushing, let me put this into perspective. As John Creedy told us last night, we need a balanced program for the development of our resources.

Ours is a great Nation and I am proud of it. With a wife and four children in college and high school, I want to be a part, however small, of our attempts to make our National more responsive to our human needs and desires. I am glad that in the area of water research, as we enter what I have called today the Third Approximation, we university people are able to participate in providing some further insight into the problems of managing this important natural resource, wherein we are really just now beginning to assess the real importance of social costs and benefits.

What is the social cost of water-based recreation? Of water pollution? Of another thermal power plant? of a riot? Of a ghetto? How badly do we want to solve these and other problems that confront us? What is the role of basic research? What are the new directions that research on water matters must take?

As we enter this Third Approximation of Water Research I ask you—better yet, I *challenge* you—to help us decide.

Thank you.

Senator Moss. Thank you, Dr. Agnew, for appearing for the association and also for the Water Research Center of the State of Washington, and the State of Washington. We are glad to have your testimony. Your full statements are in the record and will add greatly to our information.

Since this bill would increase the amount available to each of the States by about 150 percent, if it is passed, and we have discussed how some of that would be eaten up with inflation but not all of it, how much of the increase associated with the new funding would be for communication and how much for more research?

Mr. AGNEW. Well, sir, we have not mapped this out in detail yet without Joint Scientific Committee, but as a rough rule of thumb, I would say that we can consider about 50 percent of this for communication mechanisms—this would be partial support of an editor or a journalistic type person and communications devices and support—and the other 50 percent for increased funding of allotment projects, not only at our two universities but at the other colleges in the State, which we are unable to fund but where we do have existing competency. And these people in those universities and colleges have been unable to qualify for matching grant projects very readily because in these universities that are just beginning to grow they can't readily put their fingers on this kind of money. And if we can give them a start with a seed grant, then they can identify not only solutions to the problem, but other sources of funding later on. They can show a result, a concrete result.

Senator Moss. Thank you very much. We appreciate it, Dr. Agnew.

Mr. David Howells, chairman of the Universities Council on Water Resources.

Mr. Howells, glad to have you, sir.

STATEMENT OF DAVID H. HOWELLS, CHAIRMAN, EXECUTIVE BOARD, UNIVERSITIES COUNCIL ON WATER RESOURCES; AND DIRECTOR, WATER RESOURCES RESEARCH INSTITUTE OF THE UNIVERSITY OF NORTH CAROLINA

Mr. HOWELLS. Thank you, Mr. Chairman.

I am the chairman, as you have indicated, of the executive board this year of the Universities Council on Water Resources, and also director of the Water Resources Research Institute of the Consolidated University of North Carolina, located on the campus of North Carolina State University in Raleigh.

This statement, Mr. Chairman, is made on behalf of the Universities Council on Water Resources, an organization of 67 of the Nation's leading universities actively engaged in education and research in fields related to water resources development and utilization.

An additional statement in behalf of the University of North Carolina is attached to this statement for UCOWR for inclusion in the record, if you so please. I will not attempt to summarize it here.

Senator Moss. We are very glad to have it and it will appear in the record in full.

Mr. HOWELLS. It includes a good deal of specific concerning the program, the problems we are attacking in North Carolina, and I think it will be of some use in that respect.

I would like to call attention to the fact that the Governor of the State of North Carolina, Governor Scott, has endorsed this proposal and has sent a letter to the committee through the Honorable B. Everett Jordan, Senator from North Carolina, for inclusion in the record.

On the occasions of its last two annual meetings, UCOWR delegates have considered the increasing needs for amendments to title I of the Water Resources Research Act of 1964, and on July 2, 1969, adopted two resolutions proposing amendments similar to those of S. 3553. These are included in the statement and I will pass over them in the interest of time.

The proposed amendments apply to section 100 of the act, the purpose of which is to assist each participating State in establishing and carrying on the work of a competent and qualified water resources institute. Two questions which arise at this time are:

1. Has the purpose of the original act been met within the limitations of present authorizations?

And just why are the proposed amendments necessary?

I will address myself to both of these questions in this prepared statement, which, incidentally, I will just highlight.

On pages 3 and 4 I give some figures on the number and types of projects approved under the annual allotment program, certain training aspects, and so forth, which have been referred to by earlier witnesses.

The institutes have become well established in their respective universities, are widely recognized as competent centers for water research and training, and exercise valuable leadership in water resource planning and development.

The typical institute director works under the general policy guidance of a board of directors or a vice president, or both, has two advisory groups to assist with program development and administration. A statewide advisory committee composed of representatives of State and Federal agencies, local government, and private industry, helps to identify priority research areas, comments on research proposals, and keeps the director informed of research in their agencies.

The second group, composed of scientists from participating universities, assists in screening, evaluating, and selecting research proposals to be submitted to OWRR for approval.

Permit me, if you will, Mr. Chairman, to illustrate the review process a little more concretely through reference to our North Carolina program.

The majority of our studies down there are developed in close consultation with members of our 24-man advisory committee. Copies of proposals are sent to interested members for review by them and their professional staff before review by our technical committee. As indicated in my related statement on the North Carolina program, this is not pro forma. Those fellows call things as they see them.

The review process, then, includes the institute director, advisory committee, and technical committee before the annual program is put together for subsequent review by OWRR. Projects are screened against the Institute inventory of active research projects in the State, which we bring up to date every year, the Department of the Interior Water Resources Research Catalog and/or search by the Science In-

formation Exchange to avoid duplication of other current research. A literature survey is also required to assure familiarity with and avoid duplication of previous work.

For each of these projects, the purpose, objectives, and research procedures must be clearly set forth. The principal investigator must describe the relationship of the research to existing water problems and indicate how the expected research results could benefit water conditions of the Nation, region, and State. The institute director is required to provide his separate project evaluation statement describing the relevancy of the proposed research to existing and important water resource problems.

Never, in my opinion, have research proposals received closer scrutiny as to the relevancy of the study to water resource problems, scientific merit, priority, and relationship to other work previously completed or underway.

One of the principal values of the annual allotment is that it is a constant, year-to-year source of funds in contrast to project-by-project authorizations. As has been pointed out before in previous testimony, these are "hard" funds around which commitments can be made and a continuing program developed. Only in such a situation can a university attract and retain the high quality personnel required for the long haul.

The seed money effect of the annual allotment program has had a marked impact on water resources research programs in general. There are many examples throughout the country at large where modest support from the annual allotment has stimulated vigorous research efforts supported by other Federal and non-Federal funds. In North Carolina, for example, interest and preparatory work generated with very modest annual allotment funds, a matter of \$2,000 or \$3,000 developed into a major FWQA demonstration project dealing with poultry processing wastes costing nearly \$300,000.

Another example involved seed money to stimulate the development of a textile waste research program which resulted in an FWQA research grant at a level five times higher than the original investment. This year, we received a grant from a private foundation which picked up two-thirds of the cost of an important study contingent upon the remaining one-third being funded through the annual allotment program.

This is an extremely important part of our program.

Now, one of the principal strengths of this annual allotment program, it seems to me, is that it enables the States to develop strong research programs in support of their increased responsibility in the water planning and management picture. I don't agree with the implications of an earlier statement that all research should be tightly controlled from Washington. And the present legislation does provide sufficient opportunity in my opinion, for coordination into a high priority coordinated national program, and certainly this authority has been exerted by the Office of Water Resources Research.

The additional funds which would be authorized by S. 3553 and S. 3721 would compensate for losses due to inflation over the last 6 years, accelerate work now underway, support needed new research, and provide the means for initiating a much needed program for the interpretation and dissemination of research findings.

In terms of its intended effect at the time of enactment of the Water Resources Research Act in 1964, the present annual allotment authorization has been gradually reduced through inflation to somewhere between \$50,000 and \$70,000, depending upon where one is located. This means that the proposed increase is not $2\frac{1}{2}$ times the original, in the sense of its intended purchasing power in 1964, but closer to $1\frac{1}{2}$ times. In the context of the 1964 act, then, the proposed \$250,000 represents only a 50-percent increase in program capability, as it was originally visualized. This is a relatively modest increase to a very modest program in terms of total Federal investment for water resources research.

Because of the disparity between available funds and mounting research needs, it has been necessary for many institutes to fund projects at less than optimum levels in order to provide some input, at least, to problems requiring research attention. This has prolonged the course of those projects beyond the time span which would have been possible with more adequate funding. The additional authorization would eliminate this impediment to the more timely conclusion of research projects and availability of research results.

Our mounting research needs arise out of the fact that water planning and management have now reached the end of an era in which all the easy solutions have been had and a quantum jump of effort will be required to bridge the gap with the future. Pressures on the environment have mounted exponentially and each new encounter brings home another shade of the ultimate truth that the old ways of handling things just aren't good enough.

For example, cities, towns, and industry can no longer "prospect" for water supply and waste disposal on the premise that the needs of each is unaffected by the other. The conversion from individual to regional water and waste management systems is extremely complex with many unknowns. Rapidly growing, urbanizing, economic regions involving multiple river basins, where water demand and waste disposal have already exceeded the capacity of available streams—with full utilization of available technology—are a case in point.

In the riparian east, at least, this involves serious questions of law; complex system simulation studies; many alternatives in water use and waste control to minimize the cost of maintaining acceptable levels of water quality; interaction between water and contiguous land areas; institutional arrangements for the management of regional systems across city, county, and State boundaries; environmental impact from land and water resource development decisions, and other problems.

Yet, just a few years ago, and even today, decisions were viewed in a far simpler context. The hunting and picking era is over. If there is to be any order in the future, these rapidly emerging problems must be recognized and dealt with. Failure to do so will leave the nation in environmental chaos. Many more examples could be cited—all complex and demanding of solutions. Recognition of the drastic changes wrought by proliferating man on his environment and their implications for water resources research is implicit in a flight over an urban area, a walk along a stream or a trip to the beach.

The evidence of need is before us at every turn of the road. The strength of the title I program is that it can deal with all facets of

water resources management. It is not restricted to water pollution, navigation or other areas of singular concern. It can fill the gaps left by the mission-oriented agencies and effectively treat the total system.

And I would like to emphasize, Mr. Chairman, that these just aren't mere words. They illustrate in a general sense the specific type of problem emerging in many areas throughout the country. In my statement for the University of Carolina, I describe in greater detail the specific problem of the upper piedmont region with which we are now attempting to deal.

The increased authorization would also provide support for implementation of the proposed amendment providing authorization for the accelerated dissemination of the results of scientific and engineering research. In far too many sectors of research, new information is put "on the shelf" literally and figuratively. Very little stimulation is needed in conversations with consulting engineers and other practitioners, for example, to draw forth a torrent of opinion as to present limitations in this regard. Research without the means of facilitating prompt transfer into practice has very limited value.

Evidence indicates that project completion reports and the more difficult papers in the scientific and technical journals have a much, much smaller reading public than is generally assumed. The need to improve communication between researchers and users is well established.

A special effort is required if research supported by public funds is to be responsive to the needs of water planning and management agencies and the resulting new information is to flow into the hands of practitioners in a form which can be utilized by the large variety of disciplines and levels of skill involved.

The institutes are ideally situated to assume responsibility for information dissemination at the State and local level.

In conclusion, I want to express my appreciation to the committee on behalf of Universities Council on Water Resources and the Consolidated University of North Carolina for its continued interest in water resources research. We strongly support this legislation and urge its early enactment.

Thank you very much, Mr. Chairman.

I wonder if I could ask a favor. I brought along a little brochure, which in a very simple but direct way discusses our program during the present year, and I wonder if this might be incorporated by reference into the record, sir.

Senator Moss. It will be incorporated by reference. The pamphlet referred to is entitled, "Research Program 1970-71, Water Resources Research Institute of the University of North Carolina." That will be in the committee files and will be referred to in the record.

(The brochure above-referred to will be found in the files of the committee.)

(The complete prepared statements of Dr. Howells, above-referred to, follow:)

PREPARED STATEMENT OF DAVID H. HOWELLS, CHAIRMAN, EXECUTIVE BOARD, UNIVERSITIES COUNCIL ON WATER RESOURCES, AND DIRECTOR, WATER RESOURCES RESEARCH INSTITUTE OF THE UNIVERSITY OF NORTH CAROLINA

I am David H. Howells, Chairman, Executive Board, Universities Council on Water Resources (UCOWR), and Director, Water Resources Research Institute

of The University of North Carolina, located on the campus of North Carolina State University at Raleigh. This statement is made on behalf of the Universities Council on Water Resources, an organization of 67 of the Nation's leading universities actively engaged in education and research in fields related to water resource development and utilization.

On the occasions of its last two annual meetings, UCOWR delegates have considered the increasing need for amendments to Title I of the Water Resources Research Act of 1964 and on July 2, 1969, adopted the following two resolutions:

RESOLUTION 1, ON AMENDMENTS TO TITLE I OF THE WATER RESOURCES RESEARCH ACT

Whereas the Congress recognized the need for accelerated research in the field of water resources and the urgent need for trained personnel to meet the challenges of increased demand for the limited supply of water and passed the Water Resources Research Act of 1964, and

Whereas the research and training which can be accomplished with the fixed amount of monies authorized under Title I of the Water Resources Research Act of 1964 for research and training continues to decrease at an accelerated rate due to inflation, and

Whereas the restriction that funds provided under Title I of the Act cannot be used for fringe benefits results in the necessity for special accounting procedures at most universities to meet this requirement with unnecessarily high accounting costs, and

Whereas the problems associated with water resources have substantially increased since the passage of the Act and will increase in the future as increased pressure is placed on the quality of the environment, and

Whereas the cost of administering the research and training of the Act is substantially increased and made cumbersome by the requirement that the state centers and institutes report on a fiscal year basis and the Office of Water Resources Research report to the Congress on both a fiscal and a calendar year basis, and

Whereas the foundation for the partnership which exists between the states and the Federal government in water resource research and training is predicated on a sound and substantial research program at each of the state centers or institutes: Now, therefore, be it *Resolved*, That the Universities Council on Water Resources urge the U.S. Congress to amend the Water Resources Research Act of 1964 to: (1) Increase the annual allotment program of Title I to \$250,000 per year, (2) Modify the language of the act to make all reporting on a fiscal year basis, and (3) Provide specific language authorizing the use of allotment funds for the payment of fringe benefits.

RESOLUTION 2

Whereas the Universities Council on Water Resources in its 1968 Annual Meeting passed a resolution encouraging the authorization of teaching and extension-type programs in Water Resources; and

Whereas this resolution has been considered by many groups and individuals through the Nation during the past year: Now, therefore, be it

Resolved, That the Universities Council on Water Resources reaffirms the urgent need for amendments to the Water Resources Research Act of 1964, to authorize the Office of Water Resources Research and the Universities to develop educational programs for the interpretation and dissemination of water research findings and seek adequate appropriations to expedite these programs.

The two bills before the Subcommittee (S. 3553 and S. 3721) meet the two principal points of the UCOWR Resolutions, i.e., (1) increase the Section 100(a) annual allotments from \$100,000 to \$250,000, and (2) authorize programs for the interpretation and dissemination of water research findings.

Items (2) and (3) of the first resolution would simplify and reduce the cost of program administration at both the federal and state levels.

The proposed amendments apply to Section 100 of the Act, the purpose of which is to assist each participating state in establishing and carrying on the work of a competent and qualified water resources research institute. Two questions which arise at this time are: (1) Has the purpose of the original Act been met within the limitations of present authorizations? (2) Why are the proposed amendments necessary?

I would like to address myself to both of these questions during the course of this statement.

Experience under the annual allotment program

Except for the first year (fiscal year 1965) of the annual allotment program, the full amount of the authorized appropriation has been appropriated. Since fiscal year 1968, this has amounted to \$5.1 million annually, enough to provide \$100,000 to each state and the Territory of Puerto Rico. During the last four years this has partially supported an average of 483 projects per year in addition to contributing to the cost of program development and administration. This represents an average annual federal cost of about \$10,000 per project. The 3078 projects approved to date can be categorized as follows:

FCST research category	Number of projects	Percent
I. Nature of water.....	68	2.0
II. Water cycle.....	585	17.3
III. Water supply augmentation and conservation.....	198	7.1
IV. Water quantity management and control.....	218	9.5
V. Water quality management and protection.....	1,219	38.6
VI. Water resources planning.....	607	20.4
VII. Resource data.....	102	3.2
VIII. Engineering works.....	75	1.8
IX. Manpower, etc.....	5	.1
X. Information retrieval and dissemination.....	1
Total.....	3,078	100

Professional training of water resource scientists is provided during the course of this research through research assistantships. At the present time approximately 1900 students are being trained through working on Title I projects. Estimates of institute directors indicate that approximately 19 percent and 27 percent, respectively, of all water resource students graduating at the master's and doctor's levels at the end of the 1969 school year had received support from Title I research. Many other students also benefited through use of equipment, books and other materials purchased in connection with research projects. The participating universities have responded by constructing new laboratories, employing 1300 new personnel, and developing more than 1,000 new courses in this field. Rather than promote competition for existing personnel, during the past two years alone, 170 additional scientists not previously working in water resources have become involved in water resources research.

Seminars and symposia sponsored by the institutes provide students, practitioners, and the interested public with further education in the water resources field.

The institutes have become well established in their respective universities, are widely recognized as competent centers for water research and training, and exercise valuable leadership in water resource planning and development. The typical institute director works under the general policy guidance of a board of directors and/or vice president, has two advisory groups to assist with program development and administration. A statewide advisory committee composed of representatives of state and federal agencies, local government, and private industry helps to identify priority research areas, comments on research proposals, and keeps the director informed of research in their agencies. The second group, composed of scientists from participating universities, assists in screening, evaluating and selecting research proposals to be submitted to OWRR for approval.

Permit me, if you will, to illustrate the review process a little more concretely through reference to the North Carolina program. The majority of our studies down there are developed in close consultation with members of our 24-man Advisory Committee. Copies of proposals are sent to interested members for review by them and their professional staff before review by our Technical Committee. As indicated in my related statement on the North Carolina program, this is not pro-forma. Those fellows call things as they see them. The review process, then, includes the Institute Director, Advisory Committee, and Technical Committee before the annual program is put together for subsequent review by OWRR. Projects are screened against the Institute inventory of active research projects in the state, the Department of the Interior Water Resources Research Catalog and/or search by the Science Information Exchange to avoid duplication of other current research. A literature survey is also required to assure familiarity with and avoid duplication of previous work.

For each of these projects, the purpose, objectives, and research procedures must be clearly set forth. The principal investigator must describe the relationship of the research to existing water problems and indicate how the expected research results could benefit water conditions of the nation, region, and state. The institute director is required to provide his separate project evaluation statement describing the relevancy of the proposed research to existing and important water resource problems.

Never have research proposals received closer scrutiny as to the relevancy of the study to water resource problems, scientific merit, priority, and relationship to other work previously completed or underway.

One of the principal values of the annual allotment is that it is a constant, year-to-year source of funds in contrast to project-by-project authorizations. These are "hard" funds around which commitments can be made and a continuing program developed. Only in such a situation can a university attract and retain high quality personnel required for the long haul.

The seed money effect of the annual allotment program has had a marked impact on water resources research programs in general. There are many examples throughout the country at large where modest support from the annual allotment has stimulated vigorous research efforts supported by other federal and non-federal funds. In North Carolina, for example, interest and preparatory work generated from this source developed into a major FWQA demonstration project dealing with poultry processing wastes costing nearly \$200,000. Another example involved seed money to stimulate the development of a textile waste research program which resulted in an FWQA research grant at a level five times higher than the original investment. This year, we received a grant from a private foundation which picked up two-thirds of the cost of an important study contingent upon the remaining one-third being funded through the annual allotment program.

Justification for proposed amendments

The additional funds which would be authorized by S. 3553 and S. 3721 would compensate for losses due to inflation over the last six years, accelerate work now underway, support needed new research, and provide the means for initiating a much needed program for the interpretation and dissemination of research findings.

In terms of its intended effect at the time of enactment of the Water Resources Research Act in 1964, the present annual allotment authorization has been gradually reduced through inflation to somewhere between \$50,000-\$75,000. This means that the proposed increase is not 2½ times the original, in the sense of its intended purchasing power in 1964, but closer to 1½ times. In the context of the 1964 Act, then, the proposed \$250,000 represents only a 50 percent increase in program capability. This is a relatively modest increase to a very modest program in terms of total federal investment for water resources research.

Because of the disparity between available funds and mounting research needs, it has been necessary for many institutes to fund projects at less than optimum levels in order to provide some input, at least, to problems requiring research attention. This has prolonged the course of those projects beyond the time span which would have been possible with more adequate funding. The additional authorization would eliminate this impediment to the more timely conclusion of research projects and availability of research results.

Our mounting research needs arise out of the fact that water planning and management have now reached the end of an era in which all the easy solutions have been had and a quantum jump of effort will be required to bridge the gap with the future. Pressures on the environment have mounted exponentially and each new encounter brings home another shade of the ultimate truth that the old ways of handling things just aren't good enough. For example, cities, towns, and industry can no longer "prospect" for water supply and waste disposal on the premise that the needs of each is unaffected by the other. The conversion from individual to regional water and waste management systems is extremely complex with many unknowns. Rapidly growing, urbanizing, economic regions involving multiple river basins, where water demand and waste disposal have already exceeded the capacity of available streams (with full utilization of available technology) are a case in point. In the riparian east, at least, this involves serious questions of law; complex system simulation studies; many alternatives in water use and waste control to minimize the cost of maintaining acceptable levels of water quality; interaction between water and contiguous land area; institutional arrangements for the management of regional systems

across city, county and state boundaries; environmental impact from land and water resource development decisions, and other problems. Yet, just a few years ago, and even today, decisions were viewed in a far simpler context. The hunting and picking era is over. If there is to be any order in the future, these rapidly emerging problems must be recognized and dealt with. Failure to do so will leave the Nation in environmental chaos. Many more examples could be cited—all complex and demanding of solutions. Recognition of the drastic changes wrought by proliferating man on his environment and their implications for water resources research is implicit in a flight over an urban area, a walk along a stream or a trip to the beach. The evidence of need is before us at every turn of the road. The strength of the Title I program is that it can deal with all facets of water resource management. It is not restricted to water pollution, navigation or other areas of singular concern. It can fill the gaps left by the mission-oriented agencies and effectively treat the total system.

The increased authorization would also provide support for implementation of the proposed amendment providing authorization for the accelerated dissemination of the results of scientific and engineering research. In far too many sectors of research, new information is put "on the shelf" literally and figuratively. Very little stimulation is needed in conversation with consulting engineers and other practitioners, for example, to draw forth a torrent of opinion as to present limitations in this regard. Research without the means of facilitating prompt transfer into practice has very limited value. Evidence indicates that project completion reports and the more difficult papers in the scientific and technical journals have a much, much smaller reading public than is generally assumed. The need to improve communication between researchers and users is well-established. A special effort is required if research supported by public funds is to be responsive to the needs of water planning and management agencies and the resulting new information is to flow into the hands of practitioners in a form which can be utilized by the large variety of disciplines and levels of skill involved. The institutes are ideally situated to assume responsibility for information dissemination at the state and local level. They would be authoritative and objective sources of information, not biased in favor of particular action programs. Certainly, they could fill the many gaps that industry and government now leave open. Their programs include the relationships with the users in local and state government, planning agencies, consulting engineers and other practitioners. They are currently involved with these groups in the identification of research needs and the development of research projects responsive to those needs. But this feedback process would be greatly improved by more formal programs to transfer technology. What they lack is legislative authorization for the appropriations and related activities necessary to develop the second phase of their programs—the interpretation and dissemination of water research findings.

Such programs could utilize existing state extension services such as agricultural, engineering and industrial, where appropriate, in the same way that the institutes currently utilize faculty and laboratory facilities for research. Where such services are not available, they would be developed along lines best fitted to the university and the unique needs of each state. Such special tailoring of each program is essential to effectively using the resources available and truly responding to each state's very different needs. Federal funds presently authorized for Institute annual allotments and matching grants are designated for research and related training. There is no specific authorization for information interpretation and dissemination programs, nor funds for this purpose. An already effective program can best be made even more effective in this way.

In conclusion, I want to express appreciation on behalf of UCOWR to the Committee for its continued interest in water resources research. The Council strongly supports this legislation and urges its early enactment. We are deeply appreciative of the opportunity to appear before you today and present this statement.

SUPPLEMENTARY STATEMENT OF DAVID H. HOWELLS, DIRECTOR, WATER RESOURCES RESEARCH INSTITUTE OF THE UNIVERSITY OF NORTH CAROLINA, RALEIGH, N.C.

I am David H. Howells, Director, Water Resources Research Institute of The University of North Carolina, located on the North Carolina State University campus at Raleigh and Chairman, Executive Board, Universities Council on Water Resources. This statement addresses itself to the North Carolina experi-

ence under the Water Resources Research Act in contrast to my earlier statement on behalf of the Universities Council on Water Resources.

The Water Resources Research Institute in North Carolina is a unit of the Consolidated University of North Carolina. All senior colleges and universities in the state are encouraged to participate in its program and research is now being conducted on the campuses of N.C. State University at Raleigh, the University of North Carolina at Chapel Hill, Duke University and East Carolina University.

The Water Resources Research Institute of The University of North Carolina works hand in hand with the N.C. Department of Water and Air Resources and other agencies in the formulation of research studies responsive to the state's water resource problems. A twenty-five man advisory committee representative of state and federal water agencies, private industries, agriculture and local government provides program guidance and review.

The North Carolina Institute has pioneered in efforts to bring the research capabilities of a state's universities to bear on state water problems. Methods used include symposia and conferences, workshops, study committees and a steady initiative toward continuing the dialogue with state agencies and other research users to improve the university program. The workshops have been particularly effective in bringing together persons of diverse views to discuss their differences and work out rational research approaches to their problems. Communication through newspaper headlines is not nearly as effective as sitting down and reasoning together. The next workshop will deal with the ecological effects of stream channelization and is being scheduled at the express request of the N.C. Department of Water and Air Resources.

Once problems and research needs are defined, the Institute works with interested faculty members with related competence to develop research proposals. Proposals are also invited from the faculties at large to assure that all worthwhile ideas are considered.

University investigators are encouraged to discuss their research interests with members of the Advisory Committee or members of their staffs for their suggestions. This also provides an opportunity to take advantage of information and data available to them and to improve communication regarding prospective studies. When the proposals are received, copies are distributed to all interested members of the Committee for comment. This is not a pro-forma referral. They call their shots as they see them. When proposals are good, they say so, but still may make suggestions for strengthening. When the proposals are of questionable merit or low priority, they speak accordingly in no uncertain terms. While the Institute retains the final decision for approval or disapproval, it takes these recommendations very seriously. Once a proposal has passed this initial muster, it undergoes the close scrutiny of an eleven-man multi-disciplinary committee of university scientists who also set final priorities based upon recommendations of the Institute Director and members of the Advisory Committee. Priority is established on the basis of relevancy to important water resource problems and scientific merit. All proposals are screened to avoid duplication of previous or on-going research through a literature search and check against the Institute's inventory of research in North Carolina, Interior's Water Resources Research Catalog, and/or a search by the Science Information Exchange. No other water resources research program has a more demanding review for relevancy, scientific merit, and avoidance of duplication.

As with the national program, the principal limiting features affecting North Carolina are the extremely limited annual allotment and lack of a clear-cut authorization for the additional activities necessary to effectively move research results into practice. Inflation has seriously eroded the purchasing power of the present \$100,000 annual allotment. This deficiency has been compounded by the many new problems brought to light by the increased concern for environmental quality and its impact on water resource planning and development. No federal research program in the field of water resources has adequately dealt with the formidable problem of the effective translation of research findings into meaningful new information for the ultimate users. If research is worth doing in the first place, it is axiomatic that this second step is of equal importance. The Institutes are uniquely qualified to do this by virtue of their location at the interface between research producers and research users. Yet, this cannot be done without additional funding. Simply stated, there is much more to do than was originally envisaged and far less to do it with.

The state of North Carolina has responded to the intent of 1964 Act by appropriating some \$150,000 annually to the Institute program. Indirect contributions increase the state share to well over \$200,000. This far overshadows

the presently authorized federal annual allotment and would essentially match the \$250,000 proposed by the two bills under consideration. The additional funds are badly needed to conduct essential research and to move the end-product into practice.

All research now underway at the Institute is highly relevant to water resource problems of the state and region. A brief summary of the FY 1970 program is submitted as follows:

WATER RESOURCES RESEARCH INSTITUTE OF THE UNIVERSITY
OF NORTH CAROLINA

SUMMARY OF FISCAL YEAR 1970 PROGRAM

The North Carolina Water Resources Research Institute program has been conducted in close association with public agencies and the private sector. Two research workshops were held last year to discuss problems and proposed studies. A joint committee on water resource planning has met monthly to guide the development of university research in this area. Frequent sessions were held with individual members of the Institute Advisory Committee, with one formal meeting of the Committee as a whole. The Director presented statements at hearings held by the Board of Water and Air Resources and Legislative Study Commission. A study of problems associated with the transfer of research results into practice was initiated to increase the effectiveness of the Institute in serving North Carolina.

A basic need for state water resource planning and research is rapid access to hydrologic and other water-related data. A hydrologic Information Storage and Retrieval System has been developed and steps are being taken to facilitate use and eventual operation by the State. In a related investigation more efficient techniques have been developed for the analysis of stream flows with respect to floods and water quality management.

Land development in the vicinity of large multipurpose reservoirs creates many conflicts with water uses. A forecast model for testing effectiveness of alternative policy mixes in promoting desirable patterns of development around reservoirs is being developed. A preliminary report, "The Role of Reservoir Owner Policies in Guiding Reservoir and Development," has attracted wide national interest.

North Carolina's many reservoirs offer opportunities for an expanded water-based recreation industry. Planning and management, however, are made haphazard by lack of a methodology for estimating their recreational capacity. Steady progress toward meeting this need is being made through another project now nearing completion.

A neglected and crucial aspect of the conversion of raw land into urban development is the adequate treatment of natural water courses. Crabtree Creek in the Raleigh urban area reflects all the problems associated with limited purpose planning, development in the absence of land use regulation, conflicting views and lack of cooperation at the local level. The Institute has worked with the League of Women Voters in a seminar for local leaders and has initiated a study to demonstrate the use of landscape planning techniques in a cooperative setting for the integration of group objectives.

North Carolina's Piedmont cities are heavily dependent upon reservoir storage on tributary streams for future water demand. Delivery of stored water through stream channels is not assured under riparian water law. The completion report for a study, "The Use of Stream Channels to Deliver Stored Water: The Possibility of Interference by Third Parties," was requested by the Legislative Study Commission for use in considering new legislation. Another important factor in municipal water supply is the effect of changing watershed land use on both quantity and quality of water. A study of the Durham municipal watershed is evaluating prospective benefits from the application of previous research findings to watershed management.

A multi-county region in eastern North Carolina has recently been declared a "Capacity Use Area" in order to protect the ground water supply from salt water intrusion. Considerable progress is being made in the development of electrical analog and digital models of the principal aquifer to assist in guiding its orderly development.

The Outer Banks are of great importance to the State for their recreational value and a key factor in this regard is the continued availability of a fresh water supply. A simulation model has been constructed and tests have been run

to predict maximum safe pumping rates. Formal completion awaits comparison with field tests now being conducted by the Geological Survey.

Present drainage practice in the Coastal Plain of North Carolina threatens destruction of orbanic soils and interference with fish and wildlife habitat and ground water recharge. Water level control rather than free drainage offers attractive alternatives. A study of surface and subsurface irrigation and drainage criteria and water level control is producing useful new information in this area.

Streams feeding authorized new impoundments in North Carolina carry sufficient nutrients to markedly accelerate eutrophication. Two major projects are directed toward this problem. Findings to date indicate that the quantity of nitrogen rather than phosphorus determines algal growth. A related study of the Pamlico estuary found phosphorus levels far in excess of that required for eutrophication with no apparent problems because of the low nitrogen levels. If sufficient nitrogen becomes available from sewage or agricultural drainage, intense eutrophication is expected. An investigation of phosphorus and nitrogen losses from farm land has been initiated by the Institute to clarify agriculture's role in this complex picture.

Another aspect of agricultural land runoff of concern in water quality management is the loss of pesticides to ground and surface waters. Data being developed from an Institute study is providing valuable insight into pesticide pollution and its control. An Institute project produced a recommended pesticide monitoring system for the State which was recently submitted to NCDWAR for its consideration and to the Legislative Study Commission investigating the need for new pesticide legislation.

An urban land runoff study has demonstrated that pollution from this source can no longer be ignored and raised many questions about present assumptions in water quality management and the adequacy of present technology to cope with today's problems.

Recent research on pollution from intensive animal growing areas has highlighted deficiencies in present techniques for animal waste characterization and design standards for waste treatment facilities. An Institute study was commenced last year to investigate the initial phases of this needed new work.

The rapid growth of electric power demand coupled with stringent Federal temperature standards impose severe pressure on NCDWAR regulation of thermal pollution. Only limited information is available concerning impact of temperature on aquatic ecosystems. A study was initiated last year to assist the State in setting realistic temperature standards for estuarine waters.

In North Carolina, as elsewhere, water resource problems are assuming dimensions never imagined a few years ago. A good illustration of what is taking place might be the industrial Piedmont crescent where the state's major cities are located on the small tributary streams of five separate river basins. All cities are now providing secondary treatment of their wastes, yet three massive fish kills have been experienced in recent weeks in one stream, allegedly due to the sewage effluent from one of the cities coupled with land runoff. In the past, each city has sought its own water source and dealt with its own sewage disposal problems. This practice simply is not acceptable any longer. Questions of balancing out limited water supply and demand, providing for low flow augmentation, inter-basin transfers, and so forth cry out for a comprehensive study to work out the necessary planning techniques and demonstrate the utility of region-wide water resource planning. The system-wide approach is complex, but continuance of past procedures spells chaos. Research in such a case is not only desirable, but an essential concomitant to the state's water resources management program. Examples of many other complex situations arising out of the new-found awareness that water resource problems are no longer amenable to solutions of the past can be cited as justification for the proposed increase in annual authorization if required. The need, however, is abundantly evident to observers from the Mountains, through the Piedmont, to the Coastal Region.

The erosive effect of inflation over the past six years has reduced the purchasing power of the original \$100,000 by at least 30 percent in North Carolina. The proposed authorization of \$250,000, then, will buy less than \$175,000 worth of research in terms of what was anticipated in 1964. This is a relatively small sum in comparison to the levels of funding available to the mission-oriented federal agencies. It is a modest program, but one with great potential of service to North Carolina and the Southeast.

I strongly support the provisions of S. 3553 and S. 3721 and urge early enactment.

Senator Moss. We surely appreciate your testimony on behalf of the Universities Council as well as for the Resources Institute of North Carolina. And you may be assured that this has added greatly to the information that is needed by this committee.

We were talking earlier, and as so many of us in the West, we tend to think all of the water problems are out there, and to have you indicate so forcefully and eloquently the problems that you experience on the eastern seaboard and, in fact, in all areas of our country, makes us understand why this research divided out to institutes in all of the States has great importance. And I am glad to have you state the support of the Universities Council for it.

Mr. HOWELLS. Thank you, sir.

Senator Moss. Thank you.

Dr. Edward Towle, the director of the Caribbean Research Institute from the Virgin Islands.

We are pleased to have you, sir, come before us. We will be glad to hear your statement.

STATEMENT OF EDWARD L. TOWLE, DIRECTOR, CARIBBEAN RESEARCH INSTITUTE, COLLEGE OF THE VIRGIN ISLANDS

Mr. TOWLE. Thank you, Mr. Chairman.

As the director of a research institute, Caribbean Research Institute in the Caribbean, which is the only interdisciplinary institute in the whole Caribbean, I have a responsibility for programs relating to environmental quality.

I do not intend to read my entire statement.

Senator Moss. We will put it in the record in full. We will be glad to hear your summary.

Mr. TOWLE. I thought it would be useful to mention briefly the fact that the Virgin Islands was not included in the first Water Resources Research Act of 1964, principally because at that point in time there was no college or university in the Virgin Islands to be a recipient of any of the funds which accrued under the act.

Since that time, there has, in fact, been organized a new territorial 4-year accredited academic college, and as an appendage to that we have for the last 5 years operated an interdisciplinary research institute. And it is both speaking for the president of the college and as director of the institute that I come to you this afternoon.

In your deliberations of Senate bill 3553, to further amend the Water Resources Research Act, I would like to request at least that you consider the somewhat peculiar needs of these strange little islands in the Caribbean that belong to the United States, the Virgin Islands, in this area of the management of our territorial water resources and that you extend the application of the Research Act of 1964 to include the territory of the Virgin Islands, and that Senate bill 1051 be amended to include the Virgin Islands along with the District of Columbia.

Isolated and pretty dependent on tourism, the Virgin Islands are peculiarly dependent on water resources and water quality for a continuing viable economy. There exists in the Virgin Islands a very real need for intensifying what modest efforts we have put forth in the whole field of water resources research, management planning and

training, and to enable the Virgin Islands to undertake this research effort, or to expand its research effort and its management programs, Federal assistance such as would be available under the existing act or under its amended status is particularly needed at this time.

As citizens of the territory who are also citizens of the United States, we believe that we should be afforded the benefits of the Water Resources Research Act of 1964 on exactly the same basis as citizens of the several States and Puerto Rico.

I respectfully suggest that this subcommittee should not overlook the fact that the extensive continental mask of the United States with its traditional Atlantic, gulf, Pacific and Arctic coastlines is, in fact, supplemented by a variety of island clusters and island systems with different coastal ecosystems, and therefore different or slightly different water management problems.

Islands are really special entities and not only in the biological, geographical, and geological sense, but in an administrative management sense as well. And this applies to the water management. On the basis of our experience with environmental research programs at the College of the Virgin Islands, where we are making an effort to learn something about island systems, we have only come a short distance in moving toward an understanding of what an operating procedure is for a small island, and I am certain that the experiences of the Aleutian Islands or Guam, Hawaii, even perhaps the Florida Keys are not dissimilar.

The simple matter of fact is that we are unfortunately 10 to 20 years behind existing stateside research, training-development programs, and the Virgin Islands is perhaps the furthest behind because it is the newest to acquire an educational institution that would provide the faculty resources and the facilities for indigent research programs.

It is increasingly apparent, as we begin to work with our own water quality problems also that the continentally derived approaches and practices, river basin studies, for example, that they require extensive adaptation before they can be applied to our own problems. Estuarine models, engineering techniques, planning standards, even pollution control methods, even teaching materials have to be seriously adapted and localized to the insular microcosms and conditions before they can be applied effectively.

The Virgin Islands are in a new position to develop, I think, under the provisions of a proper support policy, a fairly wide spectrum of water resources planning practices, manpower training especially designed for island units or island systems, applicable not only to the Islands under the American Flag but probably appropriate to tropical insular systems anywhere in the world.

The government of the Virgin Islands has consistently lent support, encouragement to the island-oriented environmental programs of the College of the Virgin Islands and the Caribbean Research Institute. With continued assistance, and we hope expanded assistance from the Federal Government in this instance, we look forward to learning enough about our island system to develop and test out some planning procedures and some management techniques that will be useful in all island systems, not just the Virgin Islands.

May I also take a moment here to endorse Dr. Leonard Dworsky's comments earlier concerning the importance of maintaining or developing sustained support as opposed to project support. This is particularly relevant in the case where you have marginal facilities and a relatively modest faculty to begin with in the building of any integrated water resource research program.

Now, the staff of the institute has been engaged for more than a year now in developing some local water resources research programs relating to rainfall and erosion, sanitary waste disposal systems, et cetera. However, our preliminary efforts in this area would be enormously enhanced if the legislation in question were amended to include the Virgin Islands under the Water Resources Research Act of 1964, plus enabling the Virgin Islands government to move ahead in the establishment of its own water resources research center.

Within 12 months the College of the Virgin Islands will commence construction on a major environmental science research and teaching facility. This addition to our present facilities could support substantially the activities of a water resources research program. The establishment of a water resources research center would markedly increase the efficiency of our activities and our new environmental laboratory complex.

It is extremely important that we develop in the very near future a local water quality laboratory. There is none at the present time. Not only do we need basic facilities to process somewhere in the neighborhood of 2,000 water samples per month, which we are now doing in our own rather modest facility, but we need much more sophisticated analytical facilities to deal with the new problems of chemical and oil pollution introduced by the very heavy load of shipping in our semienclosed harbors, by our industrial affluence from both the large desalination plant complex which we have and the very large Harvey-Hess aluminum and oil refinery activity on St. Croix.

Our waters are in a very tenuous state of affairs right now, and it is our judgment that we are in for very real troubles in the very near future if we do not develop fairly sophisticated monitoring and control programs almost within the next 12 months.

It may be of note to this committee that with the \$50,000 in Federal funds which we are now receiving from the Federal Water Quality Control Administration under a project approach, we are currently matching this with \$200,000 of local—that is, territorial and private funds, so that we have at this point for the Virgin Islands a 4-to-1 ratio of Federal funds—or, rather, 1-to-4 Federal funds versus non-Federal funding for our current program.

In conclusion, may I express a sense of urgency and real concern for what is happening in the Virgin Islands. With maximum coastlines, and minimum land area, with rising population, which in fact exceeds the rate in the United States, and with declining water quality that result from the very heavy usage that we are giving these small islands, with expanding industry—industries that are in fact moving to the Virgin Islands for a variety of reasons—and with construction sweeping our open space and, in fact, making serious inroads on very steep hillsides, and with our own population, and with an annual inundation of nearly 1 million American tourists seeking their

own little dialog with an American island in the sun, the insular environment of the American Virgin Islands is under enormous stress.

Sound water resources and their research management programs, lending Federal and local energies, talents, techniques, and resources would go a long way in helping with these problems.

I would urge, then, the passage of Senate bill 3553 without amendment, and also the passage of Senate bill 1051 amended to include the Virgin Islands of the United States.

Thank you very much for the opportunity of testifying this afternoon.

(The complete prepared statement of Dr. Towle, above referred to, follows:)

STATEMENT OF DR. EDWARD L. TOWLE, DIRECTOR, CARIBBEAN RESEARCH INSTITUTE,
COLLEGE OF THE VIRGIN ISLANDS

Mr. Chairman and members of this subcommittee, I am Edward L. Towle, Director, Caribbean Research Institute, College of the Virgin Islands.

In your deliberations of S. 3553, to further amend the Water Resources Research Act of 1964, I ask that you consider the pressing and unique needs of the Virgin Islands in the area of management of our Territorial water resources, and that you extend the application of the Water Resources Research Act of 1964 to the territory of the Virgin Islands.

By their very nature these territorial Islands would be a perfect center for water resources research. The Virgin Islands are peculiarly dependent upon water resources for a continuing healthy economy. There exists in the Virgin Islands a very real need for intensifying our efforts in the areas of research, investigation, and experimentation, conservation and best use of available supplies of water, methods of increasing such supplies, and economic, social, engineering, recreational and ecological aspects of water use and management. To enable the Virgin Islands to undertake this research to the extent necessary, Federal financial assistance is a must. Extension of the terms of the Water Resources Research Act of 1964 to this territory would provide that financial aid. In addition, we believe that the citizens of the territory, who are also citizens of the United States, should be afforded the benefits of the Water Resources Research Act of 1964 on the same basis as the citizens of the several States and Puerto Rico.

Governor Melvin Evans is already on record as saying the total economy and the general welfare of the Virgin Islands are almost totally dependent on enlightened management of our extensive coastal areas and ocean shores, particularly at this critical era in environmental development. We need vastly greater Federal participation to expand our own activities.

The broad and complex nature of our coastal problems—and, of course, our potential for progress—prompts me to request that the formula for distribution of Federal funds should give full consideration to the special needs of the Virgin Islands. An allocation formula which gives major consideration to the resident population of the Islands would not reflect actual need and potential based on the national interest of the United States Government; neither would it meet local needs, if these needs were separable from the needs of the Nation.

I respectfully suggest that, as you proceed, this Subcommittee should not overlook the fact that the extensive continental mass of America, with its traditional Atlantic, Gulf, Pacific, and Arctic coastlines, is supplemented by a variety of island clusters or island systems, with significantly different coastal eco-systems, and, therefore, different management problems. Islands are special entities, not only in a biological, geographical and geological sense, but in an administrative management sense as well. On the basis of our experience with environmental research programs at the College of the Virgin Islands, where we are attempting to learn something useful about the Virgin Islands, and the Eastern Antilles Islands Systems, we still have only a preliminary understanding of islands coastal zones, and our information on the "operating procedure" for small island eco-systems is still marginal and highly selective. I am certain the experiences of the Aleutian Islands, Guam, Hawaii, and the Florida Keys are not dissimilar.

It is increasingly apparent, moreover, as we work with Caribbean islands, that standard, continentally derived approaches and practices are not readily

adaptable to the environmental problems of insular systems. Estuarine models, engineering techniques, planning standards, some pollution methods, and even environmental teaching materials must be localized and adapted to the insular microcosms and conditions. In a nutshell, islands are different.

In referring to the priorities and selection of projects, we deem it appropriate to opine that Public Law 88-379, while sufficient in reference to the possible areas of research, gives emphasis to the legislative intent to focus on the particular problems of the particular jurisdiction where the institute exists. This point alone affords the conclusion that such a territory of small islands, surrounded by sea, must differ greatly in their approach and priorities and selection of projects. Further, the law recognizes the fact that the problem is of an interdisciplinary character and, as such, would consider as appropriate research proposals in all areas that directly or indirectly may contribute to the fulfillment of its objectives.

The Virgin Islands is in a unique position to develop, under the provisions of a proper support policy, a wide spectrum of environmental planning practices and procedures, expressly designed for island units and systems, applicable not only to other islands under the American flag, but probably appropriate to insular systems anywhere in the world. The Government of the Virgin Islands has consistently lent encouragement and support to the environmental program of the College of the Virgin Islands and its Caribbean Research Institute. With guidance and assistance from the Federal Government, we look forward to learning enough about our unique islands system to develop and test out planning procedures and management techniques useful in other such systems, and perhaps even in certain continental areas.

At this very moment, Tektite II, a unique and historic investigation into coastal environmental processes is underway at the Caribbean Research Institute Ecological Research Station at Lameshur Bay, St. John. Under the leadership of the United States Department of Interior and with the cooperation of the Virgin Islands Government and other Federal agencies and universities, we are seeking in an underwater laboratory habitat, to learn more about the submerged portion of the coastal zone and its requirement for survival as a viable part of the eco-system. We are confident that the information derived from the scientists in the Tektite I and II programs and from the ancillary surface oceanography programs will directly improve the effectiveness of our own environmental research and planning program.

The Caribbean Research Institute, the research arm of the College of the Virgin Islands, has worked closely with the Federal Water Pollution Control Administration and with local Government officials in developing a Water Resource Research Program for the Virgin Islands. Our staff has been engaged for one year in a program dealing directly with the problems of water pollution, water resources data collection, sanitary waste disposal systems, and the like. However, our preliminary efforts in this vital area would be greatly enhanced if the subject legislation were amended to include the Virgin Islands as a recipient of funds, thus enabling the Virgin Islands Government to move ahead in the establishment of a Water Resources Research Center.

The College of the Virgin Islands will commence construction soon of an environmental science building. This addition could support substantially the activities of a water resources research program. Establishment of a Water Resources Research Center would markedly increase the efficiency of our activities.

It is extremely important that we develop in the very near future a local water quality laboratory. Not only do we need facilities to process somewhere in the neighborhood of 2,000 water samples per month, but we need sophisticated analytical facilities to deal with the complex chemical and soil pollution problems introduced by the heavy shipping in the semi-enclosed harbors of these islands, by the industrial affluence of the desalination plants and of the Harvey-Hess complex, and the multiplicity of sewage treatment plants which have sprung up on the islands. Our waters, and also our economy, are in for real trouble if we do not develop an elaborate monitoring program within the next twelve or twenty-four months.

In conclusion, may I express a sense of urgency and genuine concern. With maximum coastlines and minimum land area, with rising population and declining water quality, with expanding industry and construction shrinking our open space, with a periodic inundation of American tourists seeking a restful and healthy dialogue with an island in the sun, the coastal environment of the American Virgin Islands is under enormous stress. Sound water resources

management programs, lending Federal and local energies, talents, techniques and resources would go a long way toward solving these problems.

Thank you for your attention.

Senator Moss. Well, we do appreciate your coming to testify, Mr. Towle, because we recognize also that there are problems about water, water resources, treatment, and usages in the Virgin Islands and our other island possessions and territories that ought to be considered. Secretary Klein indicated this morning he didn't believe the Virgin Islands needed to be included because there is no ground water there; it all had to be caught from the skies or desalted from the sea.

Whether or not that is so, it seems to me there is still a problem of how you are going to treat that water, how are you going to make it potable and keep it potable, and have enough of it on hand. And what are you going to do with pollution in areas that are being subjected to pollution?

I think you made it quite clear that there is probably every bit as much need of research in these areas as there is in areas where there is a ground supply of water or a runoff supply constantly coming from mountains, or elsewhere.

So I think your statement is rather persuasive, and we are glad to have your recommendations. And we appreciate your coming up here to testify before us.

Mr TOWLE. Thank you, Mr. Chairman.

Senator Moss. In our correspondence some time earlier, you sent me a copy of the annual report of 1969 on the research institute down there. I would like to make reference to that and have it in the files of the committee so that this record would refer to it, and we can find from that the data we need.

Mr. TOWLE. That is fine, because there is a summary of our current water water quality research work in that annual report.

Senator Moss. Thank you very much.

(The annual report above referred to will be found in the files of the committee.)

Senator Moss. Our next witness will be Dr. Jay Bagley, director of Utah State Water Resources Laboratory at Utah State University in Logan, Utah.

We are pleased that you are here, Dr. Bagley. We are very proud of the Water Resources Research Laboratory at Logan. It has done some outstanding work for us in Utah and, in fact, I think Utah has been in the forefront for a long time in this area of research on water.

I am advised that you, Dr. Bagley, will have a statement from Dean Peterson who is now out of the country, but nevertheless got together a statement and sent it in here because of his great continuing interest in this matter.

We are pleased that you are here, Dr. Bagley, and we will hear from you now.

STATEMENT OF JAY M. BAGLEY, DIRECTOR, UTAH WATER RESEARCH LABORATORY; AND ACTING DIRECTOR, UTAH CENTER FOR WATER RESOURCES RESEARCH

Mr. BAGLEY. Thank you, Senator Moss.

I appreciate those kind words.

I might just add, if it is not inappropriate, that as career profes-

sionals we do appreciate the opportunity to work with a Senator who is so enthusiastic and so knowledgeable about water as evidenced by these many fine bills that you have introduced.

It is my pleasure as director of the Utah Water Research Laboratory and acting director of the Utah Center for Water Resources Research to appear before this committee and strongly urge the passage of Senate bill 3553.

And if I could just digress to request that the statement from Dr. Peterson—he learned of the hearing date while he was in Europe, and he took the time to prepare a very excellent statement, and I would like to request that it be introduced in the record.

Senator Moss. Well, thank you. It will be introduced in the record.

I should mention that Dr. Peterson is now in Switzerland attending the meetings with the coordinating council of the International Hydrological Decade. He is vice chairman of the U.S. Delegation. So he is about our business, too, on water over there.

Mr. BAGLEY. As is normal about this time of the day, Senator Moss, much of this information gets rather repetitive, and so I am going to brief the first pages of my statement and then maybe emphasize a little bit or highlight a few of the examples of research results that are coming out of this activity.

Senator Moss. Well, that will be acceptable. I have had time to run through your statement. It is a very excellent one and will be printed in the record in full. And you may highlight what you want to on the statement.

Mr. BAGLEY. I try to emphasize in the beginning that in all this hue and cry about environmental enhancement and degradation of the ecological impacts, the central importance of water and a stronger research base in water intensified rather than diminished because of its umbilical role, its inextricable association with these broader considerations, pointing out that mistakes we make in water management, or mismanagement, of course, lead to less than optimal realization of other resource combinations.

And so that with a constant level of research funding, it really means a diminishing research base, and we need to enlarge this base, and we need to certainly take advantage of the existing university base if we are going to obtain optimum solutions to many of our great environmental and sociological problems.

Now, I am going to skip over some statements that I have made here relative to the wisdom of establishing these centers on a permanent basis and locating them on campuses, because others have treated this adequately. I would like to just make one point about it, or emphasize a point that's already been made about the stabilizing and energizing effect of this allotment feature.

If our campus is any example—and I presume that it is—the allotment funds have triggered expanded programs of research, multifaceted programs, problem-oriented approaches, and have marshaled and energized a lot of peripheral talent that is now making excellent contributions in the gift and grant programs. And so I think the allotment portion has actually made the grant facets more effective.

Now, let me turn to some Utah examples to try to illustrate how we feel that our experience has suggested that this is a good investment.

From the very beginning of this OWRR program we have tried to

effectively match up or mesh the national and State research priorities and to propose research accordingly. We have been particularly anxious to get in step with our State Department of Natural Resources which has responsibility for water planning and development of Utah's waters, and we have also tried to work in closest concert with the Federal agencies who have activity in planning and management within our State.

Now, in the earlier years of the program our research emphasis was more on providing information and tools needed for broad-scale planning. As you know, the research needs come in increments or stages, and we have tried to phase these so that they fit the planning and development sequence or they meet some of the urgent needs of the time.

One of our first efforts was the preparation of what we titled "Hydrologic Atlas of Utah."

Now, it is not an atlas in the traditional sense of an exhaustive tabulation of raw data of various kinds, but rather it was put in a format and given emphasis in terms of geographical and time variations that occur in all these hydrologic and climatologic principles and then putting it in a problemistic format so that it is convenient for decisionmakers to use. And the use of this information and its particular in importance for planners at local levels, counties, and cities has exceeded our expectations.

In fact, one of the most enthusiastic users is the State Tax Commission who now incorporates these hydrologic and climatological features into appraisals for tax purposes.

We have had a number of studies aimed at trying to get at this problem of the value of water in alternative uses, industrial, agricultural, recreational, and so on, and then using this information as background for followup studies in the economic effects of allocating water in different patterns to meet these potential uses. And in so doing, of course, we have made application of some of the modern mathematical and computer techniques which allow us to examine a large number of alternative patterns of meeting these demands which might include reuse, recycling, even desalting and import.

And the results from these studies are most enlightening. And the utility of the modeling of these entire river basins and the use of those in testing out planning alternatives have been highly significant and are being used effectively at the moment in looking at possible inter-basin ties, connections, and in the three-State negotiations that are going on in dividing up the waters of the Bear River, for example. And the Bureau of Reclamation has just entered a contract now to develop a model of the Jordan River area in which they hope to look at all of these alternative ways of meeting those demands in view of the constraints that are there in terms of existing water rights, and so on.

So I think this small amount of this OWRR-supported research has been helpful in uncovering some possibilities that weren't previously considered in these gigantic schemes such as the Central Utah project, and the resulting dialogue between the Federal, State, and our own organization has been most beneficial. And I think the assurance that we are getting the proper perspective and the broad considerations of the general objectives that should be brought into development will prove of inestimable value to the people of our State.

Recognizing that ways of collecting more data, obtaining it more efficiently, and increasing its accuracy, were essential to understanding the physical world of water, but also for use in practical planning and management applications, we initiated a project to develop instrumentation for measuring and processing hydrologic and climatologic information remotely, and this effort has led to the perfection of a hydrologic telemetry system which has the highest accuracy of any FM to FM telemetry system that we know anything about. It makes use of a novel tracking filter developed there at Utah State which enables the equipment to sweep through a very noisy signal and lock on to a weak one and read it out. This makes it possible to operate under very low power.

We use just an ordinary electric fence battery, six-volt battery, and this will operate a station for a full season. So this system has become the foundation for a very sizable Utah experiment on the effectiveness of cloud seeding and augmenting snowpack under the sponsorship of the atmospheric water resources program of the Bureau of the Reclamation. And it is also being used more and more extensively in research connections.

And I might also indicate that a chemical corporation has taken over the commercial manufacture of this system and is providing this to commercial users all over the world.

Another interesting study that you might like to hear a little bit about started again with OWRR allotment funds, and that was to study the fiscal, biological, and chemical water quality factors in sewage treatment ponds. Such ponds represent a promising solution for economical wastewater treatment, especially for the small world community. And these are used extensively in the Midwest, have not been used too much in our State because the State Health Department is a little bit nervous about the erratic performance, or reports of performance.

However, using the Logan City Treatment Ponds which were placed under construction in about 1965 or 1966, right around the time that this bill was passed, we have been making some studies and arrived at some rather interesting conclusions.

One thing is these treatment ponds can be managed to encourage the production of particular aquatic insects, and I will call them insects if there are not aquatic biologists here, but the kind that are most efficient in extracting the nutrients in the dissolved state and converting them to insect flesh.

In this particulate form then, these organisms can be in term harvested by a higher form of organism; for example, fish. And placing this fish population on top of the developing plant and invertebrate communities then allows you to take care of these increased loadings of nutrients, either eliminate them or greatly minimize them. So the fish harvest then might have some commercial or recreational value at the same time that we are cleaning up the water supplies.

Another aspect of this is that traditionally these ponds are designed to be square or rectangular, and we found them to be highly inefficient insofar as the pond volume having an influence on the affluent is concerned, and we found there is a lot of short circuiting going on; although the design time is 6 days of detention, we are finding that the material is traveling through there in 1 day. And so it is obvious,

then, that some kind of a free-form design or some kind of baffling in the existing ponds would bring a greater proportion of the pond into activity and at the same time would invite a much more efficient and aesthetically pleasing structure.

Well, the results of this work, I think, point toward some very substantial improvements in efficiency and effectiveness of these treatment ponds together with some very substantial savings in construction costs.

I might just mention one other facet of our program which was initiated through the OWRR program, and that is to begin or initiate a continuing effort in these social sciences as applied to development of natural resources and water resources in particular. And using the proposed Bear River project as a prototype, or sociological and physiological experts have been able to learn a great deal about the character of these social surveys that they make and eliminating some of the social aspects of water resource developments which are pretty important to resolve.

Mr. Chairman, I think I will conclude with that. I think any objective appraisal must surely indicate that the returns from the Federal investments in this program are giving substantial dividends in many ways. I think the increased funding proposed in S. 3553 is certainly modest when you consider the inflation we have talked about, the added dimensions of a better research base, and then the broadened programs, additional expertise that can be brought to bear on our Nation's water problems.

Thank you.

(The prepared statements of Dr. Bagley and Dr. Peterson above referred to, follow:)

STATEMENT OF JAY M. BAGLEY IN SUPPORT OF S. 3553 TO AMEND THE WATER RESOURCES ACT OF 1964

It is my pleasure as Director of the Utah Water Research Laboratory and as Acting Director of the Utah Center for Water Resources Research in Dean Peterson's absence from the country at this time, to appear before you to strongly urge the passage of S 3553. In so appearing I speak for the Utah State University and also as a scientist who has had rather intimate acquaintance with the water problems of Utah, of the West, and of our great land and recognize the implications to our general well being if these are not resolved.

The Water Resources Research Act of 1964 was a national recognition of an alarming build-up of complex water problems. More importantly, it was a recognition of the fact that how we manage (or mismanage) our water supplies in large measure delimits our options and potentials in a broader environmental and social context. Senator Kerr, who headed the Senate Select Committee on Water Resources which gave impetus to the Act, said: "We can bequeath our children cities of iron and stone and aluminum, but we had better be sure we give them water to make them livable."

Environmental protection and enhancement is inextricably associated with water. The pervasive character of water, its vital necessity for maintaining all forms of life and its direct and indirect importance in practically every human endeavor, makes water a key element in molding the character of the natural environment as well as the modified environments that make our individual and community surroundings more pleasant, useful, and attractive. That the Water Resources Research Act should recognize and emphasize the signal importance of a stronger research base in water is quite logical. While we may tend to lose sight of the umbilical role of water in all the hue and cry about environmental and ecological impacts, the plain fact is that these broadened concerns merely intensify the need for water research since water is so central and intertwined in these other considerations. Mistakes made in water management in turn lead to less than optimal realization of other resource combinations.

It was logical, also, to include as a significant feature of the Research Act the establishment of permanent research centers and to locate these at universities where (1) there was already research momentum and structure which included libraries, computers, special equipment, facilities, and, above all, a highly trained multidisciplinary cadre of personnel, all of which assured a minimum of start-up time, and a balanced on-going program. (2) The dispersment of centers on a state basis gave automatic assurance of recognition and better response to differences in problems according to geographic differences. (3) The liaison with rapidly strengthening state water planning and development programs could be improved and the centers could provide the badly needed state water research arm, while at the same time contributing to the solution of priority national problems. (4) An effective and complementary training facet could be readily implemented to help meet critical needs for talent in the many private and governmental water planning, development, and management agencies.

To realize the potential advantages of centers thus established requires a certain level of basic financial support so that career opportunity can be extended to attract top talent, and so that a coherent backbone program can be planned well into the future. This is in contrast to the rather unpredictable project by project program under gift and grant kind of support. Such basic financial support, provided under the allotment feature of the Act, provides a stable underpinning for programs which may be heavily complemented by gift and grant research activity. The stabilizing and energizing effect of this basic allotment is unusually high. This energizing aspect is a plus that may not have been foreseen by the framers of the 1964 Act. While the allotment feature assures a certain minimal research program broadly dispersed geographically, the matching feature attracts additional non-federal dollars into the water research thrust and, viewed from either the federal or non-federal side, obtains double duty from the research dollar invested. Also, the Title II program makes certain that any and all competent research talent and ideas (not just university) can be attracted into the program.

How good was the judgment of those who framed the original legislation? Has the investment paid off thus far? Our Utah experience would indicate a positive affirmative answer. From the inception of the OWRR program we have tried to effectively match up or mesh the national and state research priorities and propose research accordingly. We have been particularly anxious to keep in lockstep with our State Department of Natural Resources and its Division of Water Resources who are charged with developing plans for most effective utilization of Utah's water supplies and to work in closest concert with the federal agencies active in our state.

In the early years of the OWRR program our research emphasis was on providing information and tools for broad scale planning. One of our first efforts was the preparation of a "Hydrologic Atlas of Utah." This was not an atlas in the traditional sense of exhaustively tabulating raw data. Rather the emphasis was to present the information in terms of its geographical and time variations and in a probabilistic format most suitable for decisionmaking. The use of this information and its particular importance for city and county planners has far exceeded our expectations. In fact, one of the most enthusiastic users is the state tax commission who can now incorporate hydrologic and climatologic factors into their appraisals for tax purposes.

Three separate studies on the value of water in industrial, agricultural, and recreational use have provided background for follow-up studies on the economic effects of allocating water in different patterns of potential users. The application of modern mathematical and computer techniques in examining a large number of alternative patterns of meeting these potential demands from all available sources (including reuse, recycling, treatment, desalting, and import) has been most enlightening. Investigation of various possible planning and management schemes are progressing nicely. For example, computer models have been developed for the Weber, Bear, Jordan, Sevier, and Upper Colorado River Basins. The state Water Resources Division is currently using these models to evaluate water planning alternatives including inter-basin transfers. They are also utilizing such models effectively in negotiations new underway aimed at dividing the waters of the Bear River between the states of Wyoming, Idaho, and Utah.

The broadened considerations in state water planning, energized and made possible through OWRR supported research has uncovered possibilities not previously considered in gigantic schemes such as the Central Utah Project. These

evaluations have modified long accepted concepts and have brought issues to the surface whose resolution will have a very basic and far-reaching effect on Utah's future growth pattern. While these results may have caused some discomfort and agonizing reappraisal among those oriented toward disconnected project by project development, they have enabled the small planning staff of the state to influence the direction and approach of various local, state and federal agencies with water development missions. The assurance of state-wide perspective and broader consideration of general objectives and development alternatives will prove of inestimable value in extending the utility of Utah's limited water supplies.

Recognizing that ways of collecting more data, obtaining it more efficiently, and increasing its accuracy were essential to understanding the physical world of water, as well as in practical planning and management applications, a project to develop instrumentation for measuring and processing hydrologic and climatologic data was supported under the initial allotment to the Utah Center. This effort has led to the perfection of a hydrologic telemetering system having the highest accuracy of any FM/FM telemetry system known (.05%). The system employs a novel tracking filter which enables readout of FM/FM telemetering signals with zero error in the presence of extremely high noise. Thus, the remote stations can operate on very low power requirements. A single 6-volt electric fence battery powers a station for a full winter season. A frictionless motion transducer, which reflects an electronic change activated by changes in the physical parameter being measured, assures long life and trouble free operation. Developments and improvements from this OWRR supported project are presently being used by research groups throughout western United States and Canada. The system has become the foundation for a sizable Utah experiment on the effectiveness of cloud seeding in augmenting snowpack under sponsorship of the Atmospheric Water Resources Program of the Bureau of Reclamation. The research utility of telemetry is expanding broadly into applications within other research units of the University, such as ecology and air pollution. Its value and potential is tremendous.

Another of the research studies supported under the OWRR allotment funds was to study the physical, biological, and chemical water quality factors in sewage treatment ponds. Such ponds represent a promising solution to economical wastewater treatment especially for the small rural community. They require low initial capital investment and very nominal operation and maintenance cost. However, lack of rational design criterion, based on understanding of the pond hydraulics and its ecosystem in general, have led to wide disparities in reported performance efficiencies. Sufficient work has been accomplished by specific studies of the Logan City treatment ponds to make some rather interesting conclusions. The findings include (1) the tertiary treatment ponds can be managed to encourage production of particular aquatic "insects" which are most efficient in extracting nutrients in the dissolved state and converting them to insect flesh. In the particulate form these organisms can in turn be harvested by a higher form of animal life—for example, fish. Placing a fish population on top of the developing plant and invertebrate communities gains an additional increment of entropy so that organic loading brought on by primary production in the system in addition to that which is carried by the effluent waters (converting sun's energy to algae) can be eliminated or at least minimized. The fish might then be harvested to provide some economic gain in addition to the water reclamation function. (2) The universally used square or rectangular pond is highly inefficient insofar as pond volume having a working influence on the effluent is concerned. Marked "short-circuiting" occurs as evidenced by the fact that although the design "time of travel" for the Logan pond is six days, dye measurement showed that waste water entering the pond was arriving at the exit less than one day later. A free form design which brings a greater proportion of the pond into activity and at the same time provide a more pleasing structure from an aesthetic standpoint are obvious improvements.

Analyses also indicate that conventional design rationale is inefficient from a thermodynamic point of view. Again, the additional protoplasm created by the photosynthetic process offsets the degradation of waste BOD in the aerobic zone so the net energy degradation is zero. Thus, the anaerobic (deeper) zone must be a primary cause of net energy degradation that occurs. This suggests that sewage treatment ponds should be designed deep to maximize the anaerobic zone and with small surface area so that photosynthesis is just sufficient to provide a capping effect to minimize nuisance conditions. The brunt of the energy degradation would thus be carried by the anaerobic zone and not the aerobic

zone as is currently practiced. If verified in a definitive way, this concept of design would result in small deep ponds rather than the large unsightly and hydraulically inefficient ponds now constructed.

All of these results point toward very substantial improvements in efficiency and effectiveness of treatment ponds together with substantial savings in construction costs.

In an effort to approach water problems in a broader social realm the Utah Center at its start implemented a study of social and psychological factors in water resource development. Using the proposed Bear River Project as a prototype, some valuable insights into the process of decision for development of water resources have been identified. The character and usefulness of a social survey to determine the way the public feels has been analyzed and perfected. The objective is to illuminate those social aspects of water resource development and discover ways to give them proper weight and consideration within the planning mix. Funding has been far too limited to mount the kind of social science thrust that is needed.

While many more examples could be cited which demonstrate the effectiveness of the OWRR program the foregoing is quite typical of what is happening. Although less than 10% of the federal water research dollar has gone into this program (and the Center allocation component comprises only about 3%) the relative return is clearly great. Appropriations and expenditures for few federal programs come under the close scrutiny and justification as does water programs. Any objective appraisal must surely indicate that returns from federal investments in this program are returning substantial dividends in many ways. The increased funding proposed in S 3553 is certainly modest when one considers the added dimension of better research dissemination which will be initiated and the relative decline in research purchasing power of the \$100,000 allotment since the Act was first passed. The state Research Centers have solidified their programs. They have tried to maintain a research potential equal to the growing research needs. The increased funding provided in this legislation will strengthen the water research base and provide an increased measure of assurance that attainment of the nation's broad social goals will not be curtailed as the result of unsolved water problems.

STATEMENT OF DR. D. F. PETERSON, JR., IN SUPPORT OF S. 3553 TO AMEND
THE WATER RESOURCES RESEARCH ACT OF 1964

It has come to my attention that Hearings are to be held on July 20, 1970 regarding Senate Bill 3553 to amend the Water Resources Research Act of 1964. As chairman of the Utah Center for Water Resources Research, I would like to make a statement. I learned of the Hearings earlier this week in Switzerland where I am attending the meetings of the Coordinating Council for the International Hydrological Decade as Vice Chairman of the U.S. delegation at the request of the Department of State. This statement was drafted in Switzerland without access to my records and files and accordingly may be deficient in many respects. For this I apologize. I understand that some of my associates at Utah State University will also file statements which will doubtless be more fully documented.

I strongly urge your support for increasing the basic allotment to the Water Resources Centers. I believe the basic allotments made to the states under the Water Resources Research Act to be one of the most significant and certainly one of the least expensive actions taken by the Congress over the past two or three decades insofar as improving the use of our water resources and thereby our potential for improving the general environmental quality. At last the resources are available for a small handful of professionals to dedicate their careers on an ongoing basis to this important work at a level where the pervasive decisions are made in a context where they can also train students. This effort needs to be increased now if the momentum gained is to continue; indeed, if present levels are even to be maintained.

About one decade ago, national interest in developing and conserving our water resources reached a peak following the study made by the Senate Select Committee under Senator Kerr. Questions of the future of basic water supply, pollution of our streams and ground waters, conservation of waters for recreation purposes, and preservation of natural environments and protection from floods were quite unresolved. Since that time a number of actions at state and federal levels have been taken which have greatly clarified what the nature of

our water resources are, what future needs are likely to be and where the responsibilities lie. It is not intended to catalog the numerous actions of federal and state legislative bodies, but simply to point out that much has been done. The process is still going on.

One of the accomplishments during this period was to recognize more strongly than ever before the roles of the communities and states, as well as those of the federal government, in water resources management. There were those who strongly felt that, as in the space program, if there was an objective to be obtained, one simply made the decision, appropriated enough money and established an agency to get the job done. But water resource management cannot be done this way. The nation's policy is a sum of numerous decisions shared by individuals and communities in which states and the federal government provide guidance, standards; and, in the case of the federal government, where large sectors of the country or of society are involved, financing and action.

From the very beginning of this period of evolution, thoughtful scientists, engineers, and governmental executives were concerned about the adequacy of our water research base. Do we know enough about the basic nature of the resource? Do we know enough about the effects on the resource of man's myriad uses? Do we know what the physical and biological consequences resulting from man's usage of water resources are? What are the consequences of pollution and how can these be controlled? How does water resource development relate to society's economic and aesthetic aspirations? These and numerous other general and specific questions are raised at every level of decision making. These questions do not have single answers, but need to be answered in the context of changing times and differing climatic and geographical situations. Realization of this fact led to the concept of state Water Resource Research Institutes which could help solve the grassroots problems at local levels, as well as contribute to more general solutions of national interest. Outside the specific missions of the various federal agencies, a solution was the Water Resources Research Act now in force. This provided ongoing support within the university community by states and also provided funds by which research grants could be made to any agency, institution, or individual who might be judged to have the capability for making significant contributions. Among the advantages provided by this arrangement are the following:

The research base of the universities is utilized.

Some basic continuing support is provided.

Under the matching grant program, topics of national and regional interest are tackled by those most qualified.

Under the Title II program capability may be drawn from any sector of the country's research competence.

A capability for research is established at the grass roots level where many of the problems occur.

There is a natural and continuing relationship between the institutes and the state water agencies.

Training opportunities are optimized.

The results of the water resources research effort have been effective. Personally, I have closely followed the entire research program of the federal government in the water resources area since the early 1960's when I was first associated with the Office of Science and Technology of the Executive Office of the President; in considerable detail in 1965-66 when I served on the staff of the Science Adviser to the President and as Chairman of the Committee on Water Research of the Federal Council for Science and Technology; and again in 1968 and 1969 as Director of the Water for Peace Office when the United States made efforts to strengthen exchange of water resources science and technology with many countries. It is generally agreed (see the latest general report on the activities of the Office of Science and Technology) that the 150 million dollar water resources research program is probably the best coordinated and managed research program within the government. It is my own personal opinion that by and large, the 12 million dollar program of the Water Resource Institutes has had the greatest impact per dollar on the progress made in water resource development of any of the federal water research programs. I have observed the results of this effort broadly from many contacts throughout the country and I feel that I am very well qualified to speak on this point.

Over the past two decades, first as Head of the Civil Engineering Department at Colorado State University and later as Dean of the College of Engineering at Utah State University, I have had administrative responsibilities for research programs that extend to broader areas than water resources research;

i.e., broadly across electrical, mechanical, civil, and manufacturing engineering as well as water resources. From this vantage, I can testify again as to the effectiveness of water resources research under the institutes as compared with research in other areas of engineering and technology.

I would like now to turn from the foregoing general statement more specifically to the State of Utah. In 1959, recognizing the need for research information which would improve the planning and management of its own limited water resources, contribute generally to the country's knowledge in this area, and accelerate and increase the education of students in water resources, the legislature of the State of Utah authorized the Utah Water Research Laboratory. By 1965, using state funds but with partial support from the National Science Foundation and the National Institutes of Health for about 40 percent of the cost, the \$1,500,000 Utah Water Research Laboratory was dedicated. Some basic support (about \$200,000 per year) is provided by the State of Utah for that effort. Availability of funds under the Water Resources Research Act greatly strengthened the productivity of Utah State University in water research. Efforts were broadened to include a wide range of disciplines: sociology, ecology, range management, bacteriology, etc. as well as economics, hydrology, and engineering. State agencies have participated regularly in providing matching grant support under the Title IB arrangement thus insuring the early application of results in the state's water programs.

One of our problems has been the dissemination of research results. There is only one Water Resources Specialist on the general Extension Division staff. He has worked as closely as possible with the research personnel but demands on his time have placed limits on what he can do. While there is extensive dissemination of results of our research, these efforts need to be multiplied. In its program for FY 1971, the Council of the Utah Center for Water Resources Research examined and recommended 17 matching grant proposals. The Office of Water Resources Research was able to support only four although, I understand, all 17 were judged to be worthy of support. Some 15 new proposals, judged to hold promise for producing important and needed information, were examined by the Council of the Utah Center, but only two new ones could be initiated from the available allotment funds. Not only has the cost of doing research increased by nearly 50 percent since the Water Resources Research Act was passed, but there are new capabilities in the social sciences and life sciences which could make major contributions to the state and the nation through the Utah Center if additional basic funds could be provided. If we are to capture the continuing professional attention of scientists in these areas, some basic ongoing support is needed.

An increase in the allotment grant is therefore essential to this effort. There has to be a continuing source of funding if captable scientists are to be expected to dedicate their professional lives to water resources science. With such basic support, efforts can be multiplied by gifts, grants, and contracts for specific project research. Our experience is that this multiplication may be from 5 to 10 times. But unless there exist tenured researchers with laboratories and facilities; gifts, grants, and contracts can buy very little. Today, \$100,000 will not pay very many salaries.

Among the important contributions made by the Utah Center in the short history of its existence are the following:

For the first time in the country, as far as we know, a commitment was made to support research in sociological aspects of water resources on a continuing basis. This project has produced information which elucidates the problems involved in obtaining community and regional support for water resource projects of regional interest.

A low cost system of measuring at remote locations climatic variables of rainfall, snowfall, temperature, wind, etc. and transmitting the results at low-cost using radio devices has been developed. This has proven extremely useful, for example, among other things in conducting field research on snowfall enhancement in the Wasatch Mountains of Utah.

Significant assistance was rendered to the development of the draft water plan for the State of Utah through improved planning methodology and specific economic and hydrological research relative to the state's water plan.

A sophisticated analog modeling technique has been developed which is fully capable of predicting the changes in amount and time of runoff as the result of cultural or management changes on a watershed. This technique can be used generally.

Methods have been devised to decide on the optimal sequence in which water should be used for maximum efficiency.

A computer program has been developed in cooperation with the Office of Saline Water by which the benefit to a water supply, by using desalting plants as a supplemental source, can be evaluated both as to new firm water supplies provided and with regard to their cost.

Significant new information on the use of lagoons as a method for treating sewage has been developed. These have the promise to provide new levels of sewage treatment at greatly reduced costs under many circumstances.

Our Center has made significant contributions to means for predicting the effects of urbanization on the amount and time of runoff and its quality.

Methods have been devised to evaluate the benefits of recreational aspects of water resources projects; particularly from the use of reservoirs for fishing.

A means has been developed for presenting water resource data useful to design of streets, roads, storm sewers, and water supplies using information arranged in Atlas form. This has been specifically developed for the State of Utah and should help cities, counties, and consulting engineers to make judgments about needed capacity of drainage waters or availability of supplies where streamflow records are meager or unavailable. It is also useful in interpreting at relatively low cost, detailed available records.

Underway is a project which is studying the effects of institutional arrangements for managing water resources on the efficiency with which water is used.

In conclusion, I'm certainly aware of the present concern of our entire country on the general problems of environmental quality. I'd like to point out that water is one of the three elements of the physical environment; i.e., air, water, and earth. Our supply of fresh waters is more limited than either the air or the land and yet these receive much more than an equal share of the waste load of our country. A major impact on the quality of the total environment in the future can be made by wiser management of our fresh waters. We must deal with all elements of the environment, of course. But in our water resources program we are making and will continue to make, practical grass roots level decisions that will be of great importance to the general environment. There is no magic about this. These have to be made by individuals, communities, and states, as well as by the federal government. It is my opinion that the additional \$7,500,000 (approximate) requested in order to bring needed water resources research on a continuing basis widely across the country at the level where most of the decisions are being made, could have more effect on future environmental quality than dollars spent in any other way.

Senator Moss. Well, thank you, Dr. Bagley, for a very fine statement and for giving us some examples of the types of research done at Utah State, and for your expression of need for continuing the program.

With the sudden rise in the consciousness of everyone on pollution and preserving the environment, it would follow that one of the places we would have to step up our efforts would be in water research, because water is essential to all ecology.

Thank you very much. We appreciate it.

Mr. BAGLEY. Thank you.

Senator MOSS. Mr. Dale Anderson, director of Water Resources Institute of North Dakota State University.

We are glad to have you here, Mr. Anderson. We look forward to hearing from you.

STATEMENT OF DALE O. ANDERSON, DIRECTOR, NORTH DAKOTA WATER RESOURCES RESEARCH INSTITUTE, NORTH DAKOTA STATE UNIVERSITY, FARGO, N. DAK.

Mr. ANDERSON. Thank you, Mr. Chairman.

It is a real pleasure on behalf of the North Dakota Water Resources Research Institute to take part in this hearing and to present some of the views as we see it relative to the allotment program, what it has done to the water resources research program in North Dakota and some of the things as we view them in the future.

Now, I will not incorporate, or will not discuss all of my comments orally. You have a copy of the written testimony.

Senator Moss. It will go in the record. We will be glad to hear your summary.

Mr. ANDERSON. I will highlight some of the points and add a couple of additional points that are not in the paper.

Senator Moss. Thank you.

Mr. ANDERSON. I might add that the Governor of North Dakota, the Honorable William L. Guy, who is chairman of the National Governor's Conference Natural Resources Committee has sent a letter to the Honorable Senator Jackson, chairman of the Interior and Insular Affairs Committee, supporting this amendment, and some documentary comments relative to this, and they will also be included in the record, I assume.

Senator Moss. We have some letters from other Governors, including Gov. Calvin Rampton of my State, and those letters will all be reproduced in the record at one point.

Mr. ANDERSON. As is indicated in the testimony, I am the director of the North Dakota Water Resources Research Institute, and the North Dakota Water Resources Research Institute was made possible in North Dakota by passage of Public Law 88-379.

Now, based on this law, the water resources research institute was authorized by official action of the North Dakota State Board of Higher Education in 1964. The water resources research institute is operated on a partnership basis between North Dakota State University in Fargo and the University of North Dakota at Grand Forks. Headquarters for the water resources research institute was established at North Dakota State University.

The program of the institute is, in addition to myself as director, is administered by a six-man executive committee, faculty members, three from the University of North Dakota and three faculty members from North Dakota State University. In addition we have a 35-man State advisory committee which is made up of officials in private agencies and State and Federal agencies of government which are involved in the water resources field.

The primary purpose of the North Dakota Water Resources Research Institute is to promote and aid in the development of viable research and educational activities related to development and management of water resources in North Dakota, the region, and the Nation. The program of the water resources research institute encourages competent research of a basic and applied nature as related to water resources.

These activities are fostered in an effort to enhance economic growth and increase human welfare of North Dakota and its people, the region, and the Nation.

The program of the North Dakota Water Resources Research Institute has been developed in cooperation with a statewide advisory committee. The research results of this program have been used by State and Federal agencies and private groups in achieving their objectives in the water resources management and conservation field.

Water, in my opinion, is the key to resources development and economic growth in North Dakota, throughout the Nation, but particularly in rural areas.

I also believe that the solution to many of the problems that face our large metropolitan area is going to depend upon a strong rural community and a rural economy, and it is, therefore, very important that our research be directed toward the use, management, and conservation of water resources in our rural areas.

I have listed in the written testimony several examples of types of research that have been conducted at North Dakota and the application of some of these results. I want to mention two or three of them to highlight them in our comments.

A limited amount of irrigation from the Garrison diversion irrigation project is expected to take place in the next 5 years. Research supported by the institute in part, both completed and in progress, has provided and will continue to provide much needed information for the transition from dryland to irrigated agriculture.

A planning model for biological, physical, and climatic conditions was developed in one project. This model will make it possible to provide farmers with recommendations as to the appropriate irrigation system design and associated management schemes for a given set of land and capital resources as well as expected weather conditions and the types of crops to be irrigated.

The results of this study are being used in irrigation workshops for farmers, professional meetings in the United States and Canada, and by farmers and farm advisers planning for future irrigation development in North Dakota. The results of this study are applicable on a regional basis for irrigation development in a subhumid climate.

Quantification of the economic impact of water development is vitally important to decisionmakers in appropriating tax dollars among various projects and programs. Two projects, funded through the Institute, were designed specifically to measure the economic impact of irrigation development in North Dakota. The result of these studies indicate that the multiplier effect of additional income in crops production and livestock production in North Dakota were 3 and 3.33 respectively.

These multipliers make it possible to estimate the indirect income changes in the local economy from irrigation development. The results of this study have been used by farm groups, local business groups, and private and State officials in making plans for the expected increase in economic activity expected to be generated when the first phase of the Garrison Diversion Irrigation project becomes fully developed.

A problem of particular concern to the prairie pothole region of the United States, and particularly North Dakota, is a feasible wetlands management system. Considerable controversy has developed over the

balance between soil conservation and use, and water fowl conservation use. A pilot investigation was initiated by the Institute to find means of improving public understanding of the complex problems as associated with unified water management planning and implementation in certain North Dakota watersheds.

The results of this investigation seemed to serve as a need catalyst in the process of getting plans translated finally into basic action. Results of this study provided the basis for developing the Water Bank Act, which has been and is considered in the Congress at the present time as Senate bill 2257.

The establishment of the Water Resources Research Institute in North Dakota has substantially increased the emphasis on water resources research. Since May of 1965, when the first projects were funded, 29 annual allotment projects have been funded and six matching grant projects have been funded. This has involved 34 scientists as principal investigators and 16 graduate students have completed degrees, 10 for the master of science degree and six for the doctor of philosophy degree.

Many of these men have taken employment with agencies wherein they are professionally employed in water resources research and water conservation. And I might add at this point similar to Dr. Maxey's comments this morning that all but three of these people have taken jobs somewhere outside of North Dakota. So the training that has been done in North Dakota actually is being transferred to other areas of the United States which the total United States benefits from.

This training function is vitally important to provide highly trained and interested graduates for important water-related jobs of the future. Additional funding is necessary to maintain and expand the training function in the water resources field.

Effective communications will be an essential characteristic of a viable water resources program for the seventies. One major area of concern is the communication of ideas relating to the existence of water-related problems and the presentation of possible alternative solutions to these problems to the general public.

The acceptance of action programs by the public is largely determined by the extent to which the public (1) is aware this problem exists, (2) believes that the problems present a threat to the community of the well-being of the community, and (3) believes that the corrected action is possible and practical.

The water resources research program has established itself as an important research organizational unit within the university system. Although the program has been in operation for a relatively short period of time, the institute is now firmly established and the output resulting from the expenditure of funds is now being realized. Although research is conducted, its results obtained, and these results reported in various reports, the real payoff of the research dollar is not realized until the potential users have benefited from these results. A catalyst is necessary to place increased emphasis for higher priority on interpretation and dissemination of research results, to provide effective use of the research results for which the public has been willing to expend money for their solutions.

Only when this step is accomplished will the final payoff of the research expenditure be realized. The institutes as organized have been

developed around water and, as such, provide an effective means of conducting research, education, and research dissemination, and interpretation programs. Water is an organizing concept. It is not a discipline or field of interest, but rather a physical commodity or resource known to all.

Consequently, institutes are more effective in organizing and carrying out multidisciplinary research programs. They are not operated within the context of a college or a department and as such can bring together the many different disciplines into an effective and productive research program. The cost of conducting and publishing research has increased significantly since the Water Resources Research Act was passed in 1964, and many references to this have been documented in earlier testimony.

Although the water resources research is well underway, we have merely scratched the surface on pressing water problems in North Dakota. The program of the North Dakota water resources research program for the next 5 years will be centered around the following major problem areas: biological and environmental aspects of water resources; engineering aspects of water resources; hydrological aspects of water resources; and socioeconomic legal and political aspects of water resources development and use.

There are many problems in each of these major categories. The development of research programs to find solutions to these problems will be greatly influenced by the availability of additional financial support to the annual allotment program.

The dissemination of research results must have additional financial support to influence a redirection of priorities in present programs or provide additional manpower.

The dissemination and interpretation of these research results would be done through an existing cooperative extension program as well as overall university extension system.

I have appreciated this opportunity to appear before this subcommittee to discuss with you my views on the need for additional research support in the water resources field.

In order to develop a research program adequate to find solutions to water quality and quantity problems that now and will continue to face the Nation, it is urgent that this amendment be passed. I strongly urge this committee to report Senate bill 3553 for passage.

Thank you for your time.

(The complete prepared statement of Mr. Anderson, above referred to, follows:)

STATEMENT OF DALE O. ANDERSON, NORTH DAKOTA WATER RESOURCES RESEARCH INSTITUTE, NORTH DAKOTA STATE UNIVERSITY, FARGO, N. DAK.

My name is Dale O. Anderson. I am Director of the North Dakota Water Resources Research Institute, headquartered at North Dakota State University, Fargo, North Dakota. I also hold the rank of Professor of Agricultural Economics.

I joined the staff of the Agricultural Economics Department at North Dakota State University as an assistant professor of September 1, 1963. I was responsible for developing and carrying out an active teaching and research program in Natural Resources Economics and Production Economics and Farm Management. I was appointed Director of the North Dakota Water Resources Research Institute on September 1, 1968.

I hold the degree of Bachelor of Science from North Dakota State University in 1959; Master of Science in Agricultural Economics from North Dakota State

University in 1960; and Doctor of Philosophy from Oklahoma State University in 1965. The title of my Ph. D. dissertation was "The Value of Irrigation Water in the Washita River Basin in Roger Mills County, Oklahoma."

The major portion of my teaching and research experience has been in the broad area of production and natural resource economics. I have published several reports and presented papers at several conferences and educational meetings on the subject of water and related natural resources. I co-authored a chapter entitled, "Water is Always a Critical Factor," in the 1963 yearbook of agriculture entitled "A Place to Live."

The Water Resources Research Institute was made possible in North Dakota by the Congress of the United States through passage of Public Law 88-379, "The Water Resources Research Act of 1964." Based on this law, the Water Resources Research Institute was authorized by official action of the North Dakota State Board of Higher Education in 1964. The Water Resources Research Institute is operated on a partnership basis between North Dakota State University in Fargo and the University of North Dakota at Grand Forks. Headquarters for the Water Resources Research Institute was established at North Dakota State University at Fargo.

The primary purpose of the North Dakota Water Resources Research Institute is to promote and aid in the development of viable research and educational activities related to development and management of water resources in North Dakota, the region, and the nation. The program of the Water Resources Research Institute encourages competent research of a basic and applied nature as related to water resources. These activities are fostered in an effort to enhance economic growth and increase human welfare of North Dakota and its people.

Various state and Federal agencies have the responsibilities to develop and implement plans for effective water resource development and use in an effort to enhance the economic growth of North Dakota and provide a high quality environment for its people. The development of an imaginative forward-looking research program providing vital development and planning information is essential to the formulation to sound decisions for development and implementing effective water use programs. The North Dakota Water Resources Research Institute has provided the catalyst to initiate and carry out a considerable amount of much needed research on problems related to water development, conservation, and use in North Dakota.

Water is the key to resources development and economic growth in North Dakota. The economy of the State depends mainly on income generated by the agricultural sector, with income from recreation being a distant second. Whatever is done to develop the resources of North Dakota in an effort to expand employment opportunities and general economic activity, whether through industry, recreation, agriculture or other, it will be built on land and depend on water. Although North Dakota is endowed with relatively abundant supplies of water, much of it is undeveloped for productive purposes. In order to make certain that an adequate supply of high quality water is available for future use, a long range program of research and continuing education is necessary. Research and planning are, therefore, necessary in order to provide water for agricultural, recreational, municipal and industrial uses.

Current water problems in North Dakota relate largely to the development, conservation and management of agricultural uses of water. A limited amount of irrigation from the Garrison Diversion Irrigation Project is expected to take place in the next five years. Research supported by the Institute in part, both completed and in progress, has provided and will continue to provide much needed information for the transition from dryland to irrigated agriculture. A planning model for biological, physical and climatic conditions was developed in one project. This model will make it possible to provide farmers with recommendations as to the appropriate irrigation system design and associated management scheme for a given set of land and capital resources as well as expected weather conditions and the types of crops to be irrigated. The results of this study are being used in irrigation workshops for farmers, professional meetings in the United States and Canada, and by farmers and farmer advisors planning for future irrigation development in North Dakota. The results of this study are applicable on a regional basis for irrigation development in a sub-humid climate.

Another project investigated the effect of water quality and management on the physical and chemical properties of selected soils under irrigation in North Dakota. The results of this study are being used in making recommendations on

minimum standards of water quality for irrigation given the chemical and physical properties of the soil to be irrigated. The results of this study are also being used in making recommendations on the land management system that are appropriate for irrigation development in North Dakota.

Quantification of the economic impact of water development is vitally important to decision makers in appropriating tax dollars among various projects and programs. Two projects, funded through the Institute, were designed specifically to measure the economic impact of irrigation development in North Dakota. The results of these studies indicate that the multiplier effect of additional income in crops production and livestock production in North Dakota were 3.0 and 3.3 respectively. These multipliers make it possible to estimate the indirect income changes in the local economy from irrigation development. An expected \$12,979,000 increase in agricultural income resulting from irrigation from the first phase of the Garrison Diversion project will result in additional income of \$28,184,000 in the local economy. Based on these multipliers, the total impact of the local economy from the \$12,979,000 directly generated from irrigation development was estimated to be \$41,163,000. The expected distribution of this income among the 30 sectors of the local economy was also identified. The results of this study have been used by farm groups, local business groups, and private and state officials in making plans for the expected increase in economic activity expected to be generated when the first phase of the Garrison Diversion Irrigation Project becomes fully developed.

A problem of particular concern to the prairie pothole region of the United States and particularly North Dakota, is a feasible wetlands management system. Considerable controversy has developed over the balance between soil conservation and use, and waterfowl conservation use. A pilot investigation was initiated by the Institute to find means of improving public understanding of the complex problems as associated with unified water management planning and implementation in certain North Dakota watersheds. The results of this investigation seemed to serve as a needed catalyst in the process of getting plans translated finally into basic action. Results of this study provided the basis for developing the "Water Bank Act," (S. 2257).

Another study supported in part by the Institute was designed to investigate the relationships of bottom soil profiles in Type I and Type III of wetlands of North Dakota. The results of this study are being used in developing guidelines for determining the proper capabilities, use and management of these important wetland habitats in North Dakota.

The first phase of the Garrison Diversion Irrigation Project will direct water for the restoration of Devils Lake. This was a deep fresh water lake which provided excellent fishing, habitat for waterfowl and other water based recreation. The depth of Devils Lake has dropped as much as 40 feet. This has resulted in a highly saline water lake of essentially no value. There have been no game fish in the lake for over 60 years.

Saline water from Devils Lake chain will be discharged into the Sheyenne River. This will have a depressing effect on the fish population during the flushing period. The stream to Lake Ashtabula will be essentially worthless for several years following the start of the outflow from the Devils Lake chain.

House Document No. 325 reporting on the Garrison Diversion unit reports the following:

"Data are insufficient to determine the effect of the inflow of low quality water on fishing in Lake Ashtabula, but there probably will be some depressing effect during the years of flushing of the Devils Lake chain."

Intensive study is needed to measure the impact of the proposed restoration of Devils Lake and Stump Lake on the water quality in the Sheyenne and Red River valleys. Several projects have been initiated which provide considerable information as to possible approaches to the restoration of this lake and minimizing the salinity levels in surrounding areas. Projects completed and in the process have provided and will continue to provide much useful data for future planning relative to the restoration of Devils Lake and the resulting economic social and institutional impact to the area and North Dakota. A significant amount of intensive research must yet be accomplished in a short period of time. Time is becoming extremely critical to the optimum development of this important future recreational area and its impact on interrelated areas.

Effective management of game and fish is vitally important to the recreational and aesthetic values in North Dakota. Several projects provide information useful to game and fish managers in the development of management systems.

A study currently in progress will develop a workable model for a waterfowl and wildlife management system in North Dakota. The model for wildlife management systems will apply particularly to irrigation projects. Research on environmental factors influencing egg survival of various species of fish serves as a basis for developing management systems relative to water quality in lakes for optimum survival of various species of fish. Development of fish management systems is particularly important to the inland water bodies in North Dakota. These inland water bodies represent the major area of water based recreation in North Dakota.

The establishment of the Water Resources Research Institute in North Dakota has substantially increased the emphasis on water resources research. The Institute first received funding in May of 1965. Since that time, 29 annual allotment projects and six matching grant projects have been funded. These projects have supported 34 scientists as principal investigators. In most cases, financial resources would not have been available to these scientists to conduct work in the water resources field without the water resources research program. The program has also provided financial support for 16 graduate students who have completed the Master of Science or Doctor of Philosophy degrees. Many of these men have taken employment with agencies wherein they are professionally employed in water resources research and conservation. In addition, approximately 125 graduate students have been involved in the conduct of research in various projects supported by the Institute. This training function is vitally important to providing highly trained and interested graduates for important water related jobs of the future.

The water resources research program has stimulated State expenditures in research on water problems. During the period covering the fiscal year of 1966-1969, the State contributed \$189,000 to the annual allotment program and \$140,000 to the matching grant program. It is anticipated that the contribution by the State of North Dakota will increase in the future.

Problems related to water development and management area constitute a problem of daily concern for those who work directly in man's attempt to manipulate his resources. For the general public, however, water is taken more or less for granted as being given in its environment. The North Dakota Water Resources Research Institute, created as a result of the passage of Public Law 88-379, has made a significant contribution to the creation of an environment of awareness of the citizens of North Dakota about the critical importance of water to the future economic survival of this state.

This increasing awareness is evidenced by a significant increase in requests for information, publications and speaking engagements that have been directed to the Office of the Director. Effective communications will be an essential characteristic of a viable water resources program for the 70's. One major area of concern is the communication of ideas relating to the existence of water related problems and the presentation of possible alternative solutions to these problems to the general public. Continuing education programs are extremely important as a vehicle to expedite the acceptance of proposed programs to solve water problems. The official who recognizes various water problems, present and potential, may be perplexed by public apathy toward a problem that is very important to him. Furthermore, the official responsible to educate the public concerning water problems is often frustrated by the seeming refusals of the public to seriously entertain the expert's definition of a water problem. This problem of public perception of water as a natural right of man and the lack of willingness on the part of the public to view water as a resource associated with problems makes it very difficult to introduce and implement various action programs which he may view as necessary to conserve and utilize present and future water resources. The acceptance of action programs by the public is largely determined by the extent to which the public 1) is aware that a problem exists, 2) believes that the problems present a threat to the community or the well being of the community, and 3) believes that corrected action is possible and practical.

The water resources research program has established itself as an important research organizational unit within the university system. Although the program has been in operation for a relatively short period of time, the institute is now firmly established and the output resulting from the expenditure of funds is now being realized. Although research is conducted; results obtained; and these results reported in various research reports, the real payoff of the research dollar is not realized until the potential users have benefited through the recognition of a solution to a problem. A catalyst is necessary to place increased emphasis or higher priority on dissemination of research results.

Emphasis should be placed on the development of continuing education programs with the general public and others to provide effective use of the research results for which the public has been willing to expend money for their solutions. Only when this step is accomplished will the final payoff of the research expenditure be realized.

The cost of conducting and publishing research has increased significantly since the water resources research act was passed in 1964. Although the water resources research program is well underway, we have merely scratched the surface on pressing water problems in North Dakota. The program of the North Dakota Water Resources Research program for the next five years will be centered around the following major water problem areas: 1) biological and environmental aspects of water resources; 2) engineering aspects of water resources; 3) hydrological aspects of water resources, and 4) socio-economic, legal and political aspects of water resources. There are many problem areas in each of these major categories. Development of research programs to find solutions to these problems will be greatly influenced by the added financial support to the annual allotment program.

The dissemination of research results must have additional financial support to influence a redirection of priorities in present programs or provide additional manpower.

In order to develop a research program adequate to find solutions to water quality and quantity problems that now and will continue to face the nation, it is urgent that this amendment be passed. I strongly urge this Committee to report Senate Bill 3553 for passage.

Senator Moss. Thank you, Mr. Anderson.

That was a very fine statement and gave us a rather good view of what you are doing in North Dakota with the Water Resources Research Institute.

I was interested because I know something of your problems—not in depth. But in talking about the Garrison project that we have had before us over a long period of time and finally moved ahead on, the problem of whether to drain your potholes or whether to let ducks grow has been one that we have been puzzled about. By pointing out the considerable change which will be made in your economy—by bringing in irrigation water you are preparing those who will be part of that change when the irrigation water becomes available.

All of these are of great interest to us, along with the general needs of water purity and water distribution that are universal.

Mr. ANDERSON. I might add, Mr. Chairman, that there is a considerable amount of research that we are doing in the water quality and some of the biological aspects that I did not mention in my comments. I just wanted to highlight some of what I consider to be the most important uses of our research results at this time.

Senator Moss. Thank you very much.

Mr. ANDERSON. Thank you.

Senator Moss. Mr. Charles Horsky, Vice Chairman of the District of Columbia Board of Higher Education.

Very glad to have you, Mr. Horsky.

STATEMENT OF CHARLES HORSKY, VICE CHAIRMAN, DISTRICT OF COLUMBIA BOARD OF HIGHER EDUCATION; ACCOMPANIED BY EDWIN WISE, CORPORATION COUNSEL'S OFFICE, DISTRICT OF COLUMBIA

Mr. HORSKY. May I introduce, Mr. Chairman, Mr. Edwin Wise from the Corporation Counsel's Office of the District of Columbia—

Senator Moss. Very glad to have you, sir.

Mr. HORSKY (continuing). To my right, and Dr. Harland Randolph, who has a statement of his own, which I hope you receive after I have talked, who is the president of Federal City College.

Senator Moss. Dr. Randolph, we are glad to have you, sir.

Mr. HORSKY. I think I can perhaps be most helpful, Mr. Chairman, if I give you a bit of the background for the position of the Board of Higher Education on S. 1051.

Our position in brief is that section 1 of the bill which would add the District of Columbia to the list of beneficiaries under section 100 of the 1964 act is excellent. Section 2, which would specify the people in the District of Columbia to whom the funds should go, we would like to have omitted from the final bill.

I suppose that the reason that the District was not included in 1964 was that at that point in time there was no land-grant college in the District which would be the normal recipient of these grants.

In 1966, in the latter part of 1966, Congress created a Board of Higher Education and authorized it to establish a college for the District of Columbia which was named in the bill as the Federal City College.

In 1968, Congress by specific action created the Federal City College in a land-grant college. I think the first urban land-grant college in the country. And the college opened its doors in 1968, and has been functioning since with Dr. Randolph now as its president.

The District of Columbia College, the Federal City College, is a college to which most of the residents of the District now are able to attend. The consortium which is named in the bill, consisting of American University, Catholic University, Georgetown, George Washington, and Howard, is a group of so-called national universities. They do not draw their student body largely from the District.

Howard has more than the others, but even Howard's representation of District residents is minimal. District residents get no particular preference at either Howard or any of the others.

Federal City College, on the other hand, has approximately 98 percent District residents. And it seems to us on the Board of Higher Education that it is only appropriate that it as a land-grant college should be the recipient of these funds. Indeed, it would be a departure from the normal course as is specified in the legislation if it were not, and it, I think, would have to be supported by fairly weighty reasons which do not exist.

Particularly, I would like to emphasize two aspects that are important to us. The first is that it will strengthen, it will enable us to strengthen the science and engineering, natural sciences division of the college as it continues to grow. The creation of an institute of this sort would give a focus for the kind of activity which the college would like to engage in.

It is designed to be, and hopes to be, an urban problem-solving institution, and it is this kind of problem that it is particularly anxious to undertake.

And the second and most important, perhaps because of the emphasis that other witnesses have made on the training of people, both students and faculty in water resources problems, that giving or allocating these grants, these funds, to Federal City College will provide an opportunity for District residents to have the advantage of train-

ing that this kind of research will provide, both in the faculty and in the student body.

I should add one other fact before I turn the matter over to Dr. Randolph, who will give you much more specifics of the college to undertake this, and that is, lest you be concerned, the consortium does not admit Federal City College to membership, so that the allocation as it is contained in 1051 could exclude Federal City College.

On the other hand, as other witnesses have pointed out to you, the designation of Federal City College will not prevent the utilization to the Federal City College of any extraordinary capacities or resources that do exist in the other schools here in the District which may be called upon to assist in the institute which will be set up.

With that and with one further request, that you include in your list of Governors' letters the letter from Mayor Washington to Senator Jackson, dated, I think, March 13, endorsing the position that I have just taken, I would like to ask Dr. Randolph to continue.

Senator Moss. Thank you. The letter from Mayor Washington will be included, and we appreciate that very much.

Dr. Randolph, we will be glad to hear from you now, sir.

STATEMENT OF HARLAND RANDOLPH, PRESIDENT, FEDERAL CITY COLLEGE

Mr. RANDOLPH. I have a very brief statement.

I am Harland Randolph, president of Federal City College, the State, land-grant institution of higher education for the District of Columbia.

I support S. 3553 and section 1 of S. 1051. I am requesting that these sections be passed and that section 2 of S. 1052 be changed to conform with the recommendations of the Department of the Interior, the District of Columbia government, the Board of Higher Education, and the Federal City College community.

The requested change in S. 1051 would name Federal City College as the institution to receive funds under the act.

That is the essential position.

Of course, I request that the statement be entered in the record.

Senator Moss. The entire statement will go in the record in full, and you may direct attention to any part you feel you want to.

Mr. RANDOLPH. All right. I direct attention to page 2, starting with the third paragraph.

These are reasons why I feel that Federal City College should be so named in the legislation.

1. We are the land-grant institution.
2. We are committed to meeting the needs of the District of Columbia.
3. If given the resources, we can develop capability equal to that of any of the other 51 States in this area; and
4. We presently have staff and capability available to initiate this program.
5. Federal City College has at present the kind of working relationships with residents of the District of Columbia that will facilitate the communication and citizen education involvement that this bill is deeply concerned with.

Now, assuming the subcommittee were to give us a favorable nod on our request, the college is prepared to take the following action immediately.

1. To appoint a task force to move for the establishment of this institute or center.

2. To conduct a survey of existing institutes to determine what aspects are most effective and should be included in the one for the District of Columbia.

3. To recruit a top level person as director; and

4. To make available either on a manhour overload or released time basis staff at the college and to secure the same from the District Government of Specialists who in fact can initiate this activity in Federal City College at a high quality.

(The prepared statement of Mr. Randolph follows:)

STATEMENT OF HARLAND RANDOLPH, PRESIDENT, FEDERAL CITY COLLEGE

I am Harland Randolph, President of Federal City College, the state, land-grant institution of higher education for the District of Columbia.

I support S. 3553 and section 1 of S. 1051. I am requesting that these sections be passed and that section 2 of S. 1051 be changed to conform with the recommendations of the Department of Interior, the District of Columbia Government, the Board of Higher Education and the Federal City College community.

The requested change in S. 1051 would name Federal City College as the institution to receive funds under the act.

The District of Columbia has serious water resource problems and the research made available by this legislation would provide significant assistance to finding solutions to these problems.

The following are a few of the major water resource problems that are facing the government and residents of the nation's capital:

1. What is the best plan for water re-usage in view of the proposed advanced water treatment and control plant?

2. How can more effective use be made of the Potomac River, i.e., cleaning, pollution, conservation, recreation, dams?

3. How should situations where severe water shortages occur be handled? This condition existed in 1968 and can occur again.

4. What are the legal and social problems of water usage and how can control be handled on a metropolitan basis?

5. What are the costs/benefits of recreational uses of water in connection with housing developments and how can this resource be used to improve the quality of human life in urban areas?

6. How can citizens of the District be both educated about and involved in the more effective use of their water resources?

7. How can the District rapidly develop the trained and professional manpower required to deal with problems of water resources and research?

These are just a few of the priority problems. They argue for support of S. 3553 and S. 1051.

In requesting that section 2 of S. 1051 be changed, the College has considered its brief history. While we have not fully developed in all areas typically associated with a state university, each day we receive more and more requests and demands that we fulfill these functions. Research on various problems of the state is one function that the College has and will continue to assume. Given the resources, we have demonstrated the ability to rapidly respond at a level of quality to the needs of the District. Federal City College can effectively carry out the requirements of the legislation.

We are asking that section 2 of S. 1051 be changed for the following reasons:

1. We are the Land Grant Institution of higher education for the District of Columbia and, as such, are entitled to receive the funds. The District Government, the counterpart of the states' operational authority, supports this recommendation.

2. The Federal City College, more than any other university within the District, is committed to meeting the needs of the District and to providing and using resources to assist the District in solving its urban problems; water is one of the urgent problems.

3. Although the College does not have an existing program of research in water resources, it can, just as the other land grant colleges, develop this capability if given the resources.

4. The Federal City College does have the base on which to initiate this research function. We have three members of the faculty who are presently teaching and researching in environmental ecology. They hold doctorates from the California Institute of Technology, Ohio State University and the Massachusetts Institute of Technology. In addition, the College has the cooperation of the District Government's Offices of Human Resources and Water Services. If necessary, given the fund, the College can, in accordance with established practice, contract with other universities where special expertise is necessary.

5. The Federal City College, in its short history, has established in-depth and continuing working contacts with the residents of the District that are equal to and, in many cases, superior to the contacts of other universities. We are the "state university for the District."

If this sub-committee acts favorably upon the request, the College is prepared to take the following actions to ensure that once the funds become available the program can become immediately active:

1. A task force to determine the scope and character of the Water Resource Research Institute would be established. This task force would include persons from the College, the District Government and outstanding authorities.

2. Conduct a survey of the existing and planned institutes in order to develop an institute which includes the best features of what is effective.

3. Recruit a top level person as Director of the institute.

4. Use our limited available resources by means of either man hour overload or released time to start basic cooperation between the College, District Government and residents of the nation's capital.

The College Administration, the Board of Higher Education, the District Government and Department of Interior agree in asking that section 2 of S. 1051 be changed, naming Federal City College as the institution to administer the funds.

This action will allow section 2 to conform with the existing legislation and will assist the College in meeting its responsibilities to the residents of the District.

Senator Moss. Thank you, Dr. Randolph. I am glad to have you detail the steps that you would be prepared to take immediately if the Federal City College were designated as the center or the institute here for the District of Columbia. I think you and Dr. Horsky both make a good case for choosing the Federal City College.

Senator Bible is not here this afternoon, but I rather took from what he said this morning that the bill as originally drawn more or less presupposed that there was not yet in existence a land-grant school here, and therefore the consortium approach was used. And as you point out, Mr. Horsky, that is not the normal thing to do.

Mr. HORSKY. That's right.

Senator Moss. There are other consortiums in other areas of our country, but we have so far centered assistance on one institution which has been, with one minor exception, the State University Land-Grant College. So this fits very well into the pattern.

I don't have any further questions, and I thank you—do you have any comments, sir?

Mr. WISE. Just one comment, Mr. Chairman. We do have a letter regarding the rationale of the District's policy in this regard, and it is a letter dated July 17, 1970, from the Assistant to the Commissioner, Graham W. Watt, to the Chairman of the full committee. I request it be placed in the record at this time.

Senator Moss. It will be placed in the record at this point. We will be glad to have that, too.

(The document above-referred to, follows:)

GOVERNMENT OF THE DISTRICT OF COLUMBIA,
EXECUTIVE OFFICE,
Washington, D.C., July 17, 1970.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR SENATOR JACKSON: The Commissioner of the District of Columbia desires to report on S. 1051, a bill "To amend the Water Resources Research Act of 1964."

The bill would amend the Water Resources Research Act of 1964 (Public Law 88-379; 78 Stat. 329) to include the District of Columbia within its provisions. The bill would also provide that the Consortium of Universities of the Washington Metropolitan Area be authorized to receive grants under the Act to assist in establishing and carrying out the work of a competent, qualified water resources research institute or equivalent agency in the District of Columbia.

The Water Resources Research Act of 1964 provides that the appropriations available to the States under that Act will go to the land grant college or university in the State. If a State has more than one land grant institution, the Governor will designate which institution shall receive the funds. The Act also provides that the land grant institution may arrange with other colleges and universities within the State to cooperate in the programs provided under the Act.

The Federal City College has been designated as a land grant institution in the District of Columbia (Act approved June 20, 1968; Public Law 90-354). Ordinarily, the Federal City College would be the recipient of any appropriations under the Water Resources Research Act of 1964. However, S. 1051 would amend this Act to designate the Consortium of Universities of the Washington Metropolitan Area as the recipient rather than Federal City College. Federal City College is not a member of the Consortium. The Commissioner believes that S. 1051 should be modified by removing the designation of the Consortium and allowing the same provisions to apply as apply in the original Act; namely, that the local land grant college receive the funds. In this regard, the Board of Higher Education which has responsibility for Federal City College has expressed a great interest in this area of research.

If S. 1051 is modified as suggested above, the Federal City College would be free to invite other colleges and universities in the area to participate in the grant programs. However, the bill as now drafted would make the Consortium the sole recipient.

The Commissioner therefore recommends that section 2 of S. 1051 be deleted. With such a modification, the Commissioner favors enactment of the bill.

The Commissioner of the District of Columbia has been advised by the Bureau of the Budget that, from the standpoint of the Administration's program, there is no objection to the submission of this report to the Congress.

Sincerely yours,

GRAHAM W. WATT,
Assistant to the Commissioner.
FOR WALTER E. WASHINGTON,
Commissioner.

Senator Moss. Thank you very much, gentlemen.

Mr. Dale Mallicoat, who represents the Governor of Oregon.

Would you come forward, please, Mr. Mallicoat.

STATEMENT OF DALE MALLICOAT, ADMINISTRATIVE ASSISTANT
TO HON. TOM McCALL, GOVERNOR OF THE STATE OF OREGON

Mr. MALLICOAT. Thank you, Mr. Chairman.

My name is Dale Mallicoat. I am administrative assistant to Governor Tom McCall of Oregon, and I operate our Washington, D.C., State office. Governor McCall has asked me to present a two-part statement to you. My testimony consists of the Governor's brief sum-

mary of his support of the measure, plus a more detailed report entitled, "The Universities and Oregon's Water Resources," which I will not read but which I hope will be incorporated into the record of this committee's proceedings.

Senator MOSS. It will be in the record in full.

Mr. MALLICOAT. The Governor's statement is as follows:

I strongly urge passage of Senate bill S. 3553, which seeks to amend the Water Resources Research Act of 1964. It is essential that the annual allotment to the Water Resources Research Institute or Center in each State be increased to \$250,000. The amount of research and training which can be conducted with the present amount has been greatly reduced by rising costs. Of equal importance is the second objective of the measure to provide for proper interpretation and dissemination of research findings by the institutes or centers.

The Institute of Oregon State University, since its birth in 1960, under the Administration of Governor Mark Hatfield, has worked closely with State agencies in helping to solve problems in water resources development and protection. It has done so by mustering the many skills available on several campuses—skills represented by both physical and social scientists. Proper attention to ecological factors requires this mixture of disciplines available in the required numbers only in the academic world.

Our State has benefited directly from research projects and related training conducted by the Institute with funds from the annual allotment. For example, Institute research has led to specific recommendations regarding the numerous types of water management districts. Other studies are helping to set standards for proper road-building, logging practices, and stream management so as to reduce or control water pollution. Among the current investigations which are expected to be of great assistance to government agencies are a survey of Oregon's lakes to determine their recreational status and a comprehensive survey of Oregon water law.

However, expanded research is required in several areas and this can only be accomplished by increased funding. Those Divisions of State Government charged with managing, developing and protecting our natural resources need to know a lot more about estuaries and their preservation. The increasing conflicts over multiple uses of water demand closer attention to social and cultural impacts of proposed developments. Water rights and property rights along Oregon's streams and rivers, as well as coastal areas, are in dispute and require careful study. There are many other problems which are present in major areas of water supply, water quality, and water resource institutions. The extent to which we can call upon the Institute and its faculty affiliates to address their efforts to this long list of problems is contingent upon an increased allotment.

Obviously, research and education alone cannot solve water problems, but they can provide the knowledge necessary to understand the problems and suggest possible solutions. It is vital that those charged with responsibilities in the field of water resources recognize the human and social aspects as well as the technical factors. The Institute represents an ideal tool for focusing the required talents on State and regional problems.

It is not enough, however, to enable institutes to expand their research and educational programs. They must also be franchised to communicate results more effectively. Added funds would permit Oregon's Institute to conduct more short courses, symposiums, and conferences. It would be possible to publish and disseminate more newsletters to individuals and agencies involved in planning and decision-making. Of great interest to me is the possibility of being able to send State employees to an institute sponsored course to keep them closer to the frontiers of knowledge in their particular jobs.

Thank you for this opportunity, and we sincerely hope that you will give favorable consideration to this measure.

Thank you.

(The detailed information, accompanying Mr. Mallicoat's statement, above-referred to, follows:)

THE UNIVERSITIES AND OREGON'S WATER RESOURCES

Ecologists, unfortunately, rarely come neatly wrapped in single packages. Nor is there any magic formula, other than coordination of effort by numerous people, in planning water projects so that the goal of ecological harmony is kept in sight.

First, it should be recognized that planning and management of our water resources is a complex business. In the past, principal considerations were irrigation, navigation, flood control and other direct economic benefits. The plan adopted was usually the one which ostensibly provided the most economical means of developing a specific resource. Today, however, there is great need to consider a wide range of factors, including environmental protection. Economic benefit cannot be ignored, but it should be an equal partner with consideration of other (principally social) values. All this must take place in a framework of political and legal constraints.

Federal, state, and local agencies, individuals and organizations at many levels carry the burden of water resource development. They have been doing this for many years. In the process there has been a slow progression from the single purpose approach to the multiple-use concept.

Almost overnight, however, from the historical standpoint, there has arisen a great demand that full attention be paid to the ecology of an area. This comes as an immense boost to the morale of many people who have been advocating this over a period of decades. We have finally learned that some activities can disrupt the balance of nature and cause unpredictable and even irreversible effects. We have at last become aware that land, air, and water must be managed so that their use will bring not only short range but also long range benefits to man and protection of his environment.

This has brought ecology out of the realm of theory and discussion into the general public arena where direct cause-and-effect relationships must be examined. Planners, managers, academicians, and private citizens are alert to the need to weigh the benefits of developments against the dangers of undesirable change and the value of retaining options for the future.

The task calls for a combination of talents not usually found in one organization. This pooling of assets has involved Oregon's universities and their faculty members in many joint ventures involving the state's water resources. Research, education and public service in water related matters are the three major responsibilities pursued on college campuses since the turn of the century. The Water Resources Research Institute is one of the principal catalysts in fostering and encouraging these activities.

RESEARCH

Faculty members have been directly involved in the planning process in recent years through participation in such operations as the study of Oregon's Long Range Requirements for Water and the Willamette Basin Comprehensive Study. Many continue as active committee members in the Columbia-North Pacific Framework Study. A number of federal agencies directly support research on Oregon's campuses. The same thing is true of State agencies and private industries or organizations. There must be this response to the needs of public agencies, industry and local government, as well as to the requirement for advancing the frontiers of knowledge, if research is to remain relevant to water resource management.

Universities, historically, have been the principal centers of applied research in both medicine and agriculture. Applications of the results of such research has been most effective. Experiment stations and the Extension Service have made it possible to demonstrate the economic and practical value of research results in the field of agriculture. Teaching hospitals associated with universities have provided the means in medicine of applying discoveries.

Research on campus in water resources is also becoming more problem oriented. This calls for continued and meaningful dialogue between agencies and the university community. The ability to identify and define research needs has not been well developed at any level of government. The burgeoning requirements of ecological awareness have added to the difficulty. However, it is not a one-way street. Universities are challenged to make a concerted effort to acquaint themselves with the knowledge gaps and apply the varied disciplines available to them in helping to build bridges across the gaps.

Among those on campus who are contributing to ecological deliberations are the social scientists and legal experts. These are singled out not because they

are any more important in the total scheme than those in physical and biological disciplines, but because they are not usually found on agency or governmental staffs. Staff organizations rarely include a combination of political scientists, geographers, historians, anthropologists, biologists, botanists, lawyers, engineers, chemists, and sociologists. Yet, combinations of these capabilities are available on campus. Not at a push of a button, however. There is required on the part of universities imaginative approaches in administration of research in order to incorporate resource problems into ongoing operations. A university is not like a private research firm which has a permanent staff ready to concentrate fully on a specific project.

As one example of multidisciplinary approach, at Oregon State University a lawyer, an anthropologist, and a business management specialist are conducting a study of the decision making process as related to water resource development. The investigation entails collection of detailed social, economic and legal data pertaining to a watershed improvement project initiated by the Junction City Water Control District. An attempt will be made to develop a model of the decision making process which incorporates socio-cultural values as well as cost-benefit dollar values.

Important research is underway to determine possible beneficial uses of heated water discharge from nuclear plants. Just as significant are ongoing studies regarding the effect on fish populations of pulp mill effluents.

Faculty members and students of the School of Law at the University of Oregon are engaged in studying the problem of adjudication of early water rights on streams in Oregon. A second effort is directed at the question of submerged lands. Research material from this preliminary study has been made available to the Advisory Committee to the State Land Board which is now preparing recommendations for the next legislature. Soon to be completed is a Survey of Oregon Water Law which has been underway for a number of years.

Geographers at Portland State University have a number of interesting projects in progress. These include a survey of rivers for a recreational evaluation; a survey by plane of the Pacific Northwest to study land use patterns, and a study of the possibilities of conserving electricity in the Northwest.

EDUCATION AND TRAINING

It is not possible to isolate education from research, planning, design, and the other roles which must be filled in water resource development and protection. Individuals, groups, and institutions which are involved should be in close contact and coordination with each other. Educating and training needed manpower must be a continuous process as new information becomes available through study, research, and experimentation.

The university must be aware of the types of people needed by the agencies and the type of problems its graduates will face in order to provide the proper background. Without maintaining a close working relationship with those in need of its graduates, any academic training program quickly becomes obsolete. Universities must be able to establish or expand courses of study to help relieve any shortages of trained people at the professional level in water resources.

There should be, in addition, training and educational programs at the sub-professional level to provide needed technicians. Some progress has been made in this area in the way of short courses, conferences, and symposia. This has been the subject of a number of discussions in the past between members of the academic world and various federal and state agencies. However, acceleration of modest programs has been hindered by problems of subject matter, personnel, scheduling, and budgets. Some way must be found of overcoming these.

COMMUNITY SERVICE

Community service for the universities involves the communication of ideas. This is implicit in all that has been said thus far about research and education. But there are further dimensions in this area of university responsibility.

Conducting research on campus is not enough. The faculty researchers are aware that the results of their investigations should reach the individuals and groups charged with the mission of managing Oregon's water. One of the devices used at Oregon State University is a periodic newsletter assembled by the Institute which reports on the results of research not only in Oregon but around the nation. Distribution is made not only to federal and state agencies, but also to legislators and appropriate individuals and committees at the county and municipal levels. For example, it goes to the official most concerned with water in

each of 110 cities, to water control districts, to soil and water conservation districts, and other special districts. It is here that much of the planning for water resource development takes place. It is here that many of the day-to-day decisions are made.

The university has both the resources and the environment to fill the role of "friendly critic." This is accomplished in many ways but most frequently through sponsorship of seminars designed to examine various facets of water problems. Proceedings are usually published by the Institute and given wide dissemination. Agencies of State government make extensive use of these seminar publications. These public seminars can be most constructive in helping citizens to keep abreast of alternatives and participate in the discussion of choices. People need help in recognizing the possible choices which can be made in water resource management. They are willing to learn and to listen to experts if these choices are presented in understandable terms—with price tags attached.

If academic activity in the field of water resources is to be meaningful and of possible aid to decision makers, there is an obligation to keep informed of what is happening in the political arena. Experts in some disciplines are frequently called upon to give advice to legislative committees or to serve on advisory committees or task forces. This calls for familiarity with the responsibilities of the legislative bodies working in the natural resource areas. Interested faculty members should be on the mailing list of such committees to keep abreast of pending measures. They must be aware of current issues and be adequately prepared to appear at hearings, comment in local publications, and correspond with committee members.

The requirements for bringing into focus the ecological problems of Oregon were spelled out by former OSU President James Jensen almost five years ago at the Western Interstate Water Conference in Corvallis. He observed that:

It is increasingly necessary that scientists and engineers understand water not only from a technical standpoint, but also from the humanitarian and sociological point of view. It is necessary that the scientific and technical specialists have an understanding of the interlocking concerns, the basic human relations and attitudes, as well as the needs of all the population that shares in water resources. And it is practically imperative that there be easy and understandable communications between and among everyone concerned. University responsibilities therefore extend beyond furthering the fields of knowledge in depth. The university needs likewise to be just as certain that knowledge spreads horizontally.

Considerable research that is neither purely basic nor applied requires the facilities and competencies to be found in universities and state and federal agencies. Here the university responsibility to provide new knowledge needs to be coordinated with other universities and with the agencies. Each university needs to establish and maintain a working relationship that will at least keep it informed about the activities of others and make it aware of the obstacles being encountered. It, in turn, as part of its public service responsibility should make known its activities and accomplishments. Only in this way will we keep research and education dynamic and meaningful.

The universities are especially appropriate tools for analyzing water development and management problems in view of the composite nature of these problems. The high degree of competence which exists over a broad spectrum of subject areas offers unparalleled opportunities for the comprehensive analysis required. At the same time, universities remain aware that they can only contribute to, and must not usurp, the planning and decision functions. To do otherwise would damage the proper development of state institutions in government and injure a long established reputation for objective inquiry on campus. The Water Resources Research Institute has followed this basic philosophy in its efforts to aid in the solution of problems.

ALLOTMENT BUDGET FOR FISCAL YEAR 1971

1. Administration	
a. Salaries, wages-----	\$13, 532
b. Publications, travel-----	4, 783
c. Supplies, services, reserve-----	1, 600
	<hr/>
Total -----	19, 915
	<hr/>

2. Allotment projects	
a. Hydrology	
Small streams runoff.....	5,312
Energy and heat.....	20,900
Soil water movement.....	4,600
Engineering hydrology.....	5,080
Subsurface infiltration.....	3,430
Total	<u>39,322</u>
b. Water management institutions ¹	6,725
c. Classification of lakes.....	14,928
d. Federal recreation act.....	3,000
e. Food processing wastes.....	7,810
f. Temperature prediction model.....	8,300
Total	<u>100,000</u>

¹ Joint research with University of Oregon.

<i>Title</i>	MATCHING GRANTS	<i>Total Federal funds</i>
1. Temperature requirements of salmonids..... (For 3 years beginning July 1, 1968)		\$36,712
2. Use of reactor water for irrigation..... (For 3 years beginning July 1, 1968)		36,500
3. Reactor cooling water..... (For 1 year beginning July 1, 1970)		30,000
4. Socio-cultural systems/Willamette..... (For 2 years beginning July 1, 1970)		40,211
5. Effects of pulp mill effluents—Phase II..... (For 3 years beginning July 1, 1969)		45,000
6. Decision making in water allocation..... (For 3 years beginning July 1, 1969)		63,801
7. Computer simulation of eutrophication..... (For 3 years beginning July 1, 1969)		29,000
8. Alternative economic evaluation procedures..... (For 2 years beginning July 1, 1970)		19,400
Total.....		<u>300,624</u>

Senator Moss. Well, thank you, Mr. Mallicoat, for that statement from the Governor of Oregon. We are well aware of his great interest in water. He and I have corresponded in times past about various water matters. We are glad to have his statement, and glad to place in the record the other statement that you have brought for us to help us complete the record we have.

I have now called all of the witnesses that I have on the list. If anybody was inadvertently overlooked, I will hear him now, but I think we have compiled a very excellent record. The record will remain open 10 days to get some additional information from the Department of the Interior.

At the end of that time we would hope to move very expeditiously on this matter in the expectation that we can complete our work and induce our friends on the other side of the Capitol to proceed rapidly also, hoping to have legislation completed this year before the Congress adjourn.

Thank you. We are now in adjournment.

(Whereupon, at 4:15 p.m., the Subcommittee adjourned, to reconvene subject to the call of the Chair.)

APPENDIX

(Under authority previously granted the following communications were ordered printed:)

U.S. SENATE,
Washington, D.C., July 20, 1970.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: I enclose a copy of a letter I have just received from Governor Robert W. Scott of North Carolina endorsing S. 3553 (proposing amendments to the Water Resources Research Act of 1964, now pending before your committee) and a copy of my reply to him.

You will recall that on April 17, 1970, I wrote you expressing my support of S. 3553 and urging prompt and favorable action on it by your committee. I would appreciate it very much if you would make the Governor's letter, my reply to him, and my letter to you a part of the hearing record of your committee on this bill.

Thanking you, and with all best regards,
Sincerely,

B. EVERETT JORDAN, *U.S. Senator.*

STATE OF NORTH CAROLINA,
DEPARTMENT OF ADMINISTRATION,
Raleigh, N.C., July 16, 1970.

Hon. B. EVERETT JORDAN,
U.S. Senator, Senate Office Building, Washington, D.C.

DEAR SENATOR JORDAN: I would like to encourage you to support the proposed amendments to the Water Resources Research Act. I am aware of your interest in these proposed amendments and want to lend my support to your efforts.

We were justifiably proud when President Nixon selected the University of North Carolina Water Resources Institute for special commendation earlier this year. We feel that this special recognition reflects the dedication that North Carolina has to programs which call for partnership arrangements between State and Federal agencies.

The Water Resources Institute in North Carolina is working with all colleges and universities in the State to assure that a cooperative effort is tailored to the needs of North Carolina.

One of the most important features of the Water Resources Research Act is the annual allotment programs which enables the individual states to channel their research capabilities into a direct attack on their unique water problems.

I am concerned that the original \$100,000 authorization is grossly inadequate to do the job that must be done. The expanded authorization to \$250,000 in S. 3553 would come much closer to meeting our needs.

The present Act failed to recognize the need for a few extra steps to transfer research results into practice. The proposed amendment would bridge this gap between research and application. Too often our expensive research studies end up on the book shelf with little or no attention being given to the task of translating the complicated research results into a form that is usable by the common man.

I understand that hearings on the amendments (S. 3553) to the Water Resources Research Act are scheduled for 10:00 a.m. on July 20, 1970. I would like to have my strong endorsement of these amendments as a part of the record. Therefore, I would like for you to introduce this letter into the hearing record.

Sincerely,

ROBERT W. SCOTT, *Governor.*

U.S. SENATE,
COMMITTEE ON PUBLIC WORKS,
Washington, D.C., July 20, 1970.

HON. ROBERT W. SCOTT,
Governor of North Carolina,
Raleigh, N.C.

DEAR BOB: I was glad to get your July 16 letter endorsing S. 3553 proposing amendments to the Water Resources Act of 1964, and I have complied with your request that I ask the Honorable Henry M. Jackson, Chairman of the Senate Committee on Interior and Insular Affairs, to make it a part of his committee's hearing record on the bill.

Incidentally, I wrote him myself on April 17 urging favorable action on the bill at the request of Dr. David H. Howells, who visited me today following his testimony before the committee.

I assure you I will give it my active support when it comes before the Senate, because I recognize the importance of proper development of our water resources and believe this bill will be helpful in that direction.

With all best regards,

Sincerely,

B. EVERETT JORDAN, *U.S. Senator.*

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., July 21, 1970.

HON. CLINTON P. ANDERSON,
Chairman, Water and Power Resources Subcommittee, Senate Committee on
Interior and Insular Affairs, New Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: I am enclosing herewith for your information and consideration a summary of the contributions of the Arkansas Water Resources Research Center prepared by its Director, Mr. Aubrey E. Harvey. Mr. Harvey is vitally interested in the enactment of S. 3553, which would amend the Water Resources Research Act of 1964 to increase the authorization for water resources research and institutes.

With kind regards,
Sincerely yours,

DAVID PRYOR,
Member of Congress.

Enclosure.

ARKANSAS WATER RESOURCES RESEARCH CENTER

CONTRIBUTION OF CENTER TO WATER RESOURCES TRAINING

Number of students trained with equipment and supplies purchased totally or in part with P.L. 88-379 funds—312.

Number of Master's Theses published in water related fields—15.

Number of new courses in water related fields added to the University of Arkansas curriculum, as a result of the Center's involvement in water resources research—12.

Number of reports and journal publications—26.

INVOLVEMENT OF CENTER IN PUBLIC AFFAIRS

The Director of the Center is a member of the Governor's Coordinating Committee on Water Resources under the Office of the Governor.

A member of the research staff has served as chairman of the Arkansas State Committee on Stream Preservation.

Research personnel have served as consultants to a project at the Arkansas Medical Center concerning rapid changes of oxygen in measurements of reaction rates of flavoenzyme oxidazes.

Research personnel have consulted with the United States Fish and Wildlife Service in regard to the measurement and control of oxygen consumption by fish in a controlled environment.

Research personnel have consulted with personnel at the Robert S. Kerr Water Research Center at Ada, Oklahoma, in regard to measurement of water quality parameters.

Research personnel have made presentations before the Arkansas Water Resources Planning Committee and have testified before the Parks and Recreations Sub-Committee on Senate Interior and Insular Affairs Committee concerning the need for National Park Service protection of the Buffalo River in northern Arkansas.

Research personnel have consulted with Southwestern Research Associates regarding the study of the dispersion of chloride into Lake Catherine, Arkansas as a by-product from a vanadium mining operation and have also cooperated with Greers Ferry National Fish Hatchery in regard to controlling manganese concentrations in the water supply.

Research personnel have consulted with the Water Conservation Service concerning the effect of impoundment on small watershed impoundments constructed under P.L. 566.

Research personnel have cooperated with the University of Arkansas at Little Rock in advising Arkansas Power & Light Company in their long-range study of thermal pollution in conjunction with their nuclear power plant scheduled for operation by 1972.

Research personnel have played an important role in developing water quality standards which were submitted to the Federal Water Pollution Control Administration by the Arkansas Pollution Control Commission.

One publication of the Center concerning sub-surface irrigation has received considerable interest including several international inquiries.

Reports resulting from one project of the Center have been used directly by the Arkansas-Oklahoma Compact Committee. The Committee was formed with the specific purpose of apportioning the joint water resources of Arkansas and Oklahoma.

The Center co-sponsored with Ouachita Baptist University a seminar on the DeGray Reservoir, an impoundment constructed on the Caddo River by the U.S. Corps of Engineers. This seminar was attended by fourteen federal, state, and local agencies and organizations.

U.S. SENATE,
Washington, D.C., August 5, 1970.

HON. HENRY M. JACKSON,
Chairman, Committee on the Interior and Insular Affairs,
New Senate Office Building,
Washington, D.C.

DEAR MR. CHAIRMAN: I am writing to express my support for S. 3553, a bill introduced by Senator Moss to amend the Water Resources Act of 1964.

I believe this measure will strengthen substantially the important programs being conducted by State water resources centers.

The Rhode Island Water Resources Center, I know, has, despite limited funding, made important contributions to improvement of the State's water resources. I have enclosed for the information of your Committee a copy of a report on the Rhode Island Center prepared for me by Mr. A. Ralph Thompson, Director of the Center.

I have your Committee will find it possible to give early favorable consideration to this important legislation.

All best wishes.

Ever sincerely,

CLAIBORNE PELL, *U.S. Senator.*

Enclosures.

UNIVERSITY OF RHODE ISLAND,
WATER RESOURCES CENTER,
July 15, 1970.

Senator CLAIBORNE PELL,
Old Senate Office Building,
Washington, D.C.

DEAR SENATOR PELL: Some months ago (Feb. 27, 1970) we wrote you asking you to give your strong support to the bill HR 15957 amending the Water Resources Act of 1964, P.L. 88-379.

Now, we understand, the Senate Committee on Interim and Insular Affairs has scheduled a hearing at 10 a.m. on July 20, 1970, on the corresponding senate bill introduced by Senator Moss, S-3553.

For your benefit I have enclosed a statement giving some pertinent activities of our center over the past five years which you may use in any way which you consider may be helpful.

The Rhode Island Water Resources Center, and I'm sure the other fifty centers, will appreciate whatever effort you can make to ensure passage of this bill.

Sincerely yours,

_____ A. RALPH THOMPSON, *Director.*

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., July 17, 1970.

HON. HENRY M. JACKSON,
Chairman, Interior and Insular Affairs Committee,
New Senate Office Building,
Washington, D.C.

DEAR SENATOR JACKSON: I am enclosing for your information correspondence which I received from Mr. A. Ralph Thompson, Director of the Water Resources Center at the University of Rhode Island, in support of S. 3553, the proposed amendment to the Water Resources Act.

I endorse Mr. Thompson's position and I would appreciate it very much if you would make his comments a part of the Committee records on this legislation.

With best wishes, I am,

Sincerely yours,

_____ JOHN O. PASTORE, *U.S. Senator.*

Enclosure.

UNIVERSITY OF RHODE ISLAND,
WATER RESOURCES CENTER,
Kingston, R.I., July 15, 1970.

Senator JOHN O. PASTORE,
New Senate Office Building,
Washington, D.C.

DEAR SENATOR PASTORE: Some months ago (Feb. 27, 1970) we wrote you asking you to give your strong support to the bill HR 15957 amending the Water Resources Act of 1964, P.L. 88-379.

Now, we understand, the Senate Committee on Interior and Insular Affairs has scheduled a hearing at 10 a.m. on July 20, 1970, on the corresponding senate bill introduced by Senator Moss, S-3553.

For your benefit I have enclosed a statement giving some pertinent activities of our center over the past five years which you may use in any way which you consider may be helpful.

The Rhode Island Water Resources Center, and I'm sure the other fifty centers, will appreciate whatever effort you can make to ensure passage of this bill.

Sincerely yours,

_____ A. RALPH THOMPSON, *Director.*

RHODE ISLAND WATER RESOURCES CENTER

During its five years of operation, the Rhode Island Water Resources Center has made many contributions to the solving of local, state and even regional water problems.

The establishment and organization of a research center of this type takes considerable time and with the rather modest funds available to it the Center has conducted many valuable research projects as is evident in its excellent annual reports. The Center is now geared up to do a real comprehensive job in the solution of water resources problems if sufficient financial support were available to it. We are all aware now of the tremendous magnitude of this environmental problem which can be solved only if the research centers are provided with a large enough base to be able to muster sufficient personnel to work on all necessary projects.

As an example of a local problem solved through the center's research, might be cited the development of methods for controlling the copper content in water. In a few sections of Rhode Island the aggressive nature of the groundwater from wells caused so much copper to be dissolved from piping that it was a serious health hazard. The research on this problem indicated methods of neutralization or demineralization which reduced the metal content to a satisfactory level, thereby protecting the health and perhaps the lives of many residents.

The presence of high concentrations of iron and manganese in groundwater supplies has been an important problem in many sections of the state of Rhode Island. Working in close cooperation with the Water Resources Board of the state and with the U.S. Geological Survey, the Rhode Island Water Resources Center, through two earlier projects, made definite contributions in the alleviation of this problem. A current project is making excellent progress in the development of cartridges for the filtration of iron and manganese from small groundwater supplies. This accomplishment should go a long way to overcoming a serious deterrent to making use of many water sources in the state.

For a number of years the six New England states have endeavored to initiate regional water resources research. The six institute directors have been extremely cooperative and have worked closely together through the organization, the New England Council of Water Center Directors, formed by them in 1966. The group has managed to sponsor three excellent conferences on water rights law, water resources planning and ecological effects, but to date it has not been possible to undertake regional research projects. With a view to improving this situation a Title II proposal was submitted to investigate the possibility of using a regional research coordinator to plan, coordinate and report on research undertaken by several research centers. The proposal has been approved, with the Rhode Island Director as principal investigator, and it is expected that valuable information will be obtained which should be of use to all regions of the country which are contemplating multi-center research.

STATEMENT OF THE HONORABLE ALBERT P. BREWER, GOVERNOR OF THE STATE OF ALABAMA

Senator HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs.

MR. CHAIRMAN: The Water Resources Research Act of 1964 has been effectively administered by the Office of Water Resources Research, U.S. Department of the Interior, to provide assistance for a truly cooperative Federal-State continuing effort in research and training of scientists in water and other resources affecting water. In Alabama the program is implemented through the Water Resources Research Institute at Auburn University. The Institute was established in 1964 and has built an outstanding program around the annual allotment and matching grant programs incorporated under Title I of the Act.

All senior colleges and universities are encouraged to participate in the program of the Water Resources Institute. Research is now being conducted on the campuses of Auburn University, Tuskegee Institute, the University of Alabama, and the University of South Alabama. The financial resources available under the annual allotment program have been melded with support from universities and colleges, state agencies, and industry to obtain the maximum possible return. The principal limiting factor has been the size of the annual allotment which present legislation limits to \$100,000.

I believe that Title I of the Water Resources Research Act authorizes the most effective possible use of Federal funds for water resources research and the training of scientists. An increase in the amount of the annual allotment and authorization for the State Institutes to develop more formal programs for transferring research results into practice would contribute strongly and directly to the solution of water resources problems of Alabama and of the Nation.

Respectfully submitted.

ALBERT P. BREWER.

STATE OF FLORIDA,
OFFICE OF GOVERNOR CLAUDE R. KIRK, JR.,
July 20, 1970.

HON. HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR SENATOR: It has been brought to my attention that legislation has been introduced (H.R. 15957 and S-3553) which would amend P.L. 88-379, the Water Resources Research Act of 1964, to increase annual allotments to state water research centers from \$100,000 to \$250,000.

The outstanding accomplishments of these centers deserve special merit in the area of conservation and wise utilization of water resources. The research

these centers institute is a vital part of our programs in water conservation. As you know, this research costs money. I trust, therefore, that you will concur with me in the approval of the pending legislation increasing the funds of these centers.

Thank you for your consideration of this matter.

Sincerely,

NATHANIEL P. REED,
Special Assistant, National Resources.

WESTERN UNION TELEGRAM

TALLAHASSEE, FLA., July 20, 1970.

Senator HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs
U.S. Senate,
Washington, D.C.

Understand Senate Committee on Interior and Insular Affairs is holding hearing on S. 3553. Urge you pass the amendments to the Water Resources Research Act in increase annual allotments to State Water Resources Research Centers. Florida's Water Resources Research Center conducting vital research for our State. I appreciate your efforts in this matter.

Sincerely,

NATHANIEL P. REED,
Chairman, Department of Air and Water Pollution Control.

OFFICE OF THE GOVERNOR,
Frankfort, Ky., August 5, 1970.

HON. HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs,
Senate Office Building,
Washington, D.C.

DEAR SENATOR: Your committee has before it Bill 5-3553, the Moss Bill to amend the Water Resources Research Act of 1964. The purpose of this amendment is to increase the authorized allotment to each Institute to \$250,000 annually, and in addition authorizes the Institutes to use a part of these funds to disseminate the results of their studies to the practitioners who are most competent to apply this work to the solution of practical problems. It is my hope that the committee will report on this amendment favorably.

In Kentucky the Water Resources Institute of the University of Kentucky is the major center around which water-related research in the State now revolves.

The Commonwealth has not in the past been faced with significant problems of water shortages or of water quality generally, hence the major activity related to water has been in the area of flood control. More recently, public concern has been aroused with respect to water pollution control and public health, and with the development of the State's water resources for low flow augmentation, attraction for new industry, and recreational usage. Educational and research programs have not kept pace with other developments.

To date a large share of the Institute's program has been devoted to economic analysis of various aspects of major water resources development projects. In addition to many studies of this nature, the Institute has investigated recreational potential of small streams near urban areas; the legal institutions of diversion, transfer, and storage of water in Kentucky; the persistence and removal of pesticides from water; the effects of strip mining on the microbiology of streams; and the effects of relocation on the lives of rural people when they are forced to move.

The Institute's programs have also provided a medium involving graduate studies of research if it is in the field of water problems within the Commonwealth. We would like to see this kind of work expanded.

Again let me urge the committee's favorable consideration of this amendment.

Sincerely,

LOUIE B. NUNN, *Governor.*

NEW ENGLAND GOVERNORS' CONFERENCE,
Boston, Mass., July 17, 1970.

Senator HENRY JACKSON,
*Chairman, Subcommittee on Water and Power,
 Senate Interior Committee,
 Washington, D.C.*

DEAR SENATOR JACKSON: I understand that your Subcommittee has scheduled hearings on legislation introduced by Senator Frank Moss to increase the federal allotment for State Water Resources Research Centers from \$100,000 to \$250,000 annually, S. 3553.

We in New England feel that the Centers in our Region have made excellent progress not only in their research activity but also in focusing their efforts on the practical application of existing water and related land resource management techniques. We have developed within New England a project to insure that the results developed in one State will be applied to similar problem areas in other sectors elsewhere in the region. While our States' support of environmental programs has been expanding rapidly, the \$100,000 level of support for the Water Resources Research Centers has been in effect for 6 years. Unfortunately the Centers' programs have not been able to keep pace with urgent environmental needs.

We in New England feel that the passage of this legislation would be in the National interest and hope that your Subcommittee will support its enactment. Enclosed is a statement which explains in further detail the reasons for our support. I would like to request that it be included in the Committee hearing record.

Thank you for your cooperation.

Sincerely,

KENNETH M. CURTIS,
*Governor of Maine,
 Chairman, New England Governors' Conference.*

STATEMENT OF GOVERNOR KENNETH M. CURTIS, OF MAINE, CHAIRMAN
 NEW ENGLAND GOVERNORS' CONFERENCE

The New England Governors' Conference wishes to express its support for S. 3553, a bill that would amend the Water Resources Research Act P.L. 88-379 by revising Section 100 to authorize an increase in annual allotment for the State Water Resources Research Institutes from \$100,000 to \$250,000. We in New England feel that the Water Resources Research Institutes established in our Region under P.L. 88-379 are playing an increasingly important role in protecting water and related land resources. The Conference maintains a continuing contact with these Institutes by participating in meetings of the New England Council of Water Center Directors. It has noted that the Institutes are moving ahead effectively in: (1) establishing strong Centers of water resources research direction within the individual New England states and (2) coordinating research effort of programs of major regional significance.

New England's water resources vary in kind within the region, and each type of water resource presents difficult problems for those concerned with their protection and most prudent use. Our region's research needs extend to our major interstate rivers, their wild headwater tributaries, our valuable lakes, our intensively used estuarial and coastal waters, our important ground water supplies and our coastal and inland wetlands. The complexity of research tasks is impressive indeed. These deal with problems of law, economics, the broad social sciences, planning and management, and, of course, the natural sciences and engineering. P.L. 88-379 is providing a valuable mechanism by which the Institutes catalyze and direct the efforts of specialists in many fields to the solution of important problems.

Given the very wide range of problems and the difficulty of the research tasks, the New England Governors' Conference has supported P.L. 88-379 generally and the programs of individual institutes specifically. The Conference believes that the Institutes have evolved an effective multidisciplinary research resource within each of the Universities, and are strengthening their efforts on problems of common concern. We are particularly pleased to note that the Institutes' endeavors in advancing cooperative regional research programs have the active support and participation of the New England River Basins Commission. Two recent actions by the Commission (resolutions appended) testify to increasing coordination of programs of the Institutes and the Commission.

Further evidence of progress in cooperative research effort is the appointment (with support from the OWRR) of a Regional Research Coordinator by the New England Council of Water Center Directors. The Coordinator will work closely with the New England River Basins Commission. An example of research that we believe the Institutes will conduct jointly is a project recently approved by the OWRR for the University of Massachusetts Water Resources Research Center, "Formation of Public Policy on Issues of Out-of-Basin Diversion of Connecticut River Flood Waters to Boston Metropolitan Area." A brief description of this project is attached. This program calls for effort by the Universities of Massachusetts, Connecticut, Vermont and New Hampshire, all concerned with protection and use of the Connecticut River.

The New England Governors' Conference believes that an effective start has been made by the Institutes in the State Universities of New England in focusing research effort on important State and regional problems. The Conference believes further that reinforcement of this program in the manner proposed in S. 3553 is timely and would advance the vital interests of the New England Region.

We urge that you support this bill.

RESOLUTION No. 2/69/3

COOPERATION WITH NEW ENGLAND COUNCIL OF WATER CENTER DIRECTORS

The Commission recognizes a need for close coordination between institutions and individuals engaged in research on water and related land resources, and agencies engaged in planning and management for utilization of these resources.

Each of the New England States maintains a Water Resources Research Center at a State University to provide leadership in the State for research on water and related land resources. These institutes are supported in part by funds authorized by the Water Resources Research Act of 1964, as amended. As provided by the legislative history, close coordination is to be secured between the planning programs authorized by the Water Resources Planning Act and the research programs authorized by the Water Resources Research Act.

The Commission further recognizes the establishment of a Council of Water Center Directors in New England as a forward step toward development of a cooperative research program on matters of regional significance. The Commission appreciates the Council's sponsorship of two conferences on matters of regional concern, and its efforts to secure funds for cooperative research on New England water law.

In order to secure necessary staff services for the Council, to stimulate improved liaison between the Centers and other research institutions in the region, and to provide for close cooperation between research communities and agencies responsible for planning and management, the Commission agrees that a position of research coordinator would be of benefit to the region.

With the understanding that the Council of Water Center Directors will provide funds for salary, personnel benefits and travel expenses for a regional research coordinator to be employed by the Council (or by one of the Centers on behalf of the Council) the Commission agrees to provide for the coordinator office space, clerical services and supplies.

RESOLUTION No. 3/70/1

COMMISSION PARTICIPATION IN THE COORDINATION OF REGIONAL WATER AND RELATED LAND RESOURCES RESEARCH

The Commission recognizes the need for close coordination between institutions and individuals engaged in research on water and related land resources and agencies engaged in planning and management for utilization of these resources.

It is the sense of the Commission that the following step be taken to assist in securing coordination of regional water and related land resources research and planning.

- (1) The Chairman, NERBC is authorized to appoint, with consent of the Vice Chairman, a Research-Planning Coordination Committee. One Member of the Committee may be designated by the New England Council of Water

Center Directors. Other members shall be designated by the state, interstate and federal agency members of NERBC, and other such public and private institutions as may be deemed appropriate by the Chairman.

In cooperation with the New England Council of Water Center Directors the principal responsibilities of the Committee shall be:

- (a) Identify the major water and related land resources research needs of the region and develop priorities for research efforts. Advise the Commission and the research community of these findings.
- (b) Assist in the development of a regional planning-research communications system, to help maximize the value of research programs.
- (c) Review and evaluate regional research efforts and advise the research community and the Commission on additional needs.
- (d) Assist in the development of a program to secure transfer of research results into the planning and management process.
- (e) Serve as liaison for the Commission with the Office of Water Resources Research and the New England Council of Water Center Directors.

TITLE

Formation of Public Policy on Issue of Out-of-Basin Diversion of Connecticut River Flood Waters to Boston Metropolitan Area.

ORGANIZATION OF APPLICANT

University of Massachusetts—An academic institution.

Name, title and address of the individual authorized to commit the applicant: Kenneth W. Johnson, Treasurer, University of Massachusetts.

Name, title and address of the individual accountable for receipt and disbursement of funds: Kenneth W. Johnson, Treasurer, University of Massachusetts.

Principal Investigator: Bernard B. Berger, Director, Water Resources Research Center, University of Massachusetts, Room 115, Holdsworth Hall, Amherst, Mass., 01002.

OBJECTIVES

- (1) To provide a basis for rational decision making on out-of-basin transfer of Connecticut River flood waters.
- (2) To identify the conditions influencing public attitudes on a water diversion issue.
- (3) To determine how public policy evolves on an issue of water diversion.

DESCRIPTION OF THE PROBLEM

The Metropolitan District Commission of Boston, which provides drinking water service for the metropolitan area of Boston needs additional water. Quabbin Reservoir, Boston's major source, is located in central Massachusetts and impounds waters which prior to 1940 were tributary to the Connecticut River. Quabbin Reservoir has not recovered from the drought of 1962-66 and currently is filled only to about 50% of capacity. During the period 1940-65, Boston's per capita water consumption increased from 100 gallons to 150 gallons. Because of this per capita increase and in increased population served, the Metropolitan District Commission believes Boston's current water supply will soon be inadequate to satisfy the total demand placed on it. Accordingly, legislation authorizing diversion of a portion of Connecticut River flood water to Quabbin through the Northfield Mountain Reservoir (a pumped storage facility of North East Utilities) was introduced in the General Court of Massachusetts. This legislation would authorize such diversions to be made only when Connecticut River flows at Montague, Massachusetts exceed 17,000 cubic feet per second. The amount of diversion would be limited to about 375 million gallons per day—the maximum capacity of the pump/turbines of the North East Utilities at this site. It is estimated that this diversion would increase metropolitan Boston's water supply by approximately 25%.

A growing opposition of citizen groups in the Connecticut River Basin, based largely on fear that diversions will impair important water values, is making this issue a legal, economic, ecologic, political, social and regional planning problem. This problem stems from a number of factors including: uncertainty in respect to long-term plans of the Metropolitan District Commission, fear concerning possible

ecologic impairments in the lower portion of the River, an apparent fuzziness in the language of the proposed legislation in relation to maximum permissible amount of diversion, and an absence of reliable data that could serve as a basis for rational decision making. Giving special emotional flavor to this issue is a reported interest on the part of New York City for diversion of Connecticut River water to that metropolitan area.

RESEARCH APPROACH

Answers to two sets of questions will be sought:

(1) How does public policy evolve in respect to this inter-basin transfer of water? Subordinate questions are:

(a) How did the various interested public groups form their opinions on this controversial issue?

(b) How did the attitudes of these public groups change in time and what factors accounted for these changes?

(c) How effective were public hearings in providing an opportunity for expression of public opinion?

(d) What factors most strongly influenced the attitudes of the members of the special task force assigned by the General Court to the study of the proposed legislation? This phase of research will be undertaken by Dr. Irving Howards, Department of Government, University of Massachusetts.

(2) What consequences in the Connecticut River Basin may reasonably be associated with diversions out of the basin? Subordinate questions are:

(a) What is the role of flood flows in scouring bottom deposits?

(b) What is the role of spring and autumnal flood flows in triggering movements of anadromous fish?

(c) What is the role of flood flows in nutrient supply and removal?

(d) What is the role of flood flows in the pollution of the river and its amelioration?

(e) What is the influence of flood flows on the ecology of tidal and estuarial water?

(f) What are the long-term water supply requirements of the basin region?

(g) What is the role of Connecticut River flood flows in recharging regional groundwater aquifers important to the region?

It is proposed that a status of knowledge report responsive to each of the above questions be prepared. In essence, these reports will represent a compilation of current information on the above questions. Field studies are not contemplated at this time. It is expected that the individual reports will permit an evaluation of the significance of each question. Where significance is established, the report will present the available, pertinent data. Where absence of data prevents an adequate evaluation of significance, or response to the question, the report will detail an appropriate study to obtain this knowledge.

The States of Vermont, New Hampshire, Massachusetts, and Connecticut are affected by decisions on Connecticut River diversions, flood manipulations, and management and would participate in the conduct of this research program. The following assignments have been agreed on:

Question 2a—University of Vermont.

Question 2b—University of Massachusetts.

Question 2c—University of New Hampshire.

Question 2d—University of Massachusetts.

Question 2e—University of Connecticut.

Question 2f—University of Massachusetts.

Question 2g—University of Massachusetts.

It is proposed that the four water resources research institutes involved review the final report which will be prepared in draft by the University of Massachusetts.

STATE OF NORTH DAKOTA,
EXECUTIVE OFFICE,
Bismarck, N. Dak., July 13, 1970.

Hon. HENRY JACKSON,
*U.S. Senate,
Washington, D.C.*

DEAR SENATOR JACKSON: I write to you in support of Amendment S-3-533 which would provide for an increase in the annual allotment program under Public Law 88-379 from \$100,000 to \$250,000 and authorize an information dissemination program to make research results more applicable.

The future of this state as a place for an expanding population to live depends entirely on the wisdom we can apply to conserving and beneficially using our very limited water resources.

The Water Resources Research Act has been important to our state. We have established the North Dakota Water Resources Research Institute at both the University of North Dakota and North Dakota State University.

I want you and your committee to know that I regard this amendment and its appropriation as very important to my state and to our nation.

Sincerely yours,

WILLIAM L. GUY, *Governor.*

STATE OF UTAH,
OFFICE OF THE GOVERNOR,
Salt Lake City, Utah, July 17, 1970.

Hon. HENRY JACKSON,
*Chairman, Senate Interior and Insular Affairs Committee,
Senate Office Building,
Washington, D.C.*

DEAR CHAIRMAN JACKSON: This letter is in support of Senate Bill 3553. As I read the bill, it would increase the federal allotment to land grant colleges from \$100,000 to \$250,000 annually. In addition, it would expand the qualifying activities of the water research centers to include scientific information dissemination and the training of persons to perform these activities.

We in Utah are proud of the work done by our water research center. A partnership effort is on-going where we have joined hands and welded together the facilities of the Utah Water Research Laboratory, the State Division of Water Resources, and the Federal finances available from the Office of Water Resources Research. The program of research carried on by the State university is very complementary to our own program of State water planning. We in the State are able to outline the real world problems as they apply to our everyday activities, and the academic people provide us with a sophisticated research arm as an aid to solving them.

As an example, hydrologic and river basin models have been developed to simulate several of the river systems of Utah. Included among these is a model of the Bear River System wherein we have been able to look at the very complicated interactions of the alternative water developments that might occur on that stream. This is proving to be a very practical tool in the current negotiations involving the three states of Idaho, Utah, and Wyoming towards an allocation of the waters of the Bear River. Another important jointly developed publication is the Utah Water Atlas which gives practical information that can be used by all levels of government. The State Tax Commission is presently using this as a very valuable tool in appraising lands in Utah for tax purposes. These are only two examples of many areas where the research people blend into our State programs.

I heartily endorse the concept of research at the State level and the federalization of these programs. Our center certainly has the capability to use the increased funds and since they will be of great value to our entire State, and to the nation as well, I urge passage of the Bill.

Sincerely,

CALVIN L. RAMPTON, *Governor.*

TERRITORY OF GUAM, U.S.A.,
OFFICE OF GUAM'S REPRESENTATIVE IN WASHINGTON,
Washington, D.C., July 21, 1970.

HON. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs, New Senate Office Building,
Washington, D.C.*

DEAR MR. CHAIRMAN: I am writing you with reference to S. 1051, a bill to amend the Water Resources Research Act of 1964.

The amendment as now drafted would enlarge the Act to include the District of Columbia and permit the Consortium of Universities of the Washington Metropolitan Area to receive grants to carry on the work of a competent water resources research institute.

Guam has long felt the need of a resources research institute of this kind. Its water problems are manifold. They come with the ocean. Solar radiation, tidal shifts, storms and other phenomena create changing conditions which must be constantly studied and analyzed so the people and their economy may survive and prosper. Therefore, I respectfully request you consider proposing an amendment to S. 1051 which would include Guam in its provisions in the same manner it would apply to the District of Columbia.

We trust you will give this matter your earnest consideration and any assistance will be deeply appreciated.

Sincerely,

ANTONIO B. WON PAT.

UNIVERSITY OF ARKANSAS,
WATER RESOURCES RESEARCH CENTER,
Fayetteville, Ark., July 15, 1970.

HON. J. W. FULBRIGHT,
*U.S. Senator,
New Senate Building, Washington, D.C.*

DEAR SENATOR FULBRIGHT: An April 1, 1970, Dr. David W. Mullins, President of the University of Arkansas, sent you a letter in support of Congressmen Robison and Saylor's bill H.R. 15957. Congressman Johnson has submitted a similar bill H.R. 16285, and Senator Moss has submitted bill S. 3553. These bills now pending before both Houses of the Congress propose to amend the Water Resources Research Act of 1964 thereby authorizing an increase in the annual allotments to State Water Resources Research Centers from \$100,000 to \$250,000.

I am writing you to encourage your support of these bills. Enclosed is a brief summary of the contributions of the Arkansas Water Resources Research Center. It is our feeling that you may wish to have these contributions inserted in the *Congressional Record* or submit it to the Committee to be included as a part of the record in their hearings. The Arkansas Water Resources Research Center is already in need of this increased allotment to aggressively meet the research needs of the State of Arkansas. We would appreciate your support of these bills very much.

Sincerely yours,

AUBREY E. HARVEY, *Director.*

(The summary referred to is on p. 168.)

STATEMENT OF JAMES C. WARMAN, DIRECTOR, WATER RESOURCES RESEARCH
INSTITUTE OF AUBURN UNIVERSITY, AUBURN, ALA.

Mr. Chairman, thank you for your interest in S-3553 as evidenced by the hearings you scheduled today on the bill. The Water Resources Research Act of 1964 authorized a continuing Federal-State cooperative program of research on water and other resources as they affect water and of training of young scientist by involving them with senior scientists in research efforts. The program has been effectively administered by the Office of Water Resources Research of the Department of the Interior. OWRR has provided through its Director and staff outstanding leadership at the Federal level while reserving maximum latitude for the state institutes in the development of programs responsive to their state and regional problems.

Alabama's Water Resources Research Institute was established at Auburn University in 1964 as directed and authorized by the State Legislature and the

Board of Trustees of Auburn University. All senior colleges and universities in the state are encouraged to participate in the Institute's program and research is now being conducted on the campuses of Auburn University, Tuskegee Institute, the University of Alabama, and the University of South Alabama.

The Institute works in close coordination and cooperation with the Geological Survey of Alabama and other agencies in the design and operation of research projects responsive to the state's water resources problems. A thirteen-man Water Resources Council, incorporating viewpoints of administrators and research workers from the universities and state and federal agencies, provides program guidance and review.

Alabama's Water Resources Research Institute has been successful in developing interdisciplinary research efforts which involve teams of scientists crossing department and school lines within universities and the cooperative research efforts of scientists from state agencies with university staffs. The principal limiting factor has been the size of the annual allotment program. The present legislative authorization of \$100,000 for the annual allotment program has been of tremendous assistance and has stimulated non-Federal support in excess of that amount; however, the limited available funding has been the principal limiting factor in the development of research efforts. Our present success in the Institute's program clearly indicates that a significant increase in funding and authorization of programs for the transfer of research results into practice would lead to concrete results from work in localized water problems all over the nation.

All research now underway in the program of the Water Resources Research Institute is highly relevant to water resources problems in Alabama. Several projects are producing results of regional and national significance. Some examples follow.

WATER RESOURCES PLANNING

The evaluation of water development projects requires consideration of secondary benefits. Assignment of dollar values is, at best, extremely difficult and vague. The Institute's annual allotment program is supporting a review of current and recently completed research in the area of secondary benefits related to water development projects to evaluate the results of such research and identify promising areas of research. Results indicate that input-output analysis is a good way to handle secondary benefits and costs.

Research on the ecologic impacts of wading birds on aquatic environments includes a study of aesthetics. These birds greatly enhance the appearance of the water areas where they are found because they are large and beautiful, or striking in appearance. When they feed, loaf, or even fly over, they add much to the aesthetic values of any water area. To most people they are an important addition to our fauna . . . so important that areas of land and water are set aside as refuges or sanctuaries and, when those like the Whooping Crane come south in the fall, they are headline news.

WATER IN SOILS AND ESTUARINE PROBLEMS

Research on the water cycle includes a study just completed on correlation of soil surface characteristics and rainfall-runoff-antecedent moisture relationships on agricultural watersheds on coastal plains soils. Another project is making a survey of the protozoa of Mobile Bay. Analysis of the protozoan fauna will improve our understanding of the energy transfer (food chains) within the Bay.

WATER CONSERVATION AND QUANTITY MANAGEMENT

At the present time, water is used almost exclusively as the dyeing medium for textile materials. Recently, low cost and easily handled organic solvents have been developed which could decrease the consumption of water in textile finishing processes. Research is underway on the use of organic solvent systems for dyeing textiles and the study will include identification of suitable dye solvents, determination of the effect of solvents on the polymer substrate, and calculation of the approximate costs of processes found technically feasible to evaluate the economic feasibility.

During the past five years there has been extensive industrial expansion along the Alabama River, with an attendant increase in water use. A project is nearing completion along 303 miles of the Alabama River to study the applicability of proven exploration methods for locating alluvial aquifers and deposits with potential for induced infiltration. Results from this project should assist in

better utilization of surface water and groundwater from alluvial flood plains in other parts of the Gulf Coast region and other similar areas.

WATER QUALITY MANAGEMENT

Research on water quality continues to hold an important position in the Institute's annual allotment program. Studies on the interaction of bacteria and nematodes suggest that bacteria are an important nutriment for certain nematodes. If nematodes feed on bacteria in nature, this may have an important influence on the stabilization of organic matter by bacteria. Research also is continuing on the association among virus, bacteria and nematode. Another project is studying use of the diversity of the aquatic-biotic community structure as an indicator of the degree to which a stream is polluted. Effect of pollutants on aquatic microorganisms is being studied by considering how pollutant molecules affect sunlight mortality of and sunlight-induced mutations in aquatic microorganisms. We expect to be able to predict biological activity of a pollutant from knowledge of its molecular structure.

In response to concern about the immediate and long term effects of excess fertility in the waters of our lakes and streams, research has begun on the interactions between aquatic plants and sewage effluent. This study is searching for ways to control the objectionable plants growth rather than with algicides and herbicides and it will give information on the fate of the nitrogen and phosphorus introduced in sewage effluent and on the efficiency of aquatic weeds and plankton in removing these excess nutrients from the water.

Treatment techniques presently used have not been successful in removing color from textile dye waste. Color interferes with the transmission of sunlight into the water reducing photosynthetic action and upsetting the normal biological balance in the stream. In addition, some dyes may contribute to the biological oxygen treatment of the streams and may also contribute to the formation of hydrogen sulfide gas. Because the textile industry is one of the most important industries in Alabama a project is studying the removal of color from textile dye wastes by special techniques of coagulation.

Another project of interest to the textile industry is a study of the use of gamma radiation of textile waste water to reduce pollution. Irradiation alters the character of the pollutants so they will be more amenable to present waste treatment practices. The goal is to obtain very high efficiencies in reducing biological oxygen demand, removing non-biodegradable materials adversely affecting streams, and color removal. Following a recent oral progress report, members of the Institute's Water Resources Council expressed keen enthusiasm for research results, their short-term significance in the conduct of the research, and their long-term significance for the reduction of pollution.

Before enactment of the Water Quality Act of 1965 the disposal of sludges from water treatment plants had not been controlled by regulatory agencies. Consequently, past practice has been to dispose of sludge by most expedient means, which was usually direct discharge to the nearest watercourse. Suitable disposal methods for the waste sludge have not been researched to any degree in the United States. That such research is urgently needed is evidenced by the fact that the Research Foundation of the American Water Works Association considers this problem of highest priority. Research in the Institute's annual allotment program is directed toward improving a sludge disposal method that holds considerable promise for water waste treatment. If water sludges could be rendered more amendable to treatment by vacuum filtration the problem of disposing of these sludges would be greatly reduced.

Copper is an important trace element in many biological systems. In its naturally occurring oxidation state, copper has a great affinity for sulfide groups in protein and it can be toxic to both animal and vegetable life in quite low concentrations. This situation is especially critical in natural water because algae can be killed by very small concentrations. Low concentrations from agricultural or industrial sources could, therefore, unbalance the ecology of a natural water system. All methods of analysis reported in the literature are time-consuming and require skilled technicians and/or expensive equipment. The Institute is supporting a project to evolve a simple, cheap, and reliable method for trace copper analysis which could be performed by an individual with little formal chemical knowledge. It is quite possible that the method could be extended to the analysis of other important transition metal ions.

I urge your favorable consideration of the proposed amendments. They are necessary if we are to maintain an adequate level of research effort on our water

problems and insure efficient use of new information coming from all water research programs. Each year we have been unable to support excellent research proposals submitted to the Institute because of insufficient funds. Your additional consideration is requested to the need for authorization of expenditure of Title I funds for employee benefits.

UNIVERSITY OF DENVER,
COLLEGE OF ENGINEERING,
Denver, Colo., April 16, 1970.

Hon. GORDON L. ALLOTT,
U.S. Senate,
Washington, D.C.

SIR: Recently I have become aware of some proposed amendments to P.L. 88-379, the Water Resources Research Act of 1964. As I understand it, the proposals include provision to increase the annual amount of appropriation under Section 100(a) of Title I of the Act from \$100,000 to \$250,000.

As a citizen, a practicing engineer and a professor of civil engineering at the University of Denver, I wish to urge you to support these proposed amendments. There is a great need to increase the breadth and depth of water resources training and research. The programs administered by the state water resources centers can be most effective in accomplishing this goal in that they reach to the grass roots of the educational process which is responsible for producing water resources manpower. This is sorely needed manpower in water management and water pollution control.

I would appreciate very much your support for these proposed amendments. I understand they are S.B. 3553, H.R. 16285 and H.R. 15957.

Very truly yours,

NEIL S. GRIGG,
Assistant Professor of Civil Engineering.

UNIVERSITY OF WYOMING,
OFFICE OF THE PRESIDENT,
Laramie, Wyo., July 16 1970.

Senator HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs,
U.S. Senate Building,
Washington, D.C.

DEAR SENATOR JACKSON: It is my understanding that your Committee will be holding Hearings on July 20 on Senate Bill S-3553, an amendment to the Water Resources Research Act of 1964, to increase the authorization for the operation of Institutes. We at the University of Wyoming are very proud of our Water Resources Research Institute and believe that the research underway within the Institute is applicable to the current problems facing the State and the Nation.

In addition, the interest in Water Resources Research and the coordination of research efforts on the campus of the University of Wyoming has been greatly enhanced by the presence of the Institute. With the spiraling cost-of-doing-business, it is imperative that the appropriations for the Institutes be increased. Without such an increase, the result is actually a decrease in the efforts that can be made.

I strongly endorse the concept enunciated in the Bills pending before Congress, such as Senate Bill S-3553.

Sincerely yours,

WILLIAM D. CARLSON, *President.*

WASHINGTON STATE UNIVERSITY,
STATE OF WASHINGTON WATER RESEARCH CENTER,
Pullman, Wash., July 22, 1970.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
New Senate Office Building,
Washington, D.C.

DEAR SENATOR JACKSON: In the testimony on S. 1051 before the Subcommittee on Water and Power Resources of the Senate Committee on Interior and Insular

Affairs on July 20, 1970, some statements were made about the Virgin Islands by Assistant Secretary of the Interior Carl L. Klein which might have a negative impact on the possibilities of including the Virgin Islands along with the District of Columbia in consideration for the establishment of new water research centers.

In response to a question from Senator Bible as to why the Virgin Islands was not included in Interior's report, Mr. Klein stated that he understood there was no ground water on the Islands, according to the University there. I did not have the opportunity to check this out with Mr. Towle, who presented the testimony for the Virgin Islands at the hearings but as a hydrogeologist I suspected that Mr. Klein had been misinformed. Accordingly, I went to the library of the Geological Survey in the Department of the Interior the next day, and can report that there is ground water on St. Croix, the larger of the U.S. Virgin Islands.

One report (Hendrickson, 1963, p. 1) states that "if properly developed, [ground water] should be adequate to supply the present and near-future demand for water for public supply." Another report (Tippetts, et al., 1959, Letter of Transmittal) stated that, of the sources available—ground water, surface runoff from streams and artificial catchments, and converted sea water, ground water "can more economically meet the requirements as they develop, not only at Christiansted but also at Fredericksted." A third report (Meyer, 1952) dealt with the construction of dams on the Island of St. Croix. Meyer pointed out that 46–50 inches of precipitation falls in the west and 20 inches in the east. Furthermore, the mountain streams disappear underground in a short distance, so the lower channels are dry but ground-water recharge is substantial. Because of the high potential evapotranspiration (estimated at 72 inches—Cederstrom, 1950), and the fact that dams founded on the limestone bedrock there will leak, it would appear that the possibility of surface-water storage will require detailed hydrogeological study.

Admittedly, these reports all deal with the main island, St. Croix. However, the other two U.S. Virgin Islands, St. Thomas and St. John, some 40 miles to the north, lie on an eastward extension of Puerto Rico and the adjacent small islands of Vieques and Culebra. Puerto Rico's ground-water resources and problems are well known (see bibliography of Hooker, 1969), so it would seem that St. Thomas and St. John would also present some hydrologic problems that deserve study. Furthermore, the water resources of the British Virgin Islands, just northeast of St. Thomas and St. John, have likewise been the subject of study (Jordan, 1966; Martin-Kaye, 1954), and seem to present problems.

Thus it seems that there are some exciting physical and engineering studies of the water resources of the Virgin Islands that need to be undertaken. Accordingly I do not feel that Mr. Klein's statement should negate the possibility of the establishment of a water research center at the land-grant university in the Virgin Islands.

Sincerely,

ALLEN F. AGNEW, *Director.*

Enclosure.

SELECTED REFERENCES ON GROUND WATER OF THE U.S. VIRGIN ISLANDS AND NEIGHBORING AREAS

Cederstrom, D. J., 1950, Geology and ground-water resources of St. Croix, Virgin Islands: U.S. Geol. Survey, Water-Supply Paper 1067, 117 p.

Hendrickson, Gerth E., 1963, Ground water for public supply in St. Croix, Virgin Islands: U.S. Geol. Survey, Water-Supply Paper 1663-D, 27 p.

Hooker, Marjorie, 1969, Bibliography and Index of the geology of Puerto Rico and vicinity San Juan: The Geological Society of Puerto Rico, 53 p.

Jordan, Donald G., 1966, Test well sites and preliminary evaluation of ground-water potential in Tortoln, British Virgin Islands: Wash., D.C., U.S. Geol. Survey library, 35 p.

Martin-Kaye, Peter H.A., 1954, Water supply of the British Virgin Islands: Wash., D.C., U.S. Geol. Survey library, 69 p.

Meyer, Rex R., 1952, Geology and hydrology of damsites on the island of St. Croix, Virgin Islands: Wash., D.C., U.S. Geol. Survey library, 67 p.

Tippetts-Abbett-McCarthy-Stratton, 1959, Potable water supply on St. Croix, Virgin Islands. Wash., D.C., U.S. Geol. Survey library, 61 p.

THE UNIVERSITY OF WISCONSIN,
 WATER RESOURCES CENTER,
 Madison, Wis., July 16, 1970.

HON. GAYLORD NELSON,
 U.S. Senate,
 Washington, D.C.

DEAR SENATOR NELSON: It is our understanding that there will be a hearing of the Subcommittee on Water and Power of the Senate Committee on Interior and Insular Affairs on Monday, July 20. We had hoped we could appear at that hearing and make a statement for the record; however, this proved to be impossible and, therefore, we would appreciate it if the attached statement could be placed in the record.

In our judgment S. 3553 would be a desirable piece of legislation and, therefore, our statement is in support of it.

Sincerely yours,

GERARD A. ROHLICH, *Director.*

Enclosure.

STATEMENT OF PROFS. IRVING K. FOX AND G. A. ROHLICH

A major objective of S. 3553 is to so amend the Water Resources Research Act that each state water resources center would receive an annual allotment grant of \$250,000 instead of the current allotment of \$100,000. As a director to one of these centers it is, of course, difficult for me to view this proposed change objectively. However, I would like to take advantage of the occasion of these hearings to explain to members of the Subcommittee why I feel the allotment grant program has been so valuable to the State of Wisconsin and why a substantial increase would be of inestimable assistance.

USE OF ALLOTMENT GRANT FUNDS

The annual allotment grant of \$100,000 which the Wisconsin Water Resources Center has received from the Office of Water Resources Research has provided a major part of the foundation on which a substantial program of research and education has been conducted within the State.

First, it made the Water Resources Center a practical reality. Together with funds provided by the University of Wisconsin, a modest portion of the total allotment grant made it possible to establish and maintain a continuing center for coordination and leadership in the conduct of water resources research activities. From a small beginning, a number of responsibilities gravitated to the Center, including the maintenance of a specialized reference library, the review and approval of water research projects undertaken by the state government, and the provision of general advice and information. Today we feel that the Water Resources Center is a well-established entity, providing a substantial service to the people of the State.

Second, the allotment grant program has provided much needed "seed" money for the initiation of new projects. A substantial research inquiry requires time and effort to review available data, to conceptualize the plan of study, and to design the program of work. This effort must be completed before a large scale research effort may be proposed for funding. It has been the policy of the Water Resources Committee, which oversees the program of the Wisconsin Water Resources Center (to emphasize "seed" projects in the allocation of allotment grant funds.

We believe this policy has paid in off in a handsome fashion. Early seed projects in the area of eutrophication eventually led to a major program of research at the University of Wisconsin-Madison on various aspects of eutrophication with support from the Federal Water Quality Administration. Also, a number of agencies are now supporting provision by the Center of an information service on eutrophication, including abstracts of technical articles in the field. Still another example is a project which we have called "Institutional Design for Water Quality Management: A Case Study of the Wisconsin River Basin." This major study grew out of a small allotment grant project. As it was developed it attracted support from the Office of Water Resources Research, the State of Wisconsin Department of Natural Resources, and the University. It is now nearly completed and we believe that it will indicate how substantial savings can be made through regional approaches to water quality management, and indicate

the kinds of policies and organizational arrangements that will be required to achieve this result.

Third, it has been the policy of our Water Resources Committee to give priority to the support of young researchers who are not widely known and, therefore, have difficulty securing funds from other sources. This has resulted in the supporting of promising young people at a number of small institutions around the State and they in turn have made worthwhile scientific advances.

THE VALUE OF AN INCREASE IN ALLOTMENT GRANTS

Why, one may ask, of so much is being done are more funds required? I believe there is a powerful case not only for additional investments in water resources research, but for investment in the manner permitted through allotment grant procedures as well.

The urgent need for scientific advances in water resources management are evident. It is especially urgent that we overcome the handicaps imposed by many of our existing institutional arrangements—laws, policies, tax structures, regulations, organization structures—which inhibit the utilization of knowledge being developed by the natural sciences. Research aimed at making improvements a practical reality is imperative in the decades ahead. This is especially true with regard to water pollution control.

If this increase in research is to be utilized we must find ways and means of supporting research personnel who are now underutilized. For the most part these are younger people at small institutions. These are the people that have difficulty in securing support from the large national funding agencies. But these people can be identified by the state water resources centers and guided into worthwhile research endeavors if funds are available for their support.

Here is where our deficiencies lie today in Wisconsin. In the numerous small institutions over the state, there are a great many capable researchers interested in water problems who have little or no support. With the existing levels of our matching grants we have only been able to scratch the surface. Should the larger amounts be made available, many additional individuals could be involved which would result not only in research advances, but also in the enrichment of college teaching which always flows from a stimulating research effort.

Furthermore, a portion of the increased funds would support programs to interpret technical information and promote the dissemination of such information to the decision-making processes which constitute the final step in preventing future problems and solving existing problems.

PURDUE UNIVERSITY,
WATER RESOURCES RESEARCH CENTER,
Lafayette, Ind., July 17, 1970.

HON. HENRY M. JACKSON,
*Chairman, Senate Committee on Interior and Insular Affairs,
Senate Office Building,
Washington, D.C.*

Dear SENATOR JACKSON: It is my understanding that the Senate Committee on Interior and Insular Affairs have scheduled a hearing on S. 3553—The Moss Bill amending the Water Resources Research Act of 1964.

Purdue University, as one of the land-grant universities that have participated in the Federal-State cooperative program of research on water resources problems, has endorsed this amendment.

Purdue University has a record of excellence in resident teaching, research, and extension in the field of water resources. At the inception of the program of the Water Resources Research Center in 1965, there were fifty-five staff members identified as being engaged in work related to water resources. Since that time, thirteen new staff members and twenty-four new water resources related courses have been added to Purdue's program. Formerly, the activities were based primarily in the Schools of Agriculture and Engineering. However, because of the increased interest and need, the program has expanded to five schools, including Science, Humanities, and Industrial Management, with twelve departments involved.

In the organization structure of the Water Resources Research Center, advisory committees have been formed for communication with governmental agencies, other colleges and universities in the State, and interested public lay

organizations. These committees have provided an excellent means whereby the pertinent problems and needs are related to the research teams. However, so many and so varied are the research projects which have been proposed by these groups only a fraction of them can be undertaken under present funding. These committees have also given valuable input in determining future training programs for water resources manpower needs.

Because of the diversity and urgency of the many water resources problems, the research and training programs should be expanded. After five years of operation of the Water Resources Centers, the gap between the research findings and the user or practitioner is ever widening. In order that the operations, planning and management agencies can more effectively utilize the research results, it is imperative that some means be implemented whereby communication is established. Workshops, short courses, and special publications have been proposed. However, under the present act, these are not authorized as part of the program. The authorization and intent of the proposed amendment will provide the mechanism for fulfilling the communication need.

Any additional information relative to our Water Resources Research Center's program in support of the amendment will gladly be supplied to your Senate Committee.

Yours truly,

DAN WIERSMA,

Director, Water Resources Research Center.

THE TEXAS A. & M. UNIVERSITY SYSTEM,
College Station, Tex., July 16, 1970.

HON. HENRY M. JACKSON,
*U.S. Senate, Committee on Interior and Insular Affairs,
Washington, D.C.*

DEAR SENATOR JACKSON: It has come to my attention that the Committee on Interior and Insular Affairs has scheduled hearings for Monday, July 20, on S. 3553, a bill to amend the Water Resources Research Act of 1964. It is impossible for me to be present at those hearings, but I offer for the record this letter statement in support of the proposed legislation.

When the Water Resources Research Act of 1964 was enacted, the emphasis was upon the need for research on water resources problems and for applications which would lead to problem solutions. Although the Act was sufficiently farsighted to include subject matter in economics, law and other topics outside of the physical and engineering sciences, the Act was limiting in that its entire purpose was toward research, as the title of the Act indicated. As has come to be recognized generally, the solution of many problems dealing with resources and environments does not rest always on the need to acquire new knowledge. Often the need is for the interpretation and use of existing information, for the dissemination of existing knowledge and for the attraction of talented persons to work on resource problems.

The programs of the Water Resources Research Institutes, established under the Water Resources Research Act of 1964, are deficient in not being able to deal effectively with non-research needs. They cannot engage in programs such as stimulating new academic courses and degree programs dealing with water resources; offering advisory services, short courses and other types of information dissemination to local governments, professionals or the public-at-large; or bringing together knowledgeable persons to consider and plan for a total set of educational activities that will respond to the water resources needs of the region served by the Institute.

The amendment proposed in Section II of S. 3553, whereby Section 100(b) of the Water Resources Research Act of 1964 would be broadened, is a step in the right direction. The proposed amendment is to be desired in place of the wording in the original Act. I suggest, however, that Section 100(b) might be further amended to make it possible for Water Resources Research Institutes to stimulate the development of new academic courses and new degree programs that will result in adding qualified persons to the field of water resources.

Even at the time the Water Resources Research Act of 1964 was enacted, the basic annual allocation of \$100,000 to authorized Institutes was minimum for carrying out the intent of the Act. The size of the allocation is more of a limiting factor today than it was in 1964. The intent of the program is that the Institutes capture the talents of the university community in order to advance the

cause of water resources. Most universities having the desired talents operate relatively large education and research programs. Consequently, the basic grant of \$100,000 makes very little impact on the university's program. In order to assemble a minimum university task force, the Water Resources Research Institutes should have basic funds sufficient to capture the efforts of at least 6 to 10 faculty members. One-hundred-thousand dollars will not do this.

Furthermore, in order to sustain the efforts of investigators and applied scientists for a period long enough to be effective in the solution of these important problems, the Institutes should be able to offer continuity. Very little continuity is possible with the basic grant at the \$100,000 level.

I strongly support the increase in authorization of funds for water resources research as proposed by S. 3553, particularly the proposed increase of the basic allocation from \$100,000 to \$250,000. May I suggest for the Committee's consideration, however, the possibility of adopting a sliding scale for basic support to the Institutes, relating the authorization to population of the state and its geographical area. A basic grant of \$100,000, for example, may have a different impact on a small state than on a large one.

It was my pleasure to have been in the Department of Interior when the Water Resources Research Act of 1964 was passed. I initiated the program for Secretary Udall and served as Acting Director of the Office of Water Resources Research. Since returning to Texas A&M University, I have also been active in the area of marine resources and I am Director of the Sea Grant Program here, established under the Sea Grant College and Program Act of 1968.

The Sea Grant Program and the Water Resources Research Program have similar goals. They contemplate similar uses of university talent. In my opinion, the Sea Grant Program has been more successful than the Water Resources Research Program. I think that part of this added fruitfulness can be traced to two differences. First, the Sea Grant institutional awards are sufficiently large to capture a considerable portion of a university's talents. For example, in the current year, the Sea Grant award to Texas A&M University was \$875,000. Second, the Sea Grant Program is not limited to research, but encompasses stimulation of new academic programs, dissemination of information and advisory services. My support of S. 3553 is predicted partly on these comparative experiences.

In summary, I wish to give my endorsement for favorable consideration of S. 3553 by your Committee.

Sincerely yours,

JOHN C. CALHOUN, JR.

UNIVERSITY OF WASHINGTON,
COLLEGE OF FOREST RESOURCES,
Seattle, Wash., July 27, 1970.

HON. HENRY M. JACKSON
U.S. Senate, New Senate Office Building,
Washington, D.C.

SIR: Thank you for your letter of July 10, 1970, advising me of the time and place of the hearing on Senate Bill 3553. I am very sorry that other commitments prevented my appearance and testimony at the hearing. I would, however, like to enter a few comments in the hearing records.

I believe the Water Resources Research Act of 1964 has been an outstanding piece of legislation to promote and improve the management of the nation's water resources. I also believe that the amendments to the original act as proposed in Senate Bill 3553 are very appropriate and necessary. My reasons are first, the cost of doing business has greatly increased since the Act was passed. These increased costs have greatly reduced our ability to support graduate students for training in water resource management. Initially, we were able to support a graduate student on less than \$5,000 a year including publication, salaries, and support expenses. Currently, we find it difficult to provide the same research program for \$7,000. In the State of Washington Water Resources Center Program, and particularly here at the College of Forest Resources, our prime use of the allotment monies has been the support of research assistants for advanced training in water resources. The increases in costs of doing business, I believe, are obvious and this point needs no further elaboration.

The second major amendment to the bill provides for improved dissemination of information developed by the Water Research Center's research program. Our experience has been that the research assistants, with their principal investi-

gator professors, provide a scientific report to the Water Research Center. In addition, these reports are frequently offered for publication in appropriate water research journals. However, very often the information is not translated, identified, or properly assembled in a form that is readily usable by the water resource manager working with his particular problem. We have been confronted with this problem and looked for appropriate solutions within the University and Water Research Center structure. In common with many other agencies and institutions, our budget does not permit us to provide this extension service. Agriculture has found that this effort is important in assuring the use of agriculture has found that this effort is important in assuring the use of agricultural research and it seems to me that it is also needed in the water resource field.

We would elaborate further in support of the bill, but I believe these are the two prime points. I hope these comments are of some help in your consideration of the bill.

Sincerely,

JAMES S. BETHEL, *Dean.*

CITY OF BATON ROUGE,
PARISH OF EAST BATON ROUGE,
Baton Rouge, La., July 15, 1970.

HON. H. M. JACKSON
*Committee on Interior and Insular Affairs,
Senate Office Building,
Washington, D.C.*

DEAR SENATOR JACKSON: We have been told that your Committee is now considering SB 3553, which modifies the Water Resources Research Act, P.L. 88-379.

It is possible that a brief description of the work of the Louisiana Water Resources Research Institute (financed in part under P.L. 88-379) in assisting us in solving our water supply problems may be of value to you.

For a number of years we have watched salt water in one of our principal water bearing formations move closer and closer to the well fields supplying industrial and municipal water. In 1965, a year after the Institute was founded, I, on behalf of the City-Parish Government, signed a matching-funds agreement with the L. W.-R.R.I. to finance a study to find out how to stop the underground movement of salt water. This was the first of three such annual agreements with the Institute for work on this problem.

Early this year (1970) we received a comprehensive report from the Institute (they published it as their Bulletin 5 and I am requesting them, by copy of this letter, to send you 5 copies for Committee use). This report shows where the salt water is coming from and not only contains a staged program for halting this movement, but includes cost estimates for accomplishing the work, an economic analysis, and a draft of needed legislation.

Acting upon this report, our City-Parish Council has already appropriated \$22,000 to undertake the first stage of the proposed work, pending passage of needed legislation.

I believe that this brief outline of our experience with the work of the Institute should be kept in mind as you evaluate SB 3553. We have found their help to be of great value and do not believe that such thorough and comprehensive assistance could have been obtained from any other public agency or from a private firm.

Sincerely yours,

W. W. "WOODY" DUMAS,
Mayor-President.

STATEMENT OF H. R. STUCKY, DIRECTOR, NEW MEXICO WATER RESOURCES RESEARCH
INSTITUTE, NEW MEXICO STATE UNIVERSITY

Water is a vital resource in New Mexico and is becoming more vital with each passing year. The Senate Select Committee reported in 1961 that the two major River Basins in New Mexico were the shortest of water in relation to projected demands on any other River Basins in the Nation. This was basically restated by the United States Water Resources Council report entitled *The Nation's Water Resources* published in 1968.

New Mexico's water resources are relatively small, while at the same time there has been a rapid increase in population over the last 20 years and similar population increase is projected to the year 2000 and beyond.

Because of the need for conservation and wise use of our vital water resources, it is necessary that a considerable amount of research be conducted well in advance of the immediate needs. At the same time additional research on current problems is required. New Mexico has a solid research background in water research and the state is giving strong financial support to its universities, within its ability to meet this and other needs.

The University of New Mexico at Albuquerque, the New Mexico Institute of Mining and Technology at Socorro, and New Mexico State University are co-operating in the water research work through the Water Resources Research Institute located at New Mexico State University. A basic operating agreement was signed by the Presidents of the three university units in 1966 and a supplement to that agreement was signed in June 1970. The supplement was to provide for the administration and allocation of the new \$104,000 appropriation for Water Resources Research made by the 1970 Legislature.

During each of the past four years there have been about twice as many good water research project proposals presented to the Water Resources Research Institute than could be funded. Also, there has been an increase each year in the number and quality of new project proposals. This means that many excellent water research projects have been left unfunded.

During the periods, 1965 to 1970, the New Mexico Water Resources Research Institute has supported research in over 25 different subject matter departments at the three university units and there have been over seventy publications to date. A copy of the *Publication List* as of January 1, 1970 is enclosed. Several additional publications are now in process. Five publications are being listed as examples of work in various disciplinary areas. These are:

1. Clark, Ira G., "Administration of Water Resources in New Mexico," Water Resources Research Institute in cooperation with the Department of History, New Mexico State University, WRRRI Report No. 3, June 1968, 32 pp.

2. Lansford, Robert R., Carl E. Barnes, Bobby J. Creel, Eldon G. Hanson, Harold E. Dregne, Evan Carroon and H. R. Stucky, "Irrigation Water Requirements for Crop Production—Roswell Artesian Basin, New Mexico," Water Resources Research Institute in cooperation with the Agricultural Experiment Station, Departments of Agricultural Economics, Agronomy and Soils, and Agricultural Engineering, New Mexico State University, WRRRI Report 5, November 1969, 59 pp.

3. Ingram, Helen M., "Patterns of Politics in Water Resources Development: A Case Study of New Mexico's Role in the Colorado River Basin Bill," Division of Government Research, University of New Mexico, Publication No. 79, December 1969, 96 pp.

4. King, W. E., J. W. Hawley, A.M. Taylor, and R. P. Wilson, "Hydrogeology of the Rio Grande Valley and Adjacent Intermontane Areas of Southern New Mexico," Water Resources Research Institute in cooperation with Earth Science Department, New Mexico State University, WRRRI Report No. 6, June 1969, 141 pp.

5. Hughes, William C., "Economic Feasibility of Increasing Pecos Basin Water Supplies through Reduction of Evaporation and Evapo-Transpiration," Water Resources Research Institute in cooperation with Department of Economics, University of New Mexico, WRRRI Report No. 9, June 1970, 38 pp.

Two of these, No. 3 by Dr. Ingram and No. 4 by Dr. King, were out of print in about 6 months after their release. This was due to the necessity of limiting the number of copies published to the available research funds. No funds were authorized for "information dissemination," as such, under the Act of 1964.

The increases in the Annual Allotments authorization from the present \$100,000 per state under the Water Resources Research Act of 1964, P.L. 88-379, to \$250,000 per state as provided in the Moss Bill S-3553 is needed for the following reasons.

1. The public interest in water has increased greatly since the passage of the Water Resources Research Act of 1964. This is resulting in requests for more research and in the need for more scientists to be trained in the Water Resources field. During FY 1969-70, there were 52 students receiving employment in New Mexico as research assistants through P.L. 88-379 programs in the following categories: 25 Undergraduates in eleven different disciplines; 23 Master's student in ten disciplines; and 4 Doctoral students in three fields.

At first it was expected that possibly 80 to 90 universities might carry out the proposed water research. There are now about 135 universities involved. In New Mexico, we have excellent working relationships with three university units

and have had one application from each of two other institutions of higher education in the state.

2. There is not nearly as much *information dissemination* in the Water Research field as is required to make the research results available to those who would be users, if they knew about it and/or they could get it in usable form. Funds are needed (1) for printing adequate number of research bulletins, (2) for postage and handling of publications, (3) for conferences and meetings where the Principal Investigators on the water research projects in any of the disciplines involved might meet with groups to help in the dissemination and use of his research. In New Mexico, only four of the twenty-five disciplinary departments where research has been conducted has any direct connection with our presently organized extension programs. The new funds are needed to implement a definite cooperative "information dissemination" program worked out in the state, to get the rapidly growing water research information out to the people where it could be effectively used in necessary decision making.

3. Much of the research to date has been in the physical sciences and economics, and more is needed in these fields to meet the intensifying problems. Problems such as urban hydrology, recycling of urban water, pollution control, application of desalting techniques to local conditions, rain making, evaporation suppressions, water importations, flood control, and water developments in relation to the ecology are examples from this area. There is also a great need for more work in the social science in order that the people can be given greater research information to guide the development and redevelopment of our water supplies as competition for its use increases. Changes in existing physical and institutional arrangements will be needed as the population increases and the need for food, water-base recreation, fish and wild life development, and the general quality of the environment becomes more intense.

The increased authorization in Senate Bill 3553 would permit work now on some of the more difficult and far-reaching water problems as well as on the current ones. Considerable "lead-time" is needed for research, so results can be made available in sufficient time for use in current and future decisions.

STATEMENT OF PAUL A. RECHARD, DIRECTOR, WYOMING WATER RESOURCES RESEARCH INSTITUTE

MR. CHAIRMAN: My name is Paul A. Rechar and I am the Director of the Wyoming Water Resources Research Institute at the University of Wyoming. I appear here today in support of Senate Bill S-3553 and Senate Bill S-3721. These Bills are for the purpose of increasing the authorizations for the Annual Allotment Program at the Water Resources Research Institutes within each of the fifty States and in Puerto Rico.

The impact of the Wyoming Water Resources Research Institute on the water resource activities of the University of Wyoming has been significant. Because of the recognized necessity for involving many disciplines in water resources research and activities, the Wyoming Institute has chosen to invest all of its annual allotment funds in an interdisciplinary research program. In this way, research workers from all over the campus of the University of Wyoming are encouraged to involve themselves in water resource activities and are able to work together towards solutions of common problems. While not measurable in publications, the willingness and ability of research individuals from the various disciplines to work together is, in no small way, attributable to the presence of the Institute on the campus. The members of our Panel, the policy making group consisting of one representative from each of the seven Colleges on the campus, and those faculty members working with the Institute are unanimous in their feeling that the organization of the Wyoming Institute is such that the long range impact of WRRI will be greatly enhanced as the years progress.

Interdisciplinary research is easy to talk about, but difficult to accomplish. Therefore, in a real sense, a major effort of the Institute is to investigate ways and means of accomplishing interdisciplinary research.

In addition to the development and discovery of knowledge through the research efforts, the Institute has been active in sponsoring seminars to help in the interpretation and the dissemination of the information available. Rather than attempting to engage in the editing and publishing of a newsletter, the Wyoming Institute has cooperated with the Wyoming Water Development Association in the publication of a monthly newsletter entitled *Wyoming Water Flow*. The cooperation between the state agencies involved with water resources at the administrative level, and the Wyoming Water Resources Research Institute on the

research level, has been very heartening. The Director is a member of the Governor's Interdepartmental Water Conference wherein the Director is continually advised of problems and activities of the administrative agencies. In a like manner, the Director can almost immediately disseminate information obtained from research projects.

A quick résumé of the projects within WyoWRRI helps to bring into focus the scope of our program. These projects include:

1. The Annual Allotment Program Water Resource Operations Study with areas of special investigation on (a) Criteria for Water Resource Planning; (b) Bio-physical Relationships in the Hydrologic Cycle; (c) Interrelationships of Water Quality and Water Utilization; and (d) Principles of Analysis of Water Resource Operations.

2. A matching grant with the Office of Water Resources Research of the Department of the Interior, and the Wyoming Game and Fish Commission, is looking at the value of the game and fish resources of the Green River Basin. This study is about to be concluded and there has been considerable interest in the outcome. The report will be published as a Ph.D. dissertation and as a Water Resources Series.

3. Consumptive use by high mountain meadow irrigation is being investigated under a matching grant with OWRR and the Wyoming Water Planning Program. It is important to know the quantity of water which will be utilized in the irrigation of high elevation native hay meadows, especially when developing a water plan for the State. This project is in its second year of operation. As a part of the investigation, a summary of consumptive use determination for the State of Wyoming by the Blaney-Criddle Method has been published.

4. Under contract with the Wyoming Water Planning Program, the Institute has placed on magnetic tape for automatic data processing, all of the streamflow records for the State of Wyoming. Several programs have been developed for analyzing these data. The potential for this system, know as the surface water system, for the Wyoming Water Planning Program, as well as for engineers throughout the State of Wyoming, is significant.

5. Shielding precipitation gages by snow fences is a study under contract with the U.S. Weather Bureau and is showing considerable promise. The influence of winds on precipitation gage catch, especially snowfall, is very significant. A measure of these differences and a possible way of alleviating effects of wind will be discussed in the report.

Another measure of the impact of the Institute is a review of its publications and the theses that have resulted from our work. The Wyoming Institute has published twenty reports in its Water Resources Series, six Annual Reports, four reports dealing with State Water Planning in Wyoming, and one general information report on Wyoming's Weather. Four additional reports have been processed through the College of Agriculture and nine issues of the *Land and Water Law Review* of the College of law. Twenty-two advanced degree theses have resulted from support by the Institute.

The Institute is deeply committed to utilizing the major portion of the funds for the support of undergraduate and graduate students at the University. To date, in the neighborhood of 200 students have received some measure of support through the Annual Allotment Program of the Office of Water Resources Research. It is critical to the operation of the Wyoming Water Resources Research Institute that the Annual Allotment continue to be provided and, due to the cost-of-doing-business spiral, the amount of funding should be increased.

It is firmly believed that the establishment of the Wyoming Water Resources Research Institute at the University of Wyoming has had a marked beneficial effect on the water resource program of the University and the State of Wyoming. It is sincerely hoped that the Congress will see fit to increase the authorization for the program for the benefit of the State and the Nation.

THE BATON ROUGE WATER WORKS Co.,
Baton Rouge, La., July 16, 1970.

Senator H. M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
Senate Office Building,
Washington, D.C.

DEAR SENATOR JACKSON: We have been told that your Committee is about to hold hearings on SB 3553 and that modification of the Water Resources Research

Act of 1964 is being considered. Industries in the Baton Rouge area, including this company which is franchised to supply domestic and commercial users, have had occasion to obtain assistance from the Louisiana Water Resources Research Institute and to contribute to its local funding.

Briefly, the water-bearing formations that underlie Baton Rouge have experienced an encroachment of salt water toward the well fields that supply the area. In 1965 the industrial water committee of the Baton Rouge City-Parish Council sponsored a research program conducted by the L.W.R.R.I. to determine the origin of the salt water and methods to halt its advance to our well fields, or at least to slow it up. We, of course, have supported the efforts of the industrial water committee to obtain funds and to monitor the research.

In February, 1970, the study was concluded and we obtained a comprehensive report that blended together the results of studies by professionals in the areas of geology, hydrology, engineering, economics, and law. The report describes in detail what will happen if we don't do anything, and outlines the results of a number of possible courses of action. It contains cost figures, economic comparisons of alternate plans and, most important, a draft of essential enabling legislation so that water users in the area can get the work done on the basis that the people using the water should pay in proportion to their use.

We believe that the work is sound (the first appropriations have already been made by the City-Parish to halt the encroachment of salt water) and that we were fortunate in having the Institute available to get the work done.

I hope that the information contained in this letter will enable you to decide on the value of the Water Institute. Here in Louisiana it is producing useful, applicable results.

Very truly yours,

RAYMOND E. PILLOW, *President.*

LOUISIANA POLYTECHNIC INSTITUTE,
WATER RESOURCES CENTER,
Ruston, La., June 19, 1970.

Senator RUSSELL LONG,
*U.S. Senate,
Washington, D.C.*

DEAR SENATOR LONG: It is our understanding that the bill to amend the Water Resources Research Act of 1964 (Senate Bill 3553) is still pending disposition before the Senate. This bill would increase the authorization for water resources research and institutes from \$100,000 annually to \$250,000 annually. Also, the bill provides for scientific information dissemination activities, including the training of qualified persons in the performance of such information dissemination.

We would like to encourage you to vote for approval of this legislation for several reasons. We believe that the present allotment of \$100,000 to each water research institute is inadequate to properly conduct the needed research to solve our ever-growing and rapidly increasing number of water resource problems. Administrative costs have also increased, thereby reducing the funds available for research.

The item on scientific information dissemination is becoming very important. If research is to be meaningful, the information obtained from such research has to be communicated to those persons who will put the information into practice. At the present, much research information obtained is not used because there is no way to distribute it.

Once again, let us encourage you to vote for approval of this legislation. It is needed, and it is timely.

Sincerely,

DR. FRED E. BECKETT,
Director, Division of Agriculture and Forestry Research.

DR. R. M. ALLEN,
Director, Division of Engineering Research.

DR. P. B. MOSELEY,
Director, Division of Research, Arts and Sciences.

DR. JAMES HESTER,
Director, Sponsored Programs.

DR. F. J. TAYLOR, *President.*

DR. DON C. WILCOX,
Director, Division of Business and Economic Research.

DR. BOBBY E. PRICE,
Director, Water Resources Center.

STATE OF SOUTH CAROLINA WATER RESOURCES COMMISSION,
Columbia, S.C., July 21, 1970.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR SENATOR JACKSON: At its regular monthly meeting on July 15, 1970, the South Carolina Water Resources Commission passed unanimously a motion endorsing the Moss Bill (S.3553), and the companion Bill HR-15957, amending the Water Resources Research Act of 1964 (P.L. 88-379). The Commission heartily approves of the purpose of this Bill, which is to authorize an increase to \$250,000 the annual allotment of federal funds to each State Water Resources Research Institute and to expand the program to include interpretation and dissemination of research findings.

The Water Resources Research Institute in South Carolina plays a most essential role in a water resources program of this Commission. Research findings and consulting service of the Institute personnel have provided assistance on a variety of problems with which the Commission is concerned. The State of South Carolina would benefit greatly from having the program of the Water Resources Research Institute expanded along with the necessary growth of water resources planning programs of this Commission and other state and local agencies.

On behalf of the South Carolina Water Resources Commission, I am pleased to submit this endorsement of the Bill, S-3553, to be included in the record of the hearings before the Committee on Interior and Insular Affairs held on July 20, 1970.

Sincerely yours,

HARRY S. BELL, *Chairman.*

UNIVERSITY OF IDAHO,
Moscow, Idaho, July 17, 1970.

Senator FRANK CHURCH,
U.S. Senate, New Senate Office Building,
Washington, D.C.

DEAR FRANK: This letter is to express the interest of the University of Idaho and its Water Resources Institute, in furthering the progress of Senate Bills S3553 and S3721 which will amend public law 88-379, the Water Resources Act. As you are no doubt aware, the two bills mentioned will increase the allotment funding from \$100,000 to \$250,000 annually and will also provide for a wider dissemination of research results.

In Idaho, the Water Resources Research Institute has been instrumental, through participation with the Idaho Water Resources Board, in the development of "state water plan". The institute developed the state water resources inventory, a reservoir study, a water needs report, and is currently engaged in developing criteria for the evaluation of wild and scenic rivers. In addition to these studies, many more could be enumerated which have also made important contributions to our understanding of Idaho's water resources problems.

One of the important areas in which the OWRR allotment money helps greatly, is in providing an amount of funding which can be used to support both new staff and students in the various departments of the University. The Colleges of Agriculture, Engineering, Forestry, Mines, and Letters and Sciences have all benefited in this way from the current program.

The major problem with all allotment programs at present is that the basic \$100,000 purchases far less in the way of staff, student time and other items needed in a research program than it did in 1964. A second point is, that this money makes a dramatic impact upon the quality as well as the quantity of research done. In a school such as Idaho, which can afford only a relatively small budget of its own for water resources research, the additional funding can provide for many desirable projects which otherwise could not be undertaken.

In the recent past, a significant effort of our water resources research institute has been directed toward evaluating the environmental quality of Idaho's undeveloped rivers. Seven Idaho rivers are named in the Wild and Scenic Rivers Act. These rivers all have outstanding cultural, historic, scenic, fish and wildlife, and other related values. None of these, of course, can be measured in dollars. Some of the values will have to be measured in the light of what they contribute to human welfare, personal growth and development, creativity, and other non-traditional measures of value. This type of research calls for an ever widening

multi-disciplinary approach, as I am sure you are well aware. Such an approach, fits well into the frame work of our institute as it is presently constituted among the several colleges of the University. Increased funding will insure that more disciplines can participate in these research efforts and certainly will also increase markedly our ability to publish and disseminate the results and recommendations growing from our research.

Knowing of your interest in our State's natural endowments, such as wild rivers and water resources, I earnestly solicit your support of these bills as they come before the Senate for action.

Cordially yours,

ERNEST W. HARTUNG, *President.*

THE UNIVERSITY OF NEBRASKA,
WATER RESOURCES RESEARCH INSTITUTE,
Lincoln, Nebr., July 20, 1970.

Hon. HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs, Subcommittee on Water, Power and Resources, U.S. Senate Office Building, Washington, D.C.

DEAR SENATOR JACKSON: The University of Nebraska is extremely concerned about S. 3553. We believe that this bill would provide the increases necessary to assure a highly effective water resources research program. I am enclosing a statement which outlines some of my comments relative to the need for this bill.

Your consideration is greatly appreciated.

Very truly yours,

WARREN VIESSMAN, JR., *Director.*

Enclosure.

PREPARED STATEMENT OF WARREN VIESSMAN, JR. DIRECTOR, STATE OF NEBRASKA
WATER RESOURCES RESEARCH INSTITUTE

This is a statement by Warren Viessman, Jr., Director of the State of Nebraska Water Resources Research Institute and Professor of Civil Engineering at the University of Nebraska. These remarks are offered in support of S. 3553 and S. 3721 which would amend P.L. 88-379, the Water Resources Research Act.

Nebraska is confronted with as varied a group of water problems as is likely to be found. These include floods, droughts, erosion, non-uniform distribution of precipitation, water quality deterioration, declining water tables, land drainage, effective water resources management, water rights, and the development of modern institutions capable of administering water resources programs.

Solutions to many water problems will be dependent on the availability of reliable quantitative research results and personnel skilled in the use of modern analytic techniques. The University of Nebraska is vitally interested in the development of research and educational programs which will help to satisfy this need. The opportunity for expansion of the current research effort is restricted, however, by limited financial support.

In 1964, the Nebraska Water Resources Research Institute was organized to undertake a program of research and training which could be directly oriented towards the recognized water resources problems of Nebraska. This activity has now passed through five years of operation and has become recognized as a dynamic part of the University's commitment to the field of water research and education. The Institute is concentrating its resources on those problem areas considered to be of highest priority to the state and region. The nature of the research is strongly flavored by the interdisciplinary character of the Institute. Research areas already well-established under other University departments are being coordinated with those of the Institute.

For the next five years, maximum emphasis will be placed on a select few research areas. Priorities have been established through a critical appraisal of the water resources problems of the state of Nebraska and the Midwest. Major emphasis is being given the following: (1) water quality with special emphasis on agricultural pollution and eutrophication; (2) analysis of water resources systems with particular consideration given to conjunctive use models, hydrologic system models, eco-system models, irrigation system models, management models, and sediment transport models; (3) evaporation and tran-

piration models, phreatophyte studies, and water potential-plan response studies; (4) water law; (5) the rural-urban interface as related to water resources development-management and use; and (6) water resources data with emphasis on data storage and retrieval.

Several projects have been developed to meet the needs of the state water planning effort. Projects providing useful information to water resources planners include A-013, A-014, A-016, and B-003. These projects are answering questions related to: legal problems associated with coordinated management of surface and ground water supplies; practical alternatives available for water quality control of recreational lakes; the feasibility of developing useful mathematical models for state water resources planning; and the suitability of several management practices for abating pollution from animal feedlots. Information on the maximal water demand by crops and reliable methods for predicting water use on the basis of weather conditions is being provided by project A-017. Project A-014 is evaluating practical methods to control the rate of reservoir eutrophication and preserve acceptable water quality for recreational use in small reservoirs in Nebraska and the Great Plains region. Unless a solution is found to this problem, many small reservoirs will be of little recreational benefit to a large segment of the urban population needing such facilities. The results of projects (A-013, B-007) will be used by administrators and legislators in formulating the Nebraska state water plan. Consideration is being given to modifying the law on riparian rights, transbasin diversions, conflicts between surface and groundwater users, use preferences, and supplying water to industry located outside municipal boundaries. The study will also affect the legal rules governing irrigation and reclamation districts. Other useful research results have been developed relative to: the recharge of municipal well fields using silt-laden streams (A-011); evapotranspiration mechanisms and control (A-015); the economic development of small rural water supplies through desalination (A-007); and the economics of developing irrigation projects (A-004).

Working relationships between the Institute and various state and federal agencies, other educational institutions, industries and other organizations associated with the water resources field have been expanded and strengthened. A sound basis for cooperation in planning and conducting future research in association with many of these organizations exists. Cooperative research with other state agencies and universities has become a reality. Several state agencies have been very helpful in pointing out areas of research need. The Bureau of Reclamation, the Federal Water Quality Administration and the Corps of Engineers have also contributed to program development.

The decade of the 1970's will see an increased concern over the quality of the environment. In this respect, great emphasis will be placed on all aspects of the development, management and control of the surface and ground waters of Nebraska and the nation. The competence which can be brought to bear in solving the complex problems which we face will be directly related to the quality and productivity of our water resources research and training programs and the funding level which can be developed for these programs.

When the original act was designed, it was considered by the sponsors that a basic allotment of \$100,000 annually would be adequate to initiate the program. It is very clear that inflation has significantly modified the output of research which can be purchased by the funding level originally authorized. As studies have proceeded, it has also become evident that the scope and complexity of problems which we face are far beyond those realized in 1964.

There is no question that the productivity of water resources research in Nebraska would be materially increased by the passage of Senate bills S. 3553 and S. 3721. This increased funding level would permit the in-depth studies of significant national and regional water supply and management problems that are so urgently needed. It would also provide an adequate base with which to undertake the necessary research which has already been cataloged as essential for the Midwest.

The Nebraska Water Resources Research Institute is a focal point for water resources activity. The Institute is concerned with research, training, education, and dissemination of information. It is a coordinator of University and university-agency research in water resources. The effectiveness of the water resources research program is increasing rapidly and interest on the part of researchers is at a high level.

The potential for the various water resources centers to contribute directly to the national need in water research is limited only by current funding levels. To

assure the perpetuation of this productive thrust in the field of water resources research, it is strongly urged that favorable action be taken on this legislation.

NORTH DAKOTA STATE UNIVERSITY
OF AGRICULTURAL AND APPLIED SCIENCE,
Fargo, N. Dak., July 21, 1970.

Senator HENRY JACKSON,
*Chairman, Senate Committee on Interior and Insular Affairs,
New Senate Office Building,
Washington, D.C.*

DEAR SENATOR JACKSON: I understand that your Committee is reviewing an amendment to Senate Bill 3553 which would increase the annual allotment program for OWRR from \$100,000 to \$250,000 per year, and would also provide for a certain amount of Extension activities to be supported by the allotment program.

My purpose in writing is to encourage you to give every support possible to this proposal. At a time when so much urgency must be attached to our environment and the ecological relationships of which water is a vital part, it is mandatory that increasing federal support be available for these activities.

I sincerely feel that the meager appropriations for the allotment program thus far have had outstanding results. I know that this is true on a national level and we've certainly seen much evidence of it here in North Dakota. Our studies on pollution, economic impacts of irrigation, biological aspects of man-made lakes, and the general area of watersheds and potholes already have had far-reaching ramifications for total planning here in the state.

Although our Water Institute in North Dakota is headquartered here at North Dakota State University, it is strictly a cooperative program between us and the University of North Dakota at Grand Forks. It is the one program where there has been very positive cooperation between the two institutions and I would certainly hope that there would be increasing support to continue this kind of inquiry where the problems are on such a broad scale.

Your interest and concern on this matter is appreciated.

Sincerely yours,

L. D. LOFTSGARD, *President.*

RUTGERS UNIVERSITY,
WATER RESOURCES RESEARCH INSTITUTE,
New Brunswick, N.J., July 20, 1970.

Hon. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.*

DEAR SENATOR JACKSON: It is some time since I communicated with you on water resources matters; but I was known to you about 20 years ago when I was the first district Engineer of the Walla Walla district, Corps of Engineers, and later in the Chief of Engineers' office.

This letter is to submit a statement in favor of S. 3553, which proposes to amend the Water Resources Research Act so as to increase the annual allotment fund support for each water resources research institute from \$100,000 to \$250,000 annually and to provide specific authorization for dissemination of research results.

The New Jersey Water Resources Research Institute was started in 1965 with rather limited Federal support, and has gradually been built up to a program averaging about 30 research projects, spread throughout 14 departments and two bureaus of Rutgers, and involving also both Stevens Institute and Princeton University. This is the first academic year in which a large group of projects has been completed; we have distributed project reports covering eight projects, and several more are in final stages of publication. One of these reports, on instream aeration of polluted rivers, was given two book reviews, has had 700 copies distributed, and has been very favorably received among engineering circles and by government agencies. There have already been about 15 articles in major journals associated with these reports. Research results have included such useful subjects as effects of oxygen-deficiency upon anadromous fish, water law in New Jersey, correlation of pollution growth with population growth on three New Jersey rivers, and estimates of organic pollution, showing a high proportion of pollution coming from unrecorded sources other than waste treatment plants.

The program has provided excellent training and research opportunities for graduate students; and has given emphasis to the University's program to improve the quality of our environment.

The additional funds will be applied mainly to strengthen and re-focus the efforts of existing departments concerned with water pollution, water supply and water management, and to provide for dissemination of research findings to action agencies and individuals facing water problems in the state.

Sincerely yours,

WILLIAM WHIPPLE, Jr., *Director.*

THE UNIVERSITY OF TENNESSEE,
Knoxville, Tenn., June 17, 1970.

Senator HOWARD H. BAKER, Jr.,
*Senate Office Building,
Washington, D.C.*

DEAR HOWARD: Two bills (one by Senator Moss S. 3553 and another by Senator Hansen S. 3721) to amend the Water Resources Research Act of 1964, to increase the authorization for water resources research and institutes, and for other purposes have been introduced in the Senate. The bills have been referred to the Committee on Interior and Insular Affairs.

The University of Tennessee wholeheartedly supports these bills for the following reasons:

1. For fiscal year 1971 our Water Resources Research Center received excellent allotment proposals which far exceeded the \$100,000 allotment appropriation. It will be most difficult to eliminate some worthwhile water research projects for the coming year.

2. Inflation has also reduced the amount of research that can be obtained by the present allotment allocation. These bills, which make provision for increased or decreased costs of research and training, based on the national economy, seem most realistic.

3. Interpretation and dissemination of water research results is a necessary task for improving the water phase of the environment. Implementation of Section 2 of these bills would do much to lessen the time period between research solutions and practical applications.

In view of the favorable effects which would be produced upon the environment by the passage of S. 3553 and S. 3721, I would appreciate your support of these bills.

Sincerely yours,

A. D. HOLT, *President.*

AMERICAN SOCIETY OF CIVIL ENGINEERS,
New York, N.Y., July 23, 1970.

Hon. HENRY M. JACKSON,
*Chairman, Interior and Insular Affairs Committee, U.S. Senate, New Senate
Office Building, Washington, D.C.*

SUPPORT FOR WATER RESOURCES RESEARCH PROGRAM

DEAR SENATOR JACKSON: The American Society of Civil Engineers represents over 64,000 civil engineers of this country, a substantial number of whom are directly interested in water resources planning, design, construction and operation. Thus, we are concerned with the continuous improvement in water knowledge which comes through research. Most water resources research is conducted by or sponsored by federal agencies, and one of the most central and important agencies is the Office of Water Resources Research in the Department of the Interior.

The ASCE, particularly through its Committee on National Water Policy, has followed the activities of OWRR very closely throughout its agency life beginning in 1964. It has been exceptionally well administered, and has consistently directed university research efforts into areas of highest priority. This agency has done a great deal to stimulate the research effort in water resources which our nation needs.

The authorizations of the Water Resources Research Act of 1964 provided a system of allotments to the 51 water resources centers at universities which increased from an initial annual rate of \$75,000 to \$100,000 per year, and has now

remained constant for several years. We believe this allotment should be increased to \$250,000 per year as proposed.

The annual allotment increase is made important because of the low funding under the matching grant and Title II provisions of the Act. In recent years funds for only about 10 percent of proposals could be supported. In time, if not already, this will tend to discourage rather than encourage water research efforts.

The ASCE, therefore, strongly supports the proposal to increase the annual allotment feature of OWRR funding from \$100,000 to \$250,000 per year.

Sincerely,

WILLIAM H. WISELY,
Executive Director.

LEAGUE OF WOMEN VOTERS,
U.S. Virgin Islands, July 24, 1970.

Senator HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR SENATOR JACKSON: The League of Women Voters of St. Thomas-St. John would like to express its surprise and alarm at the recent statement made by Assistant Secretary Carl L. Klein at the sub-committee hearing July 20. The statement made was to the effect that there was no need for an amendment to include the Virgin Islands in the Water Resources Research Act of 1964, Public Law 88-378 as amended in 1966 by Public Law 90-404.

I refer to the recommendations from the Water Pollution Control Advisory Board to the Secretary of the Department of the Interior, June 10, 1970:

(Item 8) Federal laws should be amended to include the Virgin Islands in the list eligible for grants under the Water Resources Research Act of 1964 to permit establishment of a Water Resources Research Institute at the College of the Virgin Islands.

Your assistance in endorsing the above recommendation would be most appreciated. It is our opinion that a more effective water resources research program is not only desirable but a prime necessity for the welfare and future development of the Virgin Islands.

Sincerely yours,

BEVERLY BANDLER,
Chairman, Environmental Quality.

NATIONAL WILDLIFE FEDERATION,
Washington, D.C., July 20, 1970.

Senator HENRY M. JACKSON,
Chairman, Senate Committee on Interior and Insular Affairs, New Senate Office Building, Washington, D.C.

DEAR MR. CHAIRMAN: Thank you for the invitation and opportunity to comment upon S. 3553, amending the Water Resources Research Act of 1964, Public Law 88-379, as further amended in 1966 by Public Law 90-404.

It is our belief and contention the Virgin Islands should be made eligible to receive annual grants now being provided for by Section 100 of this Act in the same manner that Puerto Rico and other territories have qualified. We believe that the Virgin Islands can qualify to perform both research in water resources and in performance of a training function as well.

Two members of our staff recently visited the Virgin Islands and were most favorably impressed with water resources projects already under way there under the auspices of the Governor of the Islands and most certainly many problems existing there are unique, both with relationship to water supply and water waste treatment.

To conclude, Mr. Chairman, we hope that S. 3553 can be amended to authorize the Virgin Islands as a full participant in the water resources program.

Sincerely,

THOMAS L. KIMBALL,
Executive Director.

LEAGUE OF WOMEN VOTERS OF NEW YORK STATE,
New York, N.Y., July 28, 1970.

Hon. HENRY M. JACKSON,
U.S. Senate,
Washington, D.C.

DEAR SENATOR JACKSON: As Housing Chairman for the League of Women Voters of New York State, I am very interested in your National Land Use Policy Bill as described in an editorial in the Sunday New York Times.

Could you please send me a copy of the bill and any supporting memoranda and materials which would be helpful in describing the impact of the bill.

I am at present working on a study of land-use for the League, particularly as it relates to housing in New York State. I would be grateful for any suggestions you or your staff would have on further materials, particularly on land banking methods.

Thank you very much for your help.

Sincerely,

VIRGINIA K. BOWMAN,
 MRS. JOHN E. BOWMAN,
Chairman, Development of Human Resources—Housing.

HOT SPRINGS, S. DAK., *July 27, 1970.*

Hon. HENRY M. JACKSON,
Senate Office Building,
Washington, D.C.

DEAR SENATOR JACKSON: What can be done to make the so-called seal harvest on the Pribilof Islands more humane?

As you probably know, the Humane Society of the United States has made suggestions to eliminate the long overland drive; and a more humane method of slaughter. You surely will agree there is much cruelty in the present habit of clubbing.

We are all expecting your co-operation for the improvement of this seal hunt.

Thanking you in advance,

MRS. W. M. ARNOLD.

