# FOURTH NATIONAL CONFERENCE
## Water Resources Division

Edith B. Chase and Miriam Brigida, Editors
Joan M. Rubin, Art Editor

# PROCEEDINGS

October 18—23, 1981 Ocean City, Maryland

U.S. Geological Survey Open-File Report 83-126

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

Dallas L. Peck, Director

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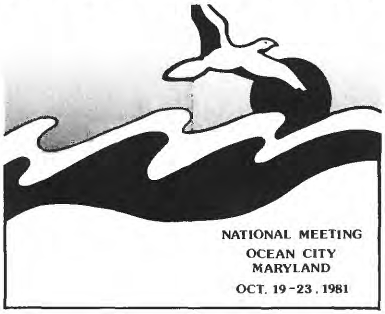


## SUNDAY, OCTOBER 18

1:00 p.m. to 9:00 p.m. CONFERENCE REGISTRATION — Lobby

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## MONDAY, OCTOBER 19

Chairman: R. H. Langford, Associate Chief Hydrologist

**8:00** CONVENE NATIONAL MEETING—OPENING REMARKS — Ballroom
R. H. Langford, Associate Chief Hydrologist

**8:10** WELCOME
J. B. Coulter, Secretary, Maryland Department of Natural Resources, introduced by
J. E. Biesecker, Regional Hydrologist, Northeastern Region

**8:35** INTRODUCTION OF DISTINGUISHED GUESTS
Philip Cohen, Chief Hydrologist

**8:45** KEYNOTE ADDRESS
Daniel N. Millar, Jr., Assistant Secretary—Energy and Minerals, Department of the Interior

**9:30** Coffee

**10:00** THRUSTS FOR THE FUTURE—A TECHNOLOGY TRANSFER WORKSHOP
L. B. Laird, Assistant Chief Hydrologist for Research and Technical Coordination, Chairman

**10:15** DISCUSSION GROUPS:
- GROUND WATER- — Leeward Room
  Gordon Bennett, Acting Chief, Ground Water Branch
- WATER QUALITY- — Midship Room
  R. J. Pickering, Chief, Quality of Water Branch
- SURFACE WATER- — Starboard Room
  Marshall Moss, Acting Chief, Surface Water Branch

**11:30** PRESENTATION OF REPORTS BY DISCUSSION GROUPS — Ballroom

**12:15** Lunch

**1:30** PLENARY SESSION — Ballroom
J. D. Bredehoeft, Regional Hydrologist, Western Region, Chairman

**1:30** Doyle G. Frederick, Associate Director, U.S. Geological Survey

**2:15** A LOOK AT THE YEARS SINCE ALBUQUERQUE
R. H. Langford

**3:00** Coffee

**3:30** WORKING GROUPS: STAGE SETTING AND CHARGE
T. J. Buchanan, Assistant Chief Hydrologist, Operations, Chairman

**4:00** WORKING GROUPS, SESSION I

A. Federal-State Cooperative Program
Chairmen: J. F. Blakey — Starboard Room; R. C. Averett — Leeward Room

B. Coping with restricted resources in the 1980's
Chairmen: T. Arnow — Rooms 318-320; I. H. Kantrowitz — Midship Room

C. The role of computers, word-processing equipment, and related hard- and software in WRD programs in the 1980's
Chairmen: J. S. Rosenshein — Leeward Room; D. E. Vaupel — Midship Room

D. Digital simulation models and the role of the WRD in documenting, verifying, and distributing them
Chairmen: I. C. James — Starboard Room; L. F. Konikow — Room 306

E. WRD goals for the 1980's
Chairman: J. F. Daniel — Room 308

**5:00** Recess

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## TUESDAY, OCTOBER 20

**8.00** PLENARY SESSION — Ballroom
Alfred Clebsch, Jr., Regional Hydrologist, Central Region, Chairman

**8:00** A LOOK AHEAD
Philip Cohen

**8:45** OPEN DISCUSSION
Philip Cohen

**9:30** WORKING GROUPS, SESSION II

**11:45** Official group photo - Poolside

**12:15** Lunch

**1:45** TECHNICAL SESSION I

<u>Concurrent sessions</u>

**1:45**
1. Solute transport modeling - L. F. Konikow — Midship Room
2. Distributed parameter rainfall-runoff modeling - G. H. Leavesley — Leeward Room
3. Surface geophysics in general water investigations - F. P. Haeni — Rooms 318-320
4. Improvements in instrumentation - R. W. Paulson — Starboard Room

*Continued on the following page*

# A G E N D A


**TECHNICAL SESSION I** *–Continued*

Concurrent sessions

| | | |
|---|---|---|
| 3:00 | 3. Surface geophysics in general water investigations - F. P. Haeni | Rooms 318-320 |
| | 5. Ground-water contamination - J. B. Robertson | Midship Room |
| | 6. Surface-water network evaluation - M. E. Moss | Leeward Room |
| | 7. Acid rain - V. C. Kennedy, R. A. Schroeder | Starboard Room |
| 4:15 | Recess | |

WEDNESDAY, OCTOBER 21

| | | |
|---|---|---|
| 8:00 | SELECTED REGIONAL MEETINGS—REGIONAL HYDROLOGISTS | |
| | Northeastern Region - | Rooms 318-320 |
| | Southern Region - | Starboard Room |
| | Central Region - | Leeward Room |
| | Western Region - | Midship Room |
| 12:00 | Lunch | |
| 1:00 | WORKING GROUPS, SESSION III | |
| 1:00 | WRD SENIOR STAFF MEETING | Rooms 302-304 |
| 5:00 | Recess | |

THURSDAY, OCTOBER 22

| | | |
|---|---|---|
| 8:00 | PLENARY SESSION<br>J. L. Cook, Regional Hydrologist, Southeastern Region, Chairman | Ballroom |
| 8:00 | AWARDS, RECOGNITION, OTHER BUSINESS<br>Philip Cohen | |
| 8:45 | WORKING GROUPS, SESSION IV | |
| 12:00 | Lunch | |
| 1:30 | TECHNICAL SESSION II | |
| | Concurrent sessions | |
| 1:30 | 1. Solute transport modeling - L. F. Konikow | Midship Room |
| | 2. Distributed parameter rainfall-runoff modeling - G. H. Leavesley | Rooms 318-320 |
| | 4. Improvements in instrumentation - R. W. Paulson | Leeward Room |
| | 8. Distributed information systems - Uyless Black | Starboard Room |

Concurrent sessions

| | | |
|---|---|---|
| 2:45 | 5. Ground-water contamination - J. B. Robertson | Midship Room |
| | 6. Surface-water network evaluation - M. E. Moss | Leeward Room |
| | 7. Acid rain - V. C. Kennedy, R. S. Schroeder | Rooms 318-320 |
| | 8. Distributed information systems - Uyless Black | Starboard Room |
| 4:00 | WORKING GROUPS, SESSION V | |
| | A. Federal-State Cooperative Program | Starboard Room |
| | B. Coping with restricted resources in the 1980's | Midship Room |
| | C. The role of computers, word-processing equipment, and related hard- and software in WRD programs in the 1980's | Leeward Room |
| | D. Digital simulation models and the role of the WRD in documenting, verifying, and distributing them | Rooms 318-320 |
| | E. WRD goals for the 1980's | Room 306 |
| 5:30 | Recess | |
| 6:30 | Clambake - Poolside | |

FRIDAY, OCTOBER 23

| | | |
|---|---|---|
| 8:00 | PLENARY SESSION<br>R. J. Dingman, Assistant Chief Hydrologist, Scientific Publications and Data Management, Chairman | Ballroom |
| 8:00 | Dallas L. Peck, Director, U.S. Geological Survey | |
| 8:45 | WORKING GROUPS, REPORTS AND DISCUSSION | |
| 12:00 | CLOSING SESSION<br>P. E. Ward, Chief, Office of Water Data Coordination, Chairman | |
| | SUMMATION<br>Philip Cohen | |
| | CONCLUDING REMARKS<br>R. H. Langford | |
| 1:00 | ADJOURN NATIONAL MEETING<br>R. H. Langford | |
| 2:00 | SELECTED REGIONAL MEETINGS—REGIONAL HYDROLOGISTS | |
| | Northeastern Region - | Rooms 318-320 |
| | Southern Region - | Starboard Room |
| | Central Region - | Leeward Room |
| | Western Region - | Midship Room |

# Opening Remarks

R. H. LANGFORD, Associate Chief Hydrologist

Welcome to the 4th National Meeting of the Geological Survey's Water Resources Division. This meeting comes at a crucial point in the Division's history—for we are faced with critical decisions at all levels that will shape the Division for years to come. The meeting was planned and structured with this in mind. It incorporates seven objectives—

**AN OPPORTUNITY**

- For us to take stock of where we are and where we want to be going.
- For our leaders at the Secretariat and Directorate levels to give us their views of the Division and how they should fit into the larger picture.
- For each of you to express your views on a wide variety of critical issues and, thereby, to help shape the Water Resources Division of the 1980's.
- By means of the technical sessions, for each of us to learn and, thereby, to leave this meeting with new knowledge of a technical nature that will help us all do a better job in the years ahead.
- For the Regions and Districts, the Senior Division Staff, and the key staff of the research program to meet and address specific issues of concern.
- To enhance communications within the Division, and to develop a common understanding among the senior managers and scientists of the critical issues and the policies and programs needed to address them.
- Finally, for the Division to get acquainted with itself, for change in the Division's leadership has been the rule, not the exception, over the last few years. We really need to get to know one another better.

Each participant at this meeting has already been at work preparing for his or her particular "piece of the action." For this is a meeting of participants, not just attendees. I urge each of you to do just that—PARTICIPATE!

P

# Welcome Address

INTRODUCTION OF J.B. COULTER BY JAMES E. BIESECKER

It is my distinct pleasure to introduce our welcoming speaker this morning. He was born in Vinita, Oklahoma, and during his earlier years, he moved to Kansas City, Missouri, where he attended high school. In 1950, he received a Bachelor of Science Degree in Civil Engineering from the University of Kansas. From 1950 to 1966, he served with the United States Public Health Service where his work included a research assignment with Robert A. Taft Center in Cincinnati and an assignment in Washington, D.C., heading the Public Health Services' assessment of the major river basins in the United States. In 1954, he took time out to receive a Master of Science Degree in Sanitary Engineering from Harvard University.

Our speaker has been employed by the State of Maryland since 1966 and has served as Secretary of the Maryland Department of Natural Resources since 1971. He oversees a number of major State units, including the Maryland Geological Survey, a Forests and Parks unit, a Fish and Wildlife unit, a Coastal Administration unit, and a unit entitled the Maryland Environmental Service. The last-named unit happens to be one of the few State agencies that owns and operates sewage treatment plants. He is a good friend of the Geological Survey and the Water Resources Division and has served on several advisory committees with the Office of Water Data Coordination, including the Non-Federal Advisory Committee and the River Quality Assessment Task Group.

Our speaker recently moved from a three-bedroom condominium to a home on 10 acres near Annapolis, Maryland, so if you want to know where to get a good tractor, he can give you some guidelines on that.

During this time when the Federal-State Cooperative Program receives a great deal of attention, it is a real pleasure and a real benefit to work with such a man. Ladies and gentlemen, I present to you the Secretary of the Maryland Department of Natural Resources, James B. (Jim) Coulter.

JAMES B. COULTER
Secretary, Maryland Department
of Natural Resources

Thank you, Jim, for that kind introduction. It is a pleasure to work with you, but Jim has it all wrong. If you want to work with me, come to that 10 acres. We have a brand new tractor and you can run it.

Secretary Miller, Hal, and all you good friends from Reston and those from across the country, it is with a great deal of pleasure that I welcome you to Ocean City, the eastermost point of Maryland. On behalf of Governor Hughes and the people who work at the Department of Natural Resources, we are delighted to have the Geological Survey, and more particularly the Water Resources Division, here for this most important meeting.

I have only a few precious moments this morning to tell you how much we appreciate the work that the Geological Survey is doing for the people of Maryland. I think probably it would take several hours to give a detailed account of all the activities we share with the Geological Survey. Because I don't have much time, I would like for you to take a verbal trip with me from the Atlantic Ocean to the Appalachians in western Maryland and hit the highlights of some of the activities of the Maryland Department of Natural Resources. As I go through these activities I will leave it to you to make the association between the Geological Survey and these good works and services that are being performed for the people of the State.

Let's begin by acquainting you with the Atlantic Ocean and its beaches. We are engaged in a 10-year battle of the beaches of Ocean City. About 10 years ago we could no longer ignore the fact that the ocean is moving westward. We thought it prudent to establish a building-limit line. Otherwise, development would soon reside in the ocean instead of behind the beaches. We entered into a public debate about what to do about the beaches of Ocean City. You have to understand that Maryland has approximately 33 miles of ocean coastline. Twenty-two miles of coastline south of here is held in a partnership between the U.S. Department of the Interior and the Maryland Department of Natural Resources. Those 22 miles are dedicated to recreation and open space in State parks and in the National Seashore. The remaining 11 miles in Ocean City proper is dedicated to high-intensity ocean-oriented family recreation. The State has spent hundreds of millions of dollars to build bottlenecks called bridges to bring people from the metropolitan areas here to enjoy the beaches, and it seems to us that they should spend a little bit of their time thinking about whether the beaches would stay where they are. It boils down to this. If you pay the ocean its due, the beaches will stabilize in their present location. The ocean demands about 150,000 cubic yards of sand a year on the average. We are locked in a debate, with a greater number of different viewpoints, on whether we should go forward with paying the ocean its dues.

Moving too quickly from the beaches we enter the Eastern Shore of Maryland, a locale that Marylanders share this time of year with about 1½ million Canada geese and ducks of all kinds. These ducks and geese depend heavily on the wetlands, the marshlands which we are now protecting. The Eastern Shore of Maryland is blessed with a bountiful supply of ground water, which we are still exploring to find better ways of measuring potential yield and protecting quality.

Maryland's blessings include the Chesapeake Bay, which we share with the Commonwealth of Virginia. We are seeing the Bay rapidly becoming for coal what the Persian Gulf is for oil. That raises questions of what to do about dredging and spoil disposal, about ports and about ships anchored in bay waters. New activities pose threats to the traditional bounty of the bay, one of which is the oyster. Maryland created an oyster navy more than 100 years ago to protect the oyster harvest. This "navy" has become a modern marine police force, something like the United States Coast Guard. It looks after a wonderful and lucrative business which in addition to the oyster harvest includes production of crabs, clams, and finfish, but, more than anything else perhaps, has to do with the preservation of a way of life for a sturdy, picturesque group of Marylanders known as watermen.

In Chesapeake Bay, we see one of the great unmapped wildernesses in the United States. The Maryland Geological Survey, with some of you from the U.S. Geological Survey, is now mapping the bay bottom. This task not only will tell us how the bottom is configured, but also will give us insight into the chemical, physical, and the biological history of Chesapeake Bay even before it was subject to the influence of civilization.

If our objectives are to maintain the natural chemical, physical, and biological integrity of a body of water like Chesapeake Bay, we should have a better understanding of what those natural characteristics were. From the mapping exercise will come the story that sediments can tell us about the natural conditions that once prevailed in Chesapeake Bay.

Across the Bay, the southern counties of Maryland depend entirely on ground water for any hopes and aspirations they may have for development. Because of water policies in the Washington Metropolitan area, upstream regions have refused to build reservoirs to impound the water of the Potomac River. Therefore, the metro area is beginning to covet the ground water in southern Maryland.

Southern Maryland also is estuarine country. People there naturally blame their problems on the people upstream—Baltimore, Washington, and populated areas in between. But, because estuaries flow upstream, much of what they see in their water in reality comes from the Atlantic Ocean and from the waters of Virginia, not just from the upstate waters of Maryland.

At a different time, about the time of World War II, there were people who believed in building things for the future, and they built a comprehensive water-supply system for Baltimore and Washington, complete with reservoir systems and with the protection of watersheds. We are cashing in on that, and we hope that we can move forward with the expected growth and development of these two areas and still protect those water supplies. Likewise, we intend to protect the other water supplies and natural resources of the State. For that reason, as Jim told you, we have created in the State of Maryland an Environmental Services Unit in the Department of Natural Resources. It owns about 110 water-supply and sewage-treatment plants. It also owns and operates some of the largest waste-reclamation centers in the world, certainly in this country, and it is becoming deeply involved in the disposal of hazardous waste. In this catlike society of ours—where we believe to get rid of waste means to bury waste—we run into all kinds of geological problems, and the Maryland Environmental Service is moving forward to solve them. The Service is finding ways to dispose of hazardous waste rather than storing it in burial grounds and thereby creating problems for centuries to come.

Between the Washington and Baltimore metropolitan areas is the Patuxent River, which is a universe of all the problems of a growing society. The Patuxent also gives us an opportunity to use a river valley to separate two emerging metropolitan areas and supply them with drinking water and recreation opportunities. We're blessed with the Susquehanna River which flows from New York and Pennsylvania. It supplies about 40 percent of the water for the headwaters of the bay. It was heavily developed for hydroelectric power, and heavily used for nuclear power production.

Time dosen't permit me to describe Maryland's Power Plant Siting Program, which creates a tremendous opportunity to work together to solve the problems in siting, monitoring, and controlling power plants. An environmental surcharge on utility bills provides about $12 million per year to fund the program. Of that $12 million, almost $10 million goes into fundamental studies, and many of those studies have been done in conjunction with the Geological Survey.

We are moving within the State of Maryland to acquire and hold in public ownership some 10 percent of the landmass in the State through a program called "Open-Space." We are engaged in a great poker-game type of arrangement where every time a piece of property is sold in the State, a cut is taken out of the pot. That cut is one-half of 1 percent of the selling price and is used to purchase land. By 1990, if we continue on our current path, we will reach the goal of reversing the clock when all the land in the State was put in private ownership and will have put about 10 percent of it back into the public domain.

On the Potomac River we have one of the most exciting challenges facing the United States today. It comes from the fact that the upstream neighbors have refused to allow reservoirs to be built to furnish the water supply for the Washington metropolitan area. In effect, they have said that the Washington metropolitan area must survive on an unregulated Potomac River flow. We have set out to establish a working policy that changes from the concept of anticipating needs and supplying all the storage of water to meet the needs to a concept of depending on the unregulated flow of the river. To do that, we have set up a system whereby people may have all of the water that they can justify during normal times, but a permitting system has written into it a low-flow allocation feature which is enforceable and requires that the entities cut back on the amount of water that can be withdrawn during those periods of drought.

Before the anti-dam group held sway, two dams were built on the Potomac—Bloomington Reservoir and Savage Reservoir. We're finding that with thinking akin to that formulated at the Water Resources Seminar at Harvard University two decades ago, we are able to put together a strategy for operating those two dams that reinforces the low-flow strategy. This strategy makes it altogether possible to develop the Washington metropolitan area dependent on unregulated flow of the Potomac River.

As we move on into Western Maryland with its open space, forests, and parks, we see another set of conditions. Again, Maryland is blessed with resources—in this area, clay, sand, gravel, and coal. After many years of hard work, a successful way of reclaiming strip mines was found. Now, there is movement back into deep mining in a big way, very deep mines, mines that go under the Potomac River and cut across much of the ground water. The U.S. Geological Survey and Maryland Geological Survey are heavily involved in studies to determine the effect of deep mining on the ground water and even on the flow of the Potomac River. They are collecting information that will eventually result in better control and better strategy.

While we are in the mountains we should visit two of the most beautiful rivers this side of the Colorado—the Youghiogheny and the Casselman. Those two rivers flow into the Ohio River, and contribute water to the Gulf of Mexico, so we are moving to protect them as wild and scenic river areas and doing it in such a way that Garrett County can still have a very productive economy.

In a nutshell, those are Maryland's resources from the sea to the mountains. This has been exhausting, I know, but I hope from this thumbnail sketch you were able to visualize ways in which the Department of Natural Resources and the U.S. Geologic Survey work together. We have some 13 major operating departments. We have many opportunities to carry out the wishes of the people in Maryland regarding their land, water, and living resources.

It seems to me that we can continue to do what is right, or else we can waste our lives by doing what is wrong. It gets me back to the reason that I am so happy that you are here and that you are doing what you're doing. It seems to me that the U.S. Geological Survey, of all the Federal agencies, epitomizes the kind of work necessary in getting the kind of information needed so that people can recognize the right things to do. Without the kind of infomation that the U.S. Geological Survey provides, many of us would waste our lives doing the wrong things.

Closing on a note about the cooperative program, I have been with the Federal side, as Jim pointed out, and now I'm on the State side. Much is different and much is the same. Those who control budgets are the same. The set of questions that come up over and over again on both sides, Federal or State, is almost the same. Questions that come up over and over are "Why is the State of Maryland paying money to the Federal Government? Why are we involved in a cooperative program and where do we gain from being in it?" I suppose you get the same kind of question on your side of the fence. Why is the U.S. Geological Survey involved in a 50/50 program with the State of Maryland? Well, it's this simple. If we do anything that's good at all we need the kind of fundamental information in the State of Maryland that's coming out of that Federal-State Cooperative program. If we do it by ourselves, as we would surely try to do if the Federal Government were not there, we would probably do a poor job, spend more money, and have less information. I'm certain that there is a major Federal responsibility to gather the same type of fundamental information whether there is a cooperative program or not.

Certainly, by carrying out that Federal responsibility with the help of the State of Maryland, the Federal Government pays less than it would if it did the work alone.

The U.S. Geological Survey has a long history of working with the States. There is a concept that people keep talking about called the "New Federalism." The "New Federalism" where Federal and State governments pool talents and money to work together on shared responsibilities is exactly what we see in the cooperative program. Our collective job from both sides of the Federal-State fence is, first, to help the administrative leaders and budget managers to see the savings that the cooperative path produces and, second, to improve and strengthen cooperative programs with individual States like Maryland.

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# Keynote Address

**INTRODUCTION OF D. N. MILLER, BY PHILIP COHEN**

I have the great honor of introducing our next speaker. Shortly after Secretary Watt was confirmed, he visited all Bureaus in the Department of the Interior, speaking to the troops. When he spoke to the Geological Survey, he made a number of points, and I wish I had the time to share all of them with you, but I can assure you that they were exciting and they were extremely welcome. He spoke very explicitly about the professionalism of the Geological Survey, about the role we played in the past, the role we are playing at present, and the role he intends for us to play in the future. He recognized us as a vital part of the Department of the Interior. As highly skilled professionals, he called upon us to assist him and his staff in moving the Department of the Interior toward the goals established by himself and the President.

One of the most important appointments he made in terms of the Geological Survey was the Assistant Secretary for Energy and Minerals. I have had the pleasure of knowing this gentleman for a number of years, mainly with regard to my interactions with the Association of American State Geologists, of which he was a prominent member. More important than that, in the past 4–5 months, I have had the opportunity, on a professional basis, to work with him directly and with his staff on more occasions than the total number of interactions I have had with the Secretariat in the previous 2 years. Our Assistant Secretary for Energy and Minerals is a professional earth scientist. He was manager of a major State Geological Survey— Wyoming. He knows the U.S. Geological Survey. He knows the Water Resources Division. He knows us from an intellectual point of view and he knows us from an operational point of view. When the chips were down during these past months, in addition to all the hard and effective, and positive work that Doyle Frederick did, our next speaker was there vigorously supporting our position—and we will spend a lot of time the next few days discussing that position with you and the issues related thereto. I might add as a result of that vigorous support from our next speaker, a rather worrisome course of events did *not* occur. I'm certain that with him at the stewardship of the Office of the Assistant Secretary for Energy and Minerals, the interests of the Geological Survey and of this Division will be well protected. It gives me a great deal of pleasure to present the Assistant Secretary of Interior for Energy and Minerals, Mr. Dan Miller.

DANIEL N. MILLER, JR.
Assistant Secretary of the Interior,
Energy and Minerals

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Let me give you just a little bit of background on myself so you will know where I am coming from. And then perhaps I can get on to subject matter that might be more important to you. Although my visit will be very brief, I hope to be able to share with you some of the objectives of this Administration, and to perhaps offer some personal comments with regard to the Survey's Water Program overall.

First, I'm a geologist—pure and simple—and while these fellows use the term "earth scientist," I'm still a geologist—that's what it says on my diploma. I think of myself as a geologist. I spent 11 years of my life in the oil and gas business in exploration, applying what I thought I had learned about geology. I spent 6 more years as a university professor and Chairman of the Department of Geology, and I spent the last 12 years working in State Government in the State of Wyoming. Believe me, after you have been on those three sides of the table, there's only one other side left to sit on—and now I'm on the Federal side. It's a totally new job for me—I'd be the first to admit I don't understand it. I don't think I ever will totally. I'm here to learn. My position in Washington as far as I'm concerned is a position of learning, but I'm also here to support. And that's what we are here to talk about today. I have mixed feelings about the United States Geological Survey programs. Perhaps unlike yourselves, I have this diversity of experience, so I may see things in a little bit different way than do many of you. Maybe I can offer something here that can help you as you convene the next few days to talk about individual problems, because I want to put a different kind of a light on the same problems. Now certainly all of us would agree that you can rank water at the top of any listing of vital national resources. Notice I say "national." I came away from a dozen years of active involvement in public issues in the State of Wyoming with a high respect for the way in which water exerts powerful controls on almost all human endeavors. And I appreciate the diversity of public and governmental activities in which water is the subject and chief concern. But almost invariably, it is also the issue of greatest controversy. The issues differ as Mr. Coulter mentioned earlier—the problems of the East are not the problems of the West, and heaven knows you folks know that, I suspect, better than I do and certainly appreciate the intricacies of the problems. But I do consider myself sensitized to the pivotal role of water from the social standpoint, environmental standpoint, and economic standpoint, and certainly in terms of the local, regional, and national affairs of nations. I'm also aware of the need for authoritative, impartial water information and basic data, and I'm even more concerned about the need for interpretation of that data and projections for the future. I'll get back to that in just a moment.

Water conflicts create emotional convictions—more so than reasoned convictions. Obviously, rational decisionmaking must rely upon facts collected scientifically and free of bias in order that they may be equally usable by all parties and, of course, that's your turf. The United States Geological Survey is an organization that has certainly led the way and set the example for standards of excellence in every facet of water resources work throughout the entire hydrologic field, and I know that you have served as an influential model for State and local programs of water investigations, and for that of many countries in both hemispheres as well. Let me simply assure you that I will also continue to press for interpretation of data and prognostications about the future and what the data mean. I was very glad to hear Mr. Coulter use the expression which perhaps went by you. He said "to help solve problems." Let me pass along a little story to you, having worked in State Government for 12 years. I served under two governors, but they both said the same thing—Governor Stan Hathaway who would pound the table with his fist repeatedly when we would meet with him and say "My God, don't help me understand the problem. I understand the problem. Tell me what to do about it. What is the solution to this problem." And then he would point to the bookshelves behind him and talk about hundreds and hundreds of reports that had been written by organizations like our local Geological Survey, by the State planning groups, and by an endless stream of Federal agencies, all of which had helped him understand the problem. His bottom line was very simple. He said, "I hope that just once during my term of office as an elected State official—just once someone will bring in here a report the front page of which says 'we recommend the following solution to this problem.'" No one ever did. But perhaps you understand a little bit more of what I'm talking about—this business of interpreting data.

Let me also add that in this last 7 months now since I've been in Washington, I've certainly come to appreciate this close working relationship with people in your organization. These have been trying times for me because I don't understand the Federal system, and maybe I hope I never will. I'm a "State's Righter" from way back, and I guess I still think like a State person. I've been told that the moment I quit thinking like a State person, I'm no longer of any value to the Federal Government. I like that.

Now you are aware of all the comprehensive examinations and appraisals on both policies and programs the Department has instituted under Secretary Watt's leadership. Under this present environment of rumor mixed with facts, change, and uncertainty, it is perfectly normal for people of science, such as yourselves, to feel uneasy about the state of programs under your responsibility and for which you naturally have some strong professional commitment. And armed with that awareness, I feel that my most useful contribution to this conference would be to try to provide a better understanding of the potential significance of our part of the Department of Interior's earth-science operation.

So let me try to summarize a lot of things in a relatively few words. Within this past year, several major things happened, one of which most certainly was the national election that resulted in an overwhelming landslide of conservative people speaking up on the part of a more conservative form of Federal Government. Immediately after that election, a transition team swung into action in an effort to define and understand the issues that faced this Nation, and then to rank those issues in terms of the most important things that could and should be addressed. By the time some of the rest of us arrived on the scene, the issues had clearly been well defined, and out of this great long list of issues, there were perhaps 6 or 7 that related directly to the Department of the Interior, and certainly related to the role that we play in the energy and mineral problems. I want to comment just briefly on these few issues.

By far the most important program that this Administration is trying to do something about comes across in the press as President Reagan's economic recovery program. It is foremost in virtually all the thinking and all the issues that are addressed. Certainly, it has been made clear through the press and the media that this Administration is trying to do what it can to enhance the role of private enterprise, and to reduce from the Federal regime those aspects of Government that had been taken over in the past that could more properly and appropriately be handled by the private sector. Another thing that you have heard a lot about lately has been the cuts in Federal spending. Let me assure you on this issue that the Office of Management and Budget has been given a clear-cut task. That can be summarized perhaps by saying, "to cut waste," and they define waste in three ways: the waste of manpower, the waste of time, and the waste of money. Since that is a prime objective of this Administration, it will apply to all the Water Resources Division, to all the United States Geological

## "Economic distress will teach men, if anything can, that realities are less dangerous than fantasies, and that factfinding is more effective than faultfinding." *Carl Lotus Becker*

Survey, and to all of our functions in Interior. One of our principal functions is to identify and define waste as we see it. It is difficult, very difficult, when we have to group and rank programs together for a judgment call, some of which have been long established programs, let's say, in your Division, in contrast to some program in a different Division that you know nothing about; and yet that is the budget process. But rather than prolong any long-term explanation of what is going on, let me be blunt again and simply say it this way. You have the opportunity to identify any waste in your own Division—waste of time, of people, or of money—and I urge you to take this opportunity as you go forward in the next few months to do precisely that. If we don't, then the Office of Mangement and Budget will do it for us. If they can identify any part of our operation that can be better handled in the private sector, they will make no bones about simply severing that part of the operation with the recommendation that it be sent to the private sector, and it will no longer be a part of Interior's operation. Help us help the President.

There are some other things that we are involved in deeply. One is Secretary Watt's complete pledge to the States to work cooperatively with them. Not just on water, on everything, on everything we do, to ensure what the press has come to identify as the good neighbor policy, and to work closely with the people who are responsible for their own State, county, and local government, and to do whatever we can to help solve problems, not necessarily identify problems. And last, you heard a good bit of comment about the concept of multiple use of the public lands. I suspect those of you from the eastern States may or may not really understand what it is all about, but those of you from the western States will relate very quickly to it. If you don't understand about public lands, call it to the attention of one of your colleagues from a western State, and I'm sure he will be glad to explain it to you. There are many different categories of lands in the West, but the multiple-use concept of public lands is vital to the future of this Nation. And certainly this is called to my attention as Assistant Secretary for Energy and Minerals.

I hope that my remarks offer you some reassurance that the rationale' for revisions, both announced and contemplated, rests in effect on careful planning and sound reasoning. And I'd also hope that you do not view the possibility of change as threatening in any way, but rather as an opportunity to add further strength and quality to the vintage programs of your agency. The goals set by the Department dictate a careful look at all functions and all programs, even those that clearly have great merit and unquestioned justification. A case in point would be the Geological Survey's Federal Cooperative Water Resources Program which has served the Nation's needs very well for more than 80 years under a proven working partnership relationship between State and local governments. And although the general configuration and content of the Cooperative Program is not questioned, the traditional cooperative funding arrangement is once again under scrutiny, as pointed out earlier. Alternative, equitable financing options are being evaluated. The Cooperative Program is the largest component of the Survey's water activities, and it is the source of most of the basic water information for the bulk of Federal, State, and local requirements. The program is only one of a broad array of Federal and State linked efforts under study that we are trying to encourage in light of the Administration's determination to streamline Federal operations and its general policy of insuring that levels of Government share costs in real proportion to the benefits received. Now, attention was directed to the Cooperative Program with no preconceived opinions regarding equity of the present arrangement and need for adjustment. At the same time, we are confident in your ability to accommodate reasonable changes if the analysis so dictates. I'm confident that only additional strengthening measures will be considered and that those most familiar with the Cooperative Program will have a voice in the decision process. This example was given to me some time ago, but I rather like it. Let me pass it along to you. A gentlemen named Carl Lotus Becker, an educator and political historian of the first half of this century, made an observation that would seem to fit the conditions under which we are all presently working. Let me close with this quote from his writings. "Economic distress will teach men, if anything can, that realities are less dangerous than fantasies, and that factfinding is more effective than faultfinding."

The unusually demanding management challenges that confront us in the conduct of minerals, water, and energy-related programs stem today from economic distress, and I could say to Dr. Becker, were he alive today, that we are indeed learning fast; that we have faced up to the realities and discarded fantasies; and, that we have rejected faultfinding as unproductive in favor of factfinding as a basis for good decisions.

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# Challenging Times for the Water Resources Division

**INTRODUCTION OF DOYLE G. FREDERICK BY PHILIP COHEN**

I introduce a man whom I have known about 9 years and have had the pleasure of working with as a colleague when he was with the former Topographic Division and I was with LIA—OESA—the Associate Director of the Geological Survey, Doyle Frederick.

It is difficult to find appropriate words to describe the past several months. It has certainly been a period of exciting and dynamic change in the Federal establishment. As all of you know, the President accepted Bill Menard's resignation early in the year and designated Doyle Frederick as the Acting Director of the Geological Survey. It has been a very exciting and a very rigorous 9 months for all of us, and he was the front man. Let me assure you, with as much conviction as I can possibly bring to bear, that he was not a caretaker Acting Director. These past 9 months were difficult ones for the Geological Survey and the Department of the Interior. Doyle served as Acting Director of the Survey during this time, and he rose to the occasion and was our leader. He's a bright, rigorous, sharp, and conscientious individual. And during the short period of time, he grappled with such profound national issues which not only have been of concern to the Secretary but in some cases have been of direct concern to the President—issues such as royalty accounting, oil theft, and national coal resources data systems, and I might add, the issue of funding ratios for the Cooperative Program. His role in these and other delicate and critical areas was more than that of an articulate spokesman for the Geological Survey. He was an effective advocate for all of the Geological Survey. We have been very fortunate to have a man like Doyle Frederick hold the reins as firmly as he did, and I'd like us all to give him a resounding round of applause. And I might add that in one of the first public statements made by our new Director, Dallas Peck, he indicated, in essence, that he recognized how lucky he was to have Doyle staying on as Associate Director.

DOYLE G. FREDERICK
Associate Director,
U.S. Geological Survey

Thank you for your kind words, Phil. I am really not sure that they are deserved, but I appreciate them anyway. It does make me feel better about the last 8 or 9 months. They have been interesting times—I assure you—and we have had occasion to concentrate on many, many aspects of the Survey program. As a cartographer coming into this job, many of these aspects have been novel but I have enjoyed attending to them nonetheless. It was a lot of fun, and I hope the programs are better as a result of our efforts.

Before I get into a discussion of budgets and people and that sort of thing, I want to mention a few things about the Water Resources Division—from my perspective. Jack Fischer, who many of you know is the Special Assistant to the Director, came from the Water Resources Division. He prepared comments for me and Dan Miller that he thought would be appropriate in this forum. His opening statement for me is "The Water Resources Division is the best Division in the Survey." Although Jack may be somewhat biased in this matter, it is pretty tough, actually, to argue about that. Rupe Southard and I had a little difference of opinion, at least when I was in National Mapping Division, about which Division was the finest. I do not think there is too much argument about the top two anyway. But in any event, I do want to let you know that I have worked with Phil and Hal and the other managers of the Water Resources Division for the 8 years I have been with the Geological Survey. Over the last year and a half up in the Associate Director's Office I have worked with them very closely, and I do hold them, all of you, and the WRD in general in very high esteem. You have a reputation for sound management and high professionalism, and I am sure you are going to be up to the challenges with which you are faced.

So, I am happy to be here, happy to say a few words to you, and to bring from the Director's office the congratulations that I think are deserved for the sound management of your Division. The Director also will be speaking to you. I can assure you that he and I share a common respect for the WRD people and programs.

Let me say a few words about the general direction of the Geological Survey as a whole and the Department of the Interior, as I see it, and then talk about some of the programs of the Water Resources Division. First of all, let us talk about the Department of the Interior. Dan Miller mentioned earlier his concerns about the waste of Federal resources and the need to pay attention and evaluate those programs that are particularly important for the Department and Administration and perhaps to phase out those that are not cost-effective. I really do not think he was talking about the Geological Survey all that much. As you know, our programs are effective and right on target; and we just do not have enough money to finance them. But the Department has insisted on taking a look at some of our activities, has asked some questions, and has required us to take cuts in those programs that are not quite as high in priority from their point of view. In general, as far as the Department of the Interior is concerned, I believe there is a recognition that the whole question of water-data information, research, and policy will be a terribly critical issue for the country in the coming years. We have a lot of people from the West in this Administration, and I can assure you that they are interested in water. Dan mentioned that Secretary Watt is intent upon giving the States as much responsibility as possible in all areas including water. I think that is the direction the Administration will pursue. However, I do not think it means that many of the things the Geological Survey is doing in the water area will be turned over to the States. I believe the quality and the usefulness of the data and information that the Geological Survey possesses is now recognized, and probably this recognition will sharpen as time goes by.

The Secretary has expressed an interest in water-resources planning, and, as you very well know, we have at least a couple of Assistant Secretaries who also are interested. The Assistant Secretary for Land and Water Resources, Garrey Carruthers, heads a subcabinet council to look at water quality and water activities in general. Phil and several of his people have talked to Carruthers over the last few months, and I believe we have an ally in him. I expect that indeed we will be able to communicate with and count on that side of the fence for help. You heard from Dan Miller; we know we have an ally in Dan. In discussions about budgets and program for water priorities he has vigorously supported us right down the line. Dan will raise questions and will challenge you to deal with many issues, but I believe he is on our side and that he recognizes the significance and the importance of the programs and activities of the Geological Survey.

Now, what about the new Director. Well, Dallas will be here to tell you about his thoughts on water and water programs in the future so I will not speak for him. However, I will tell you what I think regarding the water program, what it is, and what it ought to be. I do believe that we have a lot to offer, and I am not sure we have given it all yet. I will get back to that a little later, and try to relate my thoughts to some of the things Dan has said. The fact is that probably no where else in the country is there the hydrologic information, knowledge, and expertise that exists in the Geological Survey's Water Resources Division.

As you all know, there are significant policy issues relating to water: the whole problem of waste water and how it effects ground- and surface-water systems, the question of water supply versus demand, and how best we can profit from allocated water. Not that we have the answers to those and other questions; but, I think the questions will indeed be faced and answered in the near future. People will need the information and skill that we have available, and they will call on the expertise that exists in the Survey to help them make those difficult decisions. We may well have to respond, and, at times, this requirement may conflict with our historical tendency not to involve ourselves, even tangentially, in policy issues. Don't misunderstand me. The Survey does not have, nor do we desire, a policy role. My point is that we must be more forthcoming in assisting those who do have the policymaking responsibility. Now, this is just a kind of basic philosophical feeling on my part. We have a lot to offer, and we ought to be more active in offering help and opinions. I do not have all the answers to just how one does this, and I expect that will be the subject of many of the conversations later on this week. In any event, I do think that the water programs are important, and that over the next few years they will become more and more important.

Now, let me touch on some subjects that I know are of interest to you. Where are we going with respect to the budget? What about people? What about resources in general? You are all aware that the fiscal year 1981 budget was redone in the new Administration and was resubmitted to Congress. In addition, we have just gone through an exercise to look at further reductions in the fiscal year 1982 budget, specifically a 12-percent cut essentially across the board. That additional reduction also has been sent to Congress. I understand it is being considered now as part of the congressional process. The House of Representatives has passed the Department of the Interior budget already; the Senate has not. Dale Bajema, the Survey Program and Budget Officer, is here and he can answer specific questions on the budget and budget attitude and that sort of thing. I suggest it might be profitable to corner Dale sometime while he is here and talk about OMB and Departmental philosophy about the Water Resources Division budget, because he indeed has been involved on a daily basis. Some of the questions that have come up were not only the 12-percent reduction, but a look at 1982, where do we go from here, and the 1983 budget as well.

You also are aware of the conversations we have had on the Federal-State Cooperative Program. The Department is concerned with both the size of the program and the funding strategy. Program budget administration folks in the Department have concluded that the cooperative program looks like a fairly large chunk of money, and they have asked us many questions about the program. Also, they have wondered out loud—and on paper—whether or not the 50-50 ratio is appropriate. We dealt with that as part of the 1983 budget exercise; at this point the Secretary has agreed not to make changes in the funding ratio.

Let us take a closer look at the cooperative program itself and the setting of priorities. How do we decide what projects are appropriate for the program? Also, look at the funding strategy; does it make sense? Is there a better way? It turns out that Water Resources Division management has concluded that those will probably be the very questions we are asked. A few months ago, we started on a study to take a look at these and other related questions; I think that now the first version of the report study is ready. From my point of view, I look on this as an opportunity rather than a problem for us—an opportunity to explain, to those who do not understand the cooperative program, the values and intricacies of that program. Perhaps we can explain that it really is not a program, but that it is a combination of activities that essentially describe many of the fundamental activities in the Water Resources Division. Only this one is accomplished in cooperation with the States, and, from our point of view, it looks as if we get far more out of the activities than the 50 percent we put into it. It is a breeding ground for technology advances as well as for program development. I think we have a good case to make, and I believe we can indeed make it to the Department and to the Administration.

The Department has made inquiries from time to time about various management aspects of the Cooperative Program. Questions asked have included: How do we decide which programs to finance? Are they local problems, or indeed are they regional or national problems? And, if there are systematic ways for judging, which are the most important of those activities? Then how do you decide whether to include activities in another part of your program or in the cooperative program? I think we can provide answers that will help the Department as well as the management of the Division and the Survey to make some critical decisions over a period of time.

There are a couple of other items I want to mention with respect to the Water Resources Division program. We heard this morning that technology transfer and research will be important issues in the coming months; that we are going to have to rely more on technological developments, such as telemetry, to collect and maintain the kinds of information that we need; and that we must interpret the information and take a more active role in making it available to those who need it. At this point I would like to comment on a different aspect of something that Dan Miller said and a question or two that came from the audience—that is, the whole matter of, not necessarily technology transfer, but how far ought we to go in communicating what it is we know.

In the Survey Executive Committee we have had a lot of discussions with Phil and others on how far one goes before stepping beyond those bounds of advocacy versus nonadvocacy. My tendency perhaps would be to go farther than some of you would be comfortable with. But, I do think it is a matter of taking a hard look and making some very key decisions about just exactly how far we should go. Now, I do not think we should make political or economic decisions that have to do with issues that relate to our water supply. Drought is one area, for example. Maybe we should make recommendations in terms of whether one builds a dam or whether one uses ground water as a source for supply. This might be something that we ought to get more involved in—not making that critical decision ourselves, but providing the key information that might let others make the decision. Also there is the question about waste. What do we do with the tremendous amount of waste that we generate? Is it really as great a problem as people suggest that it might be? What are the real water issues related to this problem—both generic and specific? What about acid rain? Are magazines, newspapers, and television series correct when they talk about ecology? I do not advocate, necessarily, that the Geological Survey should get out on the stump, or that we should go out and say this is a problem and here it is, or this is not the problem because of the following information. But, on the other hand, I think those who must deal with these problems do not always have the best information to assist them in making decisions. I guess I would be in favor, perhaps, of going further than you have in the past (maybe you have and I just do not know about it), of going a little bit further to ensure that the excellent quality water information we have is indeed made available to decisionmakers so that they may make the critical decisions needed by the country on water-related issues.

A related question concerns the preparation of a national water assessment. The general description of the health and status of the water resources in the United States from an earth-science point of view would seem to be an appropriate effort in which the Geological Survey might participate. The necessary socioeconomic aspects of such an effort could be added. I believe that it should be the Geological Survey who talks about the character of the water of this country. I think it is terribly important for us to say something about that. We say a lot, through work in the Geologic Division, about other resources in the United States—oil, gas, and minerals—because it is an appropriate role for the Geological Survey. Similar analogies can be made for the Water Resources Division. We have the information and the expertise. I think we ought to make sure that we provide that information readily and not wait for the Water Resources Council or the Department to take the lead in the preparation of a new national assessment of water. I think that this is an initiative that we ought to take and pursue.

Several questions have come up about thrust programs, and, because they are programs that are turned on and off rather quickly, whether or not we ought to pay attention to those in the future. I do understand that, to some of you folks in the West, thrust programs, such as coal hydrology and oil-shale hydrology, are troublesome to you at the moment, and I guess we need to look at this approach. On the other hand, there are critical national issues with which we must deal. And again, we have to shape our program in such a way that it will provide needed information. Maybe this information can be provided as part of our core programs. For example, we might meet "thrust" needs not by creating whole new programs and activities, but by making these needs a part of existing research and data-gathering activities. Actually, the relationship of fundamental research and basic data-gathering and analysis to critical national programs is an issue that the entire Geological Survey has to address. I suspect if we had done our jobs correctly—and I think probably you could have done your job correctly at the time if you had this basic information available already in reasonable shape to meet most of the critical national issues in a timely way—it would be a matter of just shaping the programs so that indeed you can answer the questions fairly, promptly, and very well.

What is our long-term outlook for budget, people, and the like? Surely you have read the papers and talked to people who know just about as much on those issues as I do. But, for the record, I think we are looking at a rather long-term period of tight resources. I do not think we ought to plan on hunkering down for a year or two and expect to see a great deal of additional money after that time. We are going to have to look fundamentally at our programs, the organization itself, and the way we structure our activities. We are going to have to evaluate what is important for the country and the organization and to restructure our activities so that we can provide the basic data and information that we know we are going to need. We must make sure that we have a continuing and workable research program that will allow us to expand—if there is any reason to expand—in one area versus the other.

I am pleased to see in your agenda many of the issues that Phil and the rest of the Executive Committee of the Survey will be treating later on this fall. Your problems are not different from those of the other Survey Divisions. They may be more widespread in some areas and in some different activities, but basically we all are in the same boat. The WRD is noted for its sound management, its willingness to work hard on issues, its capability to plan, and to make hard choices. I am sure you will continue to do that. Today's situation is a challenge to all of us in the management of the Survey, perhaps even more so than it was in the past when we have had more resources. I am not necessarily pleased that we are working under reduced budgets. On the other hand, I think the Survey as a whole is tremendously sound; and it has got a good base of people who deal with the issues. Knowing the capabilities you have in the Water Resources Division, I have a great deal of confidence that in looking at your programs and activities, you will come out of this with a continuing sound program.

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# The Role of the U.S. Geological Survey as Seen by the Director

DALLAS L. PECK
Director, U.S. Geological Survey

I was officially sworn in as Director in late September in a short, modest ceremony at a Department of the Interior staff meeting at which only a small group could attend. A second ceremonial installation held on September 30 at the Geological Survey auditorium was done in grand style (the only way Ed Grant [Assistant Director for Administration] could do a ceremony like that) in order to enable as many of our Reston employees as possible to witness the event. I felt a performance in my work place was necessary to convince my many colleagues that this incredulous appointment actually was allowed to happen. I feel the same sense of comradeship here with you that I experienced during the installation program at headquarters. It occurred to me that my remarks to that group would be no less appropriate here. The Water Resources Division activities constitute a major share of our Survey program. Participating in a conference with a full sweep of Water Resources Division leaders is one of the most important engagements in my brief but busy new career to date. I would like to take advantage of this opportunity to introduce to you some of my views of the Survey—as it is and as I would like to see it, an old-line, traditional organization, with a first-class reputation, that is caught up in a fast-moving, fast-changing era of the 1980's. Now those who sat through the installation should really go and take a coffee break or doze off, because I really hate to have you undergo the cruel and unusual punishment of hearing the talk twice.

All of us can look back and count a handful of people whose influence determined the course of our lives at critical points. My list includes Professors Richard Jahns of Cal Tech and Marland Billings of Harvard, and, within the Survey family, Francis Wells, Hal James, Paul Bateman, Charlie Anderson, and Vince McKelvey. To these, my counselors, friends, and mentors, I will always be grateful in a way and to a measure that I can never adequately put into words. And in a special category all by himself, I want to thank Doyle Frederick, who has spent the last 9 months as the Survey's Acting Director, keeping the Survey up front where it belongs. I'm delighted that Doyle is going to stay on as Associate Director, and I look forward to having his outstanding talents available to us all for many years to come.

For more than 100 years, the USGS has served the Nation as its principal research and fact-finding organization for the Earth, its processes and its resources. For more than half that time, it has also been a steward of the Federal Government's leasable minerals, with the responsiblity for their proper classification and evaluation, for their safe and orderly development, and for a fair return to the people for the use of their resources. The Survey is, therefore, committed to two roles: first, to be a source of objective, credible, useful information about land, water, and mineral resources; and second, to be a regulator of the activities of private parties who explore for and develop Federal- and Indian-owned resources under lease.[1]

[1] On January 21, 1982, the Secretary of the Interior announced his decision to create a Minerals Management Service (MMS) within the Department to assume lease-management functions. The Conservation Division is now part of MMS; thus, the Survey no longer has a regulatory role.

These are exciting times to be in the Survey (sometimes a little more exciting than what I am prepared for), full of change and challenge. As a Nation we have undertaken to reduce our dependence on foreign oil, and one consequence of that choice has been a search of unprecedented intensity for domestic oil and gas, much of it concentrated on Federal lands both onshore and offshore.

Another consequence has been the sharp rise in the mining of Federal and Indian coal, which has increased sevenfold over the past 7 years and now constitutes 10 percent of the Nation's total production. Other consequences of great significance affecting energy resources—oil shale, geothermal energy, and nuclear fuels—also flow from the decision to seek a reasonable balance between foreign and domestic energy supply.

Our concern over foreign energy sources has recently been joined by a growing apprehension about the future availability of certain strategic and critical nonfuel minerals. The President has called attention to this issue, and so has Secretary Watt. A major requirement here is for an assessment of our potential for satisfying an increasing portion of our requirements for at least some of these commodities from domestic sources: what really is our endowment of these minerals, and where are the appropriate places to look for them?

As hydrologists, you know better than I that water resources is another area in which the Survey will play a large major role in the coming years. As the Nation's primary source of water data and expertise, the Survey can provide essential water-resource information for future decisions that must be made on such problems as the safe disposal of toxic and radioactive wastes, the impact of energy development on water resources, improved ground-water management, acid rain, and water use in drought-stricken areas.

In addition to the hazards we inflict upon ourselves, there are those that nature periodically visits upon us where urban development intrudes upon areas prone to earthquakes, mudslides, volcanic eruptions, and land subsidence. The answers—aimed to reducing losses of life and property to these events—range from acquiring a reliable capability for predicting their occurence and the development of site selection criteria to reduce their impact on the affected communities.

Mapmaking has been a responsibility of the Survey since its creation, and the need for maps of all kinds was never greater than today. We are just beginning a revolution in cartography: the assembly of a digital data base of topographic information that will enormously simplify the process of keeping our map inventory current in response to manmade changes on the land and for constructing special map products to meet the users' exact needs. But, we have a long way to go, and much hard work lies ahead.

These are just a few of the challenges that confront the Survey in the years ahead, and because we are *of* the Survey, they confront us, too. Within these major categories are literally hundreds of difficult, taxing problems that demand a response from the Survey both in its scientific and regulatory roles: we need to acquire a great deal more knowledge and understanding of the Nation's energy, mineral, water, and land resources; and we shall have to supervise and account for private exploratory and development activities on Federal and Indian lands that will proceed at a sharply accelerating pace. This latter tasks brings another: the modernizing and streamlining of past leasing and regulatory practices, including royalty accounting and collection, to more effectively serve the Nation's needs.

In particular, we are called upon for the unique contribution we can make to the success of the President's Economic Recovery Program and his measures to avoid letting our economic and foreign policies become hostage to foreign sources of energy and minerals supply. The Survey's expertise in the earth sciences and its position as gatekeeper of Federal leasable minerals are the channels through which policies toward domestic energy and mineral resources will be articulated. The President will receive our vigorous, unqualified support of these policies.

Doing the things we have to do, and in a climate of budgetary and personnel reductions, will be a tall order. Solutions will be years in coming, and I make no pretense at prescribing definitive actions today. But I do have some ideas about how we should approach these solutions, and that is what I want to talk about now.

First is the necessity for keeping a balance between our short-term and long-term goals and efforts. The troubling quandary will always be with us. It always has been, and the emphasis has shifted back and forth with the temper of the times and the temper of the Directors. But I submit that a viable balance has been maintained, else the U.S. Geological Survey would not have served 22 Presidents, 31 Secretaries of the Interior, and 51 Congresses for over 102 years with its original name and mission still intact and with only 11 Directors. It has obviously not only met the immediate demands of each period in the Nation's development, but is has done so with enough flexibility that it will be properly positioned to respond to the needs of future periods as well. This balance between the needs of today and those of tomorrow is a proven recipe for youthfulness and longevity, and we will be following it as long as I am around. In this context, I recommend to all of you, that you might read again the little brochure of short history of the USGS that Mary Rabbitt prepared a few years ago because in one sitting you can sweep through 100 years of budget limitations, conflicts with Congresses and Secretaries of the Interior, and expansions of one program at the price of contractions of another and it gives one a little historic viewpoint on the present matter of troubled times. We have survived difficult times, and we survived them by staying flexible and planning for the long haul.

Closely related to the balancing of long-term against short-term efforts is the balance we must maintain between pure and applied science. The connection between basic research and the solution of practical problems is never easy to make, and by and large we are given money and people to solve practical problems. Yet we know, as certainly as we know anything, the truth of Director Mendenhall's warning, that there can be no applied science without science to apply. I expect the Survey not only to continue pushing toward the frontiers of pure science, but to apply this emerging understanding to the solution of the Nation's problems. For example, fundamental ideas about the origin of the current configuration of the continents and oceans—the theory of plate tectonics—have led to new understanding of the distribution of petroleum and mineral deposits and the origin of earthquakes and volcanoes. Studies of the Creede district in Colorado have increased our understanding of how vein-type ore deposits are formed and have served as a critical test for the application of laboratory studies to field problems. Satellite imagery, such as that from the Landsat series, has provided new tools for assessing our energy and mineral resources. Computers and other electronic technologies are opening many avenues in earth science investigation never imagined only a few years ago. The power of these technologies for collecting, applying, and understanding topographic, hydrologic, and geologic data is immense; digital maps, modeling of hydrologic systems, and seismic prospecting for petroleum are only a few examples. Many new concepts about the Earth have sprung from these technologies, and even more must be expected in the future. These ideas will continue to lead to concrete, practical applications to the needs of our Nation. The creative and balanced combination of basic research and investigation in earth science on the one hand, and the application of existing earth science expertise to the solution of national problems on the other, has been a tradition of the Geological Survey since its founding over a century ago. This is a tradition I value highly and intend to continue.

To assure that the Geological Survey maintains its fundamental strength in basic research and investigation in earth science, I intend to take several actions. First, I intend to assure that outstanding contributions in research by Geological Survey scientists and engineers are given the appropriate recognition. As one example, I intend to continue the Mendenhall Research Lecture Series, which is aimed to recognize outstanding research contributions and to stimulate interdisciplinary communication. I am particularly pleased to announce that Dr. Mark Meier of the Water Resources Division in Tacoma—who has made truly exceptional contributions to the field of glaciology and the understanding of glaciers as a water resource— will present the Mendenhall Lecture this year.

Second, I intend to undertake careful analysis of the kinds of basic research the Geological Survey needs to be doing now in order to meet the needs of the Nation in the years ahead. In this review, we will examine carefully the opportunities of rapid progress in understanding of the Earth, and will examine the future needs of the Nation for information about the Earth, its resources, and its characteristics. Finally, we will examine the appropriate role of the Geological Survey to seize these opportunities and meet these needs relative to industry, State Geological Surveys and water agencies, Federal agencies, and the academic community. In this process, we will seek the views of the newly formed Geological Sciences Board of the National Academy of Sciences, an internal Geological Survey Research Committee, industry, State Geological Surveys and water agencies and other groups. That Academy has agreed to establish an advisory board to the Survey's four Geological Survey programs with particular emphasis on the Geological Division, and Reds Wolman has agreed to chair that advisory board. I am confident that such an analysis of the needs and opportunities for earth-science research will provide a firm foundation for making short-term decisions about our long-term investment in research.

During the evening of September 24, the President made two proposals to the Congress that I am sure caught the attention of everyone and perhaps were the focus of some discussion during the past week: a 12 percent cut in the fiscal year 1982 budget he submitted last March, and a reduction in Federal employment by 75,000 over the next 3 years. Again, as you discussed this week, we won't know for some time just how these proposals, as they are modified by the Congress, will affect our funding and staffing levels. It certainly looks as if there will be perhaps a long dialog between the Houses of Congress and between Congress and the Administration as to just what the level of FY 1982 budget will be. Certainly there will be some cuts, but we don't know whether the full 12 percent will be applied or if the cut will apply to all the programs. Major line items in the Survey are very uncertain. We do know that our funds probably will be less than the FY 1981 level. Again, as you have discussed this week, the FY 1983 proposed budget is at OMB, and Dan Miller, our Assistant Secretary, is making a presentation to OMB today. Certainly the outlook is strained also for FY 1984. We do know that we are going to have to do more with less. The words for these days are "small is beautiful"; less money, certainly, and very probably, fewer people. And this means that we are all going to have to help one another as never before. The past several years have made us all aware of the growing interdependence of our efforts.

Now, more than ever, we shall be seeking ways to facilitate communications and cooperation among the

Survey's offices and divisions, eliminating any duplicating fuctions that we can identify, redirecting our efforts into more promising programs, and in general doing only the things that survive the most rigorous review.

If we approach these hard problems as a team dedicated to doing what is best for the Survey and the Nation, I'm convinced that we shall find that together we will have produced results far exceeding the sum of our individual efforts.

At the same time that we set about improving our internal coordination we need to review our relationships with other Federal Bureaus, the States, universities, and industry, and for the same purpose: to see where we can help one another through an allocation of responsibilities that leaves each partner doing what it is best qualified to do, and by focusing our joint efforts on programs that offer the greatest return on the resource committed.

Insofar as the States are concerned, such a move toward closer understanding accords with Secretary Watt's policy of being a "good neighbor" to the States with which the Federal Government shares a community of interest in the land and its resources. The Survey has long had extensive working relationships with these States: our Water Resources Division's Cooperative Program goes back 81 years. Earlier this year the Geological Survey formalized its relationships with the State Surveys in a document outlining various areas of joint effort and cooperation. The call is for more of the same.

And so we begin a new chapter in the Survey's long and illustrious history. It will be a record to which each one of us will make his and her own contribution—all of us here, and the thousands of our fellow Survey members scattered across the Nation. Let it be a record that shows what a community of talented, loyal, resourceful people can do, *together*, when faced with an array of difficult, challenging problems. Above all, I want the record to read that we who are the Survey's custodians at this time in history, have added our share of talent and ability to administrative integrity and professional excellence.

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# A Look at the Years Since Albuquerque

## (Summary of Water Resources Division Accomplishments, 1975-81)

R. H. LANGFORD, Associate Chief Hydrologist

### DAYTON—GATLINBURG—ALBUQUERQUE

Precious few of us in attendance here this week participated in the first Division National Conference in Dayton, Ohio, in 1965, because the past 16 years have seen some fast-moving changes that included major reorganization, accelerated movement through senior positions, and wholesale retirements.

None of the original suite of District Chiefs occupy those positions today, and all other senior posts have been recycled as well, most several times over. In just the time since our Albuquerque, N. Mex., meeting [1975] alone a new Chief Hydrologist and Associate Chief Hydrologist have come on board; 39 of the 46 Districts acquired new Chiefs; 3 of the 4 Regional Hydrologists' positions were refilled; all 3 Assistant Chief Hydrologists and the Chief, Office of Water Data Coordination are new; and, 2 of the 3 Branch Chief positions have been refilled. Recognizing also the new Director, Associate Director, and virtually full complement of new Assistant Directors, we are confronted, therefore, with a nearly complete turnover of senior management and with the challenges of continuity and communications inherent in such a major change.

At the Dayton inaugural conference, much attention was devoted to the comprehensive reorganization of the Division's structure and functions then being implemented. What appeared at the time to be radical departures from traditional Division management were being instituted to improve the organization's ability to respond to clearly evident, growing water-resources problems—growing both in seriousness and complexity—and facing the States and the Nation at large. The prominent national water issues were comprehensive, orderly development and management planning and water-pollution control. Public environmental awareness so prevalent today was only beginning to emerge, and the so-called environmental movement—with its attendant demands for our hydrologic information and understanding—was yet to take form.

By the time of the next Division conference in Gatlinburg, Tenn., in 1970, the program of reorganization was fully installed and functioning, and the Division found itself in a strong position to address the ballooning basic-data and multidisciplinary information demands of the blossoming environmental era. The theme adopted for that meeting, appropriately, was broadened Division support to decisionmaking institutions through greater diversity of investigation and expanded hydrologic interpretation. It was apparent at the time that the earlier restructuring of the Division to strengthen the Division's multidisciplinary investigational capability had laid a good foundation for the enlarging technical role that lay ahead for us in support of management of environment, energy, wastes, water, and hazards.

The agenda for the Albuquerque conference in 1975 reflected a mid-decade effort to take a hard look at ourselves and our program. Much of the conference was devoted to invited papers from our Bureau officials and from several non-Survey notables who provided some insight into WRD program linkages with their own responsibilities, and some perceptions of how others see the Division in action. Speakers included the Director, the Associate Director, several Assistant Directors, the other Divison Chiefs, and an able and promising clean-shaven young spokesman for LIA by the name of Phil Cohen. From outside the Survey we heard from the Program Director (Joe Moore) for the National Commission on Water Quality, which was nearing the end of its work, and from a frank and constructively analytic State cooperator (Steve Reynolds of New Mexico).

In addition to the helpful views of these Bureau and "external" guests, the Albuquerque conference benefited from a series of workshops conducted and staffed by the District Chiefs and Senior Staff and researchers in attendance. They prepared advisory papers on six important issues confronting the Division. That this experiment paid off handsomely will surprise none of you in attendance here today. Even today, the perceptive work-group reports that evolved continue to be valuable reference documents, and they are testimony to the wealth of experience and insight of our corps of senior managers and scientists. You will note that we chose to go to the well again and have scheduled similar workshops for this conference.

Joe Cragwall predicted in Albuquerque that we would see an even greater rate of change in the coming years—more complex, more demanding issues; varied hydrologic information production supportive of alternative management options; and, the inevitable fading of official interest in issues then commanding our energies and their replacement with a new suite of priority concerns.

## OCEAN CITY

That brings us to 1981 and this scenic meeting place and the good working facilities made available to us. Let me at this time suggest to you a round of applause for our gracious and thoughtful hosts for this meeting, Jim Biesecker, Herb Freiberger, and their many coworkers, who all pitched in to accommodate our work in this attractive setting, to set up the scheduled events, and to make the many other difficult arrangements (both visible and hidden) that are inescapably part of an undertaking of this magnitude.

Looking at today's issues and problems in our field (and we will be hearing more on that later from Phil), I say that Joe Cragwall couched his predictions 6 years ago expertly, because they seem to have held up surprisingly well. No one would deny that we have experienced the accelerated rate of change he prognosticated.

The rate of acceleration of the rate of change has been most pronounced in the past 10 months, with the advent of the new administration and new fiscal and program policies. In fact, it may be fortunate that our conference was postponed for a year because the events since last January give us a grasp of circumstances and trends that would not have been available to a gathering of the clan a year ago. We are in a much better position now to discern program directions than we would have been last year, and Phil, in his talk, will be evaluating recent events as indications of the future.

### Budget and Personnel Trends

First, let's take a look at the broad budget trends over the past decade, which are shown on Handout I. *[Handouts I—VII are reproduced at the end of this talk.]* The chart shows in a very dramatic way the pronounced, approximately threefold rise in actual dollars since 1970. Unfortunately, equally dramatic is the severe effect of inflation in the years beginning about 1974. The 1981 budget expressed in constant 1972 dollars is considerably short of twofold higher than 1970.

A little later, as we get into the details of the budget, we will see some more specific examples of the effects of reduced dollar value on the programs of the Division, including comparison of our buying power at the time of the last conference and our buying power today.

No discussion of the state of the Division would be complete without mention of the personnel situation. Personnel ceilings have become a fact of life, and I think we have learned out of necessity how to live with them. Although funding of the Division's work has tripled over the past decade, as we noted on Handout I, and has about doubled since FY 1975, the number of permanent, full-time employees has remained nearly constant.

Handout II displays the record of Division staffing of professional and support personnel between 1970 and 1980. When viewed together, the two sets of graphs dictate the inescapable conclusion that over the past decade more and more of the workload is shifting from full-time professional to part-time support personnel. Despite the doleful message the charts carry, we see no relief in sight, and if true, I say it's a good thing we've learned to live with ceilings. Staffing shortages remain a major impediment to maintenance of quality standards and productivity, and certainly constitute one of the greatest continuing challenges to our management ingenuity.

### Program Changes, FY 1975–81

Traditionally at these conferences we have seen fit to compare our current program of work with activities in effect at the time of the last conference in order to document changes and to look for significant trends. The likelihood that the years ahead may bring some dramatic departures from policies and programs we have known is itself justification for orderly documentation of program changes that have evolved and for an assessment of where we stand today.

Handout III makes more specific comparisons for FY 1975 and 1981, first by sources of funds (the upper table) and then by categories of expenditure (the lower table).

As the totals in the upper table show, Water Resources Division program funds from all sources totaled $101 million in FY 1975 and $194 million in FY 1981, a dollar increase of 90 percent before adjustment for inflation. Although the total funds available to us grew almost $92 million over the 6-year period, when viewed in terms of constant dollars, the real growth amounts to only 12 percent over that period.

The table reflects the pronounced increase in Federal funds during the second half of the 1970's relating to issues of energy, wastes management, and ground-water regional supply. Federal funds rose 171 percent, an unadjusted dollar increase of nearly $62 million. The Cooperative Program grew more modestly, showing an increase of only 59 percent totaling $15.8 million. The table shows nearly a 200 percent rise for unmatched State and local funding sources, but the amount of money is small, being only 2 percent of the FY 1981 total.

Whereas the Cooperative Program clearly was the dominant source of our funds in FY 1975, percentage-wise its share declined by 1981 owing to the statistical

1965

1970

1975

1981

effect of increasing funds available for the Federal energy-hydrology program and other thrusts. Though the combined State and Federal shares of coop funding (including unmatched funds) were well over half (55 percent) of all Division money sources in 1975, together they constituted only 46 percent of the total funds in 1981. (Mere statistics, however, belie the fundamental value of the Cooperative Program, and the reliance of virtually all other water-related activities on this nationwide reservoir of data, information, and expertise).

Increased hydrologic assistance and information transfer to other Federal agencies is reflected in the 59 percent increase in OFA funding. However, adjustment for the ravages of inflation would temper the practical significance of the additional dollars. The fact that the percentage of funds devoted to work for other Federal agencies was about the same in the 2 fiscal years under comparison (19 and 16 percent, respectively) illustrates our ability to effectively control the magnitude of that segment of our operations.

With reference, now, to the lower table, we point out that new issues have necessitated changes in the subactivities of the Division's program; these changes make direct comparisons over a 6-year span difficult. Some exceptionally creative accounting allowed us to display the FY 1975 and 1981 programs as shown on the table. Its limitations recognized, the table reveals one striking change—a rise in Energy Hydrology activities of nearly 700 percent. This will surprise none of you, all of whom have been affected by this substantial program to one degree or another.

Note, however, that despite its magnitude, the Energy Hydrology program in 1981 accounted for only 10 percent of Division funds; the special accommodations it required just made it seem to be a larger share of the budget. It is important to note that the traditional data-network and investigative components still accounted for 75 percent of our work.

The Critical Problems component shown in the 1975 listing is no longer used; the work elements formerly included in that component have been shifted to other categories or have been completed. The increase shown for Research over the 6-year period is attributable, not to expansion of the Division's core research program, which has been held to COL increases, but rather to research funding support derived from new thrust money entering the Federal Program, mainly from the Energy Hydrology program and the Regional Aquifer Systems Analysis program.

## Summary of Accomplishments, FY 1975–81

A battery of adept writers and a great deal of time would be required to document comprehensively the Division's contributions to hydrology during the past 6 years. In order to accumulate a nationwide data base for preparation of this presentation and Phil's to follow, we requested that Headquarters and Regional Offices provide listings of significant accomplishments since Albuquerque.

In all, 82 pages of material were received. Looking it over, one would have to be impressed with the substance and dimensions of the Division's work, including the great diversity of our hydrologic activities, a characteristic of our efforts not apparent in the broad program components listed in the summary charts of Handouts I and II.

It is difficult to select highlight activities from such a massive and varied Division program. An effort to identify major accomplishments can be only a sampling—and a somewhat arbitrary one at that. With that important caveat, an attempt was made to group major accomplishments under four categories: Organization and Management (Handout IV), Areal and Analytical Studies (Handout V), Water Resources Data Network (Handout VI), and Research and Methods Development, (Handout VII).

The accomplishments in these four categories are too many to display on projection slides, so we have handed out copies for your information (see Handouts IV–VII). Perhaps you might find them useful for reference purposes during the workshop deliberations later this week. However, I will summarize briefly each of these categories.

*Handout IV*—Important advances in organizational structure and in administration and management would include the items shown in this handout. They range from pronounced improvement in computerized handling of management records, through new methods of cooperative funding, to major expansion of training and instrumentation facilities and a healthy increase in minority and female employment.

Some recent significant organizational and management improvements in the Division's research program are worthy of special note. We recognized the need to clarify the organizational status and the role of the National Research Program in Division operations, and the need also to make improvements in the management of the Program. Three WRD memorandums were issued between March and July 1981 (81.46, 81.81, 81.82) to address these needs.

First, a policy was enunciated that the National Research Program should be a single, well-integrated, and comprehensive program; that it should focus on a broad range of hydrologic research; and, that it should be flexible enough to address the research needs of both critical short-term national problems and longer range issues and concerns.

Second, steps were taken to strengthen the Research Advisor System and to clarify mangement roles and responsibilities of participants in the National Research Program (NRP). These actions included reduction in the number of Research Advisors and establishment of supporting Deputy Research Advisor positions, and strengthening the line responsibilities and authority of Regional Research Hydrologists as supervisors of the NRP Regional personnel. In addition, measures were adopted to enhance mutual technical support between the NRP and other programs of the Division.

Then, the Research Grade Evaluation Guide (RGEG) was devised and tested carefully among research units, and subsequently installed for all formally classified research personnel. More recently the plan was broadened, following a pilot study, to serve as a career development ladder for all professionals engaged in valid hydrologic research, irrespective of where they are in the organization. Individuals found to be performing qualified basic or applied research ("good science" in the words of our Chief Hydrologist) can be converted upon application to the classification system adopted for the RGEG program, and the expanded program is now in effect.

*Handout V*—This handout reflects the great breadth of subject matter covered in the programs of investigation conducted by the Division. The list is biased to special, prominent activities such as "thrust" programs, manuals development, and water-quality and hazards hydrology. It does not adequately reflect the massive continuing programs of cooperative and Federal investigation that constitute the backbone sources of hydrologic information, without which the topical "thrust"-type programs would be severely handicapped.

The Division demonstrated its management flexibility throughout the 1970's by accommodating major water investigations of regional and national scope that challenged its capability for interdistrict and interregional coordinated operations. Examples include successful completion of the 21-volume Professional Paper 813 series, "Summary Appraisals of the Nation's Ground Water"; design and staffing of the more sophisticated Regional Aquifer Systems Analysis program, covering all the major aquifer systems of the country, and implementation of the program through the Regional and District network; completion of 520 flood-potential studies and 1,400 flood-hazard maps; mobilization of our experts to take a lead role in preparation of the "National Handbook of Recommended Methods"; and conclusion of the Madision Limestone Aquifer Study in the Northern Great Plains region, a project that alone will yield 32 technical and scientific publications.

With the advent of the energy shortage and related hydrologic questions that accrued to us, I must boast that we demonstrated remarkable technical versatility in adapting to the varied hydrologic information requirements of coal, oil and gas, oil shale, synthetic fuels, radioactive materials, and geothermal energy development. Noteworthy, as well, are the related contributions to environmental and wastes management problems inherently tied to mineral-resources recovery and processing.

Regional hazards attributable both to natural events and to man's blunders kept us busy too. We documented the hydrology of nine disastrous floods, including two large dam failures and one hurricane; we tackled hydrologic elements of the acid-rain phenomenon; and we documented mudflows and floods resulting from the Mount St. Helens volcanic eruption.

*Handout VI*—In the period after the last confernce, the Division expanded and upgraded computerized storage, management, and processing of hydrologic data; installed satellite data-relay networks; developed and made available numerous computer data systems and files; and, completed the Divisionwide computer terminal network, including a computer terminal in every District and major field and Regional office. Handout VI reflects the Division's strong commitment to the adoption of the best possible technology for hydrologic data collection, and to its rapid transmission and processing for public and governmental use.

The Division is fully involved in real-time data collection, transmission, and processing. We are now using GOES (the Geostationary Operational Environmental Satellite) exclusively. At the present time, we have 300 relay sites throughout the country from which we transmit data on stage, rainfall, and certain quality parameters such as pH. And we are moving ahead rapidly through cooperation with NASA (National Aeronautics and Space Administration) and NOAA (National Oceanic and Atmospheric Administration) and through contract services with COMSAT General. In addition to our internal usage, we know that a real-time data network such as we are building can be very valuable in flood forecasting, irrigation, reservoir system operation, and any such major water operations.

In Handout VI, as in the others, the preponderant data collection effort at District level is submerged by the attention devoted to novel, growing nationwide data-transmission and processing developments. Although basic, repetitive data collection is a mainstay of the Division, virtually all growth of WRD activities has been in areas other than these data-collection programs—this in spite of the growing demand for just such basic hydrologic data. We will need to watch that trend. Though WATSTORE is the largest hydrologic data system in the World, it will not long remain so if the source is allowed to decline.

*Handout VII*—this handout gives an indication of the great diversity and comprehensiveness of our research program and associated laboratory analysis and methods development. Broadened simulation modeling capacity, sophisticated statistical methods, and applications of these relatively new "tools" to hydrologic problem solution are among many noteworthy advances. The research community has played a large role, through its research work and technology-transfer efforts, in the adoption of simulation as standard investigative practice in all Districts. The geochemistry and hydrology of radionuclides, biota, and organic material in water systems received growing attention, as did the principles of hydrologic-hazards management.

About 50 research reports were published in FY 1980 that extend the understanding of hydrology. We are justifiably proud of our organization's research community, and I wish that we could provide greater support than is possible for this valuable fundamental work.

## CONCLUSION

Concluding this look-back summary, I have qualms about the large numbers of contributions that have gone unmentioned or touched upon only briefly, all of which deserve better recognition than our time will permit. I have in mind, for example, the great span of contributions from the cooperative program in addition to those singled out here; the technical services we provide to other Federal agencies and the substantive public information benefits from that large program; the interagency data coordination efforts of the Office of Water Data Coordination; our contributions to international hydrology programs and direct assistance to other nations; and on and on.

I take some comfort in noting that a number of the Division programs I have mentioned inadequately will be topics of discussion in the Work Group sessions that follow, and still others will be included in the technical sessions tomorrow.

Nevertheless, even this abbreviated review reveals the substantial progress since our last conference, real progress that is important, I believe, to the welfare of the Nation. And I need not tell you that these accomplishments were attained under difficult and trying administrative constraints, not the least of which were personnel ceilings, travel ceilings, and a major turnover in senior positions. Perhaps these can be viewed as conditioning years for still further management challenges that inevitably lie ahead, and we can take pride in the fact that we have demonstrated the capacity to advance and to produce even under adversity.

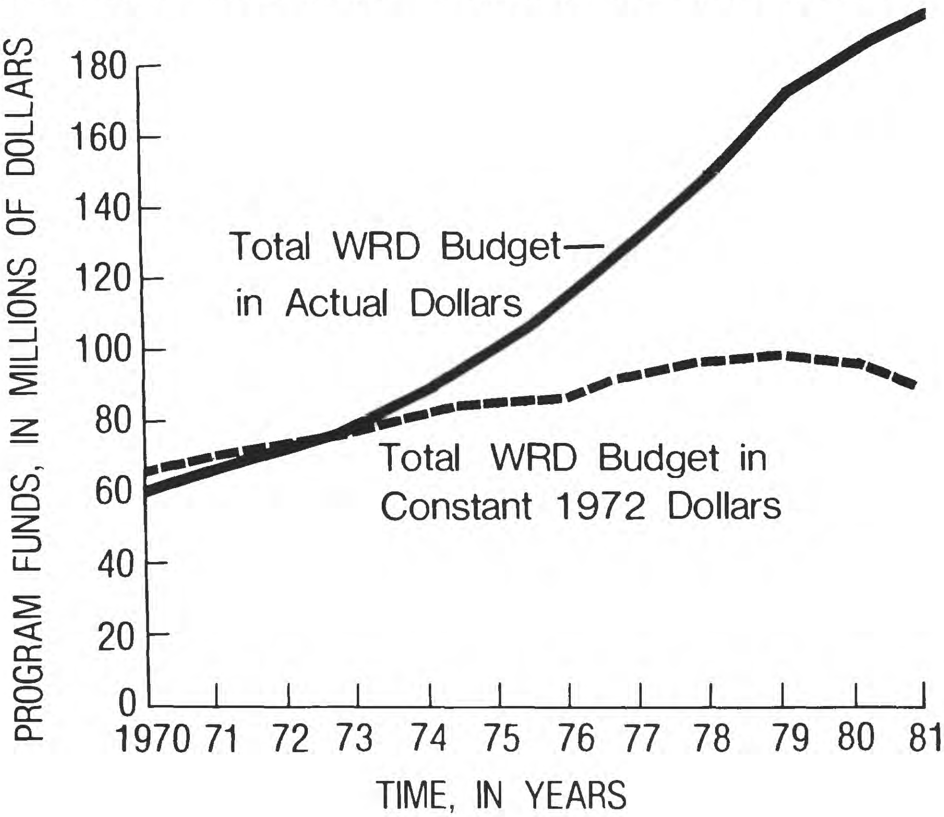
It is with great personal pride in the organization that I point to the accomplishments I have mentioned in this talk, and acknowledge in addition the many contributions I have not been able to mention. I commend each of you for the important role that you have played in our success to date.

Thank you.

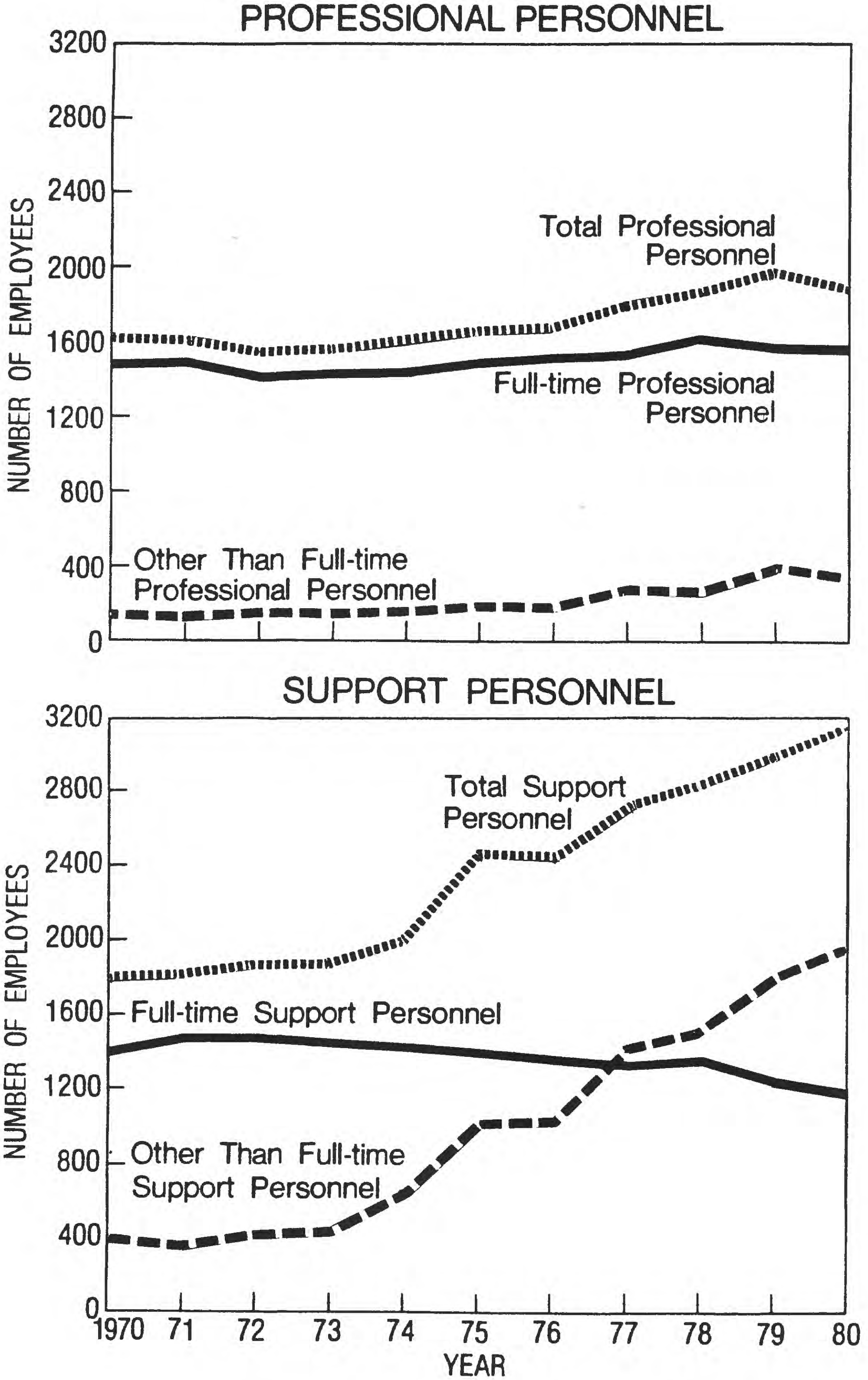
**Handouts follow. ⟶**

## HANDOUT I

BUDGET TRENDS: FISCAL YEARS 1970—1981



# HANDOUT II


PROFESSIONAL PERSONNEL
3200
2800
2400
2000
1600
1200
800
400
0
NUMBER OF EMPLOYEES
Total Professional Personnel
Full-time Professional Personnel
Other Than Full-time Professional Personnel
SUPPORT PERSONNEL
3200
2800
2400
2000
1600
1200
800
400
0
NUMBER OF EMPLOYEES
Total Support Personnel
Full-time Support Personnel
Other Than Full-time Support Personnel
1970
71
72
73
74
75
76
77
78
79
80
YEAR

# HANDOUT III

## WATER RESOURCES DIVISION BUDGET COMPARISON, BY SOURCE OF FUNDS FY 1975 AND 1981

| Funds source | FY 1975 | | FY 1981 | | Increase 1975–81 (percent) |
|---|---|---|---|---|---|
| | ($ millions) | (Percent) | ($ millions) | (Percent) | |
| Federal | 26.8 | 26 | 72.7 | 38 | 171 |
| Federal Coop | 27.0 | 27 | 42.8 | 22 | 59 |
| State Coop | 27.0 | 27 | 42.8 | 22 | 59 |
| State and local unmatched | 1.6 | 1 | 4.6 | 2 | 188 |
| Other Federal Agencies | 19.4 | 19 | 30.9 | 16 | 59 |
| Total | 101.8 | 100 | 193.8 | 100 | 90 |
| In constant $, FY 1972 base | 81.8 | ..... | 97.5 | ..... | 12 |

## WATER RESOURCES DIVISION PROGRAM COMPARISON, BY FUNDS EXPENDITURE FY 1975 AND 1981

| | FY 1975 | | FY 1981 | | Increase 1975–81 (percent) |
|---|---|---|---|---|---|
| | ($ millions) | (Percent) | ($ millions) | (Percent) | |
| Water-Resources Data Network-Quantity and Quality | 44.4 | 44 | 88.3 | 46 | +99 |
| Areal and Analytical Studies | 22.3 | 22 | 55.8 | 29 | +150 |
| Critical Problems of National Importance | 17.0 | 17 | ...... | ..... | ...... |
| Energy Hydrology | 2.5 | 2 | 19.7 | 10 | +688 |
| Research | 15.6 | 15 | 30.0 | 15 | +92 |
| Total | 101.8 | 100 | 193.8 | 100 | ...... |

# HANDOUT IV

Significant Accomplishments--Organization and Management, 1975-81

- Minority and female employment rose significantly. EEO designated a monitored objective and a staff position carrying EEO and minority employment responsibilities initiated.
- Division personnel named to key positions in newly created, emergency activated "Emergency Water Administration."
- The Denver Central Laboratory--largest and most modern in the World--was built and put into operation.
- The WRD Training Center was expanded to create the Survey National Training Center. The number of students receiving training increased three fold.
- Regional hydrologic training programs were installed to supplement the services of the National Training Center.
- The National Water Data Exchange (NAWDEX) became operational, presently including 200 member organizations and 5 foreign affiliates.
- A records-safety training course and a District safety inspection program installed.
- Acceleration of automatic-records processing and management of program, project, and fiscal documents.
- Contracting expenditures, including grants and the new-type cooperative agreements, more than doubled, and in FY 1980 amounted to 26 percent of the Division budget.
- Experimentation in commercial contracting of routine data collection yielded mixed results.
- Reverse-flow funding introduced into cooperative agreements.
- Division structure for management of scientific reports and data reorganized to expedite reports processing and data management. Responsibility for headquarters examination of reports for policy and quality assigned to SP&DM, and improved manuscript tracking system installed.
- Larger, more versatile dimensions adopted for the Water-Supply Paper series.
- Louisiana and Arkansas shifted to Southeastern Region to expedite program management.
- Formal long-range plans were derived or updated for many Districts.
- Division structure for development of hydrologic instrumentation and for instrumentation services were reorganized in the Office of the Assistant Chief Hydrologist for Operations. The Hydrologic Instrumentation Facility was installed and development of a new system of automated, electronic field data collection initiated.

# HANDOUT IV *—Continued*

- o Computerized hydrologic data-management and word-processing capability improved and expanded.
- o Distributed Information System introduced.
- o Liaison position established to provide guidance for the National Waste Terminal Storage Program.
- o The role of the National Research Program in the Division clarified and an improved management plan installed.
- o Research-advisor system instituted to improve management of research.
- o Interagency Memoranda of Understanding and Agreements concluded with EPA, OSM, DOE, BLM, and BM and conferences initiated to aid coordination of work of mutual interest and to facilitate communication.
- o WRD Senior Staff members chaired 2 of 19 task forces established in 1978 to aid implementation of the President's water policies; another participated in the President's Interagency Review Group on Nuclear Wastes Management.
- o The WRD Isotope Laboratory was established.

# HANDOUT V

Significant Accomplishments--Areal and Analytical Studies

- o A comprehensive manual of modern stream-gaging procedures. "Measurement and Computation of Streamflow," was prepared for publication as Water-Supply Paper 2175.
- o Ten surface- and ground-water chapters were added to the Survey series "Techniques of Water Resources Investigations."
- o The National Handbook of Recommended Methods for Water Data Aquisition was established and seven chapters completed.
- o Nationwide standards and frequency curves for flood-frequency analyses were updated, and a study of urban flood frequency completed.
- o Nine disastrous floods, including two major dam failures and hydrologic impacts of one hurricane, were documented. Topographic and climatic flood characteristics were defined.
- o 520 flood-potential studies and 1,400 flood hazard maps were completed to aid implementation of the Floodplain Insurance Act.
- o New techniques for design and evaluation of surface-water data networks were tested in four Districts.
- o The 21-volume Professional Paper 813 series, "Summary Appraisals of the Nation's Ground-Water Resources," was completed.

# HANDOUT V —*Continued*

- o The Regional Aquifer Systems Analysis Program (RASA) was initiated. The first 2 regional studies are nearing completion and 15 others are under way, covering all major sources of ground water in the Nation.

- o The Madison Limestone Aquifer investigation in the Northern Great Plains Region is practically completed, eventually to yield 32 technical and scientific reports.

- o Subsurface waste storage potential of the South Carolina-Georgia Coastal Plain region, of the southern Appalachian region, and of a part of the Texas Gulf Coast were appraised.

- o Hydrologic events associated with the Mount St. Helens volcanic eruption were documented in the Circular series 850.

- o River Quality Assessments were completed for five basins, technology transferred for district application, and the program concluded.

- o Atmospheric deposition networks of measurement stations were established in seven northeastern States following an assessment of acid-rain sources and hydrologic data requirements.

- o Discharge of sediment from agricultural areas of central Pennsylvania to Chesapeake Bay was determined quantitatively.

- o WRD has lead roles in the International Hydrologic Program (IHP); hydrological collaboration with the People's Republic of China; technical assistance to a number of countries, including 45 missions to developing countries; training of foreign nationals (150 trainees from 41 countries); and hosting technical tours in the USA by visiting foreign nationals (175 visitors from 75 countries).

- o Technical support to the NRC and DOE on policy decisions concerning management and disposal of low-level wastes. Collaboration with DOE on the Earth Science Technical Plan for disposal of radioactive wastes in mined repositories.

- o Major program efforts devoted to energy-related hydrology, including coal regions, oil shale deposits, slurry conveyance, geothermal systems, nuclear, and nonradioactive energy wastes management.

- o Development of geohydrologic science and criteria to aid selection and operation of sites for radioactive-waste disposal; WRD criteria used to select five sites. Site evaluations included Gulf Coast salt domes, thick unsaturated underground zones in southwestern USA.

- o Demonstration that plutonium from low-level wastes exists and migrates in ground water as a dissolved complexed solute.

- o "The Nation's Water Resources--Facts and Issues," an overview of the Nation's water resources, was prepared at the request of the Assistant Secretary for Land and Water Resources for his use in briefing the Cabinet Council on Natural Resources and the Environment and its Working Group on Water Resources.

- o A Hydrologic Unit Map of the United States and individual State Hydrologic Unit Maps were prepared and printed for public and governmental uses. Boundaries were digitized and that data base also made available.

# HANDOUT VI

## Significant Accomplishments--Water Resources Data Network

- o Large data bases introduced or improved, including the Ground Water Site Inventory, the National Water Use Data System, the Urban-Hydrology data base, the time-of-travel file, and the Peak Flow file.
- o The Division's computer, terminal network was expanded to include a facility in every District, Regional, and major field office.
- o Substitution of the more versatile NOAA Geostationary Orbital Environmental Satellite (GOES) for Landsat in the Division data relay system. WRD is the largest user of GOES (375 stations).
- o A commercial satellite was tested to demonstrate feasibility of sharing radio frequencies presently utilized for commercial telephone and television signal transmission.
- o The first WRD local direct-readout ground station was installed (Tacoma).
- o Pilot project completed in collaboration with COMSAT utilizing 105 gaging sites to determine the economics of real-time data collection and processing by contract, and to identify data requirements of real-time users.
- o Contracting for collection of surface-water flow data has become operational to a limited extent only.
- o Institution of the National Water-Use Data System (NWUDS) and, to date, several companion State computerized water-use data systems.
- o Enlargement of the National Stream Quality Accounting Network (NASQAN) to a full complement of sampling stations (515).
- o Development of a National Urban Stormwater data management system.
- o Design and implementation of the Water-Quality Alert System.
- o NAWDEX water-data indexing completed for 400 organizations holding water data; search assistance, data dissemination, and request-referral services, were expanded; and 45 Assistance Centers installed, with an additional 5 scheduled for FY 1982.
- o WATSTORE was expanded and more fully automated to improve user access. It is the largest hydrologic data system in the world.

# HANDOUT VII

Significant Accomplishments--Research and Methods Development

- Investigation of the Potomac River in the vicinity of Washington, D.C. revealed that nutrient nitrogen derived from benthic deposits in winter rivals the magnitude of nitrogen derived from summer effluent from sewage treatment plants.
- Techniques developed for measurement of surface-water reaeration coefficients using flourescent and gas tracers.
- Advance in streamflow and stream quality simulation, including improvements in precipitation-runoff modeling.
- Simulation models of ground-water flow (3-dimensional) and of solute transport, developed largely within the Division, are operational and utilized in the field program.
- Simulation methods for predicting the magnitude of flooding from dam breaks were developed.
- A significant role for sophisticated statistical methods has been established for stream systems analysis, parameter determination, and identification of trends in water quality in large rivers. Similar advanced statistical methods for the determination of ground-water system parameters are being devised.
- A streamflow nutrient transport model was developed.
- Status reports on surface- and ground-water modeling in the Division were published as Circulars.
- Simulation methods for multi-phase fluid flow in geothermal systems were developed.
- Improved methods for streamflow drought analysis were devised.
- An oil-spill risk analysis model was developed.
- Understanding of the hydraulic interactions of lakes and ground water was improved.
- Understanding of the movement of radionuclides in soil-moisture and ground-water environments was improved, an aid to design of disposal and storage facilities for radioactive wastes.
- The Central Laboratory facility was expanded to include determination of organic pollutants.
- The Division collaborated with the Environmental Protection Agency and the National Bureau of Standards to establish analytical standards for organic and inorganic substances in water.
- Fluid pressures and other hydrologic aspects of earthquakes were studied.

- The oil shale rich Piceance Creek Basin's ground water system was modeled to enable computation of the availability rate for ground water and the impacts of shale extraction on the hydrologic system.

- The Nuclear Hydrology program determined that although some nuclide migration in ground water is occurring at waste-burial sites in eastern USA; it appears possible that adequate investigation can identify hydrologically acceptable sites in the East. Studies in arid areas (Nevada Test Site) indicated that downward flux rates are probably negligible in terms of radionuclide transport.

- A mathematical model of the Columbia Glacier has been used to determine that the glacier in on the verge of drastic retreat, with the potential effect of increase in large icebergs in oil-tanker shipping lanes.

- LANDSAT imagery proved useful for determination of irrigation acreage and water-use computation.

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# A LOOK AHEAD

PHILIP COHEN, Chief Hydrologist

A number of points I had intended to make have been touched on by Dan Miller, Doyle Frederick, and several other speakers, but some points bear repeating with my own thoughts added. In addition, I want to address certain other major issues confronting us, and the management approaches we are adopting to deal with those issues. Most important, I want to provide a philosophical statement on where I think we are, the events that led us to our present circumstances, the options we face, and finally, my perception of the directions in which we will want to go.

Reflecting back to the characterization by earlier speakers of recent political events and their relationships to our programs, we heard that the new Administration, bouyed by the November election results, is considering significant changes in political and economic directions for the country. I think we would be realistic to adopt as a backdrop for our deliberations at this conference the new economic and other directions the Government is likely to follow, and their inevitable effects on our programs.

We are necessarily in a dynamic state of flux in budget and program development. Dependable short-term predictions are difficult to derive. Last June [1981], I spoke to the Colorado Water Resources Information Exchange meeting in Denver, and I described the many significant changes taking place at that time, 6 months after the beginning of the new Administration. For background, it may be useful to recount those events. Although many agencies were experiencing severe budget cuts and consequent serious personnel and program problems, the Water Resources Division was in reasonably good shape. At that time, we had gone through only the first iteration of the present Administration's budget for FY 1982. The previous Administration's budget submittal to Congress contained a $6 million increase in funds for WRD in FY 1982, and the new President's budget kept us in the black. This was an uncommon state of finances among Federal agencies at the time.

Unpredictably, imposition of the general 12-percent reduction that we are now wrestling with followed—one major action among many swift cost-cutting and reallocation measures taken by the new Administration. In addressing this drastic cut, I carry the conviction that our role as the primary water science agency of the Government requires that we maintain the inherent strength and integrity of our technical programs while at the same time effectively supporting the Administration's goals and objectives. Our recommendations for water-program redesign and reductions were developed with great care, in consultation with both field and headquarters Division personnel. We believe we were successful in conveying our perception of the needs and priorities for water information. In the latest version of the Departmental budget, our program components survived nearly the same as we had submitted, although with some notable modifications. [Editor's note: Although the 12-percent budget proposal subsequently was not implemented as such, lesser reductions totaling about 10 percent for WRD were later put into effect.]

This bit of budget history illustrates the Division's efforts to meld its hydrologic mission with the Administration's goals, and to make the best of a tightening fiscal situation. The future is not reliably predictable. It depends to a large extent on happenings in national politics and economics, neither of which has a dependable prediction capability. We may be facing additional reductions of unknown magnitude, and for that reason, I view the present time as one of great challenge and potential significant change for the Division and Survey.

However, comparison of our present situation with stringent circumstances the organization has faced in the past helps to place current events in perspective and provides reassurance. There have been truly traumatic experiences in our history. During the inceptive years of the Survey, for example, John Wesley Powell carried the simultaneous burdens of Director of the agency, supervisor of the Irrigation Survey, and a number of other major responsibilities. Development of the West was a highly controversial issue, and Powell's views on allocation and management of Western water were at the forefront of the controversy. The Irrigation Survey, instituted in 1888, might well be viewed as the forerunner of our Water Resources Division, although the Geological Survey was involved in water investigations since its inception 9 years earlier, in 1879. Thus, among these events the Water Resources Division was beginning to take form. But note that in 2 years the Irrigation Survey was zeroed out. Those were troubled times for water science and water scientists, and most subsequent problems experienced by the Bureau, including our present circumstances, pale by comparison.

The Survey and its water functions survived, and its programs prospered. Other setbacks were to follow. You will recall that shortly after the turn of the century, major functions were excised from the Survey to create the Bureau of Mines and Bureau of Reclamation. Subsequently, immediately following World War I, the Survey experienced a sharp loss of funding that necessitated drastic reduction in programs and personnel. And, more recently, in 1957 the elimination of the Bureau's uranium exploration and mapping program required massive adjustments. More than a few of our Districts have suffered similar setbacks, on a smaller scale but no less painful to the affected parties. For example, from my own personal experience, when Bob Dingman became District Chief for New York in 1969 and I was a member of the Long Island subdistrict staff, Bob found upon his arrival a deep reduction in funds already on the table that required immediate curtailment of program, personnel transfers, even resignations, and other painful but necessary actions. Those were difficult days for the New York program, but today New York is one of our strongest Districts.

So, in the past we have undergone wrenching change of major proportions, and in every instance we have demonstrated resiliency and the ability to continue to advance. I believe we have stood the test of periodic adversity because the organization is rooted in the sound technical and scientific philosophies of Powell, including his unshakable commitment both to science and to its applications to the solution of national natural-resources problems.

We now need to move forward positively, and I'll enumerate some of the deliberate steps being taken. First, we are improving communication. We all need to be full partners in the critical decisions that must be made. This is a large, structured organization with established channels, and I urge you to take advantage of them. Important information should be communicated up,

## " I believe we have stood the test of periodic adversity because the organization is rooted in the sound technical and scientific philosophies of Powell.... "

down, or across the line with no lost time. If it is truly necessary to skip a link in the chain to expedite an important communication, the circumvented party will understand and will not be offended. Use your good judgment. In today's administrative climate, rapid communication and good decisionmaking go hand in hand.

I am convinced of the worth of new management measures adopted during the past several years, and I want to see them strengthened and applied energetically. The measures instituted to improve information management, program management including research, and personnel and career management take on even more importance under current and near future financial and programmatic constraints. We need, additionally, to take a hard look at the 10-year time frame and longer still. A principal purpose of the workshop activities included in this conference is to provide opportunity for serious deliberation on our ambitions for this organization a decade or more ahead. What is the best organizational structure to accomplish our goals? What are the best means of coping with sharp losses in funding and with personnel shortages? What are our management options? I believe we have a wide range of options, some along traditional lines, others untried, and still others yet to be conceived.

The variable funding-ratio proposal for our cooperative program is an example of a nontraditional, untried approach to funding water investigations with State and local agencies, and I will look forward to your evaluation of this idea which arose about 6 months ago. Equitable sharing of program costs has been a point of discussion ever since the first collaborative financial arrangements between the Survey and State agencies were initiated, and the possible merits of departure from the standard 50/50 funding program are worthy of careful evaluation.

History being a teacher, I think our efforts to frame our future could profit from a brief review of advancements during the past 2 decades and the legacies imparted by my predecessors. First, let's reflect on Luna Leopold's goals for the Division during the early 1960's, a period of both organizational trauma and organizational advancement. Luna's primary objective was to bring the Division organization into a proper blend with the three principal hydrologic disciplines—ground water, surface water, and water quality—and he was reasonably successful. The effective Regional-Hydrologist and District-Chief structure in existence today is the most visible evidence.

In a second objective, Luna strove to intertwine or meld the research program and the District program (alternatively called the Cooperative Program and, in recent years, the Operational Program). He was more successful in his first objective than this second one. Over the past several years we have built on Leopold's start by instituting new management structure for research and clarifying the organizational relationships of research and operations, and by taking additional measures that I believe place us on the path to better orientation of research and operational activities toward common goals. Reorganization of the management framework for Division research, upgrading the Research Advisor system, and opening the Research Grade Evaluation Guide procedure (RGEG) to all Division technical personnel are major steps in that direction. Career ladders for research and operations are now less apart, helping to relieve that point of frustration for many employees charting their careers.

The subsequent years under the leadership of Roy Hendricks and Joe Cragwall (late 1960's and 1970's) were years of consolidation, strengthening, and sound growth in all quarters of the Division program. They were years of highly significant accomplishment, thanks to good leadership and wisdom. We evolved into the best managed Division in the Geological Survey in my judgment, with paralleling advancements in the scientific capabilities of the Division.

Which brings us up to the present and a look ahead. Let me comment on recent budget and program events. Last fiscal year (FY 1981) we experienced a midwinter reduction of about $6 million. Nevertheless, as a result of several adjustments including a $2.8 million increase obtained for the Cooperative Program, we netted a slight increase in funds for the year. I might note that that was the first major increase in cooperative funds that the Division has been able to achieve through the normal budget process in many years. In the recent past, except for the water-use program, funding increases for the Cooperative Program were obtained mainly as a result of congressional budget add-ons.

Those recent successes taught us that we are still capable of being masters of our own fate to some degree—that is, strong commitment and defense of an important program element can lead to budgetary support. This year (FY 1982) we had two especially significant new starts—the acid rain and the ground-water contamination programs, both of which have substantial components earmarked for the Research Program. Thus, we have been able to muster new funding support for both the Cooperative Program and our Federal Program in the current year. However, subsequent need to accommodate the proposed 12-percent reduction necessitated sizable cuts in coal hydrology, oil shale, and river-basin water-quality assessments. Other agencies have experienced similar budget reductions that can be expected to reduce transfer of funds to our OFA program.

For FY 1983, we have requested another $3.5 million for ground-water contamination, about $1 million for acid-rain investigations, and $400,000 for the Cooperative Program. But, at this time, we foresee further reductions in coal hydrology and river-quality assessment. Looking farther ahead to FY 1984, our financial future is as unpredictable as the economy and political changes, but the situation will become clearer in the year ahead. In my judgment, reduction of funds comparable to that experienced in FY 1982 is likely in fiscal years 1983 and 1984.

With regard to levels of employment, the nature of our Division's expenditures is such that budget levels and employment levels are closely allied. Salaries account for the expenditure of most of our funds, and reductions in budget of any significant magnitude will necessitate personnel reduction. One stated element of the Administration's policy is the reduction of the size of the Federal work force, and we, undoubtedly, will be asked to bear our share.

During the week of October 5, just before this meeting, we held Regional Program Reviews. The Headquarters staff met in Reston with representatives of each Region to review program requests for the current fiscal year. We spent most of the time attempting to accommodate the budgetary reductions we faced. We adopted the policy of reducing direct-credit expenditures by our cooperators by 10 percent. We requested that District Chiefs take a harder look at low-priority water-management gaging stations. Les Laird [Assistant Chief Hydrologist, Research & Technical Coordination] is chairing a committee that is overseeing efforts by Marshall Moss [Chief, Surface Water Branch] and the Surface Water Branch to streamline the streamflow network system to increase efficiency and reduce cost. Out of necessity, we terminated some highly worthy contracts with State Geologists and other State agencies, and we terminated a large commercial contract for streamflow data collection in the Central Region. Finally, we advised District personnel to reduce discretionary travel by 75 percent during the next few months.

I explored with the Geologic and National Mapping Divisions possible economic alternatives for fulfilling our publications needs, which cost about $2–$3 million each year, and much of which is transferred to those Divisions. The necessity of decreasing funds for publications is expecially distressing for me personally, inasmuch as only a year ago WRD embarked upon a program to enhance and revitalize our water-supply paper series.

The Nation is now under the influence of economic policies that are designed to reduce the magnitude of the Federal role in public programs. We will undoubtedly need to continue to seek new ways of belt tightening. I hope we will have the wisdom to execute these requirements in a constructive manner that yields a leaner but nevertheless better organization. There may be some reassurance in the proposition that "small is beautiful." Historically, marked enlargement commonly has worked to the detriment of Federal agencies, often creating indistinct diffused missions, political controversy, and reduced life expectancy. The Geological Survey is only of modest size, has been in existence for a long time and has weathered many storms, enjoys a clearly specified mission with distinct boundaries, and has a record of proven worth. I feel, under these circumstances, that as we enter the period of belt tightening that lies ahead, we are in a healthy state and face a bright, though possibly constrained, future.

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# Thrusts for the Future— A Technology Transfer Workshop

## Discussion Groups

## Ground Water

G. D. BENNETT, Chief, Ground Water Branch
Reston, Virginia

The Ground Water Discussion Group of the Technology Transfer Workshop began its meeting with an attempt to identify Division problems in the area of technical performance. The group agreed that the basic problem was not failure to apply modern technology, but inadequate understanding of that technology, and in fact of underlying hydrologic principles. As a consequence, the group agreed to a correspondingly broad definition of technology transfer—transfer of *all sorts of technical knowledge from people who have it to people who don't have it.*

There was considerable discussion concerning the most effective methods of implementing this form of technology transfer. At the close of the session, a vote was taken, and five specific techniques were ranked as follows:

1. Short courses staged within the District.
2. Use of courses at local universities.
3. Consultation by technically capable personnel. This would include not only research personnel and Branch staff, but qualified District personnel as well.
4. Short courses at the Denver Training Center or at Regional centers. In general, the low ranking of this activity reflected the belief of many District Chiefs that, because of funding and travel constraints, training for sufficient numbers of personnel within any reasonable timespan was impossible if we used the Training Center alone.
5. Development of training materials, such as TWRI's,self-paced instruction materials, and user manuals. Although this was ranked lowest, several people commented that such materials would have to be prepared for use in courses to be given in the Districts, if adequate quality control and effectiveness of teaching were to be assured.

Regardless of the method, the group felt that the emphasis should be on theory—that is, on developing understanding, rather than on application.

With regard to the intensive technology transfer efforts—that is, the "sales campaigns, "—the group agreed that despite the name, these should consist primarily of efforts to build understanding of the technology in question, not just to increase its application. A vote was taken regarding the technologies for which the need for an intensive effort of this sort was greatest. The four leading technologies were, in order: Solute transport simulation, three-dimensional finite difference simulation, parameter estimation, and stream-aquifer simulation. Other topics in which interest was shown included geochemical equilibrium modeling, finite-element simulation, and geophysical methods.

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# Thrusts for the Future— A Technology Transfer Workshop

## Discussion Groups

## Quality of Water

R. J. PICKERING, Chief, Quality of Water Branch
Reston, Virginia

The primary topics discussed at the Water Quality Technology Transfer Workshop were the identification of the technologies most appropriate for transfer and the relative priorities of each. The technologies identified were:

- Modeling of solute transport in surface waters.
- Sampling, preservation, and analysis techniques for toxic organic material.
- Methods for interpretation and presentation of data on sediment chemistry.
- Sampling, preservation, and analysis techniques for atmospheric deposition.
- Trend analysis methods.
- Nationwide goals for water-quality data collection.

The members of the workshop agreed almost unanimously that the highest priority need by far is the WRD field offices' need for assistance in acquiring the capability to model solute transport in surface waters, with particular emphasis on nonconservative substances, both organic and inorganic, and on biochemical processes. Generally acknowledged also was the importance of laying a groundwork for transferring the technology by developing and packaging broad-scope models with clear documentation and by identifying recipients in the field offices that have the proper background for applying the new technology. Training was identified as a very important element of the transfer, and implementation of the previously planned training courses in solute transport in surface waters was strongly urged.

In a brief discussion of the publication series, Techniques of Water Resources Investigations (TWRI), there was general agreement on the continued importance of this form of publication in furthering technology transfer. All agreed that priority consideration should be given to the effort. Considerable concern was expressed about the capacity of the small Branch staff to complete the many TWRI's planned and needed in an appropriate time frame. Coordination was proposed as the proper Branch role, with much of the actual writing being done by field-office or research personnel with resources provided by the Branch. Particular interest was shown in the following TWRIs:

- Statistical Methods for Analysis of Water-Quality Data
- Methods for Field Measurement of Water-Quality Characteristics
- Methods for Collection of Water-Quality Samples

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# Thrusts for the Future—A Technology Transfer Workshop

## Discussion Groups

## Surface Water

M. E. MOSS, Chief, Surface Water Branch
Reston Virginia

The initial plan for the Surface Water Technology Transfer Workshop was aimed at getting input from the participants to aid the Surface Water Branch in scheduling technology sales campaigns for a 5-year horizon. Preliminary discussion centered on:

- Why "sell" technology?
  1. To develop new, relevant information products.
  2. To increase efficiency of current operations.
  3. To enhance the expertise of WRD personnel.

- How to "sell" technology?
  1. Regional District Chiefs' conferences.
  2. Regional seminars and workshops.
  3. The National Training Center.
  4. Video productions.
  5. Demonstration projects.

- Factors to be considered in selecting technologies of the year—
  1. Status of the technology.
     a. Scientific quality.
     b. Operations (computer programs, equipment, etc.).
     c. Documentation.
     d. Back-up consulting.
  2. Costs of "sales campaign."
  3. Costs of implementation.
  4. Expected benfits to WRD.

The list of candidate technologies considered were:
For FY 1982:
  Solute-transport modeling.
  1-dimensional flow modeling.
  Time of travel and mixing characteristics.
  Network analysis.
  Hydraulic geometry.
For subsequent years:
  Precipitation-runoff modeing.
  2-dimensional flow modeling.
  Finite-element modeling of upland streams.
  Kalman-filter records processing.
  Drought analysis.

Subsequent discussions touched on the following points:

- "Sales" has a negative connotation to many District Chiefs.
- Documentation and consulting availability are usually the keys to whether or not new technologies are readily accepted in the operational program.
- At a minimum, the campaign of the year should guarantee one well-documented technology each year.
- Campaign should assiduously avoid the appearance of a solution looking for a problem.
- Instead of a plan for a technology of the year, a plan to address a problem of the year might be preferred.
- Overselling a technology can be as detrimental as underselling it.
- The most current needs of the District Chiefs participating in the session indicated that Network Analysis should be the first issue addressed by the Surface Water Branch.

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# Issues and Goals— Charge to the Working Groups

Thomas J. Buchanan, Assistant Chief Hydrologist for Operations

One of the remarks made this morning was to the effect that the Division has many critical decisions to make in the days ahead. The main purpose of the work-group sessions this week is to help us make some of those critital decisions. I think that many of us in Reston address problems as we think they are in the field, but often we're handicapped by a lack of day-to-day knowledge and first-hand perceptions of the situation. The work-group efforts this week will enable us to take advantage of the wealth of experience that you have.

Dan Miller suggested this morning that "Those of you east of the Mississippi get together with your colleagues west of the Mississippi, so you can see what the real world of water problems is like." I think that is the essence of what the senior staff wants of you—to bring to us some insights into the real-world problems as you see them from your vantage point. That input is going to be very valuable to us. The Division at this time has major problems in both the short range and the long range. We have to cope immediately with the budget reductions that we're facing. We've already taken some actions, but many more will be needed. Another short-range problem is the scrutiny that the Cooperative Program is receiving. The principal long-range problem that we have to face is "What will the Division be like during the 1980's?"

If you look at the subjects that the work groups will discuss, you will see that these problems will be addressed in the coming days.

We have a group that is to look at the Coop Program, and another to look at coping with restrictive resources, which is going to be a major concern in 1982 and probably again in 1983 and 1984. We also have a group that will look at WRD goals in the 1980's. In addition, another group will look at the role of computers and digital simulation in the Water Resources Division in the 1980's.

The senior staff needs your help in guiding the destiny of this Division. In the field, many have the opinion that "Headquarters makes the decisions, and they don't really care what we think." But we really do care what you think. Unfortunately, we don't have the luxury of time to go out and ask each of you for an opinion on issues that must be decided within a matter of hours. What we are attempting to do this week is to have your experience, your knowledge, and your thoughts reflected as input in your final work-group reports. Thus, we will have this information at hand when we need help to make decisions.

It was stated earlier today that the products of the Albuquerque Meeting have been of considerable value. Without question, the work-group reports from that meeting have often been used as reference documents in making decisions regarding the Division in the past 5 years. Hal Langford said this morning that this was to be a meeting of participants. Until now, you really haven't had much chance to be participants, but this is going to be one of your prime opportunities. The schedule shows that in total about 10 hours of discussion time are alloted for each work group. You will be meeting with your work group for at least that much time, and this should be sufficient time for everyone to take part.

"Take this opportunity to examine some of the concepts that our organization holds as sacred and consider how they might be reshaped."

You will note that the work groups are made up of District Chiefs, researchers, Regional staff, and Headquarters staff. We intentionally structured this kind of mix so that as many perspectives as possible would develop. You may say to yourself, "Well, I really know more about computers than I know about the Coop Program, and I think I'm on the wrong working group." Please be assured that your assignment is no accident. Some people in each working group are very close to the problems to be addressed, but others really aren't too involved in those particular issues. In addition to having some individuals who are thoroughly familiar with the problem, we hope to have identified a couple of participants who perhaps have never even thought about the questions now being raised. The work groups have been designed this way, and even though you might prefer otherwise, your present work group assignment has been made with a specific purpose in mind.

We hope that each work group will go back to the very basics because perhaps some of our fundamental assumptions are wrong. We expect the work groups to have a free interchange of views and we hope that no one will hesitate to make some bold statements. Take this opportunity to examine some of the concepts that our organization holds as sacred, and consider how they might be reshaped.

Let's not start the discussion from where we are, but let's go back to determine how we arrived at where we are. Let's not be shocked by new and perhaps foreign ideas. Three months ago, many of us would have been shocked if somebody said that we are going to consider changing the funding ratio in the Cooperative Program. Today, it is a fact of life that we must address that question and scrutinize that which we have taken as given for our entire careers.

I hope that each chairman will use all the human resources that are in the group. We want each of you to be a very strong participant. We don't want any group to be dominated by one or two individuals, because we are really seeking the thoughts of all the eight or nine individuals in each of the work groups. So, even though you believe that you are not an expert in the particular subject, we want your participation in the work-group discussions.

Let's talk briefly about the mechanics of what we are going to do. As I told you earlier, each work group is going to spend at least 10 hours in discussions. We have two groups addressing each of the topics, except for the single work group on goals for the 1980's. The two group chairmen for each topic, and anyone else that they wish to designate, will meet on Thursday afternoon to develop a consensus report for the two groups. In this report, give us your recommendations in writing. We will make the two chairmen responsible for providing a written report to us in the next few weeks on the work-group activity. To recap, on Thursday afternoon, the work-group representatives will get together and come up with a consensus report, and will decide who will present the report; that individual will present the recommendations of the group at the session on Friday morning. We are also interested in any minority reports. If it's impossible for the group to agree on a consensus report, we would be delighted to have a majority report and a minority report.

If there are no questions, let's go to it.

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[There were five work groups. Four of them were divided into two sections. Each of these sections had a chairman and a recorder, and prepared a preliminary report of the group's deliberations. The two chairmen, assisted by the recorders, then prepared the final report for each workshop. The reports of all five work groups are presented on the following pages.]

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# The Federal-State Cooperative Program

## Working Group A

Presented by R. C. AVERETT
Regional Research Hydrologist, Central Region

The Federal-State Cooperative Water-Resources Program of the U.S. Geological Survey began in Kansas during 1905 as a small but unofficial endeavor. During 1905, Congress recognized the benefits of such a Federal-State venture and provided specific funding for the program. On February 27, 1928, Congress formally recognized the joint Federal-State partnership in assessing the Nation's water resources. Today, the Federal-State Cooperative Program is nationwide, includes some 750 State and local agencies, and the fiscal year 1981 funding was about $83 million dollars (Gilbert and Buchanan, 1981).

As the above historical summary indicates, the Federal-State Cooperative Program has had a relatively long but steady evolution. The focal point has, and remains, the Water Resources Division (WRD) of the U.S. Geological Survey. Cooperating agencies have changed from time to time throughout the years, but many have a long-standing relation with the WRD. Although the program is popularly labeled as Federal-State, this is a misnomer. Any non-Federal tax-supported agency can enter into a Cooperative Agreement with the U.S. Geological Survey, and many present-day cooperating agencies are local rather than State governments.

The cooperative funding agreement for the Federal side is mandated at no more than 50 percent of the cost of a particular program. It is permissible, however, for WRD to accept more than 50 percent of the funding for a program from a State or local cooperating agency. Because the Federal-State Cooperative Program represents a sizable appropriation and activity of the WRD (about 44 percent of the total funding for FY 1980), it has received an in-depth review several times in the past.

Recently, the Assistant Secretary for Energy and Minerals (AS/EM) asked the Geological Survey to undertake another in-depth review of the Federal-State Cooperative Program before November 15, 1981. Specific items requested by the AS/EM were procedures for incorporating other agency needs into the project-approval process, procedures for ranking project proposals in priority order, procedures for establishing a Headquarters' review of project proposals, and the feasibility of implementing a variable rate-cost-sharing formula for the Federal-State Cooperative Program. Regarding this request, the Chief Hydrologist and his staff increased the number of questions asked by the AS/EM to eight, and appointed a Headquarters Review Committee to address the questions in detail. Furthermore, because a National WRD Meeting had been scheduled during the review period of the Federal-State Cooperative Program, two work groups consisting primarily of field personnel were established to address the eight questions. This report contains the thoughts and ideas of the two work groups assembled at the WRD National Meeting.

*Question 1*: Define Federal interest.

The term "Federal interest" has been used for decades in regard to the Federal-State Cooperative Program. In a general sense, the term has connotation toward that part of the program controlled by the Federal Government. In a broader and more contemporary sense, Federal interest could logically be extended to refer to anything having regional or national application; that is, not restricted by State or other political boundaries. In regard to water resources, this definition describes the role of Federal agencies. Streams, lakes, and aquifers are not sensitive to political boundaries, and only the Federal system can include interstate water systems in its program.

The term "Federal interest" has a somewhat negative connotation in regard to the Federal-State Cooperative Program because it portrays an image of control. A more realistic and contemporary approach is to substitute the term "Federal responsibility" for the term "Federal interest." In the spirit of the U.S. Geological Survey Federal-State Cooperative Program, the term "Federal responsibility" is meaningful. It simply refers to that part of water-resource investigations in which the Federal Government has a responsibility. Moreover, the term describes well the present-day mission of the U.S. Geological Survey; to wit, "Examination of the mineral (water) resources of the national domain." This definition includes, as its scope, all investigations of water. The Federal responsibility must include a long-term commitment in water investigations, provide a data base of sufficient extent to ensure meaningful and reliable trends in water quantity and quality, and provide sufficient reliable data for understanding hydrologic processes. The WRD of the U.S. Geological Survey conducts this Federal responsibility by bringing together expertise and resources at all levels (Federal and non-Federal) to address problems related to water resources.

If the Federal responsibility extends beyond State and local boundaries, then the question of it becoming a dominant or single interest must be considered. Truly, the question of Federal responsibility must be cloaked within the needs of the Federal-State Cooperative Program. But the question can be logically asked, "Is the Cooperative Program needed?" Stated another way, "Given sufficient funding, could the U.S. Geological Survey conduct all water resources investigations of the Nation?" Certainly the answer would be yes, were sufficient resources available. But doing the task and effectively doing the task are different entities. Aside from the changes such a funding structure would make on the Federal side, consideration of how the Cooperative Program assists the Federal side also must be considered. A number of considerations could be listed, but the few that follow will suffice:

a. A single water agency would not be as responsive from the standpoint of meeting national needs. The Cooperative Program provides grassroots input from diverse agencies that, themselves, have missions and viewpoints different from those of WRD. This diversity of ideas and viewpoints results in a more comprehensive approach to understanding national water needs and problems.
b. Constructive controversy between agencies brings real water problems to the forefront of discussion. The Cooperative Program provides a sharing of resources, including technical expertise, equipment, and responsibility.
c. The Cooperative Program provides for more long-term projects required for the understanding of hydrologic changes and events. Interagency agreements and studies are less likely to be short lived or deleted because of changes in the political climate by one side or the other.

Although the Federal-State Cooperative Program commonly is viewed as a funding source, its ramifications are much deeper. As mentioned above, it also provides a structure for intellectual input, recognition of grassroots water needs and problems, and greater insurance of continued support for mutually agreed upon studies.

*Question 2:* How can the process of identifying water problems/issues be improved?

Although some water-related problems are self-evident or of such magnitude that they are of universal concern, probably most water problems are identified initially at the local level. The Federal-State Cooperative Program provides a mechanism for input of local problems; indeed, many of the national water-resources problems/issues under study today were first recognized at the local level and brought to the forefront of national concern through the Federal-State Cooperative Program.

Determination of local water-resources needs, problems/issues from the Federal side is, and must remain, the responsibility of the basic operating unit of the WRD, the District. Clearly, it is the responsibility of the District Chief to keep abreast of local problems/issues and to rank the importance of these problems/issues at the local level. Contacts and discussion with local cooperators and other Federal agencies (OFA) coupled with a clear and detailed understanding of local water problems are paramount to the Geological Survey's ability to conduct its mission as stated above. Understanding, as used above, refers to understanding not only local hydrological processes, but also local political processes. In this regard, it is important that hydrologic needs and political desires or events be separated at the local level to prevent confusion at higher levels. However, when identifying water problems/issues, the District also must keep in mind the Federal responsibility.

Techniques that the District Chief uses in identifying water problems/issues will vary according to the area, types of problems, and cooperator and OFA relations. The present method of identifying water problems/issues can be improved through formalized information-exchange meetings, both internally and externally at all WRD levels, with cooperating agencies, other Federal agencies, and water-oriented groups. A major objective of such meetings should be to identify current and foreseeable data and information needs. Many Districts schedule such meetings on an annual or semiannual basis. The process of identifying water problems/issues at such meetings should be brought to the forefront and given greater emphasis. This recommendation ties directly to Question 8 below, which deals with OFA needs. Thus, such meetings should not be restricted to agencies that are a part of the Federal-State Cooperative Program, but should include OFA's as well and other State and local agencies concerned with water.

The prediction of future water problems/issues and where and how to adjust resources (people and money) to meet these needs is complex, and no simple or universal answer is available. One such mechanism would be for the Chief Hydrologist to appoint a study committee to keep abreast of problems/issues and to meet annually to formulate their recommendations. Such a committee should consist of select District Chiefs, research scientists, and Headquarters staff personnel.

Obviously, the Office of Water Data Coordination should continue its significant role in information exchange and in the identification of water problems/issues. Also, members of the National Research Program (NRP) should participate to a much greater degree in the identification of water problems/issues within the WRD; in the past, the NRP has not been effectively used for the identification of water problems/issues.

*Question 3:* Analyze the impact of a potential change in the Federal-State funding ratio.

The effects of a change in funding ratio in the Federal-State Cooperative Program have been argued throughout the life of the program. Gilbert and Buchanan (1981, p. 22–23) discussed this question in some detail. The four alternatives they presented and discussed encompass the *potential* effects well, and little more can be added. A variable ratio among cooperators or a variable ratio based upon funding allotment would cause additional effort in the management of the Federal-State Cooperative Program and may, as Gilbert and Buchanan (1981) stated, result in cooperator discontent with the program.

Although all these alternatives have been proposed and discussed, none have been tested. The law limiting the Federal contribution to 50 percent was established in 1928. Thus, only speculation of the effects of a change in the funding ratio can be given, and this speculation is well covered in Gilbert and Buchanan (1981). A noteworthy point to mention at this time is that should the funding ratio be in the order of, for example, 25 percent Federal, 75 percent non-Federal, then the non-Federal cooperator may feel that he virtually is paying most of the Federal side plus the Federal overhead charge. District-office overhead has always been a point of discussion with some cooperators, although it is probably not a widespread point of discontent.

*Question 4:* What are the projected effects of a decreased Federal budget on potential cooperator offerings?

A specific answer to this question would depend upon how much the Federal budget is decreased. The Federal matching money has been less than "needed" in recent years, and the matter is discussed in Gilbert and Buchanan (1981, p. 21). Specifically, they stated, "The fact that the shortfall (in Federal matching funds) has not increased at a rate proportional to growth in overall environmental program expenditures suggests that cooperators have curtailed their offerings in anticipation of insufficient Federal matching funds." Although there has been a chronic shortfall in Federal matching funds, overall funding for the Federal-State Cooperative Program has increased steadily in recent years, ranging from $34.58 million in FY 1970 to $82.90 million in FY 1980 (Gilbert and Buchanan, table 1, p. 5). This increase in Federal matching funds does not, however, reflect inflation. Thus, the actual rate increase is much smaller. Nevertheless, the effects that a greatly decreased Federal budget would have on cooperator offerings have yet to be experienced. Because the Federal-State Cooperative Program is long standing and because it is an integrated part of many non-Federal water-resources investigations, drastically decreased Federal funding could have a profound effect upon cooperator programs and, hence, offerings. Seemingly, one of the first effects would be that the cooperating agency increases its own staff or increases its own capabiltiy to conduct work that normally has been undertaken by the U.S. Geological Survey. Cooperating agencies also may increase the use of consultants to study their water problems, or combine their expertise with other State and local agencies to conduct water-related investigations.

Should any of the above alternatives be effected as a result of a decreased Federal budget, the U.S. Geological Survey would be hampered by being excluded from water problems/issues at the local level. Moreover, if the alternatives listed above are long term, cooperator interest in U.S. Geological Survey programs could gradually decrease.

If Question 4 is modified slightly to read, "How can the U.S. Geological Survey offset the effects of a decreased Federal budget on cooperator offerings," then several additional alternatives can be derived; they are:

a. Federal-State Cooperative Programs must be realistic in distinguishing between what must be done (Federal responsibility) and what would be idealistic to do. Every Cooperative Program should be reviewed carefully and completely on an annual basis, and low-priority programs discontinued or decreased in scope. (Much of this alternative is discussed in Question 5, below.)
b. Federal-State Cooperative Programs should, from the standpoint of their Federal responsibility, be upgraded as far as possible to ensure that the work is truly directed toward forthcoming water information needs, and is conducted using "state-of-the-science" techniques. State-of-the-science techniques include not only modern analytical techniques, but studies directed toward contemporary water-resources needs and data collection. Yesterday's needs should not be confused with tomorrow's objectives. As an example, the need for data on inorganic ions versus the need

for data on organic compounds should be carefully considered—what is really needed must be compared to what is easiest to obtain. Simply stated, the following questions always should be asked; "Is the data-collection program or study really needed, and what will we know if we do it?" The need for a committee appointed by the Chief Hydrologist as discussed in Question 2, as well as input from the NRP, is paramount to fulfilling this alternative.

c. The final distribution of the cooperative Federal dollar within the WRD needs a single focal point. The proposal has been made that such a final focal point be under the direction of a Headquarters group. At present, this proposal does not seem to be realistic because of the programmatic distance between WRD Districts and Headquarters. An intermediate approach seems to be more reasonable. The Regional Hydrologist and his staff meet annually with each District Chief and review the Cooperative Program as well as other Federal programs. At the conclusion of these meetings, the Regional Hydrologist and his staff rank, in priority order, the Cooperative Programs in the region. Perhaps this is the place and time for Headquarters' input; that is, when the regional staff ranks their proposals according to priority. Assignment of a Headquarters' representative to the Regional Office at this point in the program-review process seems a logical and efficient way to determine the distribution of the Federal cooperator dollar.

Without doubt, a decreased Federal budget will have an effect on cooperator offerings to the U.S. Geological Survey. This effect can be mitigated and probably even circumvented by means of an annual review and modernization of the Federal-State Cooperative Program. The program has always and should always be lean and effective, and should not have to rely on a decreased Federal budget for remedial action of weak elements.

*Question 5:* What criteria can be used in ranking project proposals?

This question, by itself, is a major undertaking for any group to consider. It will become more of a cornerstone item as we face a decreased Federal budget. A few criteria for ranking project proposals follow. They are not in any particular priority order, but they are presented insofar as possible in order of their relation to one another.

A. Project proposals for the Federal-State Cooperative Program should meet the requirements of the Federal responsibility as discussed under Question 1. Components of this criterion include:

- The project must have a reasonable chance of being sucessful. Considerations include the availiability and application of the state-of-the-science adequate funding for a sufficient length of time, cooperator and WRD management commitment, and the ability of professional personnel to derive an adequate experimental design that will provide an adequate result.
- The project should provide an opportunity for good science. In addition, the proposed project should be challenging to personnel who undertake the work of the study. Only by offering scientifically challenging studies can the Geological Survey continuously upgrade and maintain high-caliber personnel.
- The cost of the project should be reasonable, the term "reasonable" being defined as within the boundaries of worth of results (data) relation to all other projects and, of course, Federal/non-Federal needs and responsibilities.
- The project should have a relatively high degree of transfer value, or be unique.

B. Cooperator needs should be considered. Here again, the District Chief must provide first-echelon insight into the needs of the cooperator as well as understand and include societal and other constraints in relation to the temper of the times.

C. Project proposals also must be considered and ranked with regard to Federal thrust programs. If it is assumed that such programs represent our best thinking toward future water-information needs, then certainly a significant link between cooperative proposals and Federal thrusts is needed.

The above represent but a few of the criteria useful for ranking cooperative project proposals. Others perhaps could be given and certainly some negative criteria also could be given. For example, project proposals should not be funded simply to support an otherwise weak District data-collection or study program, nor be supported to equalize the sharing of the cooperative dollar. The criteria listed above, especially those listed under A, will aid in preventing development of too many negative criteria.

Finally, it should be emphasized that whatever criteria are adopted for ranking project proposals, they should be the same throughout the proposal reviewing system; that is, from WRD District to WRD Region, to WRD Headquarters. Only by following such a procedure can a uniform proposal-ranking process become a reality.

*Question 6:* How can the project-proposal selection process be modified to enhance Federal-State interest (responsibilities)?

Active input by the District Chief and his technical staff plus close cooperator contact and input, coupled with faithful review by the Regional Hydrologist are paramount to any wise selection of project proposals. Project proposals should be prepared at the District-cooperator level on the basis of good science, challenging water problems, and wherever possible, widespread need.

As mentioned earlier, the selection of proposals for funding can be enhanced by Headquarters' input. The Headquarters' review should assess how well the proposals complement or contribute to nationwide thrusts. If the criteria for ranking proposals as given in question 5 (above) are used, the Federal responsibility will be enhanced, and the Federal-State Cooperative Projects updated and modernized.

*Question 7:* What changes in the policy on direct services are needed?

The policy statement on pages B16.1 to B16.3 in the *WRD Data Book* (see WRD supplement to U.S. Geological Survey Manual 500.1.3) provides an adequate policy for direct services. This policy should be reviewed in detail by District and Regional management personnel, and supported fully by Headquarters management personnel.

*Question 8:* How can the needs of OFA's be incorporated in the Cooperative Program?

Most of the needs of OFA's are being met by the Cooperative Program in an adequate manner. For example, the needs of National Oceanographic and Atmospheric Administration for flood forecasting are met by the WRD cooperative stream-gaging program. In addition, many of the needs of the U.S. Army Corps of Engineers for streamflow and sediment data are met through the Cooperative Program. Hydrologic studies or data-collection programs are sometimes undertaken, however, without consultation with OFA's. This is unfortunate, because OFA's often can contribute funding, additional expertise, or both.

Clearly, incorporating the needs of OFA's into the WRD Federal-non-Federal Cooperative Program lies first with the District Chief. The District Chief must provide information on WRD activities to water information users on a continuing basis through meetings, briefings, seminars, annual activities reports, and through personal contacts. When a new program/project is in the planning stage, thought should be given by the District staff about which agencies should be informed and included in the program or project.

As a final note on this subject, the WRD Operational Program should include as an OFA the WRD National Research Program. There is no reason why research personnel cannot use cooperative funds to assist them in select projects. There also is no reason why research funds cannot be used to support select Federal/non-Federal cooperative projects where a mutual interest exists. The NRP should be considered as an OFA in the design of any Federal-State Cooperative Program.

In summary, the U.S. Geological Survey Federal-State Cooperative Program has served the Nation well as a means of identifying and solving national water problems. Because it has evolved throughout the years and has passed the test of changing priorities, it remains today, as yesterday, an effective mechanism for undertaking the study of water-related problems. Rightly so, however, the program needs constant review and refinement.

As the Federal-State Cooperative Program enters the 1980's with its attendant water-resources problems and faces a decreased Federal (as well as State and local) budget, the program will become a more critical element in solving water-resource problems. In meeting this challenge we must constantly update the program, we must incorporate state-of-the-science techniques at the beginning of the study or data-collection program, and we must realize that yesterday's needs will not solve tomorrow's problems. Simply stated, while the U.S. Geological Survey Federal-State Cooperative Program is well and alive, it will require frequent scientific "tune-ups" to carry it through the 1980's.

**REFERENCE CITED**

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# Working with Restricted Resources in the 1980's

## Working Group B

Presented by T. ARNOW
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The Working Group was given seven questions to address. The questions and the recommendations of the Working Group are listed below:

1. *Can the Division utilize "centers of excellence" to share resources and improve efficiency? Candidates for centers of excellence include computer facilities, technical illustrations, report processing, and unique technical skills.*

• On the basis of the success of the research centers and activities, such as illustrations preparation in centralized facilities (Wisconsin), we believe that the concept can be used for other human resources. Unlike centralized research centers, however, centers for sharing human resources would be in the form of a National Technical Assistance Directory. The centers would be established by the Regions (in cooperation with Districts), and individuals in each discipline specialty who have notable competence in specific fields would be identified. [Note by Ted Arnow regarding the proposed National Technical Assistance Directory: "The Central Region has already developed and distributed a list of District personnel who have particular technical competence."] The Division would take input from the Regions and Branches when appropriate, and compile the Directory. Individuals listed in the Directory would be available as much as 20 percent of their time to assist other Districts. The Directory would be kept current. Possibilities for this approach are: illustrations, computer facilities, reports processing, and unique technical skills. A good sales job at the local level will be needed to emphasize how both individuals and Districts will benefit.

• Interdivisional cooperation should be encouraged. Pooling of resources should be required at Menlo Park, Denver, Rolla, and Reston. Existing facilities in any Division should be available to all. Personnel of other Divisions should be encouraged to locate in existing WRD offices rather than in separate Field Offices.

2. *Personnel. Are there staffing plans that WRD should be using to optimize the work force? How can WRD best respond to a static or declining work force? How can the best match between personnel and tasks be accomplished?*

• Make a Divisionwide study of management and staff functions to see where reductions in personnel can be made.

• Assign people the maximum amount of work that they can handle competently.

• Serious consideration should be given to combining some adjacent Districts in order to: (a) establish the "critical mass" needed for advanced technical work; and (b) reduce management, administrative, and support personnel. (This may not actually be an improvement and may even lead to great political problems.)

• Evaluate carefully whether the Division has sufficient manpower to enter into new long-term commitments. Do not propose or accept new work when we do not have manpower to do the work.

• Use innovative position description such as "Physical Science Technician/Typing" in order to turn two jobs into one. This concept will provide greater flexibility in personnel assignments and will be most helpful in small offices.

• Project chiefs who have unique skills may not be located in the same District as their project area. Frequent travel to project areas may be less expensive than transfers. It will also be less disruptive to employees and will encourage the technical interaction and communication among professionals which are essential to quality assurance.

• Adopt unified staffing plan. The Manpower Committee should not create disruptive vacancies in the process of filling other vacancies. The Committee should also address the problem of removing chronic nonproducers.

3. *Training. Are WRD employees receiving the proper*

*mix of training and are we getting a fair return on WRD training? What is the proper mix of outside, Denver, Regional, and District training?*

• The work group does not believe that the Division is receiving either the proper mix or a fair return on training. The Division should establish an ad hoc work group to implement the following high-priority items:

Move field-oriented courses from Denver to the local level—Region, subregion, or District; for example, Water Quality Field Techniques (G0042), and Surface Water Techniques for Technicians (G0833).

Sponsor heavily needed technical courses locally; for example, Ground Water Concepts (G0761).

• To accommodate the increased number of training sessions that will be held, identify qualified people and train them to be instructors.

• Encourage people to take courses at local universities.

• Distribute professionally prepared training tapes with appropriate handout material. (Training tapes also can be obtained from some universities.)

• Expand interagency training (for example, greater use of the Corps of Engineers' HEC facility at Davis, California).

• Encourage in-house technical seminars.

• Training should be limited to employees who can directly and immediately apply the knowledge.

4. *Contracts. With restricted funds, what role can contracting play in meeting WRD commitments?*

• Contracting in the near future should take a back seat (be deemphasized) except where in-house capabilities are not available (for example, well drilling); where contracts are truly cost effective (for example, certain laboratory analysis); or where expertise is not available (for example, biomathematics).

• *A minority report:* In order to take full advantage and put to pratical use past training and unused capability, contract out Regional activities.

5. *Management techniques. Is effective program and project planning a possible solution to restricted resources?*

• Effective project and program planning is a possible solution to problems created by restricted resources—money, time, and personnel. Some Districts prepare project proposals better than do others. Effective proposal techniques can be shared through District associations and through Regional coordination. Proposals cannot be ill conceived or too elaborate. A computer listing of approved project proposals would facilitate coordination of proposal preparation among Regions. The computer file would permit circulation of project proposals nationwide.

• Resources personnel (discipline specialists, etc.) identified in the National Technical Assistance Directory should be consulted in the earliest planning activities for new projects. This input should be received before commitments are made to cooperators or OFAs.

• Diversification of cooperators, a good mix of discipline work, and a balance of data collection, interpretive studies, and research are all needed. A balanced program among coop, Federal, and OFA must be maintained. We must emphasize quality of work rather than size of program.

• All employees should participate in "Quality Circles"-type activities, i.e., participatory management, in order for management to receive maximum input in identifying areas of potential savings.

6. *Automation. Can the "electronic" office improve efficiency? Be sure not to tread on the other work groups here.*

• We fully support the concept of automation provided that uniformity is followed. Minicomputers should be shared among Districts or other units, and telemetry should be encouraged for collection and transmittal of data.

• Use of word processors and other electronic aids should not, however, lead to unnecessary revisions of internal documents. Pen and ink changes or handwritten notes should be used wherever possible. Let's not be dazzled by technology when simpler methods will suffice.

7. *Improved productivity. What are the best ways to get the biggest "bang for the buck" in WRD?*

• Use positive motivations techniques on a continuing basis, and greater emphasis and objectivity in performance evaluations.

• Staff reductions should be made in all levels of management in order to keep as many people as possible engaged in productive technical work. This reduction should be accompanied by a parallel reduction in paper work and will *require* the cooperation of Division, Bureau, and Department managers.

• Research money should be used as *de facto* matching money to generate unmatched coop offerings. In other words, solicit unmatched coop money to perform separate but parallel projects financed by research money. An example would be to have a local cooperator offer unmatched money for a hazardous-waste-disposal project while having a separate, complementary project ongoing in the same area financed by research funds.

- More emphasis should be given to rewarding employees who come up with truly innovative suggestions that increase productivity. Sustained achievement awards also can be used to reward highly productive employees.

In addition to the seven specific topics assigned and discussed, the work group also completed a brief list of additional measures that they considered potentially helpful in dealing with restricted resources. Many of the items have been mentioned before, but the group felt that a reevaluation of these items might be useful in light of recently imposed restrictions.

- Make less frequent trips to field installations.
- Combine discipline trips and where possible combine routine data and project oriented trips.
- Offer option to convert from full-time to part-time employment.
- Work career-seasonal employees only 6 months.
- Have WAE's work only when critically needed.
- Reevaluate the procedures currently being used for routine QW sampling—emphasize sampling streamflow variations rather than sampling at set time intervals.

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# Role of Computers in WRD Programs in the 1980's

## Working Group C

Presented by J. S. ROSENSHEIN
District Chief, Kansas

### INTRODUCTION

The pending acquisition of a large number of minicomputers by the Division is the single most important computer-related event on the WRD horizon that influenced both work-group discussions. This acquisition, including upgrades, is planned to take place during an 8-year period, and the initial systems are expected within the first 3 years. A 5-year period will be allowed for upgrading each initial system. If it can be accomplished in spite of the funding problems WRD currently faces, the acquisition will dominate computer-related activities in WRD programs well into the 1990's. If the acquisition and related activities are well coordinated, carefully planned, and effectively handled at all levels, the common system of minicomputers can result in an increase in the Division's overall productivity; upgrade scientific and technical capabilities within the Division; and aid the Division in improving the scientific and technical quality of its activities and products.

The common system of minicomputers in the Districts will form the cornerstone of WRD's Distributed Information System (DIS) and will result in standardizing principal hardware and software. Just as important, the Distributed Information System will change the way in which the Division operates at all levels and the role of National Headquarters in computer-related activities.

### WORK GROUP DISCUSSIONS

The discussions were directed toward meeting the objectives of the work-group sessions as defined by the Assistant Chief Hydrologist for Scientific Publications and Data Management. Our discussions were aided by orientation presentations on the minicomputer acquisition by R. J. Dingman and on distributed information systems by Uyless Black.

In their discussions, both work groups attempted to come to grips with the problems associated with necessary changes as the Division moves from a centralized mainframe computer system to a distributed minicomputer system. We tried to visualize the effects of direct data entry and computer-supported word processing, the luxury of short computer response times, the responsibility of locally maintained data bases, and the problems of maintaining data-base integrity, as well as many other aspects.

Before the National Meeting, a questionnaire on the role of computers was prepared and distributed to the Districts. The results of this survey were tabulated and made available to the work groups. One work group addressed the implications of the District responses to the questionnaire. As part of its effort, this group recommended activities that should be addressed at Headquarters, Regional, and District management levels during the pre-procurement and procurement phases of the minicomputer acquisition. The second group tried to anticipate effects of potential changes that will take place in the Division as the minicomputers are installed and the Distributed Information System becomes a reality. These changes were expected to affect all phases of our activities—i.e. scientific, technical and management activities, data processing, administrative operations, reports preparation, review and approval, etc. This group's discussions were wide-ranging as they explored aspects of standardization of hardware and software (including needs of coordination, referencing, documentation and transportability); quality control and data-base integrity; communications; orientation, training and software development under DIS; cooperator and other Federal agency interfacing; etc.

### RECOMMENDATIONS

The work groups defined a number of needs that merited consideration by the Division to aid the transition to a Distributed Information System. The following recommendations are offered to meet these needs:

1. Prepare an information package (slide show, video tape, brochures) that explains to the Districts the

Division's concept of the Distributed Information System.

2. Prepare specific guidelines for minicomputer site preparation, startup, and operation that are based on experience gained from the prototype sites.
3. Provide guidelines for identifying existing ADP and computer-related costs at District and other levels that can be diverted to fund local acquisition of minicomputers so that additional out-of-pocket costs can be estimated.
4. Develop two orientation courses on DIS, including the minicomputer; one to meet the needs of managers and one to meet the needs of their technical staffs.
5. Develop one or more courses, based on usage of software currently running on the prototype computers in Kansas and New Mexico, for the users of the new minicomputers as they are installed.
6. Inform the field personnel on a regular basis about the activities underway to establish the DIS, including up-to-date information on minicomputer acquisition, software development, communications, etc.
7. Establish within the Division one or more advisory groups with direct District representation or District representation through the Regions to—

a. Develop policy and flexible guidelines for start-up and management of that part of the National Data Base down-loaded to District computers.
   —Develop and coordinate quality assurance programs to ensure data-base integrity.
   —Provide guidelines for cooperator and Other Federal Agency access to local data base and use of District minicomputers.
b. Prepare standards for software development and documentation to meet the requirements of the Division's DIS, including indexing District-developed programs that have transfer value.
c. Formulate an electronic report handling system geared to the word-processing capabilities of the DIS.
d. Develop and provide guidelines for operation of the individual computer systems in an open-shop environment, i.e. a computing environment that makes possible direct access of the computer via interactive terminals to a wide range of district personnel.

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# Digital Simulation Models and the Role of the Water Resources Division in Documenting, Verifying, and Distributing Them

## Working Group D

Presented by L. F. KONIKOW
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### INTRODUCTION

The Water Resources Division has increased its use of digital simulation during the past decade, particularly in ground-water investigations. As this trend developed, questions have arisen about Division policy on hydrologic models—in particular, with regard to official Division policy on documentation, use, approval, distribution, and support of these models.

The term "hydrologic model" as used herein refers to a computer code for solving a set of equations that represent one or more hydrologic and related processes. Two levels of hydrologic models are being developed and applied in the Water Resources Division. The first is the "generic" model, which is a general, transferable, equation solver. The second is the "field" model, which includes the parameters and related information necessary to apply that model to a unique field situation.

The work groups found that related technical and management problems *do* exist and that these problems can probably be minimized in the future if a clear and workable policy is formulated by the Division. Most of the problems have arisen in the realm of the field model, so we have focused primarily on these. Nevertheless, the groups concluded that some corresponding and interrelated issues are relevant to generic models; these were addressed briefly and may warrant additional consideration.

### HYDROLOGIC MODELS

#### Field Models

The consensus of the working groups is that the problem can best be approached from the philosophical basis of the scientific method. As such, the Division's products are normally scientific reports, not "models." Simulation is a tool, similar to geophysical well logging, hydrograph analysis, or pumping tests. It is certainly one of our most powerful tools, and should be used in virtually every hydrologic investigation; but this does not change its basic nature—it is still a tool, not a product. Frequently, the goal of simulation is to achieve an improved understanding of the hydrologic system rather than to provide a predictive capability. But whatever the goal, the final report of any investigation should contain or cite reference to a thorough discussion of all simulations used in the study so that a qualified reader will be able to duplicate the models, reproduce simulation results given in the report, and use the models for further predictive work. In fact, to discuss the "approval" of a model is meaningless except in the context of a report that explains its assumptions, limitations, and application; there should be no independent mechanism of review and approval for USGS models. Normal project-review procedures should ensure that simulations are properly developed and utilized; normal procedures for the review and approval of reports should ensure that documentation is adequate, and should convey official USGS approval of all models used in the study and of all simulation results given the report.

No simulation model is more than an approximation to the complex field situation. Improvements in the approximation are always possible; models should be considered dynamic representations of nature, subject to continual refinement, evolution, and improvement. Thus, the word "verification" has no clear-cut or absolute meaning with respect to hydrologic simulation. A model developed in conjunction with a given project may be calibrated by means of various techniques; the calibration process, its shortcomings, and the degree to which the model succeeds in approximating the natural system should all be discussed thoroughly in the report of the investigation, but no fixed standard can be applied by project reviewers in stipulating whether or not a calibration is "acceptable." The basic questions are (1) whether the model is a sufficiently good representation of the natural system to lead to an improvement in our understanding of the system; (2) whether the level of complexity (or simplicity) of the selected model is appropriate for its application and intended use; and (3) whether the report adequately discusses the disparities between the model and the field situation. Uniform procedures and standards of model calibration are neither feasible nor desirable.

### Generic Models

Generic hydrologic models can simulate, reproduce, or represent one or more hydrologic processes. If a newly developed generic model is more general, more readily transferable, more easily used, more accurate, or more efficient than available models, then it should be adequately documented and made available to the public through normal publication channels. Such a model is a valid product of the Division, just as documentation of a new or significantly improved geophysical method or analytical-chemistry procedure would be a valid product.

The stimulus for new generic models in the Division has often come from the individual researcher working at the forefront of his science. Only more modestly have new generic models been achieved through a conscious long-term planning or decisionmaking process of research, field, and senior managers. The achievements in the future may require more group efforts based on several specialties. Direction and support for such efforts require a more broad-based process, but care must be taken not to stifle individual creativeness.

## MODEL DOCUMENTATION

A model documentation is a written description of the model. In general, the documentation should include a description of methodology, accuracy, efficiency, and usability. Different levels of documentation are appropriate to different stages of modeling.

1. A description of the underlying theory is appropriate for the researcher or model developer; this would describe the equations and the numerical methods, and, for example, may be published in a scientific research journal.
2. A user's guide usually is appropriate for a generic model (and occasionally for a field model) and represents a technology-transfer function; preparation of a user's guide is warranted if widespread and frequent use of that model is anticipated.
3. The application of a generic model to a field problem requires a description of the coefficients or parameters for the specific system, including initial conditions, boundary conditions, stresses, and system properties.

The first level is clearly the obligation of the researcher, and the third level is clearly the responsibility of the authors who wrote the report of the investigation in which the model was applied. However, if we accept that level 2 is a technology-transfer function, does an operationally effective means exist within the Division to implement it? The answer is not clear. It is desirable, and probably necessary, for the researcher to be involved at this level of documentation, but the incentives and support for doing so appear small.

Any modeling, model development, or model modification should embody, at an appropriate organizational level, the commitment for adequate and timely documentation. An exception seems reasonable if a model is used primarily as an investigative tool during a project to help test alternative hypotheses or to help optimize data collection; such model uses need not be reported, and hence, need not be documented. This exception further requires that the conclusions or recommendations of the project are not dependent or contingent upon the model analysis and that they could be verified without the model. The undocumented model should not be released.

Deficiencies do exist in the level of model documentation evident in WRD modeling projects. Some problems occur because others have developed erroneous perceptions of the intended purposes of the documented model. The nature of the model is dictated by knowledge of the hydrology (boundaries, properties, and stresses) *and* by the nature and scale of the problem to be solved. The model is a simplification that has applicability limited by its original objectives. If the objectives are modified, the model may yield erroneous results.

Additional problems arise because updates and revisions to documented models are often not adequately documented. This may prevent successful subsequent use of the model by others. A good practice is to keep a log book in which *all* program changes are recorded, but it is not necessary for the published documentation to describe every new or changed line in a program. The guiding principle for documentation of field models should be that the documentation can be used to reproduce the results.

Ground Water Branch Technical Memorandum No. 75.11 provides guidelines for reporting and documenting aquifer modeling studies. It has withstood the test of time and is still a good representation of WRD policy. It should be updated and generalized to provide guidelines for all modeling studies in the WRD and released as a WRD Memorandum.

The data associated with a field model are part of the model and should be documented in the report to an extent of detail that would allow another qualified investigator to independently obtain essentially the same results. In general, a listing of all input data, including discretized nodal values, need not be published. Long-term preservation of input data files is often desirable. Data cards should be available in the originating office for a minimum of 2 years, and microfilmed or archived thereafter. The approval of a modeling report implicitly connotes approval for the release of corresponding input data decks.

## MODEL VERIFICATION

Much confusion centers on the concept of model verification, largely because the term "verification" itself is misleading and misunderstood. The brief journal article, "Hydrologic Semantics," by Matalas and Maddock (1976, *Water Resources Research*, v. 12, no. 1, p. 123) should be required reading for all WRD personnel involved in conducting, managing, or supervising a modeling project. They argue that the term implies a "***greater understanding of and control over the physical processes than actually exist."

A common argument is that before a model is used for predictive purposes, it should be verified through comparisons with observations of dependent variables that have not been used during the calibration procedure. This implies that data for verification are independent of data for calibration. Such independent data may be available for some types of surface-water models, but would rarely be available for ground-water models.

Formal procedures and standards for model verification are neither feasible nor desirable. The objective should be to develop confidence in the ability of the model's representation of the system to predict the results of the changed stress situations to be evaluated. The model documentation should convey adequately the range of conditions or stresses for which valid prediction or simulations are anticipated. Accordingly, sensitivity analyses are an important part of model calibration and documentation; the results of sensitivity tests should provide the basis for quantifying the influence of errors or uncertainties in the input data (properties, boundaries, and stresses) on the output and, hence, on the reliability of the results. Adequate documentation will help to minimize misuse or misinterpretation by others of our models and modeling results.

## DISTRIBUTION

The development, approval, and release of generic hydrologic models is within the mission (and perhaps an obligation) of the Water Resources Division. Subsequent operational support for these models and their associated code is the responsibility of the user. Insofar as the WRD maintains an interest in that particular model, new versions will be made available to the outside community on a new release basis. Models under development (that is, formally undocumented) should be released to outsiders only on a very limited basis and only for purposes of peer review and evaluation.

For several reasons, undocumented generic models under development within WRD are distributed internally and used for field applications. This has led to problems on occasion when the report of the field investigation was ready for processing before documentation of the model that was used in the field investigation was completed. The solution of this issue remains unresolved. The viewpoint of some Work Group participants is that timely documentation of generic models is best done as a technology-transfer function by those with access to, and some support from, the researchers doing the model development. District programs are neither financed nor staffed to provide this function, which should be done to the satisfaction of technical coordination (Branch) considerations and should have broad benefits within the Division. The viewpoint of some other participants is that a policy requiring such documentation by a technology-transfer group could degenerate into a policy requiring that user documentation be prepared by the researcher who developed the theoretical model. Because there is little professional reward to researchers for time spent documenting and preparing a user's guide (as opposed to publishing new research results), this would stifle the early release of new models and hence reduce the benefits of interaction between field and research personnel in model development and in providing feedback from practical applications. These Work-Group participants also think that the field-level user of a research model that remains undocumented must assume the responsibility for providing some level of documentation in time for the publication of the field-investigation results. A number of other alternatives were discussed, such as having an operational models group complete such documentation (this has been done for some surface-water and water-quality models), through training positions for newly hired modelers before moving on to research or field programs, or through farming this out as a supported task to qualified District-level employees. This issue, as defined, remains to be resolved by a higher level management decision. (A description of what constitutes an adequate documentation is included in Ground Water Branch Memos 75.11 and 79.04. A complete user's guide is not a necessity; simple comparisons with analytical solutions for several simple test cases, combined with references to relevant published literature, will often suffice.)

Field models and their associated data should be made available equally to all with the publication of the report. No operational support for these models is intended. The policy of the WRD generally is not to undertake service work in operating previously developed models where this work is largely the assessment of management alternatives and generates no new scientific information. Exceptions to this may be necessary and can be negotiated through normal program-management activities. Model runs and analyses made by the Survey subsequent to the release of the model report should not, in turn, be released without a new report approved through normal channels.

The work group generally agreed that new output from runs or simulations using an approved, published, and documented field model constitutes interpretive information, and should be treated according to WRD policy for release of interpretive information. However, when this opinion was reported to the conference during the final plenary session, a dissenting view was expressed which held that new model outputs by themselves are merely data, and new outputs are provided and released to requesters without review and without approval. Further consideration and clarification of this question is warranted.

Occasionally (we hope rarely), errors in documented models are detected after publication. No clear agreement was expressed within the working groups on the extent of our obligation (if any) to make a reasonable attempt to notify users of corrections that may significantly affect model accuracy and reliability; it was agreed that we need not take affirmative actions for updates or refinements that merely improve efficiency or usability. Although we have no obligation to track users, consideration should be given to maintenance of mailing lists of known users of certain high-visibility or widely used models (perhaps only those released in the TWRI series) so that "model recalls" can be readily implemented.

Even if our models are free of "bugs," they may still be misused or misapplied by others, regardless of explicit precautions and qualifications presented in the text of the report. Hence, we considered whether or not our models and modeling reports should contain a disclaimer. There are several advantages and disadvantages of doing so, and the two working groups came to opposite conclusions regarding a recommended policy for printing disclaimers.

It also was suggested that for any models being documented in the form of a user's guide, the review procedure should include, at some level, an independent compilation and execution of the program to assure that it can do at least a small sampling of the basic types of simulations indicated by the text. A test run of all possible combinations of options would be impractical.

## USE OF OUTSIDE MODELS

Project personnel should be encouraged to use the best available methods in the course of their investigations. Sometimes this will mean that they will use one of the many digital simulation models available from sources outside WRD. Our standards for documenting the use of outside models should be no different from those for our own models. Two cautions are appropriate. First, if the user runs into a problem, no one within WRD may be sufficiently familiar with the outside program to provide any technical support or assistance. Second, the model may be proprietary or WRD may have some restrictions on its redistribution, which may conflict with our intentions for public availability and release of our documented models. Another suggestion was that a valid technology-transfer function of the Branches would be to ascertain the status and availability of hydrologic models developed outside the WRD and to be ready to answer relevant inquiries from WRD personnel.

## OTHER CONSIDERATIONS

The Water Resources Division needs high-level specialized skills in numerical analysis and computer software to take advantage of rapid advances in these fields. Embedding these talents within the WRD will require careful planning to be successful. Research and training should be important functions of these specialists.

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E. G. Patten, Jr., and C. A. Appel, Ground-Water Branch, Headquarters, and R. D. MacNish, District Chief, Arizona, also contributed significantly to the group's discussion.

P

# WRD Goals for the 1980's

## Working Group E

Presented by J. F. DANIEL
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*In Xanadu did Kubla Khan*
*A stately pleasure dome decree:*
*Where Alph, the sacred river ran*
*Through caverns measureless to man*
*Down to a sunless sea . . . .*
*Coleridge*

The charge to the WRD Goals Work Group was not a specific list of discussion questions to answer. Rather, it was a single, broad question asking what sort of organization should we be in 1990. In a sense, then, we five were allowed to set our own charge and reach some consensus regarding what the goals should be.

As a first step, we concluded that, in times of severe constraints and/or reductions in personnel and funding, writing a laundry list of programmatic goals (technical problems) to address was not a productive exercise. Therefore, we concentrated on identifying objectives which are deemed achievable, in part, by implementing organizational changes to "ready" the Division for the scientific responsiveness and interdisciplinary depth deemed necessary to meet the challenges of the 80's.

Given a mission for WRD that, in so many words, is to play a significant role in serving the Nation's water needs, our goals for the 80's are to:

1. Help solve, or contribute to the understanding of the factors (processes) involved in, water problems at all levels of society;
2. Maintain an accounting of the Nation's water resources;
3. Improve WRD's scientific/technical contributions to the water-resource community;

and, perhaps most important, these external goals can best be achieved internally by consciously taking steps to:

4. Strengthen WRD's uniqueness.

### RESOURCE PROBLEMS AND WRD

Although new problems (both real and imagined) do crop up from time to time, consider the following list of water problem areas:

1. Adequacy of the supply
2. Effect of waste disposal on the supply
3. Conjunctive use of surface and ground water
4. Improved technology for ground-water development
5. Improved technology for ground-water recharge
6. Intrusion of saline water
7. Use of impure ground water
8. Overdraft
9. Keeping the public informed
10. Type of information needed

These items are quoted directly from *Water for a Space Age Economy*, Ground Water Branch Program, *1961* Fiscal Year. With slight editing and only a few additions, they could serve as technical goals today. In today's jargon, the priority list of 1980's water resource problems might read:

1. Energy development
2. Food production
3. Contamination/degradation
4. Supply variability
5. Changes in use
6. Shifting demand

There will always be problems. Although the impetus for the problems can change from decade to decade, the basic technical requirements necessary to help solve the problems tend to be somewhat less variable. What makes the 1980's unique is the perceived magnitude of the problems and their number.

In order to "see" 1990, and still be an effective organization, WRD must strengthen its unique characteristics in order to play a significant role in solving these problems. That raises the question of: "Why WRD?"

As recognized by most people, WRD no longer has a "lock" on its traditional strong points of research, data collection, and interpretation. Research is done in universities, institutes, national laboratories, and the like. Data collection can be, and is, done by contractors, industry, and other agencies. Interpretation (used here synonymously with "problem solving") can be done by consultants, other agencies, etc.

However, WRD *uniquely* combines all three on a national scale, with the obvious additional strong points of continuity, visibility, impartiality, credibility, and interdisciplinary expertise. We must capitalize on our uniqueness, and our primary effort in the 1980's must be to strengthen it. That means that the Division must consciously judge all its decisions in the next few years in light of their effect on a well-balanced program of all three aspects. The consensus of the group is that in the present circumstances, "problem solving," i.e., activities related to perceived water problems, is a logical focus for the Division; data acquisition and research, however, cannot be permitted to atrophy as a short-term expedient.

## EFFECTS OF SHORT-TERM DECISIONS

With all the above in mind, we discussed proposed changes in WRD as examples of how these goals could be furthered. In other words, we felt that the water information needs of the Nation are dynamic, thereby necessitating a dynamic organization to supply such information. Organizational change, designed to enhance our uniqueness, can have positive effects on our capability to respond to changing needs. Three general approaches resulted. They are, in no particular order:

1. Mobilize talent
2. Improve communication
3. Minimize management (maximize productivity)

**1. Mobilize talent** is our catch phrase for the positive results of, among other things, combining Districts. This is very nearly a fact in some places, although the reason seems to be to solve financial problems. We submit that in the long term, there will be no financial benefit. One has only to inspect other consolidations in government or the private sector to reach that conclusion. However, there are some positive benefits from consolidations that can help us reach our goals.

Two actions could help. The first is to adopt a mode of operation, which has long been under consideration, in which all interpretive projects would be staffed with ad hoc teams without regard to the members' physical locations. The second action is to aggregate field units (Districts) to assure that broader discipline expertise and state-of-the-art technical support functions are made available to tackle the broad and complex issues facing WRD. By this action, some management control is retained. Several benefits could accrue:

- Fewer residence relocations for employees
- Quicker response to needs
- Employee development promoted by exposure to a wider range of hydrologic problems
- Improved technical products
- Aid in solving the "next assignment" problem for RGEG (Research Grade Evaluation Guide) positions in the field

By adopting a policy that we *will* combine Districts, we can *plan* the combinations that would achieve our goals rather than accepting a haphazard alinment based on fire fighting.

**2. Improve communication** serves to highlight an approach to solving current difficulties in technology transfer by reducing the levels through which communication must be sent and by clearly identifying who has responsibilities.

First, we need to separate the technology-transfer functions from the quality-assurance functions, both currently embodied in the discipline branches under the Assistant Chief Hydrologist, R&TC. Whether this means abolishment of the Branches is an open question, but, certainly, it means changes in their structures as we know them now. Second, we need to reduce the levels of communication by enhancing direct organizational access between aggregated field units and Headquarters. In other words, maxi-Districts become mini-Regions. By such changes, we could accomplish the following:

- More rapid identification of current research needs
- Timely availability of techniques
- Improved quality assurance

With larger field units, we have less need for the Regional communications funnel. In fact, it is not funnel-shaped, but is currently closer to an hour-glass shape.

**3. Minimize management** is not meant to imply that, ipso facto, less management is better. Rather it is meant to imply that fewer management personnel means a higher percentage of personnel directly involved in production. Two actions could be tailored to achieve overall goals.

First, a single Headquarters unit could be established to coordinate development of Division programs *and* to allocate funds directly to aggregated field units, using uniform procedures and criteria. A coordinator, assistant coordinator, and associated staff should not be required for each and every thrust program currently residing in all three offices of Assistant Chief Hydrologists. Second, the responsibility for *all* program management could be placed at the aggregated field unit level.

Benefits are:

- Decision making that is closer to the problems
- Quicker response to needs
- Improved communication
- Elimination of duplication of "Research/ Operational" management
- Availability of more personnel for direct technical work

Implicit in all three approaches discussed above are internal needs for talented manpower, data (new and continuing), techniques (new and improved), and technical support (human and hardware). If all three changes were adopted exactly as stated, organization of WRD could, in 1990, look like that shown in figure 1.

## SUMMARY

Our work group did not set out to reorganize WRD, nor is that our intent in the foregoing discussion. We have tried with these few examples to point out that because the economic "facts of life" dictate that "small is beautiful" changes are upon us, those changes we make can have a positive impact on our identified goals of:

1. Help to solve, or contribute to the understanding of the factors (processes) involved in, water problems at all levels of society
2. Maintain an accounting of the Nation's water resources
3. Improve WRD's scientific/technical contributions to the water-resources community
4. Strengthen WRD's uniqueness

While seeking solutions to the Division's current problems, we can build upon and strengthen the uniqueness of the Water Resources Division, U.S. Geological Survey. We can do better science, provide better, more relevant information critical to the solution of water problems, and fulfill our data-acquisition responsibilities. The sooner we address the need for changes, the more likely our success in assisting the Nation in the 1980's to meet its water information needs.

My thanks to each of the group members for their contributions in making this report a true consensus rather than five minority reports.

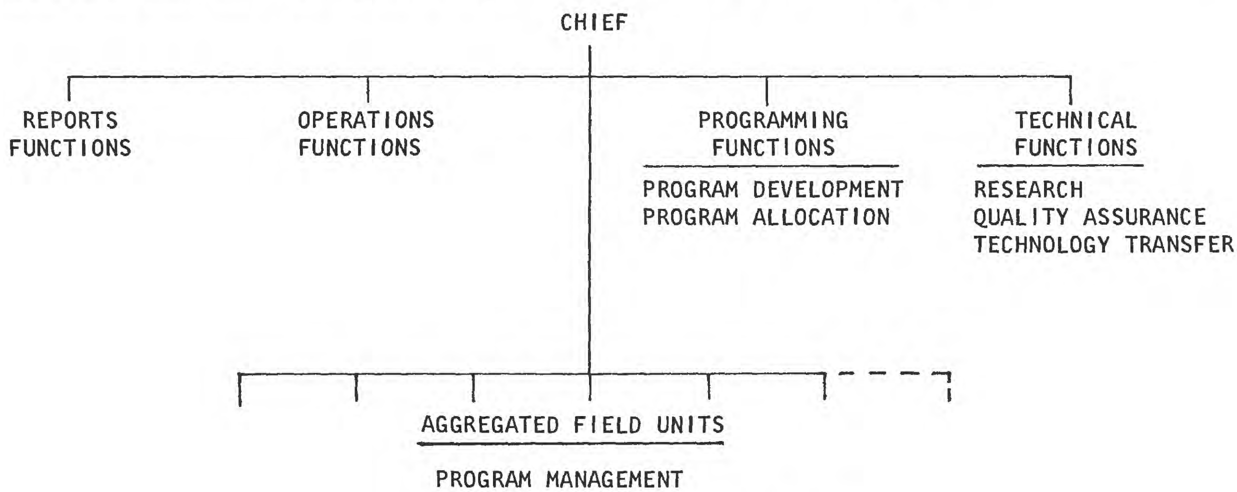


**Figure 1.** WRD in 1990 could look like this.

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# Solute-Transport Modeling

## Technical Sessions

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Although prevention of ground-water contamination is undoubtedly the best cure, contamination is already serious in many places in the United States. In such places, even if the source of contamination were to be eliminated, contaminants already in the aquifer will continue to migrate and spread through the aquifer unless they are immobilized, neutralized, or removed. These numerous site-specific problems have created a need for general and transferable models to simulate and predict the movement of contaminants in flowing ground water. However, because of controversies that often arise over the origins and liabilities for sources of contamination, ground-water quality models and modeling analyses are undergoing increasingly greater scrutiny.

For ground-water contamination problems, needs for aquifer analysis frequently focus on one of two general types of situations: (1) assessments of already contaminated sites, and (2) planning to minimize contamination hazards from future activities or waste-disposal operations. Both types of situations require the capability to predict the behavior of chemical contaminants in flowing ground water. Reliable and quantitative predictions of contaminant movement can be made only if the processes controlling convective transport, hydrodynamic dispersion, and chemical, physical, and biological reactions that affect solute concentrations in the ground are understood. These processes, in turn, must be expressed in precise mathematical equations having defined parameters. Although many of the processes that affect waste movement are individually well understood, their complex interactions may not be understood well enough for the net outcome to be reliably predicted. Analysis of ground-water contamination problems can be greatly aided by the application of deterministic numerical simulation models, which solve the equations describing ground-water flow and solute transport.

Figure 1 illustrates in a general manner the role of models in providing input to the analysis of ground-water contamination problems. The value of the modeling approach is its capability to integrate site-specific data with equations describing the relevant processes as a basis for *predicting* changes or responses in ground-water quality. Site-specific data include (1) hydraulic and chemical properties of the aquifer (derived from field and laboratory tests), (2) geometry and boundary conditions (derived primarily from hydrogeologic mapping), (3) aquifer stresses, such as well pumpage, recharge rates, and chemical concentrations in fluid sources (estimated from direct or indirect field measurements whenever possible), and (4) spatial and temporal variations in dependent variables, such as hydraulic head and chemical concentration, which provide initial conditions and calibration criteria (derived from systematic hydraulic and chemical monitoring).

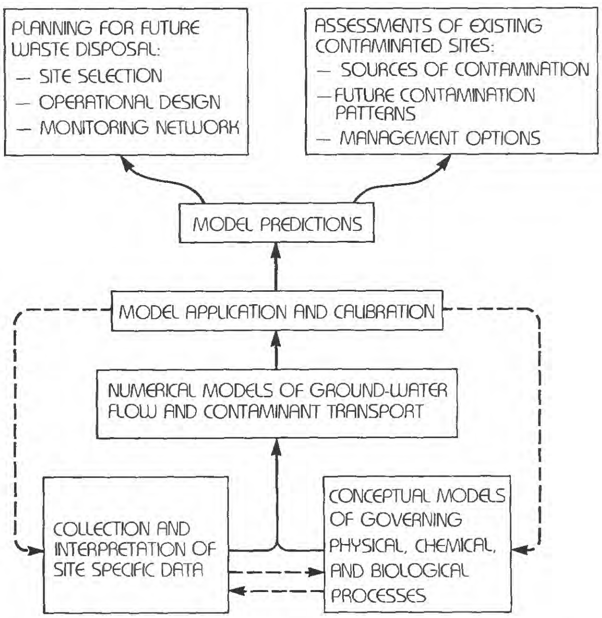


**Figure 1. Schematic overview of the role of simulation models in evaluating ground-water contamination problems.**

Perhaps the most common type of problem is analyzing sites contaminated at present. Typically, the need for analyzing such a site has arisen because contaminants have been detected where they were not expected. For these sites, a numerical simulation model can help to assess the hazards or consequences of continued spreading of contaminants, either if no action is taken or if some particular management option is implemented. The predictive capabilities of a simulation model can also provide valuable input to planning future waste-disposal operations, so that any consequent ground-water contamination will be expected, tolerable, minimal, and detectable. The model analysis can help to meet these constraints of planning through (1) predictions of contaminant spreading patterns for alternative sites being considered, (2) comparisons of alternative design specifications and operational options for specific sites, and (3) optimizing requirements for spatial and temporal sampling densities for a monitoring network.

A major difference between evaluating existing sites and new sites is that for the former, if the contaminant source can be reasonably well defined, the history of contamination itself can, in effect, serve as a surrogate long-term tracer test that provides critical information on velocity and dispersion at a regional scale. At new sites, historical data are commonly not available to provide a basis for model calibration and to serve as a control on the accuracy of predictions. As indicated in figure 1, there should be allowances for feedback from the stage of interpreting model output both to the data collection and analysis phase and to the conceptualization and mathematical definition of the relevant governing processes.

Perhaps the most important technical advancement in the analysis of ground-water contamination problems during the past 10 years has been the development of deterministic numerical simulation models that efficiently solve the governing flow and transport equations for the heterogeneous properties and complex boundaries of a specific field situation. However, no single model is available yet that is equally suitable for the entire spectrum of possible problems. Particularly difficult numerical problems arise where the chemical reaction terms are highly nonlinear or where the concentration of the solute of interest is strongly dependent on the concentration of numerous other chemical constituents.

Three types of numerical methods are usually used to solve the solute-transport equation: finite-difference methods, finite-element methods, and the method of characteristics. Each has some advantages, disadvantages, and special limitations for applications to field problems. Each method also requires that the area of interest be divided by a grid into a number of smaller subareas. Each of these methods has been applied successfully to one or more field projects within the Water Resources Division. Because of numerical problems associated with solving the transport equation, it must be cautioned that the available solute-transport models are *not* simple black-box tools that can be easily applied by those who are unfamiliar with the numerical techniques and theoretical basis of the model.

In general, calibrating a solute-transport model of an aquifer is more difficult than calibrating a ground-water flow model. Fewer parameters need to be defined to compute the head distribution with a flow model than are required to compute concentration changes with a solute-transport model. Because the ground-water seepage velocity is determined from the head distribution, and because both convective transport and hydrodynamic dispersion are functions of the seepage velocity, a model of ground-water flow is usually calibrated before an adequate and reliable solute-transport model can be developed.

The results of applying a solute-transport model to a ground-water contamination problem at the Rocky Mountain Arsenal, Colorado, indicate that a simulation model can adequately and quantitatively integrate the effects of the major factors that control changes in solute concentration in a 30-year history of chloride contamination. This example (*see* Konikow, 1977, for details) illustrates the value of a solute-transport model as an investigative tool to help understand the processes and parameters controlling the movement and fate of contaminants in ground-water systems. Although every ground-water contamination problem is in many ways unique, the solute-transport principles and investigative approaches are general and transferable; they are linked by the universal nature of the physical and chemical laws governing fluid flow, transport processes, and chemical solubility.

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**P**

# Distributed Parameter Precipitation-Runoff Modeling

## Technical Sessions

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Changes in land use associated with urbanization, surface mining, agricultural and forestry practices, or natural processes can produce significant changes in the hydrology of a watershed. Distributed parameter precipitation-runoff models are important tools available for evaluating the effects of such land-use changes on watershed hydrology. These distributed-parameter models provide a means of accounting for the spatial and temporal variability of watershed and climatic characteristics associated with land-use changes. Distributed-parameter modeling capabilities are provided by partitioning a watershed into units based on slope, aspect, altitude, vegetation, soils, precipitation distribution, or other measurable characteristics. Each watershed unit is considered homogeneous with respect to its physical characteristics and hydrologic response. The units are termed hydrologic response units (HRU's). The sum of the responses of all HRU's, weighted on a unit-area basis, produces the total watershed response. A set of parameters is defined for each HRU.

Several distributed parameter precipitation-runoff models are available. Three are being used in the Water Resources Division of the U.S. Geological Survey. They are (1) the distributed routing rainfall-runoff model (DR3M) (Dawdy and others, 1978); (2) the hydrologic simulation program-Fortran (HSPF) (Johanson and others, 1980); and (3) the precipitation-runoff modeling system (PRMS) (Leavesley and others, written communications, 1982). The overall design of these models is similar, but they differ in the approach, scope, and algorithms used to simulate specific hydrologic processes. PRMS will be used in this discussion to provide an example of the concepts, components, and capabilities of distributed-parameter models.

### WATERSHED SYSTEM

The distributed-parameter concept produces a watershed system that is composed of a number of segments or HRU's. A water balance and an energy balance are computed for each HRU, and the responses of all HRU's are integrated to produce the watershed response. A typical HRU and the processes and flow paths normally simulated are shown in figure 1. For precipitation-runoff modeling purposes, an HRU is conceptualized as a series of reservoirs whose outputs combine to produce the HRU response, as shown in figure 2. The upper soil-zone reservoir (USZ) represents the part of the soil mantle that can lose water through the processes of evaporation and transpiration. Average rooting depth of the predominant vegetation covering the soil surface defines the depth of this zone. Water storage in the USZ is increased by infiltration of rainfall and snowmelt and depleted by evapotranspiration. Maximum retention storage occurs at field capacity; minimum storage (assumed to be zero) occurs at wilting point. The USZ is treated as a two-layered system. The upper layer is termed the recharge zone and is user defined as to depth and water-storage characteristics. Losses from the recharge zone are assumed to take place from evaporation and transpiration; losses from the remainder of the USZ take place only through transpiration.

The computation of surface runoff ($Q_1$) is dependent on the source of input (either rainfall or snowmelt), and the time increment used. For daily rainfall inputs, $Q_1$ is computed by using an empirical relation based on the relative saturation of the recharge zone. Daily infiltration is net rainfall minus $Q_1$. When a snowpack exists, all snowmelt is assumed to infiltrate the USZ until field capacity is reached. At field capacity, snowmelt infiltrates until it exceeds a daily infiltration capacity and the remaining melt becomes $Q_1$. Infiltration in excess of field capacity becomes seepage to the subsurface reservoir ($S_1$). For storm-hydrograph simulations, infiltration is computed at time intervals of 5 minutes or less. For each time increment, a rainfall excess is computed as net precipitation minus infiltration. Rainfall excess quantities can be totaled for $Q_1$ volume or routed over the USZ surface using the kinematic-wave equations to produce the overland-flow hydrograph of $Q_1$.

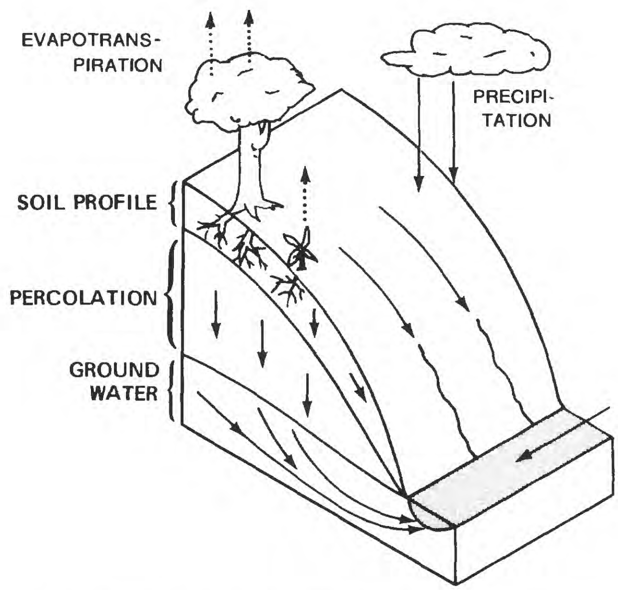


Figure 1. Hydrologic response unit (HRU) and the processes and flow paths simulated.

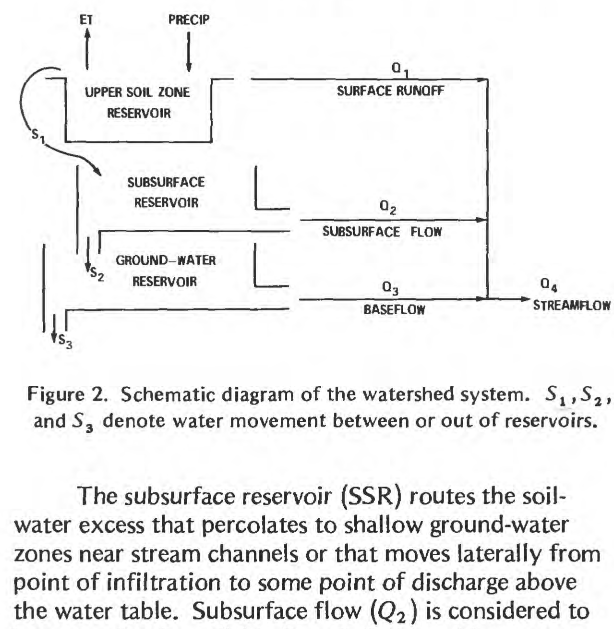


Figure 2. Schematic diagram of the watershed system. $S_1$, $S_2$, and $S_3$ denote water movement between or out of reservoirs.

The subsurface reservoir (SSR) routes the soil-water excess that percolates to shallow ground-water zones near stream channels or that moves laterally from point of infiltration to some point of discharge above the water table. Subsurface flow ($Q_2$) is considered to be water that is available for relatively rapid movement to a channel system. The SSR can be defined as either linear or nonlinear.

Seepage to the ground-water reservoir ($S_2$) is computed as a function of a daily seepage rate and the volume of water in storage in the SSR. The ground-water reservoir (GWR) is a linear reservoir and is the source of all baseflow ($Q_3$). Movement of water through the ground-water system to points beyond the area of interest or measurement can be handled by seepage $S_3$.

Streamflow ($Q_4$) is the sum of the outputs $Q_1$, $Q_2$, and $Q_3$. Daily flows from the watershed are computed by summing $Q_4$ from all HRUs. Stormflow hydrographs are computed by routing $Q_4$ from each HRU through the watershed channel system using the kinematic-wave equations. Sediment and water quality components are coupled to the flow components ($Q$) and seepage components ($S$).

## PARAMETER OPTIMIZATION AND SENSITIVITY ANALYSIS

A model parameter is broadly defined as a value that is used to represent a physical or hydrologic characteristic of a watershed or HRU, and is held constant during a simulation run. Optimization is the adjustment of model parameters to obtain a better agreement between observed and predicted runoff. Runoff prediction error is the sum of three error components:

$$\text{Runoff prediction error} = \text{Model error} + \text{Input error} + \text{Parameter error} \quad (1)$$

Where poorly conceived models or erroneous data sets are used, parameter values must be adjusted to compensate for these errors so that runoff-prediction error is minimized. Therefore, the confidence that can be placed in optimized parameter values and their transferability to other basins is a function of the model and data being used.

The method used to obtain an optimal set of parameter values is the Rosenbrock optimization technique (Rosenbrock, 1960). Spatially distributed parameters have an initial value assigned to each HRU, subsurface reservoir, or ground-water reservoir. Temporally distributed parameters have an initial value assigned for each time increment. One or any combination of parameters can be selected for optimization. During each iteration of the fitting procedure, a single parameter is adjusted and an objective function is computed and tested for improvement. For each iteration of a distributed parameter, all values of the parameter are moved in the same direction. The amount that each value is moved can be selected either as the same magnitude or as the same percentage of the initial value. A major assumption in this fitting procedure is that the initial estimates of the values of a given distributed parameter are correct with regard to their relative differences in space or time.

The objective function used can influence optimized parameter values through the weighting that is given to different size errors. Least squares equations typically used are:

$$\sum_{i=1}^{n} (P_i - O_i)^2 \quad (2)$$

$$\sum_{i=1}^{n} (1nP_i - 1nO_i)^2 \qquad (3)$$

where

$n$ = number of days or storm events,
$P$ = predicted runoff,
$O$ = observed.

Equation 2 weights large errors more than small errors whereas equation 3 weights errors proportionally to the size of flow. Because larger errors ususally occur at high flows, parameter values fitted using equation 2 tend to be biased to higher flows. Equation 3 produces parameter values that reflect the influence of a larger range of flows. Use of equations 2 and 3 assumes independence between successive prediction errors. This condition is met when $P$ represents individual storm events. However, when daily mean flows are used to fit parameters, daily runoff-prediction errors have a correlation component that must be removed. An objective function to do this is:

$$\sum_{i=1}^{n} [(P_i - O_i) - \rho (P_{i-1} - O_{i-1})]^2$$

where

$\rho$ = correlation between prediction errors on the $(i-1)$th and $i$th days.

Sensitivity analysis is used to determine the extent to which uncertainty in parameters results in uncertainty in predicted runoff. Knowledge of which parameters are having the largest influence on prediction errors tells the user which hydrologic components and data are most important in simulation computations. Assessments can be made of the adequacy of both the simulation algorithms and the data used in these components, and improvements can be made as required. When optimization and sensitivity analysis computations are coupled, the magnitude of parameter standard errors and parameter intercorrelations can be assessed. Parameters that are highly correlated will have similar influence on predicted runoff. Locating optimal values of parameters that are highly correlated is a problem for many optimization algorithms, including the Rosenbrock technique. One approach to minimizing this difficulty is to use a step-wise fitting procedure where groups of uncorrelated parameters are fitted in separate runs. A second approach is to determine the relationship between correlated parameters, then optimize one and compute the other from this relationship.

One of the objectives of hydrologic modeling is to develop the ability to simulate the hydrology of ungaged basins. This requires the transferability of model parameters from gaged to ungaged sites. Optimization and sensitivity analysis techniques are powerful tools for fitting and analyzing model parameters in the distributed-parameter framework. However, the optimum technique for determining transferable parameters is to define the relationships between parameters and measurable watershed and climatic characteristics. A primary goal of the current precipitation-runoff modeling research is to develop model components and parameter-estimation procedures that produce minimum prediction errors without the use of parameter-optimization techniques.

## MODELING SYSTEM

The precipitation-runoff modeling system (PRMS) has a modular design. Each component of the hydrologic system is defined by one or more subroutines that are maintained in a computer-system library. All subroutines are compatible for linkage to each other. Given a specific hydrologic problem and its associated constraints, the user can select an established model from the library or can design a model using selected library and user-supplied subroutines. The library also contains subroutines for parameter optimization, sensitivity analysis, and model-output handling and analysis.

The system structure has three major components as shown in figure 3: (1) The data-management component handles manipulation and storage of hydrologic and climatic data into a model-compatible direct access file, (2) the system-library component contains compatible subroutines used to generate the hydrologic-simulation model, and (3) the output component provides the model output handling and analysis capabilities.

## WRD DISTRICT APPLICATIONS

Model selection, data network design, and parameter transferability are the areas of major concern in applying distributed-parameter models to District projects. The model selected will be a function of project objectives, data constraints, manpower, and funding. A model's assumptions and limitations must be evaluated to ensure compatibility between the model and the physical system. Modular modeling systems provide the flexibility of permitting modification of selected components to better represent a watershed system without having to change the entire model. If modifications are planned, project personnel must have the required modeling and computer skills. Costs for distributed parameter simulations vary, depending on numbers of HRU's, model components, and storm-hydrograph periods selected. The more complete

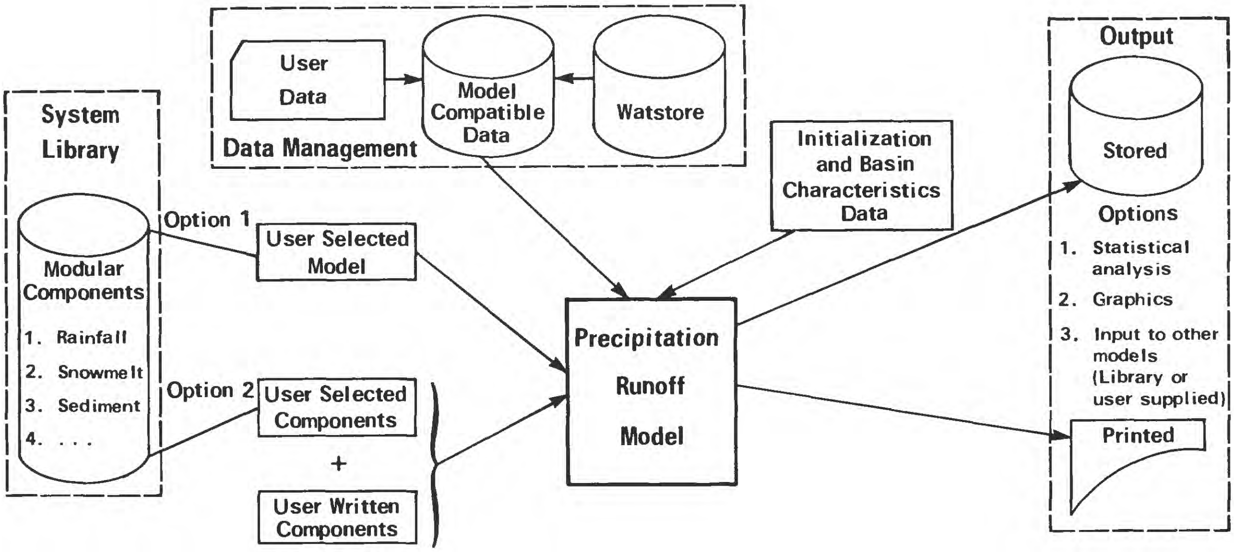


Figure 3. Schematic diagram of the precipitation-runoff modeling system.

models performing storm-routing, sediment, and water-quality computations can exceed the cost of lumped-parameter storm hydrograph models by a factor of 10 or more. Thus, project objectives must be balanced against simulation costs.

Data requirements are set by the model selected. Spatial and temporal variability of watershed and climatic characteristics must be determined to make HRU delineations, and physical and hydrologic characteristics of the HRU's must be measured. These characteristics may include data types not normally collected in the past; thus, they would require additional effort by project personnel to learn new data-collection techniques. Simulation results are normally verified using observed streamflow data at the mouth of the watershed. However, predicted streamflow in a distributed-parameter model is the integrated outputs of all HRU's. Therefore, direct measures such as runoff, soil moisture, and snow cover should be collected periodically on selected HRU's to verify HRU simulation results and integration algorithms.

Parameter transferability will be strongly influenced by the ability to estimate parameters from measurable watershed and climatic characteristics. Distributed parameters can be optimized; at the current state-of-the-art, several must be optimized. However, if models are to be applied with confidence to ungaged basins, the relationships between model parameters and measurable physical characteristics must be established. Some of these relationships can be defined in District-level projects.

## SUMMARY


Distributed parameter precipitation-runoff modeling is a valuable tool for evaluating the effects of land-use change. Application of this tool requires an effort by the user to fully understand both the watershed system and the model assumptions and limitations. Data requirements for both simulation and verification are increased over past modeling approaches, but are necessary to provide the ability to account for spatial and temporal variability in watershed and climatic characteristics. Through knowledgeable and scientifically based applications in District programs and strong research and development in the Division, distributed-parameter modeling capabilities will expand and improve to meet current and future water-resources needs.


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P

# Surface Geophysics in Hydrologic Investigations

## Technical Sessions

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Surface geophysical techniques have been developed and used extensively in the petroleum, mineral, and engineering fields, and, to a lesser degree, in hydrologic investigations. Recent advances in electronic equipment, computer interpretation programs, and the development of new techniques, make surface geophysical methods a more effective tool for hydrologists.

WRD projects have used surface geophysical techniques in the past, but only to a limited degree. These techniques should be treated as a tool, similar to pump tests, simulation modeling, test holes, geologic maps, borehole geophysical techniques, etc., and used to help solve hydrologic problems. They should be considered in the planning stages of projects, used where appropriate, and disregarded where inappropriate.

Classically, surface geophysical techniques have been used early in the exploration process. Hydrologists, following this example, should use these techniques early in their studies and before using more expensive data-collection techniques, such as drilling. The early use of surface geophysics will result in fewer expensive data-collection activities and in higher quality and more efficient hydrologic studies.

All surface geophysical methods measure, from the surface of the earth, some physical property of subsurface materials or fluids. Selection of the appropriate geophysical method is determined by the specific physical property that is to be measured. Typical physical properties measured are resistivity or conductivity, velocity of sound, density, and magnetic fields. The knowledge of the physical properties of the subsurface unit of interest and the properties of surrounding units is critical for the successful application of surface geophysical methods.

Because many different methods are used in surface geophysics, it is helpful to separate these methods into two groups: those that have been used in hydrologic studies in the past, and those that are new or have had limited application in hydrologic studies. For the first group, equipment is readily available, interpretation techniques are well documented, and field procedures are standardized. These techniques, the physical properties they measure, and their hydrologic applications are shown in table 1.

The second group of methods consists of new or modified techniques that have not been used in many hydrologic studies in the past; therefore, field procedures, interpretation procedures, and equipment are in the experimental stage. These techniques are very important to hydrologists inasmuch as they have many potential hydrologic uses. These methods, the physical properties they measure, and their potential hydrologic uses are shown in table 2.

One technique from each group is discussed below to show how and why each was used in hydrologic studies.

### STANDARD TECHNIQUES – SEISMIC REFRACTION

The hydrologic setting of glacial aquifers in New England consists of unconsolidated sand and gravel deposits underlain by crystalline bedrock. In order to select a geophysical technique, we must know the physical contrasts of the subsurface materials. Table 3 shows the velocity of sound in the various hydrologic units in New England.

It is evident from table 3 that significant velocity changes can define several important hydrologic boundaries of the unconsolidated aquifers and that the velocity of the sediments increases as depth increases. In this setting, seismic refraction techniques can be used to determine the depth to the water table and the shape of the till or bedrock surface. Thus, this technique can be a very valuable tool.

Figure 1 is a block diagram of a seismic refraction or reflection system. The sound source for this system can be a sledge hammer or a weight drop for shallow depths, a land sparker system for intermediate depths, or explosives for very deep areas or in special situations. The explosive source consists of a relatively safe two-component mixture buried 6 to 12 feet in the ground and detonated by a blasting cap.

**Table 1.** *Standard surface geophysical techniques*

| Technique | Physical property measured | Hydrologic uses |
|---|---|---|
| Resistivity . . . . . . . . . . . . . . . . . . | Resistivity of subsurface rocks or sediments and the interstitial fluid. | Fresh-saltwater interface.<br>Determining thick clay layers.<br>Finding buried stream channels in clay matrix.<br>Defining contamination plumes. |
| Seismic refraction. . . . . . . . . . . . . . | Compressional velocity of sediments or rocks. | Depth to water table in unconsolidated deposits.<br>Depth to bedrock underlying unconsolidated deposits.<br>Depth to crystalline bedrock underlying sedimentary rock aquifers. |
| Gravity. . . . . . . . . . . . . . . . . . . . | Density of subsurface materials. | Depth to bedrock underlying unconsolidated aquifers.<br>Definition of buried sink holes. |
| Magnetics . . . . . . . . . . . . . . . . . . | Magnetic intensity of rocks. | Extent and shape of volcanic rocks, presence of faults. |

**Table 2.** *New or modified surface geophysical techniques*

| Technique | Physical property measured | Potential hydrologic uses |
|---|---|---|
| Shallow seismic reflection . . . . . . . . . | Compressional velocity of sediments and rocks. | Depth to bedrock underlying unconsolidated aquifers.<br>Depth to and thickness of aquifers between high velocity layers.<br>Depth to and thickness of aquifers in sedimentary sequences. |
| Marine seismic reflection. . . . . . . . . . | Compressional velocity of sediments and rocks. | Depth to and thickness of aquifers.<br>Continuity of aquifers.<br>Depositional framework of aquifers. |
| Electromagnetics . . . . . . . . . . . . . . | Conductivity of subsurface rocks or sediments and the interstitial fluid. | Freshwater-saltwater interface.<br>Defining conductive contamination plumes.<br>Finding buried stream channels in clay matrix.<br>Determining extent of clay units. |

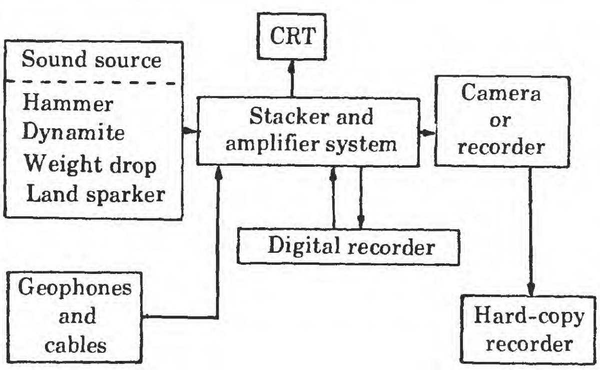


**Figure 1.** Land refraction/reflection system.

**Table 3.** *Velocity of sound in hydrologic units in New England*

| | *1,000 ft/sec* |
|---|---|
| Unconsolidated materials: | |
| Unsaturated . . . . . . . . . . . . . . . . . . . . | 1–2 |
| Saturated. . . . . . . . . . . . . . . . . . . . . . | 4–6 |
| Till (lodgement). . . . . . . . . . . . . . . . . . . | 7–8 |
| Triassic sedimentary rocks. . . . . . . . . . . . . . | 11–14 |
| Crystalline rocks . . . . . . . . . . . . . . . . . . | 15–20 |

The heart of the system is a 12-channel seismograph that electronically fires the sound source and amplifies, filters, processes, and records the resultant seismic signals.

The output data can be stored on magnetic tape or printed on a hard-copy record.

The sound waves produced by the sound source travel through the ground and are received by geophones placed at intervals along the surface of the ground. The signals are transmitted from the geophones to the seismograph through cables. Figure 2 shows the seismic wave fronts and travel-time plot for an idealized earth.

The data collected in the field is loaded into a small portable computer terminal and, through telephone connections, transmitted to and interpreted on the Denver Multics computer system. The result of the interactive Seismic Computer Modeling Program (Scott and others, 1972) is a profile of the subsurface refraction layers. Figure 3 shows a typical seismic refraction profile of a stratified-drift valley in New England.

A ground-water modeling study was conducted in Newtown, Conn., and nine seismic refraction lines were run in this valley (fig. 4) (Haeni, 1978). The seismic refraction profiles conducted for this study were used to:

1. Determine the shape of the bedrock surface.
2. Determine the depth to the water table.
3. Plan an efficient drilling program.
4. Provide data in areas inaccessible to heavy equipment.

## NEW OR MODIFIED TECHNIQUE – MARINE SEISMIC REFLECTION

Many hydrologic studies are conducted in areas that are traversed by rivers or contain lakes and ponds. If these water bodies are within areas where geohydrologic data is needed, a marine seismic reflection technique is an excellent tool for exploring the subsurface.

This technique has been used for many years in deep ocean and continental margin marine geology studies. Recent and continuing modifications of this deep-water technology have made this technique applicable to studies of shallow water, where the top several hundred feet of earth materials are of interest.

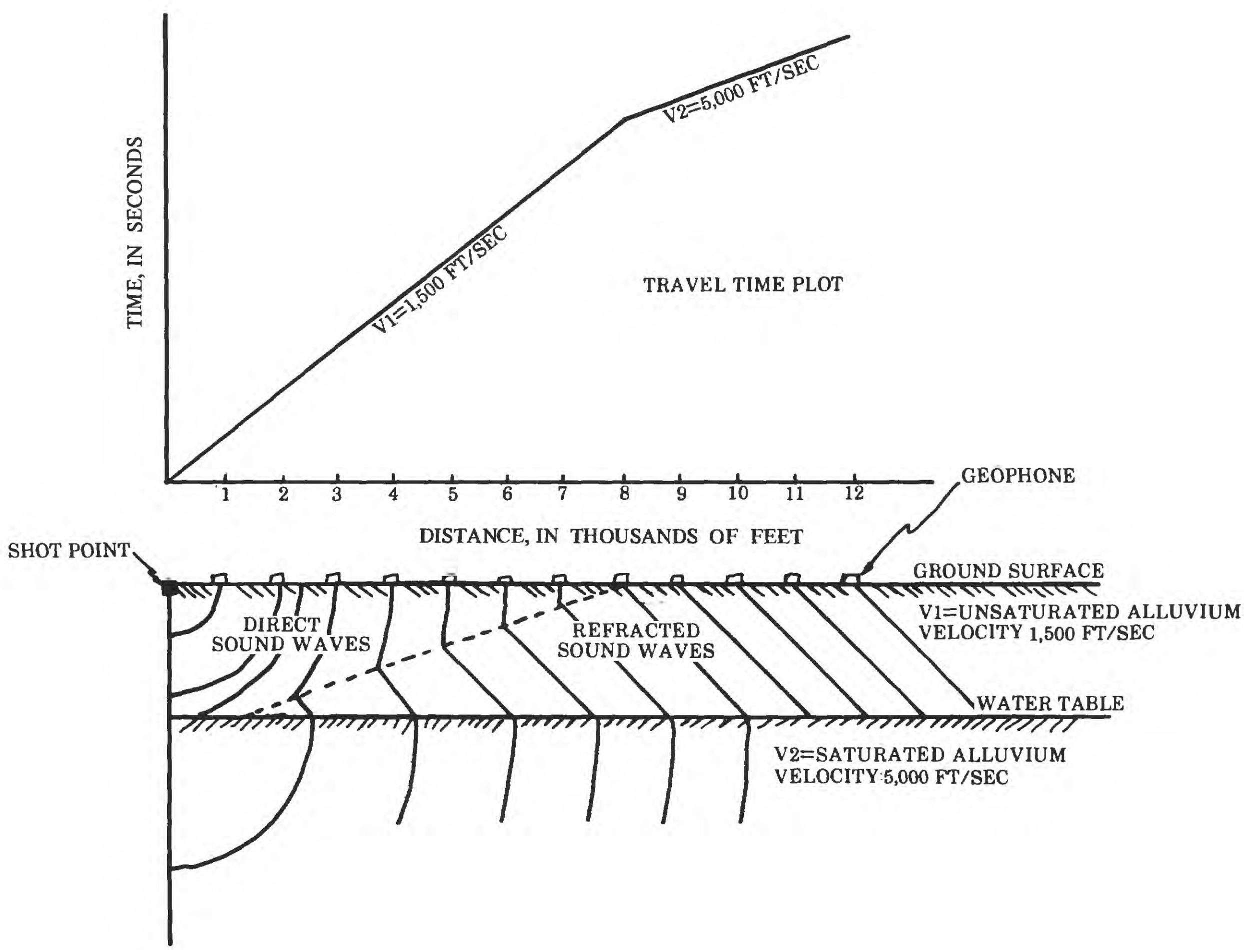


Figure 2. Diagrammatic travel-time plot and cross section.

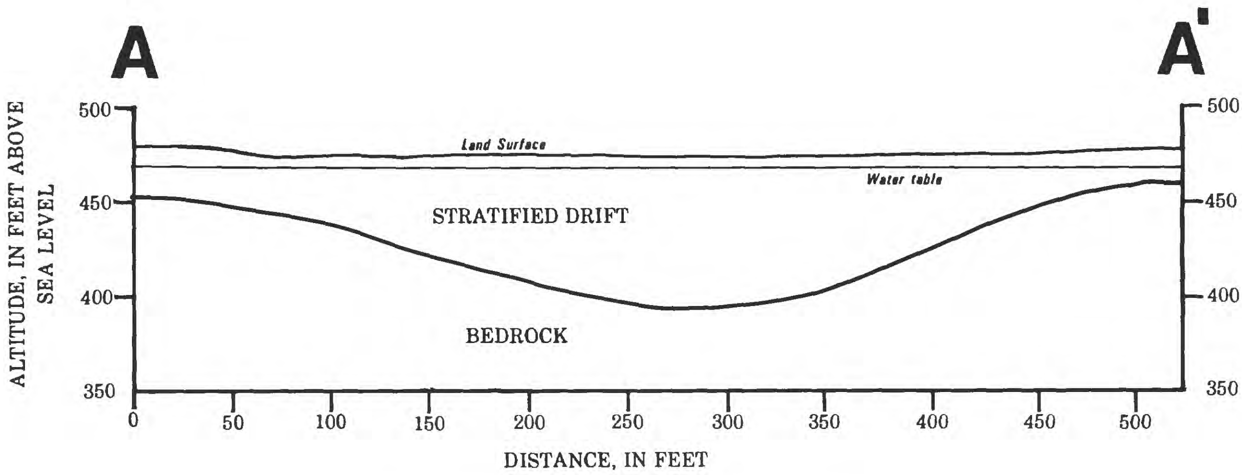


**Figure 3.** Seismic refraction profile, Monroe, Connecticut.

Because this is a seismic technique, the hydrologic or geologic subsurface targets must have velocity contrasts between units. This method is a seismic reflection technique and, consequently, the velocity contrasts do not have to increase with depth; all that is required is that velocity contrasts exist.

As with all geophysical techniques, marine seismic reflection methods have some unique advantages and limitations. These are listed in table 4.

**Table 4.** *Marine seismic reflection techniques*

*Advantages:*

1. Data collection is rapid.
2. Continuous subsurface profile is provided.
3. Sound source is a nonexplosive.
4. Analog records resemble geologic cross section.
5. Minimal data processing is needed.

*Limitations:*

1. Area must be water covered.
2. Bottom sediments can prevent data acquisition.
3. Investigations in deep water require complex field and interpretation procedures.
4. Very shallow water may prevent data acquisition.

Figure 5 is a block diagram of a marine seismic reflection system. The system consists of a sound source that is fired every 1/4 to 1/8 second in water. Common sound sources are transducers, sparkers, unibooms, and air guns. The sound source is electronically fired from the recording system and receives its power from portable generators or compressors.

The sound emitted from the sound source travels vertically down through the water column and into the subsurface sediments. At each acoustic interface, part of the sound is reflected back to the surface and part of it is transmitted into the next subsurface layer. When the sound reaches the surface of the water, it is received by hydrophones and transmitted back to the boat. Here, the signal is amplified, filtered, plotted, and recorded. Because this process happens almost continuously, a continuous record of the subsurface reflection is obtained on the recorder. Figure 6 shows the signal travel paths in the water and subsurface.

Figure 7 is a marine reflection record from hydrologic studies in Florida.

The hydrologic uses of marine reflection techniques are varied and have been used effectively in the following studies.

1. To define the depth to bedrock in a glaciated New England valley (Connecticut).
2. To define the thickness of organic sediment in river impoundments (Connecticut).
3. To define the shallow aquifer system in carbonate terrains (Puerto Rico, Florida).
4. To define the thickness of mudflow deposits in rivers (Washington-Oregon).

The advantages of using marine reflection profiling techniques in these studies are:

1. Rapid and inexpensive data collection.
2. Continuous subsurface profiles of geologic or hydrologic units.
3. Collection of data not economically obtainable by other means.

## CONCLUSION

Surface geophysical techniques are an extremely important tool for hydrologists. The selection of individual techniques and the application of the results requires a knowledge of the limitations and advantages of each technique and a knowledge of the hydrogeology of the study area.

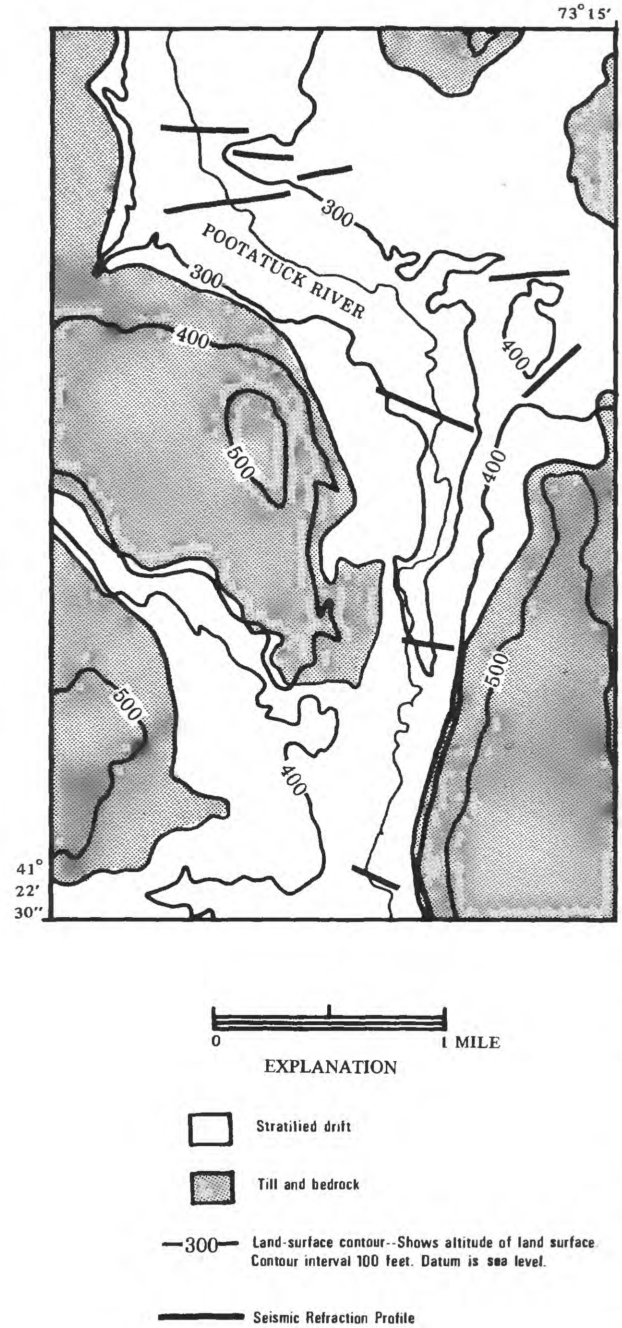


**Figure 4.** Location of seismic refraction profiles, Pootatuck River Valley, Newtown, Connecticut.

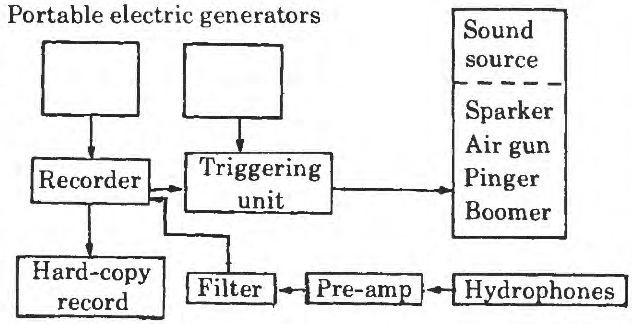


**Figure 5.** Marine seismic reflection system.

The use of these techniques should be included in the planning stages of all hydrologic projects. These techniques should be scheduled for use early in the field investigation so that the data can be used efficiently to plan the more costly data-collection activities. The advantages of using surface geophysical techniques in hydrologic investigations are:

1. More efficient data-collection activities.
2. Economic collection of data (possibly the *only* economic method).
3. IMPROVED STUDY RESULTS.

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*Figures 6 and 7 on following page.*

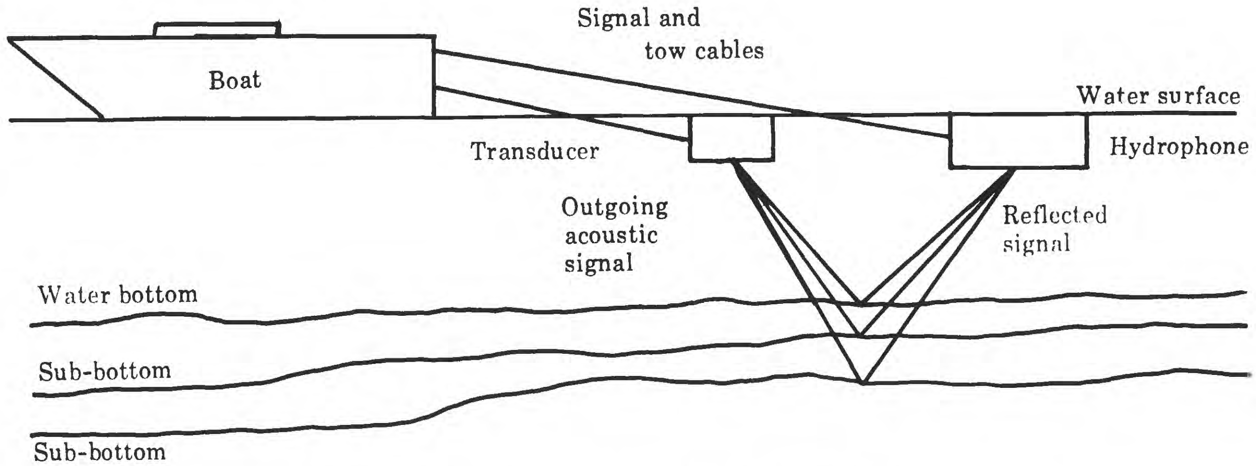


Figure 6. Seismic ray paths for marine reflection techniques.

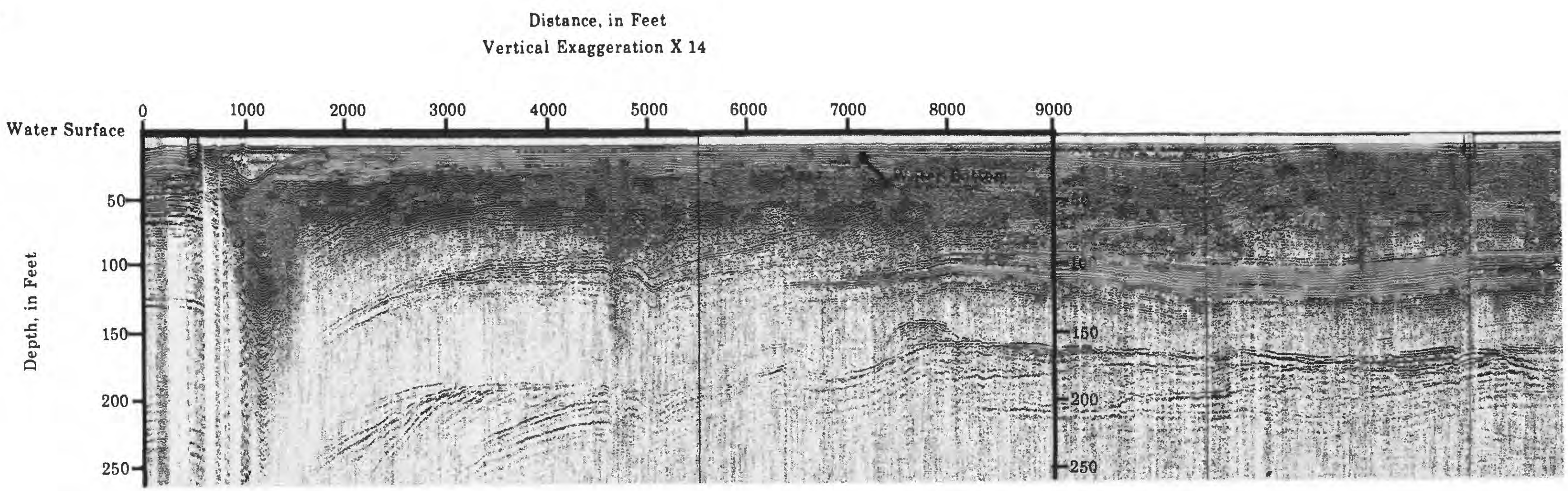


Figure 7. Marine reflection record for Port Charlotte area, Florida. (Wolanski and others, 1982)

# Improvements in Instrumentation

## Technical Sessions

R. W. PAULSON, Instrumentation Coordinator
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Any discussion of improvements in instrumentation being made by the Water Resources Division must consider WRD's capabilities for developing and supporting instrumentation as well as the systems that are developed. This presentation provides a brief overview of WRD's program for improved instrumentation followed by an overview of the status of the Division's automated hydrologic data collection system. A plan to upgrade this system with new technology and expand the types of automated data collection also is presented.

### PROGRAM OVERVIEW

Several organizations and projects within the WRD contribute to the development of instrumentation. The first and most important organization is the Hydrologic Instrumentation Facility (HIF) at Bay St. Louis, Miss. A second is the Satellite Data Relay Project at the National Center in Reston. In addition, numerous research projects throughout the Division require specialized hydrologic instrumentation to meet their research goals. Finally, the Survey and several other agencies cooperate in an Interagency Sedimentation Project that is located at St. Anthony Falls, Minn. WRD's formal Instrumentation Program is composed of the HIF and the Satellite Data Relay Project. These two activities maintain technical liaison with the Interagency Sedimentation Project and numerous research projects throughout the Division.

The cornerstone of WRD's Instrumentation Program is the HIF which was established during the period 1978–1980. The HIF provides for planning and developing of hydrologic instrumentation, tests and evaluates commercially available instrumentation, and provides a broad range of logistical supply and repair of instrumentation for WRD field offices. The HIF has a staff of approximately 50 personnel, and has 32,000 square feet of office, laboratory, shop, and warehouse space. In FY 81, the HIF had a budget of approximately $5.4 million, of which $3.1 million were derived from WRD Districts and projects from the sale, rental, or repair of hydrologic instrumentation. During the last 2 years, the HIF staff has developed considerable expertise in a broad range of instrumentation support.

The other project within WRD's formal Instrumentation Program is the Satellite Data Relay Project, which, since 1972, has been testing and evaluating the use of satellite telemetry for relay of hydrologic data. At present, approximately 400 WRD gaging stations telemeter data through the Geostationary Operational Environmental Satellite (GOES) system. Of this number, approximately 25 percent are being operated for the Division by the COMSAT General Corporation as a Pilot Program to determine the feasibility of a contracted commercial service. A new technology that is stimulating the use of satellite telemetry is the direct-readout ground station. This low-cost ($120,000), reliable, and easily operated ground station allows a WRD District to receive data directly from the satellite, bypassing a variety of Geological Survey and NOAA computers that distribute data received by a NOAA ground station. The Washington and Arizona Districts currently have direct-readout ground stations, and the Hawaii District will have one early in calendar year 1982.

### STATUS OF WRD'S INSTRUMENTED DATA COLLECTION NETWORK

WRD's instrumented network for automated hydrologic data collection is built primarily around the Analog to Digital Recorder (ADR), of which WRD has about 12,000 in operation. Ninety percent of these are used in a single parameter application, such as rainfall or stage, and 10 percent are used in a multi-parameter application with flow-through water-quality monitors, minimonitors, urban hydrology monitors, servo programmers, and a variety of commercial systems. In a systems engineering sense, WRD does not have a field-data-acquisition system. We have a set of subsystems that generally are mutually incompatible, do not share common power supplies, logic circuits, sensor interfaces, or timing circuits, and require a diverse set of logistical support systems. There are inherent technical problems because the technologies we use range from 20- or 30-year old electromechanical to modern microprocessor driven data collection platforms. The current systems are inflexible because they do use electromechanical technology and, where we use microprocessor technology, we do not own the operating software. There are also inherent procurement problems. Because most of the technology WRD uses is old, it is difficult to procure components. We also must rely on a number of sole-source vendors, and frequently we do not own the system design, and changes are costly and time consuming.

## PLANS TO DEVELOP AN INTEGRATED FIELD DATA ACQUISITION SYSTEM

WRD plans a new data acquisition system known as the Adaptable Hydrologic Data Acquisition System (AHDAS). It will be a system of complementary modules that may be arranged and configured in a variety of ways to support the total WRD automatic field-data-collection program. With it, we intend to integrate all present and foreseeable automated data requirements into one system, including satellite telemetry. We expect it to be an electronic system with solid-state technology and memory, and it will have standard interfaces to which current and future measurement sensors can be connected. The Division is developing an integrated logistical support system to procure, adapt, and maintain the system by the HIF. The Division will own the system design and software so that it can be modified and reprocured under WRD control. It will incorporate future technology development into system modules as performance and cost dictate. The firm requirements for the system will be developed in FY 82. We anticipate issuing a Request For Proposal in early FY 83, and take delivery of 10 to 20 prototypes in early FY 84. After the prototypes have been thoroughly tested in the laboratory and the field, we anticipate going into an operational production procurement by late FY 84 or early FY 85.

## MEASUREMENT TECHNOLOGIES

The AHDAS system will provide all the automation functions necessary to support our data-collection program. We must continue our efforts to increase the capability of the AHDAS system to sense and measure the hydrologic environment. WRD is taking some action to develop these sensor (or measurement) technologies.

The ADR is a combination shaft encoder and punched paper-type recorder. The shaft on the ADR rotates as the float in the stilling well moves with the water surface. This is an elegantly simple scheme to monitor water level, and we intend to use it with the AHDAS system. We presently are developing at the HIF two shaft encoders, one absolute and one incremental, which will allow us to monitor the position of a float via a shaft rotation and could provide the shaft position to an AHDAS interface in an electronic form. We have by contract conducted a feasibility study of the use of laser as a stage measuring device, and, if funds are available in FY 82, we will move ahead and develop a prototype stage measuring system using this technology. We presently are using acoustics to measure water level in the Mount St. Helen's area, and will continue to evaluate the use of this technology for stage measurement. We have begun to extensively explore the use of acoustics for measuring water velocity. In one approach, we are testing the time-of-travel technique that has been used for some years in the Pacific Northwest by the Division, but now are evaluating hardware that costs about 10 percent of the previous system. In addition, we are looking at acoustic pulsed doppler systems for measuring water velocity, one in a fixed-site and one in a moving-boat application. In the latter application, we will mount a battery-operated portable system on a boat and proceed across a large river making estimates of the velocity structure of the stream beneath the boat as the vessel transits the stream. An estimate of stream discharge will be computed at the end of the transit. We also are evaluating the potential for using the faraday effect for stream-discharge measurement. This has been an intriguing possibility for some time, and we are conducting a demonstration project by contract to determine whether modern signal-processing techniques can be used to detect and recognize the weak voltage generated by river discharge.

## FORECAST

Since the last national WRD meeting (1975), the Division has developed an improved capability to support hydrologic instrumentation. An evaluation of WRD's data acquisition system needs and modern technology should allow WRD to begin implementing a new generation field data acquisition system well before the next WRD national meeting.

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# Contaminated Ground Water

## Technical Sessions

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Is ground-water contamination, which as been termed "the environmental issue of the 1980's," a new phenomena of the past decade or two—a result of our generation's modern obsession with chemicals and irresponsible stewardship of our environment? The answer, of course, is no; people have undoubtedly been plagued—literally—with contaminated ground water for millenia. Documented cases go back centuries. People, their wastes, and their water supplies constitute one of man's two eternal triangles; where one is, the other two are almost always present.

Why then are we hearing so much about the problem in recent years? First of all, the problem is a growing one—more and more ground water is becoming contaminated. Second, we are developing more ground water each year for drinking-water supplies. Third, we are looking harder for contamination, and, of course, finding it. Fourth, we have been consuming more and more toxic waste products per capita each year. Fifth, it takes many years for contamination to spread in ground water, and we are now reaping the fruits of our mistakes over the past century or so. Finally, we are simply more interested, aware, and concerned about environmental problems than we were 20 years ago, so that contamination problems like those at Love Canal and Valley of the Drums make popular news.

*How Big Is The Problem?*

Has the news media blown the problem out of proportion? The media has certainly distorted the problem, but not necessarily overblown it. The National Water Well Association has estimated that perhaps 1 percent or less of the area of our potable shallow groundwater supplies is potentially contaminated. Their estimate is based on quantities of waste generated and numbers of disposal, storage, and spill sites; however, it neglected agricultural sources, which might double the area.

Obviously, then, most of our ground water, at least 98 percent or so, is uncontaminated—therefore, what's all the fuss about? The main problem relates to the eternal triangle—the contamination almost always occurs where the people and their drinking-water supplies are. Also, keep in mind that about 95 percent of the world's readily available potable water is ground water and that one-half the population of the United States relies on ground water for domestic supply. Therefore, a 2 percent loss of this invaluable resource is a loss of significant consequence.

The chemical and biological degradation of our ground water has resulted from a variety of sources, including approximately 7,000 known hazardous-waste disposal sites, 180,000 other chemical sites and impoundments, 200,000 municipal landfills, and countless septic tanks, disposal wells, leaks, and spills. An estimated 6 billion metric tons of hazardous waste have been disposed in or on our land since 1950; the rate of disposal, which is increasing 5 percent annually, is currently about 40 million metric tons per year. Septic tanks discharge 800 billion gallons of sewage to our ground water per year.

The drinking-water supplies (ground water) of more than 2 million people in places such as Long Island, N.Y.; St. Louis Park, Minn.; Barstow, Calif.; and thousands of other communities have been lost in recent years owing to contamination. Clearly, the problem is a large one that promises to get worse before it gets better.

*Sources of Contamination*

Are the Love Canals—the industrial toxic waste disposal sites—the biggest problem? No; the Environmental Protection Agency ranks pollution sources in the following order: (a) septic tanks, (2) petroleum exploration and development activities, (3) landfills and dumps, (4) agricultural practices, and (5) waste piles, sumps, and lagoons.

Ordinary citizens and small businesses are often large contributors to local contamination problems by their discards to trash cans or discharges to the ground (pesticide containers, crankcase oil, organic solvents, petroleum fuels, etc.).

*What Are Some of the Most Common Toxic Contaminants in Ground Water?*

Toxic contaminants include dozens of inorganic and radioactive elements and compounds, tens of thousands of organic compounds and numerous bacterial and viral micro-organisms. Among the most common toxic contaminants are nitrate, heavy metals, polynuclear aromatic hydrocarbons (from petroleum fuels and coal-tar derivatives), trichloroethylene and related solvents, pthalates, toluene, and benzene. Ground water is more apt to retain volatile compounds such as trichloroethylene than surface water.

*What Processes Control the Fate of Contaminants in Ground Water?*

The behavior and fate of contaminants in ground water is governed by a complex matrix of interdependent physical, geochemical, and biochemical processes. Physical processes include ground-water flow and dispersion, evaporation, filtration, and buoyant and phase separations. Geochemical reactions include solution/precipitation, hydrolysis, oxidation/reduction, complexation, and ion exchange/sorption. Microbiological effects involve decomposition, cell-synthesis, and transpiration processes.

Although we know something about all these processes, our knowledge is woefully inadequate to make quantitative assessments or predictions of contaminant behavior and fate in most real-world systems. We are in great need of developing better techniques for collecting and handling samples and better methods for determining key parameters in the field for nearly all the above processes. Considerable effort is needed to understand the relative importance of these processes to the point that we can incorporate simplified, yet realistic, approximations into simulation models. Also demanding attention is better monitoring technology and enhancement of indirect sensing techniques such as surface geophysical methods.

*Can Contaminated Ground Water Be Cleansed?*

For most ground water, the answer is probably no, at least not economically or completely. However, this is another area about which we know little. In some circumstances it has been demonstrated that microbial decomposition of some pollutants, such as gasoline, can be artificially induced or stimulated in the subsurface. Other remedial actions that have varying degrees of effectiveness include low-permeability grout curtains, physical removal, and chemical treatment. However, preventing contamination will always be much easier, cheaper, and more effective than cleaning it up.

*The Division's Role in Meeting the Challenge*

Recognizing the neglected state of ground-water-contamination technology, the Water Resources Division has made recent efforts to enhance our studies relating to those problems. First, we developed a new proposal for additional research that received tentative approval for funding in Fiscal Year 1982 (pending congressional appropriation). Second, the Office of Hazardous Waste Hydrology has been established in the Division to integrate and coordinate all the ground-water-contamination studies, both radioactive and non-radioactive.

Our new thrust has five major objectives over the next several years:

1. To provide scientific knowledge to enhance the technology and safety of hazardous waste disposal and for remedial actions on existing or potential contamination problems.
2. To develop interdisciplinary nuclei of scientists to conduct needed research, to provide consultative expertise, and to develop technical solutions to disposal and contamination problems.
3. To provide baseline data on the current and potential extent of ground-water contamination.
4. To develop procedures and earth-science guidelines for identifying favorable areas for waste-disposal sites and for selecting suitable sites.
5. To communicate useful technical information to those who need it in a clear and timely form.

The approach will involve three major areas of activity:

a. *Fundamental research on physical, geochemical, and biochemical processes that control behavior and fate of contaminants in ground water.*—This will involve interdisciplinary efforts including modeling, geologic characterization, and geophysics; both core research and appropriate District technical talent will be used. Lab and desk research will complement intensive field research on a few carefully selected contamination sites.

b. *Assessment of current and potential status of ground-water quality.*—This effort would not begin until FY 1983 or 1984 and for the most part would involve statewide assessments carried out by District offices.

c. *Screening of large regions of the country for areas potentially favorable for toxic-waste disposal sites.*—This program would be aimed at assisting States and other agencies in selecting suitable disposal sites from the standpoint of earth science. It will build on related programs such as the high-level radioactive waste investigations and regional aquifer studies.

The FY 1982 program will be devoted solely to enhance our research capabilities to meet the challenge. Additional activities will be initiated in FY 1983, 1984, and beyond, as appropriations allow.

The Geologic Division will be a significant participant in activities a and c. The Survey, and more specifically WRD, already has considerable experience and expertise in many aspects of this program. Thus, in the years to come, we will have a great opportunity to provide technical leadership in responding to this challenge.

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# Surface-Water Network Evaluation

## Technical Sessions

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The goal in collecting hydrologic data is the reduction of uncertainty in the description of hydrologic processes; that is, the generation of hydrologic information. Thus, the evaluation of a surface-water-data network should include a quantification of the pertinent information that the network generates.

Hydrologic information is most commonly measured in a parameter-specific sense; information theory is the basis of this measure. However, data users are more interested in an integrated measure of information, the impact that the data have on their decisions. Decision theory, which provides for the impacts of data as well as their informational properties, would seem to be an ideal structure for network evaluation.

An idealized structure for the application of decision theory to the evaluation of surface-water-data networks is illustrated in figure 1. The base of this structure is the science of hydrology. Mathematical descriptions or models of either the hydrologic processes or their effects on society would be of very limited use unless the scientific aspects of hydrology are properly treated. This fundamental role of hydrologic understanding has been the forte of WRD and is one of the reasons that our surface-water networks have served so well in the past with so little quantitative evaluation.

Superimposed on the hydrologic base is an awareness of the probabilistic nature of the hydrologic processes and of the data that are collected to describe them.

Probability theory supports statistical tools, represented in figure 1 by correlation and regression analyses and sampling theory, that are used to quantify the information that a data set contains. However, the use of these tools in network evaluation assumes knowledge of the statistical properties of the streamflow process on which the data are to be collected. The primary reason for collecting the data usually is to generate this prerequisite knowledge. Thus, the network analyst needs another level of analysis to solve this chicken-or-egg-like problem. Bayesian analysis (Box and Tiao, 1973) provides for complications of this sort.

The right-hand side of the network-evaluation structure represents the part that provides the economic supply curve for streamflow information. In other words, these analyses can lead to functions describing the costs to supply various levels of surface-water information.

Equally important in arriving at an efficient and effective data network is the economic demand curve for surface-water information. Socioeconomic analysis, the left-hand side of the structure, is used to quantify the effects of various levels of information on society.

Optimization theory, the central support of the structure, is the means by which the supply and demand curves are combined to derive a decision-theoretics data-network design.

An expanded discussion of this structural approach to network evaluation can be found in Moss (1982).

Two techniques developed by WRD have been used recently to evaluate their use in managing ongoing surface-water-data networks of four WRD Districts: Idaho, Iowa, New England (Maine), and Pennsylvania. The two techniques are: (1) NARI, the acronym for Network Analysis for Regional Information, and (2) K-CERA, the acronym for Kalman-filtering for Cost Effective Resource Allocation.

NARI provides measures of error reduction in regional streamflow estimates as a function of the number of stream gages that are operated in future regional-streamflow-information networks (Moss and Karlinger, 1974). The answers are functions of the streamflow variability in the region of interest, the current levels of streamflow-data availability, and the accuracy of the regional information-transfer model (usually a regression model).

With the exception of Iowa, each District used NARI to evaluate one or more networks. Each evaluation showed that very little additional regional information could be generated by collection of additional

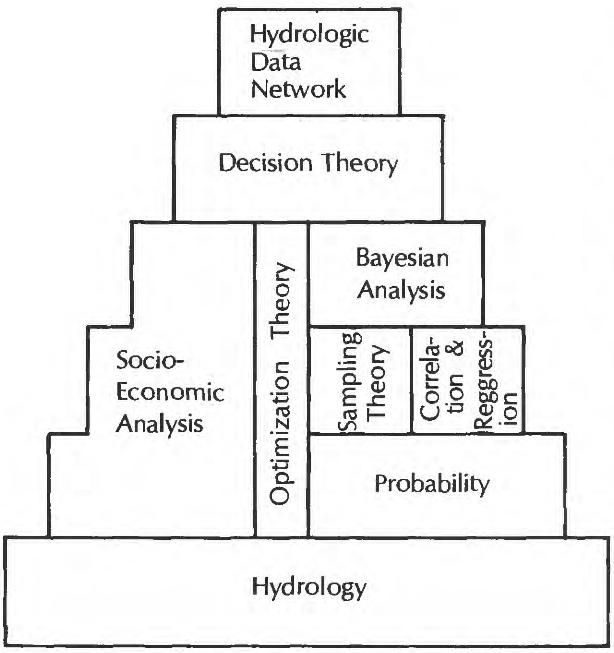


**Figure 1. The basic building blocks of network design.**

streamflow data. The implication of these studies is that no further data should be collected solely for calibration of regional streamflow-information models. This implication should be tempered, however, because the utility of data collection for conditions and locations outside the range of applicability of the models investigated was not determined in any of the studies.

K-CERA provides the network analyst with routings of hydrographers to stream gages such that budgetary and operational constraints are met and the resulting level of accuracy of streamflow information generated at the sites is a maximum; that is, the resulting streamflow records contain a minimum of estimation error (Moss and Gilroy, 1980). The original development of K-CERA was aimed at an annual water-balance, and information was expressed relative to the determination of annual mean discharges. Two of the case studies found this to be an inappropriate measure for their networks, and changes were made to provide relevant measures for their situations. A measure of the accuracy of "instantaneous" (6-hour) discharges was used in the Iowa study; percent error as opposed to absolute error was derived for the Idaho study.

The results of the K-CERA analyses ranged from those in Maine, where little improvement in accuracy or cost reduction could be developed, to those of Iowa, where the desired accuracy could be attained at a cost of 20 percent less than the current operating expenditures for that network. The results in Idaho and Pennsylvania pointed to possible savings, but less than the 20 percent in Iowa's study. Reports of these studies are currently being prepared by each of the four Districts.

These tools, NARI and K-CERA, are but two of the many techniques that are required to fully evaluate our surface-water-data networks. Much research and development remains to be done in network evaluation and design. However, the existing techniques are a beginning, and they can make significant impacts on our streamflow data program if they are used wisely.

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# Acid Rain

## Technical Sessions

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Office of the Regional Research Hydrologist, Western Region

R. A. SCHROEDER, Hydrologist
New York District

### INTRODUCTION

The term "acid rain" has sometimes been used in the literal sense to refer to rainfall that has a pH below about 5.6; that is, the pH that distilled water would have if it were in equilibrium with carbon dioxide in the atmosphere. The same term has also been used to describe the overall phenomenon of acidic atmospheric deposition, including many of the pollutants associated with the acid. In this discussion, acid rain is used in the latter broad sense to identify a general environmental problem and because there seems to be little scientific support for the idea that pH 5.6 is necessarily the proper limit for acid rain. Rather, an upper limit of pH 5.0 may be more appropriate.

Although only slight evidence exists at this time that acid rain produces harmful effects on field plants, evidence of harmful effects on some lakes and streams in Scandinavia, Canada, and the United States is very convincing. Increasingly, there is belief that soils may be slowly degraded by acid rain and that rehabilitation will be expensive and difficult.

The present Administration views acid-rain studies as being important, and additional financial support for such studies in FY 1983 is a distinct possibility. This is at a time when most other programs do not have such a favorable outlook.

### INTERAGENCY TASK FORCE ON ACID PRECIPITATION

In 1980, the Congress set up an Interagency Task Force to coordinate and guide research on acid precipitation. An organizational chart for the task force is shown as figure 1. Each of the task groups is led by an agency whose job is to coordinate work in a particular category. The Geological Survey, representing the Department of the Interior (DOI), is responsible for leading the task group charged with setting up a nationwide atmospheric-deposition-monitoring program. The National Park Service (NPS) represents the DOI in leading the task group on materials effects because of the Park Service's interest in the effects of acid rain on historic structures. The Geological Survey is working closely with the Environmental Protection Agency (EPA) in studying aquatic effects of acid atmospheric deposition and has the option of participating in other task groups where its expertise is needed.

The Executive Director of the interagency task force is Dr. Chris Bernabo, on loan to the Council on Environmental Quality from the National Oceanic and Atmospheric Administration (NOAA). Under his direction, the task force prepared a draft of a National Acid Precipitation Assessment Plan that was released for public review early in 1981. The Plan is presently being revised and should be published about mid-1982.

### THE U.S. GEOLOGICAL SURVEY'S ACID-RAIN PROGRAM

#### Federal Interagency Program

##### GOALS

The Geological Survey acid-rain activities that are part of the Federal interagency program have several goals: (1) help measure the amount and chemical composition of atmospheric deposition throughout the conterminous United States, (2) determine the extent and the processes by which atmospheric deposition affects the quality of surface and ground water, especially in acid-sensitive areas, (3) help determine the susceptibility to acidification of lakes and streams, emphasizing areas in which soils have low buffering capacities, (4) monitor the chemical composition of poorly buffered natural waters over a long period to observe subtle changes that may be due to atmospheric deposition, (5) provide quality assurance support for chemical analyses for the National Atmospheric Deposition Program and other governmentally funded programs, and (6) on the basis of the information gained, predict the effect that increased or decreased concentrations of pollutants in atmospheric deposition will have on the characteristics of soils, rocks and natural waters.

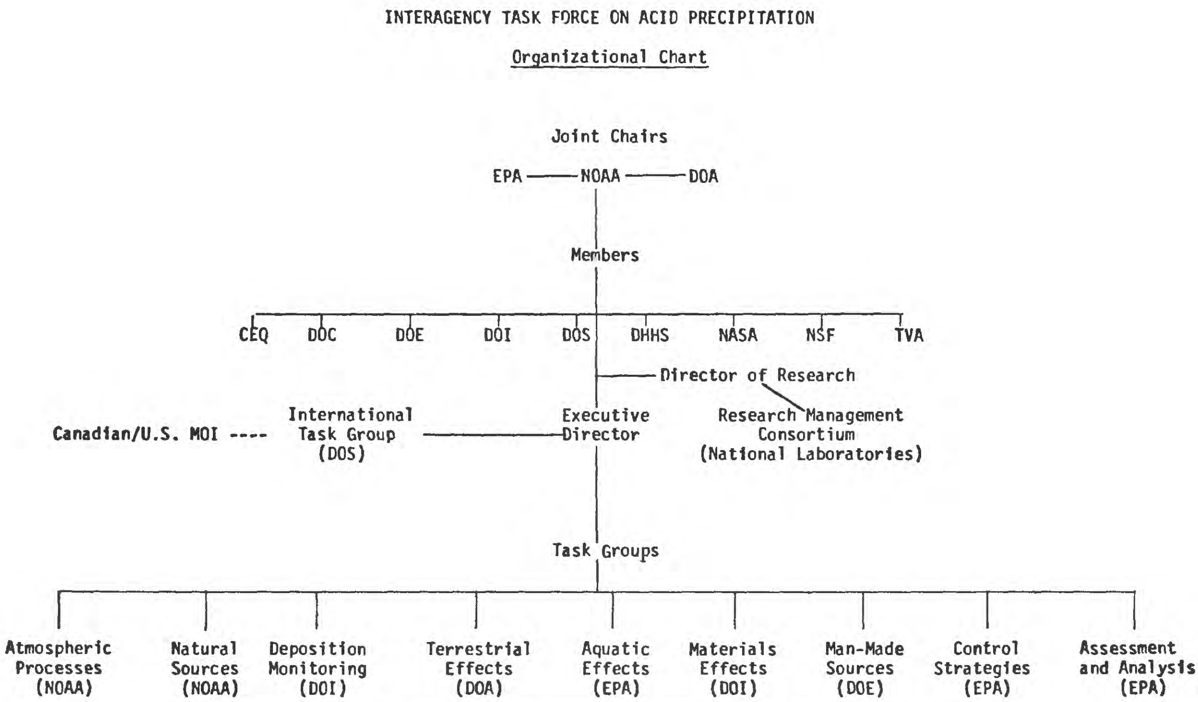


**Figure 1.** Organization of the Interagency Task Force on Acid Precipitation.

## ROLE OF THE WATER RESOURCES DIVISION

The two major components to WRD's program for acid-rain studies are a network-design and operation component for deposition monitoring and a research-on-processes component. Each of these components is summarized below. The total budget for acid-rain studies in the WRD for FY 1982 is approximately $1.4 million, of which about 40 percent will go into monitoring-related programs and the remainder into research.

*Design and Operation of Atmospheric Deposition Monitoring Network*

A. Coordinate work of the Task Group on Deposition Monitoring in setting up a nationwide monitoring network (i.e., a National Trends Network).
B. Define general monitoring site locations based on "ecoregions" of U.S., known distribution of acid precipitation in U.S. emissions data, and meteorology (contracted to Dr. John Robertson, U.S. Military Academy, due May 1, 1982).
C. Apply location criteria provided by the task group (contracted to Dr. John Robertson, U.S. Military Academy, due July 1, 1982) to—(1) existing sites, and (2) new sites, if necessary.
D. Visit and select suitable sites, coordinated with Federal and State agencies (FY 1982).
E. Supplement effort at existing sites or set up and operate new sites using available personnel (GS or other agencies, FY 1982–83).
F. Continue to provide a quality-assurance program to the MAP3S Program, Ontario Ministry of the Environment, Manitoba Province, the EPA Great Lakes Program, and the Central Analytical Laboratory of the National Atmospheric Deposition Program.

Some WRD District personnel may be asked to participate in a site visitation-selection committee, but that will depend upon the decision of the task group as a whole.

Long-term monitoring of lakes and streams for effects of acid rain is expected to be a WRD District function, but the initial reconnaissance will be done largely by EPA contractors in consultation with WRD Headquarters personnel. The approach is outlined below.

A. Reconnaissance of available information (FY 1982)—
    1. Contractor personnel utilize NAWDEX and other information sources to locate chemical data for lakes and headwater streams under specified hydrologic conditions.
    2. Each State is then requested to supply supplementary data to round out the data base.
    3. EPA prepares maps of possible "sensitive" regions and selects areas of deficient data. (Target data for completion is mid-1982.)
    4. WRD District offices are requested to collect water samples fo fill in deficient data (EPA and GS acid-rain funds).

5. EPA prepares map of "sensitive" areas.

B. Selection of a limited number of long-term monitoring sites across the United States (FY 1982–83)—

1. Locate related research sites within sensitive areas.

2. Locate water-monitoring sites near related research where feasible.

3. Set up separate monitoring sites as needed for widespread coverage.

4. Begin operation of long-term monitoring sites.

*Research Program*

The research component of the Federal interagency acid-rain program is composed of five projects as follows:

| *Title* | *Project leader* |
|---|---|
| 1. Geochemistry of small watersheds | O. P. Bricker |
| 2. Stream chemistry | V. C. Kennedy |
| 3. Effects of atmospheric deposition in the Catoctin Mountains, Md | D. J. Lang |
| 4. Geological evidence for global carbon fluxes. | E. T. Sunquist |
| 5. Modeling of regional snow chemisty | N. E. Peters |

### District Studies

District studies in acid rain outside the Federal interagency program amount to $1 million in FY 1982 and include such topics as determination of spatial and temporal trends in water quality using network data, studies of chemical processes in watershed acidification, and monitoring of the composition of atmospheric deposition. Results obtained from several recently completed studies can be found in the references listed at the end of this article.

A study of the chemical effects of atmospheric deposition on water quality in a small stream in northeastern Minnesota showed the now familiar increase in sulfate acidity during and immediately following spring snowmelt (Siegel, 1981). An extensive collaborative investigation to assess the response of three small lakes (acidic, neutral, and intermediate) to atmospheric deposition in the Adirondack Mountains of New York (Troutman and Peters, 1981) noted a similar phenomenon. A model, being developed this year, will account for differences in the extent to which the respective watersheds have neutralized the effects of acid rain in each of the three lakes. The model will be tested in Wisconsin on two lakes that are fed almost entirely by ground water. Additional work, after the current study is completed in 1982, is being planned in the Adirondacks to determine the minimal amount of data necessary for the model to quantitatively predict susceptibility of any given lake to acidification. Results obtained are pointing increasingly to the important role ground water plays in neutralizing acidity. To better define this role, future studies are needed on the kinetics of soil-water reactions, rates of ground-water movement, and relative contributions of surface water and ground water throughout the year.

Since 1964, a precipitation-monitoring network has been operating in New York State for determination of chemical composition of monthly bulk deposition. Factors that influence concentration include seasonal effects, washout relationships (dilution by increasing precipitation quantity), spatial variation, and temporal trends. Statistical treatment of the data (Peters and others, 1981; Barnes and others, 1981) shows little change in pH, a decrease of about 2 percent per year for sulfate concentration and possibly a slight increase in nitrate concentration. The decrease in sulfate is comparable to the decrease observed in surface water of Pennsylvania (Ritter and Brown, 1981). It may reflect, in part, the shift to cleaner fuels and environmental controls.

As noted already, chemical composition of the snowpack plays a major role in quality of surface water during the spring snowmelt. Analyses for 26 constituents at nearly 200 sites in the Northeast were made during the 1980–81 winter. Description of spatial relationships has recently been completed (Peters and Bonelli, 1982). New York personnel are also determining chemical concentrations for a few selected constituents (pH, chloride, and conductance) in snow cores. This method should prove to be a relatively simple and inexpensive way of monitoring atmospheric deposition in suitable climates.

The potential effect on atmospheric deposition quality from future energy development in the West is the subject of a study by John Turk in the Flat Tops Wilderness area of northwestern Colorado. Precipitation is not now markedly acidic; pH ranges from 4.5 to 6. However, the fact that alkalinities in lakes decrease from about 50 mg/L (as $CaCO_3$) at 9,000 feet to less than 10 mg/L above 11,000 feet indicates the susceptibility to acidification of high alpine lakes in this area.

As in the past, statistical determination of trends and watershed water-quality are likely to remain the major areas of District studies in the future. However, it is important to recognize that acid rain has many consequences outside the Survey's traditional realms of concern. For example, low-conductance low-pH waters can result in increased leaching of cooper and lead from water-supply distribution pipes (Turk and Peters, 1977). In the future, we may want to provide support and expertise in studies of health effects, increased weathering of man-made structures, effects on forest and crop growth, etc.

### Want More Information on the Survey's Acid-Rain Program?

As WRD's program on acid rain grows, a rapid and an effective information exchange will be needed between field offices and headquarters. Listed below are the names of persons who can furnish information on specific aspects of the acid-rain program.

| | | *FTS* |
|---|---|---|
| A. General policy | Chief, QW Branch | 928-6834 or MS 412 Reston |
| B. National Trends Network i.e. atmospheric deposition monitoring | Paul Kapinos | 928-6971 or MS 414 Reston |
| C. Reconnaissance of sensitive natural waters | Owen Bricker | 928-6834 or MS 431 Reston |
| D. Monitoring of streams, lakes, and ground water for acid-rain effects | Wesley Bradford or Owen Bricker | |
| E. Research activities: Geochemistry of small watersheds, et al | Owen Bricker, or Chief, QW Branch | |
| F. Quality assurance-activities | Bernard Malo | 928-6834 or MS 412 Reston |
| | or | |
| | Leroy Schroeder | 234-3975 or MS 407 Denver |

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## POSTSCRIPT

### Wet Versus Dry Deposition

There has been considerable discussion recently regarding the merits of collecting and analyzing the material caught in a bucket or other container which is open only during dry periods. Such material may properly be referred to as dustfall and is only a part (i.e., the settleable fraction) of the dry deposition. Other components of dry deposition not significantly retained in a dry bucket include fine particulates, which are removed by impaction on various surfaces, and the absorption and adsorption of gases by plants, soil, and other materials at the land surface. Inasmuch as dry deposition may reside on a collector surface only temporarily before reentrainment, an accurate measurement of *net* dry deposition for a set period of time is extremely difficult. In fact, no methodology is presently available for making such measurements, although rough estimates can be made from atmospheric concentrations of particulates and gases along with meteorological information. This means that an investigator interested in net dry depositon should be extremely cautious in implying that dustfall in a "dry bucket" is a valid measure of such dry deposition.

The measurement of wet deposition, such as rain, snow, sleet, or dew, is relatively simple compared to measuring dry deposition, and, in humid areas, wet depositon probably accounts for most atmospheric deposition. In arid to semiarid areas the reverse situation is probably true, and reliable estimates of total atmospheric deposition will have to await further research on methods of measuring dry deposition.

P

# Distributed Processing: Promises and Possible Pitfalls

## Technical Sessions

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I want to discuss with you the concept of distributed processing. Some of my comments will be related directly to what you are doing and others will not. First, I want to develop some definitions. I recognize that many of you are not in the computer field or in the telecommunications field; however, some of you do work with computers, and most of you have at one time or another been exposed to computers, so some of these terms may not be new to you.

*Distributed processing* generally can be considered to be processing elements that are tied together in some fashion to form a network (fig. 1). The processing elements need not just be computers. They can be source machines that sample data and transfer the data to a computer somewhere else. Generally speaking, processing elements are defined as computers or terminal devices. In distributed processing, these computers are processing elements located away from what we know as the classical traditional central site (in your case, Reston). The processing that is done, the software that is written, can be organized on a geographical basis, in which case you may have machines disbursed throughout the country, or the processing can be organized on a functional basis. Many organizations in the country are placing application programs on their machines, and specializing those machines to do only certain applications functions, such as sediment analysis or water-table analysis. An interesting thing about distributed processing is that the connection between computers need not be a common carrier. By a common carrier, I mean the telephone company. We do not necessarily have to lease paths from the common carrier. Some of the distributed systems are being designed by organizations developing their own paths; buying coaxial cable, for example, and linking the computers together. Now I know you are doing quite a bit of work with satellite communications and many, many distributed systems today are implemented by using satellite carriers. Tremendous opportunity is there, especially for data acquisition. We will come back to more of that in just a moment.

Data may be distributed, it may be disbursed. Data may reside at the local sites, and the local District area. First and foremost, there are control mechanisms in the network to assure that the network processing elements function as a unit. There is a great deal of difference between decentralization and distribution. Distribution is dispersion, with the parts integrated to a whole. On the other hand, decentralization is dispersion with the parts *not* integrated to a whole. Both approaches make sense, as long as the organization recognizes what strategy is being implemented. Unfortunately, I have witnessed several instances where companies moved computing resources of differing architectures and protocols to their branches and departments, only to find later that nothing fit together. In essence, they decentralized even though they thought

**Distributed Processing**

**·Network of Processing Elements(PE s)**

**·PEs located away from Central Site**

**·Processing Organized on a Functional or Geographic Basis**

**·Interconnection of Elements need not be by Common Carrier**

**·Data may be Dispersed**

**·Control Mechanisms Exist**

Figure 1.

they were going distributed. This often occurs because of inadequate planning and management commitment.

Initial decisions as to what you are doing with distributed processing are important. Figure 2 illustrates the best approach to making decisions about distributed processing. Many companies make the statement, "Look, we keep hearing about distributed processing, let's look into it and see if it can help us." A much better approach is, "What do we want to achieve, and can distribution help or hinder us?" Even after adopting a distributed system, you still may not want to distribute certain parts of the work. Do not distribute just because you have the instructions to do it. There may be occasions when you want to keep everything simple. Many of the thoughts that I will give you in the next hour will alert you to possible pitfalls that you want to avoid. There are organizations which have distributed systems whose approach has led them to more grief and greater cost than if they had remained nondistributed. I have been working with a government agency in the Washington, D.C., area for some time. About 8 years ago, they decided they wanted to try distribution of resources. They had been working in a traditional main-frame environment. They had a large scale computer and all the trimmings and were tied into this one computer from around the country. Each department was allowed to develop its own unique requirements concerning the kind of hardware needed. One department got some Hewlett Packard mini's, another department Novas, another department went to

| **Beware** | **Rather** |
|---|---|
| **Management** | **Management** |
| "....look into distributed processing and determine if it can help...." | ".... **what** do we want to achieve, and can distribution help or hinder? ...." |

Figure 2.

PDP 11's from DEC, still another department aquired an IBM System 34 machine. Another department acquired an IBM Series 1. These departments were given considerable latitude and control of their budgets, even though much of the work that was being done was interrelated. When they decided to develop data bases and wanted to share some of these resources, they could not do it. They system 34 will not, in most cases, communicate with the Hewlett Packard. They had several problems. The data bases which supported these vendors' architecture differed, the format of the data differed, and the access methods differed. Worse than that, the software that was developed in each of those machines was not compatible. A Cobol program or Fortran program may look the same, but when they are run on different machines, they operate differently. The third problem they had was that once they developed methods to convert the software and to convert the data, they could not get these conversions moving across the common carrier path because this path was controlled through what is known as a protocol. A protocol manages messages that go from one computer to another, and involves fairly complex software or chip logic. In this case, the protocol did not mesh and this organization had to spend additional resources to make the translations between their architectures. They subsequently found that their software conversion and protocol conversion costs were greater than their initial hardware investment. These pitfalls are quite common in the industry, and are especially common in those organiziations that have separate profit centers where the managers are asked to account for a bottom line as far as their product of their mission is concerned. Those managers want control of their automated resources.

One of the major reasons for using distributed processing deals with the relative costs. The relative costs we find in industry show that communication costs such as common carrier paths are decreasing relative to people costs. For example, processing costs (C.P.U., memory) are decreasing about 25 percent a year; communication costs are decreasing about 11 percent a year. However, they are decreasing even faster for the hardware or processing costs. Therefore, many organizations have decided they are going to spend some money on hardware to decrease the costs in the communications area, which makes sense. But you have to go further than that. Our ability to deal with communications and processing costs have improved. We can handle much more now than we could in the past. But the costs in the people area continue to escalate very rapidly. In many industries, we find that the cost per person including benefits, is going up from 15 to 25 percent a year. I will come back to this in just a minute and give you some ideas about how you can swing this cost back to cost processing.

The pros and cons of distributed systems are shown in figure 3. I want to alert you to the problems you may encounter if you do not take steps early in the process to avoid them.

*Communications costs*—Most of the companies that move to distributed systems do so for this reason. Assume we have sites A, B, and C. A, B, and C are processing elements that have computers in a Region or District. Storing data locally, processing the data locally, and editing the data locally, then moving only the data that is needed, for example, at Headquarters or somewhere in the network, across expensive communication paths is what distributed processing is all about. With

# Distributed Systems

**Pros:**

- Communications Costs
- Response Time
- Organization's Philosophy
- Resource Sharing
- Load Leveling
- Less Contention
- Bottlenecks Reduced
- Technical Challenge

**Cons:**

- Duplication
- Corporate Standards
- Control
- Complexity
- Field Servicing
- CPU Power
- New Approach
- Variety

Figure 3.

the centralized approach, all the data are stored in one location. If the sites need data, they have to go across the common carrier paths to obtain it. That eventually translates into additional communication costs, for example, for the additional paths. With the data stored locally and manipulated locally, aggregated data are sent around the network as needed. Quite often, companies can justify the cost of the distributed systems on the basis of that one fact.

*Response time*—Data being accessed locally is going to be obtained faster than that accessed across one of these common carrier paths. Common carrier paths today operate in approximately 1200 binary bits per second. You might have a fast one that goes up to 9600 bits per second. If you want to bring data around the network, you are sending it around at 9.6 kilobits per second, which is very slow in relationship to the tremendous speed of the computer that operates in nanoseconds today. When obtaining data locally, you are not going across a common carrier path, but across a specialized channel between the disk and the computer. It operates today in millions of bits per second, millions—not scores or tens, so the speed ratio can give you better response time to your local data access.

*Organizational philosophy*—An increasing number of organizations believe that some of the automated resources should be moved to the field managers, and many field managers are insisting on it. Many managers wish to have more control over that increasingly important resource, the computer.

*Resource sharing and load leveling*—I would like to discuss these two points together. Vendors today are developing ways in which to request that work be transferred to another site in the event we run out of processing space or the local computer becomes saturated. In this way application A could reside at site A, or it could move around the network to load the network's resources. Sharing resources could also be done assuming you are using the same data base standards. However, you *cannot* share resources if you do not develop identical software development standards and carrier protocol.

*Contention* can result from bottleneck problems. If you are accessing everything centrally, then you are going to have more such problems. The advantages of distributed processing come down to queuing theory where more servers are available to take care of your needs. Also, distributed processing is interesting, a fascinating topic. Some of your technical people might want to do it because it's here.

Beware of a few things, possible problems you may have with distributed processing. You could have duplication of your work. This is especially true in two areas—application software and data. It would be my impression that many of your offices around the country do the same kinds of things with different data. It is only common sense to me that you should not duplicate those functions and programs in each different office. If your needs can be similarly established, you will want to develop one program only. Yet, we find many organizations that have 30 sites in the network and 30 separately developed copies of accounts receivable code.

Corporate standards are important. There is a possibility that standards in an organization will not work very well if a lot of control is given to distributed sites. People may be doing what they want to do, what they perceive to be the need of the distributed sites, but they will eventually create some problems in sharing data and moving messages around the network.

Some companies have problems with field

servicing if they want to put a computer in a remote area. They may have trouble getting the people to come out and service there, or have trouble getting people to live in these remote areas. However, the problem is not as great as it once was, because more and more people are beginning to enjoy living in out-of-the-way places.

Central Processing Unit (CPU) power can also be a problem, although this system works very well from the standpoint of having more CPU power if needed. Many distributed systems have their software partitioned and allocated among several computers. Allocating software to different computers to give greater machine capacity is an integral part of many systems. If you cannot partition the work, then the numerical analysis work can be sent to a larger computer somewhere in the network. Distributed processing is a relatively new approach. All of us who work in the computer profession are very comfortable with the one site, one computer, one big giant main frame. We are moving computers to departments, field offices, regions, and one might reasonably assume the following attitude: I feel a little ill at ease with it. How do I get a handle on the resources I am going to manage? I just do not feel comfortable about it yet.

The traditional processing environment is shown in figure 4. A main frame CPU, most of which are fairly large machines today, is responsible for running applications programs; for example, hydrologic analysis, sediment analysis, acid-rain analysis. The data bases reside in one area, and the data are manipulated by this very large powerful machine. A third element in the traditional environment is a specialized computer called a front end, or a communications control unit. A decision was made many years ago in the industry to flow work away from the main frame, specifically, to control the common carrier path, or the messages that go back and forth on the network. The CPU is designed to do generalized work such as scientific or business oriented calculation. However, it does not do any of this work very well. Consequently, we increasingly have seen machines specifically designed to do a very few functions, but to do them very efficiently. This is really the genesis of distributed processing—moving some of this telecommunications logic away from the applications computer.

Figure 5 illustrates functional distributed processing, the direction industry is now taking. We are now seeing a trend to take all the codes that search data bases and files and write data bases and files (in other words, data base management systems) and move them into specialized machines. These systems are now on the market and are commercially available. They are called a number of things in the literature, such as data base machines, or back door networks. This is where we see ourselves in the next 5 to 7 years, in this kind of

## CENTRALIZED SINGLE COMPUTER

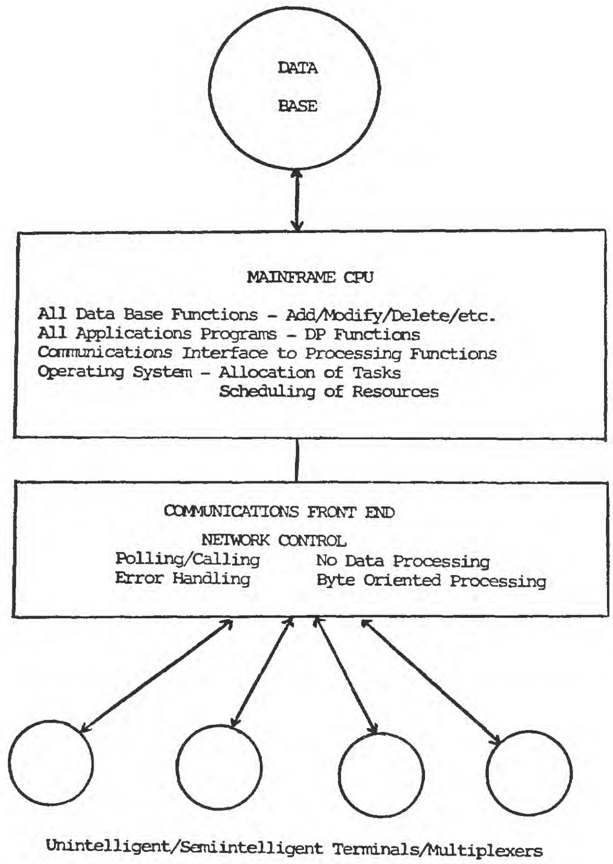



Figure 4.

environment. Interestingly enough, we will find the next generation will be machines that you have in your data acquisition area now. You will see computers designed from the ground up to do one specific application.

Computers are becoming smaller and less expensive to build. Intel recently announced a computer that is three chips in size. I could place the computer on my thumb. It has the processing power of the largest machine we had in existence 8 years ago. That machine took up half a room. The industry recently announced that, in 1984, a 64 byte microcomputer will be available for $80.

Figure 6 defines the division of responsibilities between distributed and centralized systems. I think the best way to approach the distributed system is to allow some work to be done at the centralized Headquarters and certainly to allow much of the work to be done down at the distributed sites. I am not going to go through each of these individually. Here is what should be done in decentralized corporate sites. Selections of applications for intersite use, and then the development of the intersite applications can be done

## FUNCTIONAL DISTRIBUTED PROCESSING

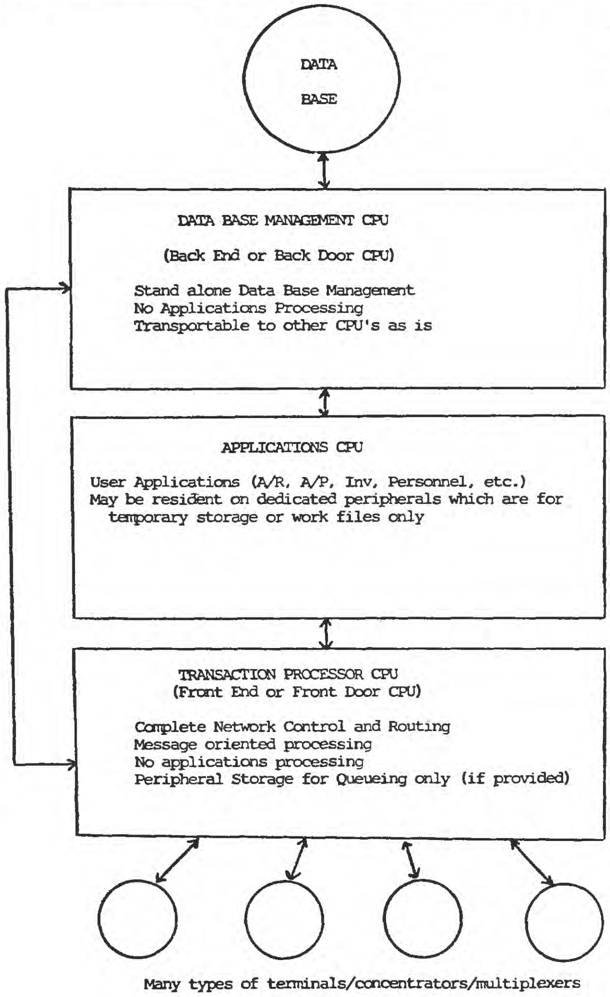



**Figure 5.**

after central and local responsibilities have been defined. However, applications should be developed under standards developed for the whole organization. The entire organization should be on the same architecture. The operating release of all software should be on the same date. All elements of the systems should become operational at the same time. Design standards should be the same across all sites. It should be emphasized at this point that distributed processing requires unified coordination, and centralized direction (fig. 7). If you do not have that in your organization, the distributed processing not only will not help you, but it will hinder your work.

Figure 8 shows a very common approach, hierarchical distributed processing. This involves a primary site, usually a larger main frame that stores a portion of the data base, and a tie-in to smaller machines, perhaps minicomputers. Notice that the data bases are also stored at the secondary sites. The network is connected by the paths that are common carrier lines, such as a leased telephone line from Bell Telephone, or a satellite path. Data are distributed either vertically, called a vertically distributed data base in which the data are divided in some manner lower in the hierarchy, or horizontally, in which the data base is distributed across peer sites, a horizontally distributed data base. Although this discussion is restricted to two levels, some organizations have used hierarchical distributed systems to as far as four levels; for example Headquarters, Regions, Districts, and individual offices.

Generally, the data for an organization can be stored in three ways. It can be centralized, it can be partitioned, or it can be replicated. For example, assume we have a network with a site in San Francisco at which all the data about the organization resides. These are files, subsystems, and data bases. We can partition that data. We can place certain parts of that data in Atlanta, and certain parts in San Francisco. We will assume that San Francisco does not use data very much, but Atlanta does. In that case, separate the data, and place the parts where they are most frequently used. If San Francisco and Atlanta have an equal amount of use and if response time is critical, then you might choose to replicate your data bases. There is nothing wrong with replication as long as the copies are consistent. This is the biggest problem with replicated data bases. However, replication in itself might make sense in some applications if you want to spend the cost for the disk storage.

I prepared the list of high payoffs shown in figure 9 after speaking with many people around the country, in private industry and in government, who are involved in distributed processing. Most of them have found they got the best payoff by using distribution for local data entry, by validating or editing the data locally, by sharing software, code and data instead of developing duplicate copies, by reducing the complex environment, and by looking for ways to decrease people costs. People costs in an organization can be reduced by moving people into more productive work. Most companies are finding this to be the case when they develop a coherent distributed processing environment.

Many of the potential problems we face in distributed processing deal with control (fig. 10). The following is a hypothetical situation, but it exists in many organizations. Headquarters produces a report and in the report are data elements, pieces of information. The report might have in it data elements U, V, and W. This report goes to the various sites around the network. Managers receive and distribute it to their product managers. The data might be taken from these documents and loaded into computer oriented files, perhaps cards, magnetic tape, or disk files. After the

# DIVISION OF RESPONSIBILITIES

| CENTRALIZED | DISTRIBUTED |
|---|---|
| o DEFINITION OF CENTRAL AND LOCAL RESPONSIBILITIES | |
| o SELECTION AND DESIGN OF APPLICATIONS TO SERVE MULTIPLE LOCATIONS | o PARTICIPATION IN SELECTION AND DESIGN OF APPLICATIONS TO SERVE MULTIPLE LOCATIONS |
| o MAINTENANCE OF CORPORATE DATA DICTIONARY. REVIEW OF LOCAL SITES INPUT TO DICTIONARY | o INPUT OF LOCAL DATA TO CORPORATE DICTIONARY |
| o CHOICE OF NETWORK STANDARDS, DATA DESCRIPTION LANGUAGE AND DATA BASE SOFTWARE | o PARTICIPATION IN SELECTION OF STANDARDS, DATA DESCRIPTION LANGUAGE AND DATA BASE SOFTWARE |
| o MAINTENANCE OF MASTER DATA BASES | o INPUT TO LOCAL COPIES OF DATA BASES, AND UPLINE LOADING TO MASTER DATA BASES |
| o SELECTION OF APPLICATIONS FOR INTERSITE USE | o DEVELOPMENT OF INTERSITE APPLICATIONS |
| o REVIEW OF INTERSITE APPLICATION FOR ADHERENCE TO STANDARDS | |
| o REVIEW OF LOCAL APPLICATION DEVELOPMENT TRENDS | o LOCAL APPLICATION DEVELOPMENT, WITHIN STANDARDS |
| o REVIEW OF LOCAL DATA BASE TRENDS | o DESIGN OF LOCAL DATA BASES, WITHIN STANDARDS |
| o REVIEW OF LOCAL SUBSCHEMAS | o DESIGN OF SUBSCHEMAS FOR SYSTEM-WIDE DATA BASES |
| o REVIEW OF EQUIPMENT SELECTION TRENDS | o SELECTION OF LOCALLY USED EQUIPMENT, WITHIN STANDARDS |
| o CONSULTING SERVICES | |
| o SYSTEM SECURITY POLICIES | o PARTICIPATION IN DEVELOPMENT OF SECURITY POLICIES |
| o AUDITING POLICIES AND PROCEDURES | o PARTICIPATION IN DEVELOPMENT OF AUDITING PROCEDURES |
| o COORDINATION OF OPERATIONAL REVIEWS | o CONDUCTING OF OPERATIONAL REVIEWS |
| o COORDINATION OF SECONDARY SITE TESTING | o SECONDARY SITE TESTING |
| o REVIEW OF TRENDS | o USE OF SITE-SPECIFIC EXITS FROM MULTIPLE-SITE APPLICATIONS |
| o GLOBAL DATA BASE ADMINISTRATION WITH DESIGN REVIEW AUTHORITY | o LOCAL DATA BASE ADMINISTRATION FUNCTIONS |

Figure 6.

data are stored, other data may be added. In case B in figure 10, we have transferred the report data to magnetic tape, deleted the data W, and inserted data Y in its place. In case C, we have altered the report itself. Data W has been deleted, data X has been inserted, and the information has been transferred onto a card file. Now other actions can take place. Perhaps the magnetic tape file is read into another disk file (example B), another user application program. The data is manipulated in some way with V primes ($v^1$), perhaps updating the starting values. The same actions could take place in example C with the X or X primed ($x^1$) update value set. The point I am trying to make through this illustration is that it is very easy in a distributed environment for data and, consequently, reports to become inconsistent.

Many organizations have reached the point where their software development and data mangement environment have gotten so out of control that they are starting to develop data base or file inventories. DAM (Distributed Automation Management) is really nothing more than a repository of information about information (fig. 11). It describes the data in use in the organization, and it defines individual data items that exist in the file or data bases. Some organizations have standard names for each item. The recurring elipses shown in figure 12 indicate that it is known which site uses which data. The same inventory is done for software. A list of software program inventory along with the modules, subroutines that reside in the systems, is established, and an identification is made of all the sites that have access to that software. Finally, a source uses repository that refers to paper reports of the company is established. It describes where those paper reports go, and identifies the data items relating to the reports and the software that manipulates those data items. This is an expensive process. You can imagine that the clerical work to trap all this data can be fairly expensive. However, if a change is to be made in a report, it can be made consistently. The organization knows how many company sites are using the report. They also know how many software systems and automated files use the report. They know exactly where the reports are, they know who is using them, and they know the ripple effect of any changes that occur.

There is absolutely nothing wrong with distributing the development and use of application software as long as you control it, as long as you are sure that the software is being developed according to the standards you have in your company. However, how you go about

## Distributed Processing Requires

**·Unified Coordination**

**·Centralized Direction**

Figure 7.

HIERARCHICAL DISTRIBUTED PROCESSING

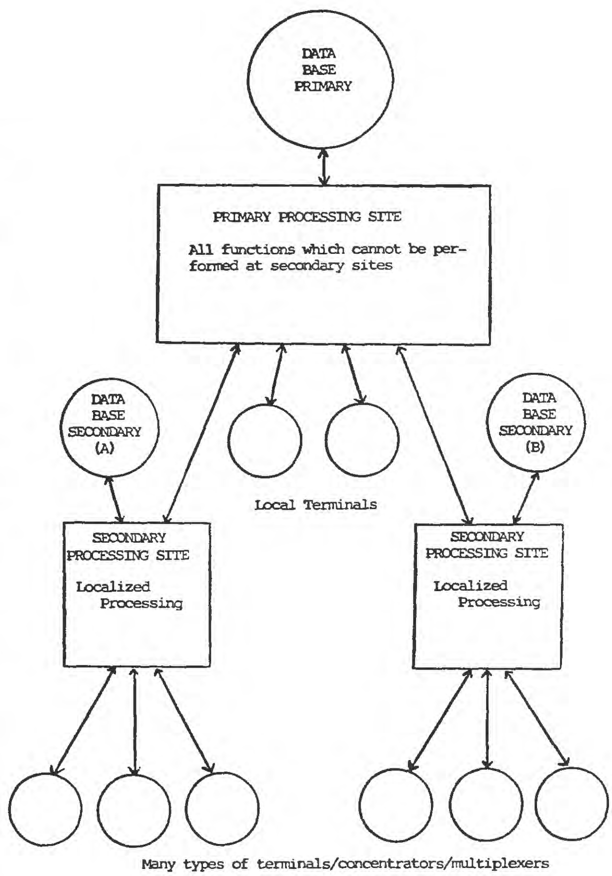



Figure 8.

## Look for High Payoffs

- **Data entry**
- **Data validation**
- **Sharing software**
- **Sharing data**
- **Reducing complex environment**
- **Decreasing people costs**

Figure 9.

doing this is going to have an effect on costs and on management decisions. Design interdependencies (fig. 12) should be recognized during a design process. Standing committees should be working in all these areas and involving the user in the process at all times. Many of you are using automated systems, but are not involved in the development of them. You certainly should insist that you are in the designing cycle all the way.

## Control Problems

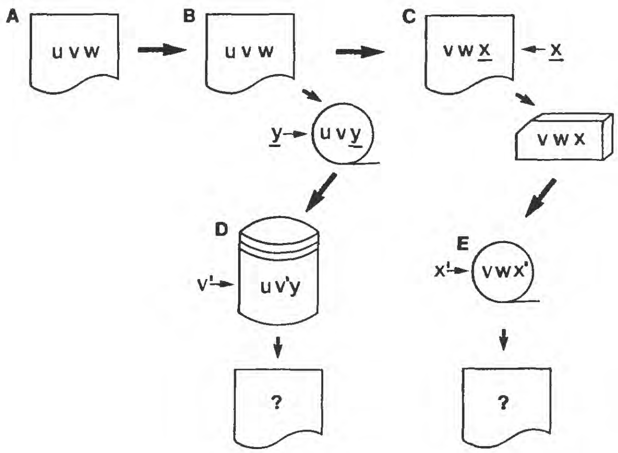



Figure 10.

USGS has been doing work with the ISO (International Standards Organization) in developing water sample standards and other international standards. The ISO is very much involved in developing distributed network standards (fig. 13), which it calls the OSI (Open System Interconnection). OSI is really nothing more than a series of fairly complex documents describing seven layers of software or hardware that will enable us as users to issue a command at one place and, from an application at a terminal, go through the network to data located elsewhere. For instance, following a command issued in Reston, the software will access the data in Phoenix, Arizona, and bring it back to Reston. All this will be done in standard type formats, with ISO standard type protocols. I feel rather strongly that the ISO model will be influential in the industry very soon. It behooves your organization to keep up with new developments and, as vendors come in to sell their product, ask them what they are doing in terms of the ISO standards. There is a serious concern in this country among some of our larger network and computer vendors, such as IBM and Burroughs, that we have gone our own way for too long. The standards that are developed in this country are not the ISO model, and they do not work with other countries' machines, so our marketplace in Europe and Japan is eroding. It is eroding because we are slow to get on the bandwagon with the ISO model.

Figure 14 describes a concept called Local Area Networks (LAN's), or you may see that defined as Local Computer Networks (LCN's), a rapidly emerging technology that I think you will be using quite a bit in the very near future. The interesting thing about these networks is that they are not using Bell Telephone's communication links. No common carrier links are involved. The distance between computers or processing elements usually measures thousands of feet instead of miles. There is usually a very high capacity pack to send the data across the machines. There may be a difference of 1,000 to 1 ratio in speed between a common carrier link and some of the high capacity facilities the LAN's are using, for example, micowave transmission or coaxial cable. There also is rapid progress toward developing optic fibers to communicate between computers. The LAN's will connect computers, terminals and other machines and will be the basis for the office of the future, the automated office we keep hearing so much about. Vendors of word processors, and copiers, electronic files, and similar machines, especially word processors, intend to combine their products into a local network and to market the network. I agree with the approach. I know that in my job as a manager, I could use more automation to support my correspondence and my files. I spend a great deal of time just shuffling papers, which I know, with my experience in the field, could be automated very easily. A word of caution. One of the most important functions of these local area networks will be in connecting word processing equipment. If you are using word processors now and you wish to establish LAN's, you are probably already in trouble. The word processors from one company cannot have their files stored on a machine from another company, so all the individual machines around your buildings, which are going to need to be tied in with the local network, will not mesh. The same holds true on the other machines as well—terminals, computers, electronic files, copiers. My recommendation would be that you begin looking at this technology and planning for an automated office in the future.

Some anticipated technology for future networks is shown in figure 15. What we see in the future is a very exciting field that is going to make life easier. We are going to see increased numbers of systems using digital transmissions for voice and data. Instead of sending a signal over the line, such as an analog signal, our voice will be represented by bit streams. What we see eventually is only one network that will carry voice, data facsimile, TV images, and even music. We will see a technology evolving using digital techniques called packet technology, and increased use of the ISO model.

## AUTOMATION MANAGEMENT

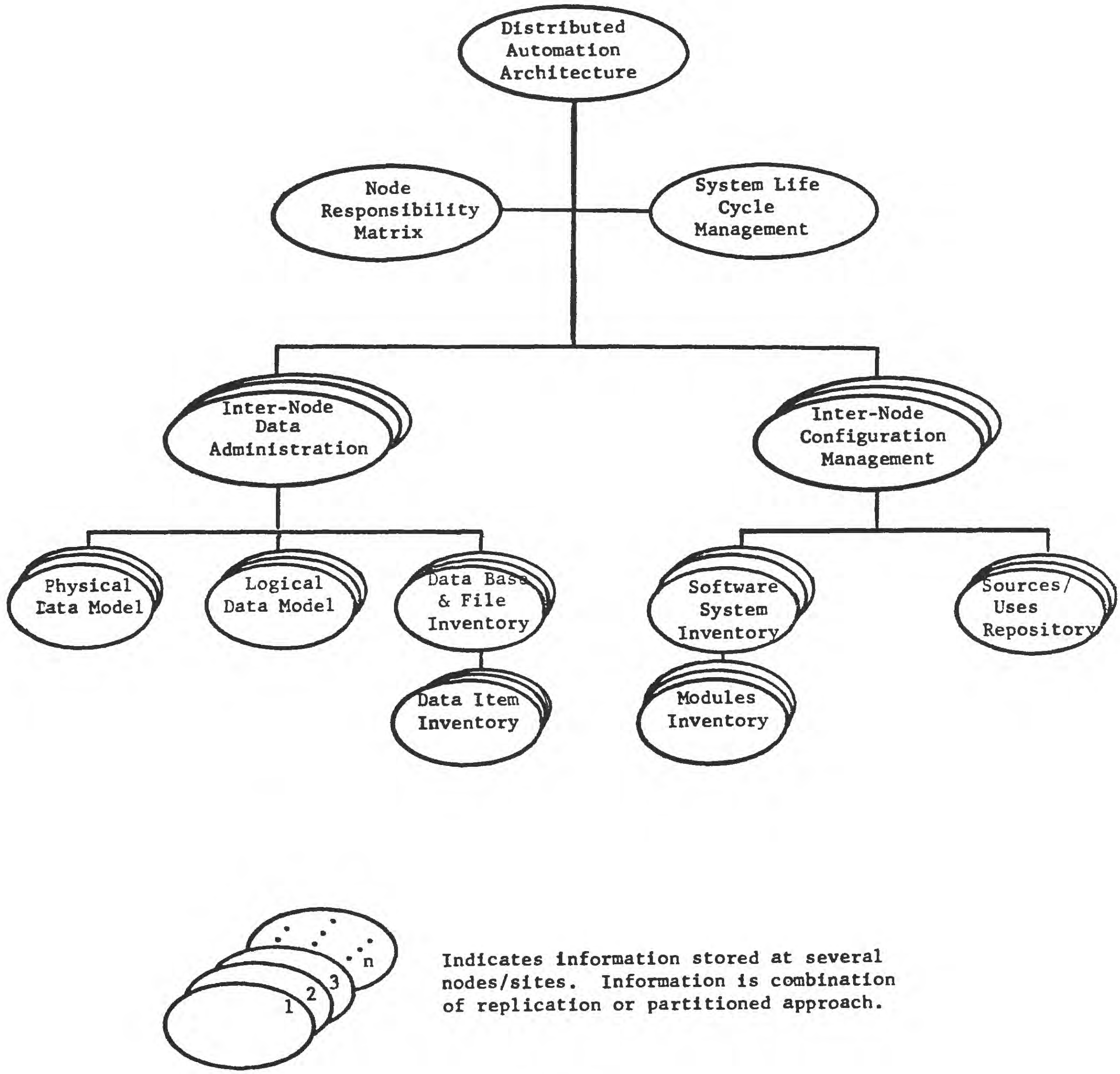
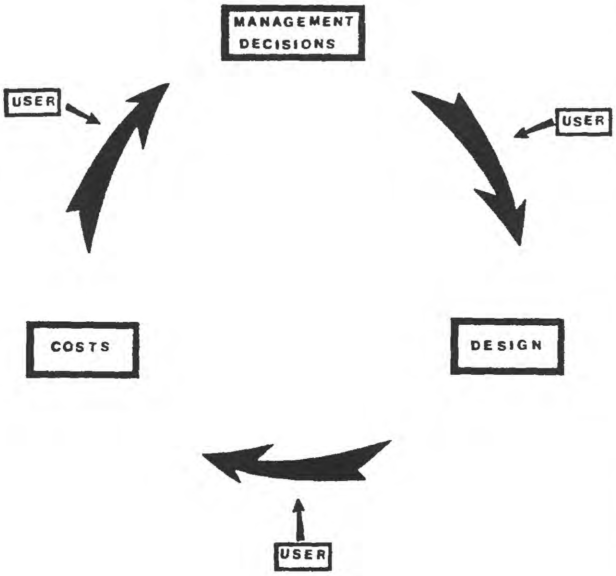



Figure 11.

We are going to be using more satellite links. Technology has been developed in the last 3 or 4 years to allow us to use more satellites. We were simply running out of space up there. Now we have moved to a higher electromagnetic frequency range that translates into shorter wave lengths and smaller antenna, which means that we can put more satellites in the sky. The fastest satellite in the sky right now is the IBM, which has a total capacity of over 400 million bits per second. Theoretically, increased capacity is going to depend on the ability to move higher up in the electromagnetic spectrum to increase the frequency. The faster the frequency, the more bits you can place on the cycle. I believe that there will be a continued emphasis on distributed processing. We will definitely see more local area networks, more integrated automated offices, and certainly an increased use of optic fibers to carry those computer data around in light impulses instead of electrical pulses.

In figure 16, we see some really fantastic possibilities. We are going to see local area networks in our homes and in our offices. We are going to see the public networks we are using now, such as TELENET and TYMNET, interfaced through gateway computers. These gateway computers are being developed using an




DESIGN INTERDEPENDENCIES

Figure 12.

## Emerging Standards: Layered Protocols

**International Standards Organization Open System Interconnection**

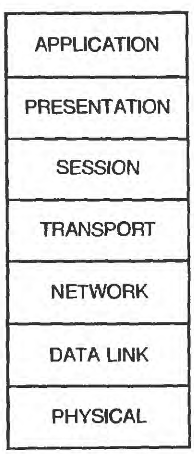



Figure 13.

ISO standard. The ISO standard is called X.75 which defines how you can get two X.25 networks like TELENET and TYMNET to communicate. In the future, we will be able to see these kinds of things in the home. There is at present a prototype experimental project being conducted in Ohio involving several homeowners, a bank, a cleaning establishment, and a supermarket. The homeowner can key into a keyboard using a television set that has a coaxial cable. Cable TV

## Local Area Networks (LAN)

- Distance in 1000's of feet
- Transport data
- Usually, no common carrier links
- High capacity facility for throughput
- Connects computers, terminals, and other machines
- Implemented within a building or plant

Figure 14.

## Future Networks

- Integrated systems using digital transmission for voice/data
- Digital packet technology
- Increased use of ISO model
- Increased use of satellite links in the higher electromagnetic frequency range
- Continued emphasis on distributed processing
- Local area networks creating a more integrated automated office
- Increased use of optic fibers

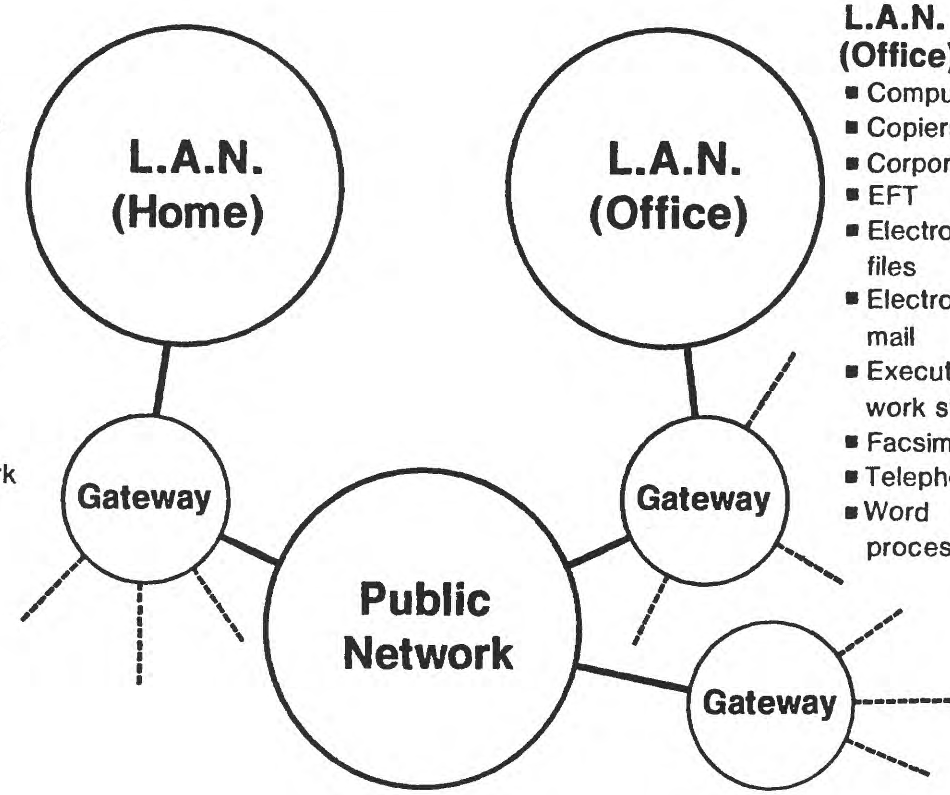
Figure 15.

contains enough capacity for 10,000 conversations at once. The homeowner can call in the computer messages that appear on a screen in the supermarket. The supermarket will give him an inventory of what is available. The homeowner can then issue an order for groceries across this local network, into the computer facility in the store. The order is filled by a clerk and is waiting for the homeowner when he comes into the store. The check is written automatically by the machine, the homeowner's demand deposit at the bank is debited through an EFT electronic punch transfer notification, and the order is deducted from the store's inventory control program to deplete the stock. As a further example, a large vacuum cleaner company has developed and made a cost justifiable microprocessor, microcomputer for installation in vacuum cleaners to control the vacuum's air filter. The filter will determine the amount of debris that is swept up and will power itself higher or lower and adjust the force of the brushes according to how dirty the floor is. These are the kinds of developments which are merging.

Well I thank you very much. I have given you more or less a potpourri of thoughts in this area. You have been very gracious, and I wish you luck in your endeavors.

# Coming Up:

**L.A.N. (Home)**
- Accounts and budgets
- EFT
- Electronic mail
- Electronic shopping
- Environment control
- TV
- Telephone
- Terminal work station




**L.A.N. (Office)**
- Computers
- Copiers
- Corporate D.B.
- EFT
- Electronic files
- Electronic mail
- Executive work stations
- Facsimile
- Telephones
- Word processors

Figure 16.

# Concluding Remarks

R. H. LANGFORD, Associate Chief Hydrologist

When I opened this meeting 4½ days ago, I stated seven objectives that I thought were appropriate for this meeting. I put those objectives in the form of some opportunities for all of us. Let us judge whether or not we—collectively and individually—took advantage of those opportunities.

Ladies and Gentlemen, I submit that we have met each of these objectives during the last 4½ days, and I submit we have met them rather fully. I hope you share that view.

I participated in the Gatlinburg and the Albuquerque meetings. I did not attend the Dayton meeting, but I can say without any hesitation that our meeting here in Ocean City this week is quite different from both those previous two meetings. I think largely because we all face, and we realize that we face, a time when our abilities are going to be very sorely tested. I think that each of us sees the importance of this particular meeting in assisting us to carry out those responsibilities at whatever level of the organization we may find ourselves.

Before I adjourn this meeting, I want to extend some thanks to each of you here for being participants and not just attendees at this meeting. I think, from my observation of the meeting, we have had vigorous participation with a great deal of thought and input from each of you, and I thank *each* of you for that.

Dallas [Peck], we greatly benefited from your participation and from that of Doyle Frederick and Dan Miller. Please convey to them our thanks for that participation. It was fine of you and them to give of your time to be with us.

I want to extend some special thanks to the chairmen of the working groups for their excellent leadership in this critically important phase of this meeting; to the leaders of the technical sessions, and to the Branch Chiefs, who I trust came away from these technology transfer workshops with new views on the Division's needs for improved technology transfer. Well done, gentlemen.

The exhibits at this meeting were top drawer, and we thank those who went to a great deal of effort to prepare and man them during the meetings. They include Pete Haeni, Dick Paulson, Russ Wagner, and Roger Booker.

These meetings don't just happen, as you know. We had a great deal of help at Headquarters level in planning this meeting, with a rather short fuse I might add. Our committee included Les Laird, Bob Dingman, Tom Buchanan, and Jim Biesecker. Each of these gentlemen really helped shape this meeting in a major way.

We were assisted in a staff capacity by Bill Doyle who, many of you know, has come back as a rehired annuitant. He handled a lot of the staff work for our committee. And we had very valuable input from the other three Regional Hydrologists—Al Clebsch, Jim Cook, and John Bredehoeft—and from Porter Ward during the development of our plans and agenda.

Last and not least, by any means, I want to extend our thanks for a job well done to the secretaries who were here and who helped make this meeting a success: Linda Meadows, Kathy Wilson, Peggy Martin, and Eva Cockey.

Of course, Herb Freiberger and his staff did a fine job in making the arrangements for this meeting and working under rather frustrating changing conditions. They handled it superbly. Herb and his staff, which includes Eva Cockey, Denis Gillen, John Hornlein, Dave Lang, Sheryl Protani, Yvonne Von Steen, and Jean Hyatt, some of whom were not here but who worked behind the scenes, deserve our heartfelt thanks for a job well done.

Unless there is further business, I now turn the podium over to our Chief Hydrologist for the "last word" on our Water Resources Division National Conference—1981.

AN OVATION FOR HAL LANGFORD

ADDENDUM BY PHILIP COHEN

Hal did his usual superb job in extending thanks to all the people who made this meeting possible. There is one individual here who has not been recognized. One individual who basically conceived the meeting. Much of the success—more than I can tell you—is a result of his efforts. We owe him two things. First, we have to make sure he gets a chance to visit the Alaska District when the salmon run on the Kenai River, and second, a resounding ovation for Hal Langford.

AN OVATION FOR HAL LANGFORD

AN OVATION FOR HAL LANGFORD

# Summary

PHILIP COHEN, Chief Hydrologist

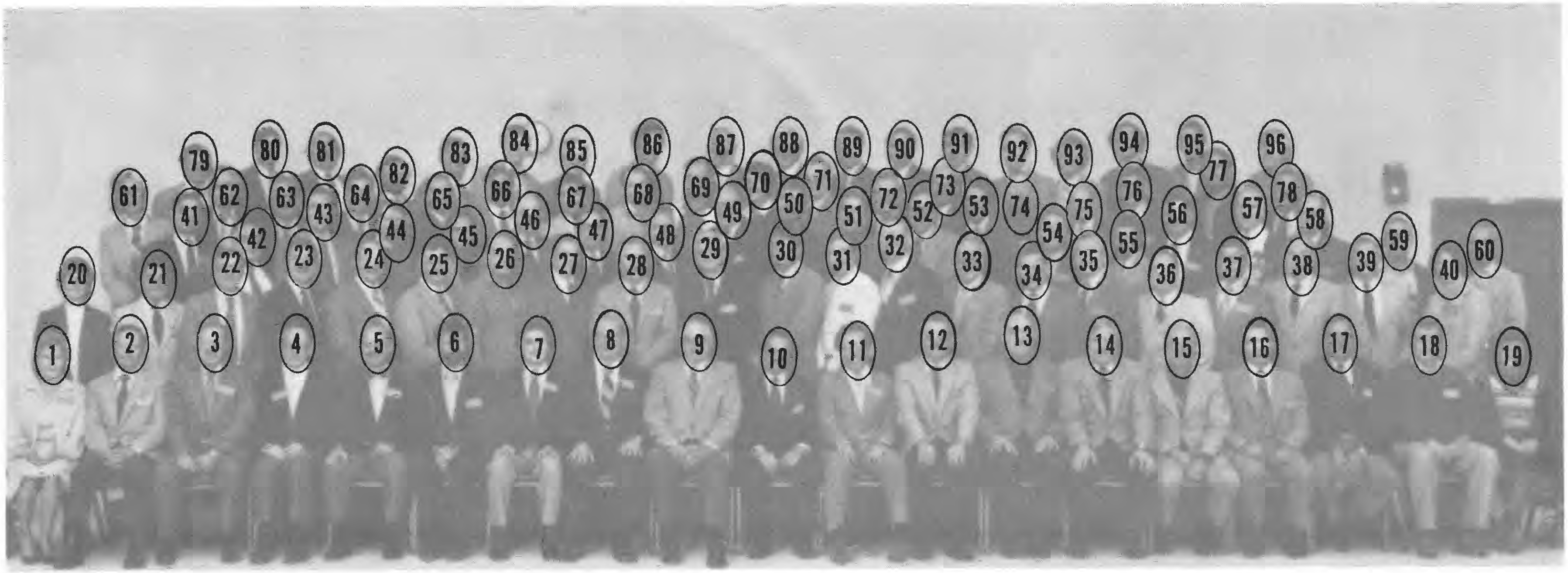
As in the past, the results of our deliberations will be published as a volume of the WRD Bulletin. As a documentation of what has transpired here, it will be as valuable as the previous summaries have proven to be. The record will show rather dramatic changes in the Division. Numerous new concepts, changes, and developments have been enumerated. Our recorded thoughts likely will influence the course of the Division, and their effects may be quite evident when we examine ourselves again in 5 years.

We heard a consistent theme from our Assistant Secretary, our Director, and our Associate Director about the realistic state of affairs of Government and effects on Bureau programs, and their remarks provided a necessary realistic backdrop for our deliberations. The Survey is a rapidly changing organization, as is the Water Resources Division, and this is as it should be in this dynamic era. We are changing and, yet, we remain the same. To our advantage, our mission is clearly and sharply defined in the Organic Act. We continue to represent the ideals, scientific aspirations, and commitments to public service exemplified by John Wesley Powell's career—zealous ideals and aspirations that have made this a valued scientific agency. The dual themes that we heard time and again throughout this conference were (1) we hold a position of preeminence in science that must be maintained, and (2) we must ensure that those special talents are used most effectively in the search for solutions to difficult national resources problems.

Constraints pressuring us are likely to continue. Nevertheless, we will be grasping opportunities to improve our capability and scientific service. It has always been so, and we have always measured up.

# FOURTH NATIONAL CONFERENCE

Water Resources Division, U.S. GEOLOGICAL SURVEY
Ocean City, Maryland, October 18—23, 1981



1. E. J. Cockey
2. D. K. Stewart
3. W. M. Kastner
4. D. E. Click
5. D. D. Knochenmus
6. T. L. Katzer
7. J. T. Armbruster
8. J. H. Irwin
9. R. H. Langford
10. P. Cohen
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12. G. G. Parker, Jr.
13. D. McCartney
14. H. J. Freiberger
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28. H. G. Jeffery
29. D. K. Leifeste
30. R. E. Fidler
31. I. H. Kantrowitz
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51. T. Arnow
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53. E. F. Hubbard, Jr.
54. B. L. Jones
55. L. F. Konikow
56. R. C. Averett
57. R. A. Baker
58. F. B. Sessums
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63. A. Clebsch, Jr.
64. R. J. Dingman
65. J. F. McCain
66. C. A. Pascale
67. D. R. Albin
68. V. W. Norman
69. J. F. Blakey
70. L. G. Moore
71. G. M. Pike
72. C. R. Collier
73. V. R. Schneider
74. B. F. Jones
75. K. V. Slack
76. D. B. Grove
77. R. A. Schroeder
78. J. D. Hem
79. L. E. Young
80. F. P. Haeni
81. J. E. Biesecker
82. G. H. Leavesley
83. R. J. Pickering
84. L. B. Laird
85. P. E. Greeson
86. R. G. Wolff
87. J. L. Cook
88. P. H. Carrigan, Jr.
89. J. N. Fischer, Jr.
90. H. E. Taylor
91. D. E. Erdmann
92. M. E. Moss
93. D. D. Bajema
94. J. B. Robertson
95. W. W. Emmett
96. J. D. Bredehoeft

# DISTRICT CHIEFS

*Left to right:*

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Dennis Stewart
Bill Kastner
Dave Click
Darwin Knochenmus
Terry Katzer (Acting)
Jeff Armbruster
Jim Irwin
Bill Boning
Ben Jones
Fred Quinones
Jerry Parker
Dave McCartney
Herb Freiberger
Bill Dudley
Dave Appel
Rod Cherry

**Second row**

Gene Gann
Art Putnam
Bob MacNish
Al Knight
Horace Jeffery
Don Leifeste
Dick Fidler
Irv Kantrowitz
Steve Hindall
Larry Toler
Joe Rosenshein
Stan Kapustka

**Third row**

Jim Daniel
Phil Emery
Don Vaupel
Larry Martens
Ray Cummings
Bill Forrest
Ivan James
Ted Arnow
Jerre McClelland (Acting)
Ernie Hubbard

**Fourth row**

Jerry Pascale
Don Albin
Vern Norman
Jim Blakey
Grady Moore
George Pike
Chuck Collier

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Russell H. Langford, Associate Chief Hydrologist
Philip Cohen, Chief Hydrologist
Porter E. Ward, Chief, Office of Water Data Coordination
James E. Biesecker, Regional Hydrologist, NR

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Robert J. Dingman, Assistant Chief Hydrologist, SP&DM
Roger G. Wolff, Deputy Assistant Chief Hydrologist, R&TC
Marshall E. Moss, Chief, Surface Water Branch

**Third row**

Francis B. Sessums, Program Officer
Thomas J. Buchanan, Assistant Chief Hydrologist, Operations
John D. Bredehoeft, Regional Hydrologist, WR

**Fourth row**

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Leslie B. Laird, Assistant Chief Hydrologist, R&TC
Ranard J. Pickering, Chief, Quality of Water Branch

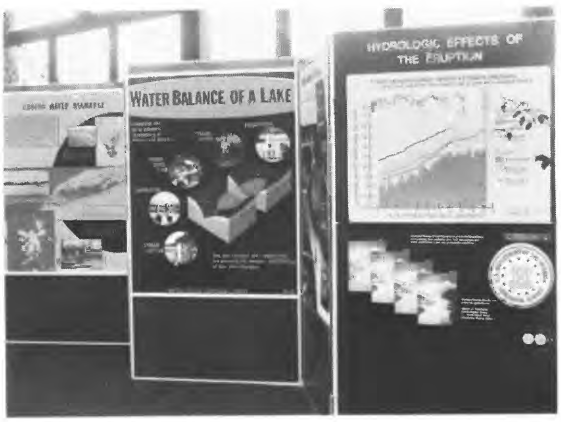









TEST & EVALUATION SECTION


WATER BALANCE OF A LAKE
HYDROLOGIC EFFECTS OF THE ERUPTION


...as urban growth continues, what happens













URBAN HYDROLOGY
MONITOR SYSTEM


Marine Seismic Reflection

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District Chief, Mississippi (12)
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Chief, OWDC, Headquarters (22)
Wark, John W.
Assistant Regional Hydrologist, WR (62)
Weeks, Edwin P.
Hydrologist, CR
Wershaw, Robert
Research Advisor, CR
Wolff, Roger G.
Deputy Assistant Chief Hydrologist, R&TC, Headquarters (86)
Young, Loren E.
Program Officer, WR (79)

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## GUESTS

Bajema, Dale
Assistant Director for Programs, U.S. Geological Survey (93)
Coulter, James B.
Secretary of Natural Resources, State of Maryland
Devine, James F.
Assistant Director for Engineering Geology, U.S. Geological Survey
Frederick, Doyle G.
Associate Director, U.S. Geological Survey
Miller, Daniel N., Jr.
Assistant Secretary of the Interior for Energy and Minerals
Peck, Dallas L.
Director, U.S. Geological Survey
Southard, Rupert B.
Chief, National Mapping Division, U.S. Geological Survey

## CONSULTANT

Black, Uyless,
Vice President, Center for Advanced Professional Education (CAPC), Orange, California

## SPOUSES

Forty-four spouses attended the conference.

PARTICIPANTS — *Continued*

CONFERENCE STAFF

*Maryland-Delaware-D.C. District*

Herb Freiberger
Pat Freiberger (spouse activities)
Denis Gillen
Eva J. Cockey (1)
Joe Bachman
Jean Hyatt
John Hornlein
Dave Lang
Carol Taylor
Yvonne Von Steen
Sheryl Protani
Mary Dee Mayfield

*Office of the Chief Hydrologist*

Linda E. Meadows (20)
Kathy G. Wilson (19)

*Office of the Regional Hydrologist, NR*

Margaret M. Martin (40)

Special thanks to Denis for assuming the overall responsibility of coordinating the conference with the hotel.

The following individuals contributed to a guide book for a planned field trip, which was cancelled.

*Northeastern Region Research Group*

Jim Bennett
Owen Bricker
Virginia Carter
Wayne Webb