

---

**Chapter 4**  
**Federal Use and Support**  
**of Water Resource Models**

# Contents

	<i>Page</i>
Analysis of Current Federal Modeling Capabilities . . . . .	67
Methods Used to Survey and Analyze Federal Model Use. . . . .	67
Findings From the Federal Agency Survey . . . . .	70
Findings From the Federal Workshop . . . . .	72
Current Approaches to Federal Model Management . . . . .	76
Consideration of Models in Governmentwide Water R&D Policies . . . . .	77
Existing Governmentwide Mechanisms for Coordinating Modeling and Model-Related Information . . . . .	80
Existing Support Structures for Agency-Level Modeling Activities . . . . .	84
Agency-Level Mechanisms for Providing Information on and Access to Existing Models . . . . .	88

## TABLES

<i>Table No.</i>	<i>Page</i>
3. Federal Model Use by Program . . . . .	68
4. Agency Estimates of Fiscal Year 1979 Expenditures for Water Resource Models and Related Activities . . . . .	70

## Chapter 4

# Federal Use and Support of Water Resource Models

---

The Federal Government has a very broad range of water resource responsibilities. It is a major investor in facilities to control water supplies and treat polluted waters. It has taken the lead in programs to bring additional supplies to water-short areas of the country, and more recently to encourage more cost-effective approaches to water use in these areas. It has provided the legal and institutional framework within which States work to set water quality standards and ensure that they are met. Moreover, it is responsible for managing the water that flows through the 776 million acres of the country directly under Federal jurisdiction.

These responsibilities are expressed in numerous laws, and are administered by an array of Federal departments, agencies, and regulatory authorities. Water resource concerns touch virtually every aspect of the Nation's economic, social, and political well-being; thus, they are an integral part of the missions of many governmental institutions.

In analyzing Federal use of water resource models, the Office of Technology Assessment (OTA) collected and evaluated information from over 20 agencies and agency offices. Model use was examined by agency, by authorizing legislation, by resource issue, and by professional discipline.

## ANALYSIS OF CURRENT FEDERAL MODELING CAPABILITIES

### *Methods Used to Survey and Analyze Federal Model Use*

OTA used two primary approaches in soliciting information on Federal modeling efforts. It initially held a 2-day workshop for Federal modelers during October 1979, to determine their views on current major problems in Federal water resource modeling efforts. Attended by representatives from 21 Federal organizations, the workshop revealed significant institutional constraints to effective model development and use. In preparation for the workshops, each agency represented was requested to provide written responses to questions regarding its current use and development of models; critical problem areas, appropriate roles, and reasons for using models; anticipated future modeling needs; and current levels of monetary and personnel resources devoted to modeling.

At the workshop, modelers met in groups according to areas of professional expertise. Each group listed, discussed, and ranked the importance of its

model-related concerns. Major findings from the workshop are summarized below; a more extensive summary of the Federal workshop, and of a subsequent workshop held for modelers from universities and the private sector, is presented in appendix A.

The second major component of OTA's information-gathering activity was a survey of the 22 Federal entities with substantive water resource responsibilities, conducted in June 1980. Each agency or office was requested to provide information on its model use under more than 20 major pieces of water resource legislation. Respondents were asked to specify legislatively assigned responsibilities, and areas in which models are employed, according to eight general use categories: 1) program planning; 2) promulgating regulations; 3) enforcing regulations; 4) complying with regulations; 5) planning or evaluating projects; 6) allocating funds; 7) technology transfer; and 8) operations and management. Statistical results of this survey are tabulated in table 3. Detailed descriptions of each agency's model use under specific laws and programs are

Table 3.—Federal Model Use by Program

	Section	Number of agencies with program involvement	Number of agencies using models to meet program responsibilities	Agencies using models to meet program responsibilities
<b>Federal Water Pollution Control Act Amendments of 1972 (as amended by the Clean Water Act of 1977)</b>				
Grants for pollution control program. . . . .	106	2	0	
Mine water pollution control programs. . . . .	107	2	2	FS, BM
Grants for construction of treatment works. . . . .	201	5	4	ESCS, CORPS, USGS, EPA-OWRS
Areawide waste treatment management. . . . .	208	7	6	EPA-OWRS, BR, FS, ESCS, SEA
Basin planning. . . . .	209	9	7	BR, FS, EPA-OWRS, ESCS, NOAA, WRC, USGS
Water quality waivers. . . . .	301	2	2	EPA-OWE, NOAA
Water quality-related effluent limitations. . . . .	302	4	1	EPA-OWRS
Water quality standards and implementation plans. . . . .	303	6	4	BR,FS, NOAA, EPA-SWER
Toxic and pretreatment effluent standards. . . . .	307	8	2	EPA-OWRS, NOAA
Oil and hazardous substances liability. . . . .	311	4	1	USGS
Clean lakes. . . . .	314	6	3	FS, NOAA, USGS
Thermal discharges and exemptions. . . . .	316	3	2	USGS, EPA-OWE
Guidelines and permits for dredged or fill material. . . . .	404	7	1	USGS
Disposal of sewage sludge. . . . .	405	7	1	ESCS
<b>Safe Drinking Act</b>				
Determining adverse health effects. . . . .	1412	1	1	EPA-DW
Protection of underground sources of drinking water. . . . .	1421	8	3	USGS, MINES, EPA-DW
Protection of sole-source aquifer systems. . . . .	1424	1	1	EPA-DW
Surface impoundment assessment.	1442	1	1	EPA-DW
State program grants. . . . .	1443	1	1	EPA-DW
Special study and demonstration project grants. . . . .	1444	5	1	USGS
<b>Toxic Substances Control Act</b>				
Testing of chemical substances and mixtures. . . . .	4	4	1	EPA-PTS
Regulation of hazardous chemicals and mixtures. . . . .	6	5	1	EPA-PTS
<b>Resource Conservation and Recovery Act</b>				
Solid waste management guidelines Identification and listing of hazardous wastes. . . . .	1008 3001	4 4	1 0	USGS
Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities. . .	3004	7	0	
Consolidated permits for hazardous waste management facilities. . . .	3005	5	0	

Table 3.-Federal Model Use by Program (Continued)

	Section	Number of agencies with program involvement	Number of agencies using models to meet program responsibilities	Agencies using models to meet program responsibilities
Grants for State resource recovery and conservation plans. . . . .	4008	1	0	
Full-scale demonstration facilities grants. . . . .	8004	1	0	
Resource recovery system and improved solid waste. . . . .	<b>8006</b>	<b>3</b>	1	USGS
<b>Endangered Species Act</b>				
Minimizations of impacts of Federal activities modifying critical habitats. . . . .	7	<b>9</b>	<b>3</b>	BR, FS, FWS
<b>Surface Mining Control and Reclamation Act</b>				
Surface coal mine reclamation permitting. . . . .	<b>506</b>	<b>6</b>	<b>3</b>	FS, USGS, OSM
Permit approval or denial. . . . .	510	1	1	OSM
Environmental protection performance standards for surface coal mine reclamation. . .	515	<b>6</b>	<b>4</b>	FS, USGS, BM, OSM
<b>Soil and Water Resource Conservation Act of 1977</b>				
Data collection about soil, water, and related resources. . . . .	<b>5</b>	<b>6</b>	<b>2</b>	FS, USGS
Soil and water conservation programs. . . . .	<b>6</b>	<b>7</b>	<b>5</b>	FS, ESCS, NOAA USGS, BM
<b>Water Resources Planning Act</b>				
Regional or river basin plans and programs and their relation to larger requirements. . . . .	102	10	7	BM, BR, ESCS, CORPS, NOAA, USGS, WRC
Coordinating Federal water and related land resources programs and policies. . . . .	102	7	<b>2</b>	<b>USGS, BM</b>
Assessment of the Nation's water resources conditions. . . . .	102	1	1	WRC
<b>Coastal Zone Management Act</b>				
State coastal zone land and water resources management program development and management grants. . . . .	305	<b>6</b>	2	NOAA, USGS
<b>Executive Order 11988</b>				
Flood plain management. . . . .	2 & 3	<b>9</b>	5	FS, CORPS, USGS, WRC, NRC
<b>Flood Control Act of 1936 and Amendments</b>				
Flood control structures. . . . .	<b>1,2,3,</b>	7	<b>5</b>	BR, FS, CORPS, NOAA, USGS
<b>National Flood Insurance Act of 1968</b>				
Identification of flood-prone areas. .	1360	<b>2</b>	<b>2</b>	FEMA, SCS
<b>Federal Reclamation Act of 1902 and Amendments</b>				
Irrigation distribution systems. . . .	(43U.S.C.421)	<b>5</b>	<b>3</b>	USGS, FS, BR
Construction of small projects. . . .	(43U.S.C.422)	<b>3</b>	1	FWS
<b>National Environmental Policy Act</b>				
Administration; EIS review and comment. . . . .	102,103	<b>5</b>	<b>5</b>	BR, FS, CORPS, NOAA, NRC

**Table 3.—Federal Model Use by Program (Continued)**

Section	Number of agencies with program involvement	Number of agencies using models to meet program responsibilities	Agencies using models to meet program responsibilities
<b>Atomic Energy Act of 1954</b>			
Flood protection of nuclear facilities. . . . .	10 CFR 50	1	NRC
Water supply for nuclear power facilities. . . . .	10 CFR 50	1	NRC
Limitation of radioactive liquid to ground and surface water. . . . .	10 CFR 20, 50, 61	2	NRC, USGS
<b>Fish and Wildlife Coordination Act</b>			
Consultation and provision of recommendations; surveys and investigations. . . . .	182	2	FWS, NOAA
Colorado River Basin Salinity Control Program. . . . .	10, 201, 202, 203	2	BR, SCS

Agency abbreviation key:

ASCS — Agricultural Stabilization and Conservation Service	ESCS — Economics and Statistics Cooperative Service
CORPS — Army Corps of Engineers	FEMA — Federal Emergency Management Agency
BM — Bureau of Mines	FS — Forest Service
BR — Bureau of Reclamation	FWS — Fish and Wildlife Service
DOE — Department of Energy	NOAA — National Oceanic and Atmospheric Administration
EPA — Environmental Protection Agency	NRC — Nuclear Regulatory Commission
DW — Office of Drinking Water	OSM — Office of Surface Mining Reclamation and Enforcement
OWE — Office of Water Enforcement	SCS — Soil Conservation Service
OWRS — Office of Water Regulations and Standards	SEA — Science and Education Administration
SWER — Solid Waste and Emergency Response Program	USGS — U.S. Geological Survey
PTS — Pesticides and Toxic Substances Program	WRC — Water Resources Council

provided in appendix B. Insofar as OTA has been able to ascertain, no previous governmentwide compendium of water resource model use and application has been attempted.

These information-gathering activities were supplemented by OTA-commissioned reports on model uses, limitations, and appropriate roles in four broad water resource areas, and by telephone surveys regarding costs associated with modeling activities for fiscal year 1979. Estimates of fiscal year 1979 expenditures for water resource models are provided in table 4. OTA has also relied on previously published studies of Federal, Canadian, and international model use to corroborate its general findings. Five of the most relevant studies are summarized in appendix C; individual references to these findings are also made throughout this chapter.

### ***Findings From the Federal Agency Survey***

Table 3, which summarizes agency model use by law, and compares areas of responsibility to areas in which models are employed, provides a

**Table 4.—Agency Estimates of Fiscal Year 1979 Expenditures for Water Resource Models and Related Activities (in millions of dollars)**

U.S. Geological Survey:	
Research. . . . .	3.0–4.0
Application. . . . .	12.0–15.0
Army Corps of Engineers. . . . .	6.5–7.7
National Science Foundation. . . . .	2.8
National Oceanic and Atmospheric Administration. . . . .	2.8
Department of Energy. . . . .	0.9–1.1
Department of Agriculture. . . . .	0.7 <sup>a</sup>
Department of Interior. . . . .	4.7–5.9
Environmental Protection Agency. . . . .	7.8–9.4
Total. . . . .	40.2–49.4

<sup>a</sup>Includes estimate only from SCS and ESCS.

SOURCE: Developed from information provided in agency responses to OTA questions regarding model use, October 1979, and from a June 1979 telephone survey of selected Federal agencies. Figures include expenditures for both research and application.

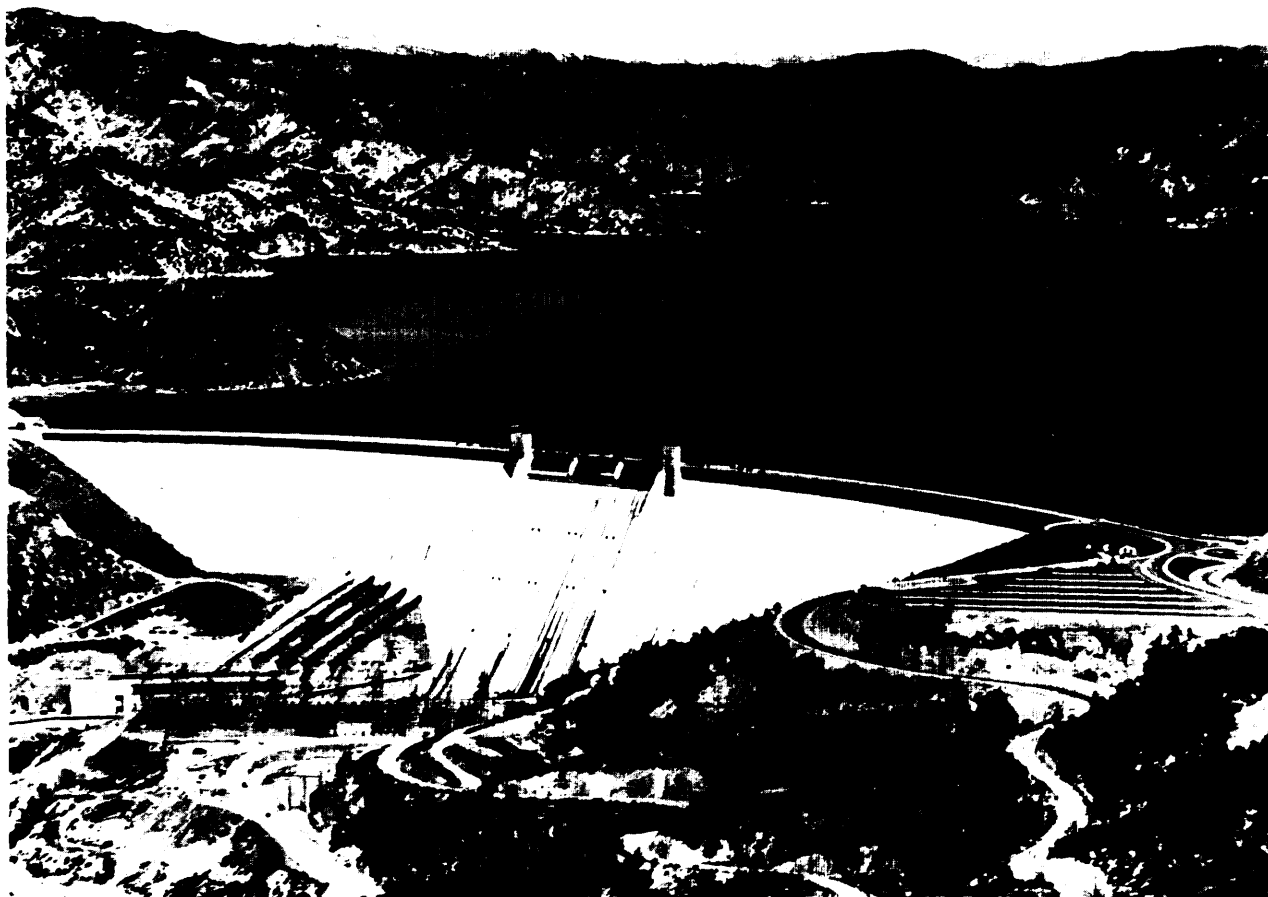
general indication of current patterns of Federal water resource activities and model use. As might be expected, the more comprehensive the scope of a water resource-related law, the greater the number of agencies whose missions are affected by it. The widest-ranging of current water resource laws, the Clean Water Act of 1977, involves about 15 agencies and offices, which are assigned various

responsibilities under or must comply with regulations stemming from 14 different sections of the law. Twelve agencies or offices indicated model use under this act. Some laws, such as the National Flood Insurance Act of 1968 (Public Law 90-448), are the responsibility of a single agency—in this case, the Federal Emergency Management Agency. On the whole, however, most pieces of Federal legislation affect more than a single agency, office, or regulatory authority.

None of the laws identified in the Federal agency survey specifically require the use of models to analyze a water resource issue. However, many of the analytic responsibilities specified in the legisla-

tion are routinely carried out with models. Under the Forest and Rangeland Renewable Resources Act of 1974 (Public Law 93-378), for example, the Forest Service of the U.S. Department of Agriculture (USDA) is charged with developing and implementing long-range land and resource management plans for the federally owned forests under its jurisdiction. It uses models that assess the effects of different management practices on water supply, water quality, other significant natural resources, and local economic activity. The information generated by these models is used in determining National Forest Management Act Regulations.

Much of the current Federal legislation directs individual agencies to determine standards that may



red

M      m      g w      D      w      m      g m      G  
           g w                    S      g      g      m      w      m  
           C      D m                    W      g      g      m      w      m

affect the program responsibilities of other agencies. Under the Clean Water Act (Public Law 95-217), the Safe Drinking Water Act (Public Law 93-523), and the Toxic Substances Control Act (Public Law 94-469), the Environmental Protection Agency (EPA) regulates and sets allowable concentrations for a number of toxic substances, organic chemicals, pesticides, and other residuals. A variety of models are used to determine how these substances are transported to and within receiving waters, and to estimate their effects on human and aquatic populations. Such regulations must subsequently be incorporated into analyses performed by various agencies of USDA and the Bureau of Mines, land and forest management practices of the Department of the Interior (DOI) and the Forest Service, and permitting processes of the Nuclear Regulatory Commission for thermal effluents, among others.

The findings outlined in table 3 reflect a highly uneven pattern of Federal model use for water resource analysis. While some agencies use models to analyze a particular resource issue throughout the range of their statutorily assigned program responsibilities, others use them only for a particular responsibility (e.g., complying with regulations), and still others rely solely on noncomputerized analytical approaches. These inconsistencies cause such problems as inconsistent flood plain delineations by different agencies, confusion over best management practices for controlling nonpoint source pollution, and disputes over projections of the amount of water available for energy development in the Western United States. Further, while highly efficient model-based management techniques have been developed in several Federal agencies (e.g., for operating reservoirs), many agencies do not benefit from this already-developed expertise.

A number of factors underlie agency decisions regarding model use. Developing a model is an expensive and technically complex undertaking, involving highly specialized personnel requirements, extensive computer facilities, and appropriate data bases. If the problem to be analyzed is not *directly* related to the agency's mission, the agency will often be reluctant to commit the resources necessary to develop a model to address the problem.

Moreover, substantial difficulties often deter agencies from adapting models that have already

been developed elsewhere in the Federal Government. When practicable, model adaptation permits significant cost-savings, although adequate data bases and computer facilities, in addition to technical assistance in adapting the model, are still necessary. However, information about the availability of many existing Federal models is not readily obtainable. Few agencies have taken steps to disseminate information on the models they have developed. In addition, Federal models are often so poorly documented that a manager cannot determine their suitability for use by his agency.

### ***Findings From the Federal Workshop***

Although Federal agency modelers met and discussed issues in four separate professional groupings—1) surface water flow and supply; 2) surface water quality; 3) ground water; and 4) economic/social—the majority of their concerns were not specific to these areas, but encompassed the broader problem of providing adequate and appropriate institutional support for modeling activities in general. In-depth summaries of modelers' deliberations on such issues as research and development (R&D) needs, data needs, documentation, validation, technology transfer, model maintenance, the utility of model clearinghouses, and interagency coordination, are provided in appendix A.

Participants ranked the following issues as being among the most significant of those discussed:

- collecting accurate and adequate data to develop, test, and apply models;
- improving decisionmaker understanding of general capabilities and limitations of models;
- improvements in user support, training in model use, and analysis of results;
- greater emphasis on documentation of models;
- improved planning and resources for model maintenance and management;
- making federally developed models known and available to other Federal agencies and to the public; and
- improving coordination among agencies for model development and use.

The significance of these issues to water resource analysis and problem-solving capabilities at the Federal level is discussed below.



## Data Availability

The availability of sufficient data to characterize a physical system is critical to modeling it successfully. Computer models are often highly data intensive, requiring independent data sets for development, calibration, verification, and application phases. Workshop participants pointed to the expense of collecting water resource data as a major limiting factor in constructing models.

Most existing Federal data bases are created to serve program purposes rather than for research and analysis per se. Developers consequently find much of the existing data unsuitable for modeling activities. Participants suggested coordinated approaches to data collection and model development, as well as sensitizing model developers to the potential data requirements (and costs) of their models. Emphasis was also placed on the need to improve access to existing data bases, and improve the cost effectiveness of future data collection efforts, particularly through interagency coordination and data base consolidation.

Coordinating and integrating data collection on a governmentwide basis is a major Federal management issue, and concerns many informational purposes in addition to modeling efforts. Consequently, an indepth analysis of Federal data-gathering activities is beyond the scope of this report. However, results from the OTA workshop and surveys, as well as surveys of federally developed models by the National Science Foundation (NSF)<sup>1</sup> and the General Accounting Office (GAO),<sup>2</sup> indicate that modelers and managers alike consider problems in obtaining data to be the most prevalent limitation on model development efforts. Three of the four OTA workshop groups considered this to be their top priority concern, while respondents to the GAO survey attributed one-fifth of all identified modeling problems to data availability. Any future attempts to improve Federal data-gathering practices and procedures will have major effects on the modeling community. Input from this community should be solicited in data collection planning to

<sup>1</sup>Gary Fromm, William L. Hamilton, and Diane E. Hamilton, *Federally Supported Mathematical Models Survey and Analysis*, under contract with the Division of Social Systems and Human Resources of the National Science Foundation, June 1974.

<sup>2</sup>*Ways to Improve Management of Federally Funded Computerized Models*, General Accounting Office, August 1976.



A d R m m w m g  
m d g p p m m

minimize additional data-gathering costs associated with future modeling efforts.

## Improving Decisionmaker Understanding of Models

Information gaps between decisionmakers and modelers were among the top three priority concerns for all four modeling groups at the OTA Federal workshop. Workshop participants focused on the relationship between modeling and the decision-making process as a major deficiency in current Federal modeling practices. Upper-level managers were characterized as being unaware of basic modeling concepts and of the limitations and capabilities of the specific models they use. Modelers pointed to a lack of mechanisms throughout the Federal Government for bringing managers and modelers

together to plan and develop models. Such a lack of interaction was seen as a major contributor to management-level mistrust of models, and the inadequacy of current levels of support for planning long-range model development, documenting and maintaining models, and providing user services.

These findings are strongly in accord with those from earlier studies. The survey of 222 nondefense Federal models conducted in 1974 for NSF found highest rates of failure in modeling projects designed to provide information to policy makers. The low utilization rate of such models was attributed primarily to lack of communication between model builders and potential policy makers during model development, and secondarily to policymakers' limited understanding of models that had already been developed.<sup>3</sup> Similarly, one-fifth of modeling problems identified in the GAO survey (1976) were attributed to "lack of management acceptance and knowledge of modeling techniques."<sup>4</sup>

Integrating the needs of decisionmakers into model development processes is especially critical if models are to be used effectively at agency decisionmaking levels. Federal managerial personnel often have a great deal of discretion over what procedures to employ in analyzing an issue. Some may have obtained favorable results from modeling in the past, while others may have been "burnt" by relying on the accuracy of model-based information. Since the Federal Government provides no guidelines regarding model uses for analytical purposes, and offers very little management-level education in model use and interpretation, decisionmakers are generally 'on their own' in deciding when to commit their agencies to modeling efforts.

In practice, Federal agencies tend to commission models in response to a specific problem, when a decisionmaker becomes aware of the need for otherwise unavailable information. All too frequently, however, Federal modelers are given little instruction regarding the nature of the desired information, and are not provided access to the individual(s) who must act on the information generated. Technically sophisticated, yet impractical models often

result, and are quickly abandoned to agency archives.

### User Support

Participants in the OTA modeling workshop frequently asserted that Federal modeling efforts have overconcentrated on model development, and devoted inadequate resources to transferring modeling technology and expertise to potential users. All four workshop groups placed some aspect of user services among their top three priorities. Many participants stated, however, that current agency career evaluation systems discourage modelers from providing such technology transfer to model users. While incentives are provided for developing increasingly sophisticated models, no incentive structure currently encourages modelers to aid users in understanding, running, and interpreting the results of such tools.

Workshop participants singled out three major aspects of technology transfer as needing additional attention and resources: 1) documentation; 2) training in model use and interpretation; and 3) technical assistance. Most participants appeared to consider documentation the most critical of technology transfer needs. Because documentation is time consuming and expensive to produce, decisionmakers and modelers alike have tended to assign it low priority, concentrating on the production of 'bottom-line' information. Without adequate documentation, however, decisionmakers cannot subsequently determine how the information was generated, nor evaluate it. Documentation is also crucial for providing individuals in other Federal agencies a means of determining whether they can use a previously developed model. A 1974 GAO survey of 710 Federal data-processing personnel and auditors who reported problems due to inadequate documentation, revealed that nearly one-third (233) of the related programs had to be totally rewritten, and one-sixth (127) of the automated data-processing systems had to be redesigned. Moreover, more than half (428) of the documentation-related problems resulted in substantial delays in the completion of assignments.<sup>5</sup>

<sup>3</sup>Fromm, Hamilton, and Hamilton, op. cit., pp. 3-7, 51-54

<sup>4</sup>General Accounting Office (1976), op. cit., p. 37.

<sup>5</sup>*Improvement Needed in Documenting Computer Systems*, General Accounting Office, October 1974, pp. 6-7.

Concern over the inadequacy of current levels of documentation for Federal models is corroborated by the 1974 NSF survey, and by a 1979 survey of 39 modelers conducted for the National Bureau of Standards (NBS). NSF found that for about 75 percent of the 222 surveyed models, the documentation supplied by the developer was inadequate to enable nonproject personnel to set up and run the model.<sup>6</sup> Developers surveyed by NBS showed strong support for governmentwide model documentation guidelines, including the specification of a documentation plan in model development contracts, detailing the documents to be produced, the resources allocated, and personnel responsibilities.<sup>7</sup>

Training *opportunities* are essential to developing in-house capabilities for running and interpreting models. Unless training is supplied, agencies are totally dependent on model developers for model-generated information. The 1974 GAO survey found the third-largest source of major modeling problems to be “lack of qualified personnel to operate and maintain the model. Workshop participants were similarly concerned to find ways of encouraging agencies to provide adequate resources for model-related training. Different levels of training for decisionmakers and for users were repeatedly advocated, the latter type to incorporate “hands-on” interaction with the model and “one-on-one” instruction where possible.

Workshop participants also pointed to the routine provision of *technical assistance* as an inexpensive means of troubleshooting in model use. The availability of knowledgeable individuals to answer simple “over-the-phone” questions can save man-hours and computer time that are otherwise lost to trial-and-error attempts to operate the model. For more complex models and/or modeling problems, participants suggested temporarily assigning developers to user organizations to facilitate the initial setting-up of the model.

<sup>6</sup>Fromm, Hamilton, and Hamilton, op. cit. , p. 6.

<sup>7</sup>Saul I. Gass, “Assessing Ways to Improve the Utility of Large-Scale Models,” in *Validation and Assessment Issues of Energy Models*, National Bureau of Standards, Special Publication 569, February 1980, p. 251.

## Maintenance and Dissemination

The current structure of Federal modeling activities gives agencies little incentive to consider potential uses for models once they have served the agency’s primary purpose. Consequently, most models are not updated, or maintained, to keep them technologically current, nor is information about their existence or availability circulated among potential users in government and the private sector. One of the most frequently voiced concerns of workshop participants was the difficulty of locating and obtaining existing Federal models. Many modelers considered improving access to current models a higher priority than improving and developing new ones. Participants generally agreed that lack of information regarding the availability of Federal models is a significant barrier to their widespread use.

Participants also noted the Federal Government lack of commitment to maintaining the models it has already developed. They stressed the need to develop mechanisms and/or organizational units with routine responsibilities for periodic model analysis and updating. The need to inform model users of changes made to a model was also considered to be neglected in current agency procedures.

## Interagency Coordination

Federal modelers identified the lack of interagency coordination as a major bottleneck in efforts to advance the state of the modeling art. Managers tend to be unaware of the modeling and model development projects being supported by other agencies, a situation that may lead to decisions to build models already in existence or in process of development. A certain amount of duplication in modeling has potentially beneficial effects—it fosters a kind of competition from which more accurate and efficient modeling techniques can result. However, for highly complex modeling tasks, interagency pooling of resources and technical expertise could facilitate greater and more rapid advances than are possible when each agency functions independently. As explained in a USDA Soil Conservation Service background paper for the OTA modeling workshops, “There would be value in encouraging broader use of certain water resource models among

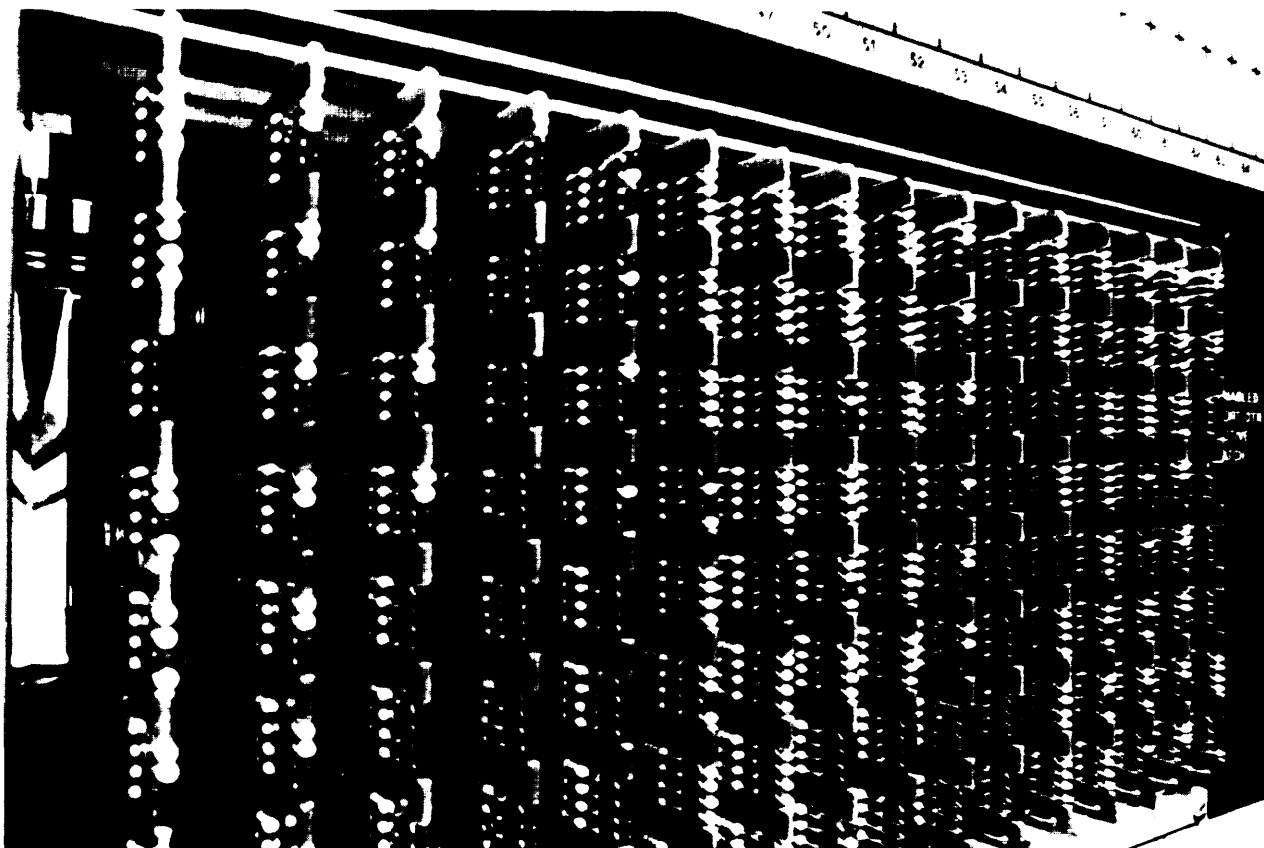


Photo credit: @ Ted Spiegel, 1982

Federal agencies with modeling expertise and computing facilities provide extensive assistance to State and local users, as well as to users in other Federal offices. Miniature lights on these panels at USGS computer facilities in Reston, Va., glow when telephone hookup lines to computers are currently in use

Federal agencies both to reduce duplication of modeling effort and to obtain the benefit of multiple agency comment following their use.

Further, for highly complex and interdisciplinary modeling, interagency participation may be the

only means of assuring that high-quality models are brought to completion. The creation of adequate data bases to support sophisticated modeling projects, in particular, calls for interagency coordination and planning.

## CURRENT APPROACHES TO FEDERAL MODEL MANAGEMENT

This section reviews the Federal legislation and program activities that affect the development and use of water resource models. It analyzes the planning framework through which funding is provided for model-related work. This section further describes the major organizational and institutional

arrangements currently responsible for disseminating water resource models and/or assisting other water resource agencies to use them. Because modeling is an integral part of Federal responsibilities for water resource analysis, data collection, and R&D, this section also addresses a number of Fed-

eral agencies and offices for which the advancement of modeling capabilities is not a primary objective. The section is organized according to four major areas of Federal involvement: 1 ) governmentwide water R&D policies; 2) governmentwide coordination and dissemination activities; 3) agency-level modeling activities; and 4) agency-level dissemination activities.

### ***Consideration of Models in Governmentwide Water R&D Policies***

#### **The Water Research and Development Act of 1978**

The Water Research and Development Act of 1978 is currently the major legislative mechanism for coordinating the development of analytical tools to address water resource issues. It states the congressional finding that “the Nation’s capabilities for technological assessment and planning and for policy formulation for water resources must be strengthened at both the Federal and State levels, and assigns responsibilities to the President and the Secretary of the Interior for developing a coordinated Federal program of water-related research and technology.

The act directs the President to:

Clarify agency responsibilities for Federal water resources research and development and provide for interagency coordination of such research, including the research authorized by this Act. Such coordination shall include: 1 ) continuing review of the adequacy of the Government-wide program in water resources research and development and identification of technical needs in various water resources research categories, 2) identification and elimination of duplication and overlaps between two or more programs, 3) recommendations with respect to allocation of technical efforts among the Federal agencies, 4) review of technical manpower needs and findings concerning the technical manpower base of the program, 5) recommendations concerning management policies to improve the quality of the Government-wide research effort, and 6) actions to facilitate interagency communication at management levels (sec. 406(b)).

In addition, the act assigns specific responsibility to the Secretary of the Interior to:

Develop a five-year water resources research program in cooperation with the (state water research) institutes and appropriate water entities, indicating goals, objectives, priorities, and funding requirements (sec. 103 (b)).

To fulfill these objectives, and other objectives of the act:

The Secretary shall cooperate fully with, and shall obtain the continuing advice and cooperation of, all agencies of the Federal Government concerned with water problems, State and local governments, and private institutions and individuals, to assure that the programs conducted under this Act will supplement and not duplicate other water research and technology programs, will stimulate research and development in neglected areas, and will provide a comprehensive, nationwide program of water resources research and development (sec. 406 (a)).

In assigning responsibility for developing a comprehensive 5-year water resources research program to the Secretary of the Interior, the act broadly outlined a new mechanism for coordinating Federal water resources analysis. Between 1963 and 1977, such a task had been the responsibility of the Committee on Water Resources Research (COWRR), under the aegis of the Federal Council for Science and Technology within the Executive Office of the President (EOP). Beginning in 1966, COWRR developed and annually updated a long-term program for water resources research. Its reports recommended priority research areas and were intended to guide Federal agencies in allocating research funds.

The 1978 act calls, in general terms, for EOP to play a lead role in coordinating the conduct of water resources analysis among the Federal agencies, relying on DOI to develop a research and technology agenda as a basis for EOP decisions. President Carter’s message on science and technology, delivered to the Congress on March 27, 1979, further directed the Secretary of the Interior and the Director of the Office of Science and Technology Policy (OSTP) to determine research priorities for meeting the Nation’s long-range water needs.

## Development of the Five-Year Water Resources Research Program

Under the joint direction of DOI and OSTP, interagency policy and working groups summarized current agency-level programs of water research and short-term priorities in "Water Research Priorities for the 1980's" (April 1979),<sup>8</sup> and developed recommendations for improving the Federal effort in 10 broad subject areas in "Interim Report—Priorities in Federal Water Resources Research" (August 1979).<sup>9</sup>

"Proposed U.S. National Water Resources Research, Development, Demonstration, and Technology Transfer Program, 1982-87, draft, an expanded version of the agency summaries with projected funding levels for fiscal years 1982 to 1987, was delivered to the Water Resources Research Review Committee of the National Academy of Sciences (NAS) for review in December 1980. The NAS evaluation, *Federal Water Resources Research: A Review of the Proposed Five-Year Program Plan*, was published in May 1981.

Water resources models figure prominently in the description of agency research efforts in the April 1979 and December 1980 documents. The extent of the Federal commitment to modeling activities is exemplified by frequently occurring references to them in many of the agency reports. EPA, for example, lists among its research priorities the need to:

... develop, test and validate models for simulating source loads and "in-stream" processes for use in assessing water quality problems, allocating source loads, and evaluating alternative management strategies; and expand modeling capability to include toxics, especially with regard to sediment processes. 12

<sup>8</sup> "Water Research Priorities for the 1980's," Department of the Interior, Office of Water Research and Technology, April 1979.

<sup>9</sup> Interim Report—priorities in Federal Water Resources Research, Department of the Interior and the Office of Science and Technology Policy, August 1979.

<sup>10</sup> "Proposed U.S. National Water Resources Research, Development, Demonstration and Technology Transfer Program, 1982-1987, Draft, Department of the Interior, December 1980.

<sup>11</sup> *Federal Water Resources Research: A Review of the Proposed Five-Year Program Plan*, Water Resources Research Review Committee of the National Research Council (Washington, D. C.: National Academy Press, 1981).

<sup>12</sup> "Water Research Priorities for the 1980's," p. 67.

Agencies also report needs for information and models in areas where, lacking authorization to fund model development, they must rely on the modeling effort of other agencies. The Soil Conservation Service of USDA pointed out the need 'to improve estimates of erosion potential and nutrient loss from forest and rangelands; similarly, the Department of Transportation stated that it could benefit from work to "develop operational two-dimensional model simulating stream degradations, aggravation, and local erosional processes.

Both documents are compendiums of individual agency research plans; consequently, opportunities for interagency coordination of modeling efforts, or other research and technology-related activities, are not addressed. In addition, neither document describes agency activities in sufficient detail to permit a determination of levels of funding allocated to modeling activities, or the means used to coordinate modeling and related support efforts within each agency. No summary of State needs was included in either document, and it is difficult to determine how or whether the State water resources research institutes' 5-year programs were considered in formulating the agency research plans that constitute the December 1980 draft.

The 'Interim Report' of September 1979 sets out goals and general priorities for governmentwide water resources R&D. It indicates many areas in which improved modeling capabilities are needed, including conjunctive ground water/surface water systems, aquatic ecosystems, environmental impacts to wetlands, chemical transport, verification of water quality and wasteload allocation models, flood plain delineation, streamflow forecasting, and hydrological/meteorological forecasting. No attempt is made, however, to relate general goals to specific agency activities, or to recommend divisions of responsibility and funding allocation levels among agencies. The report provides broad guidelines to agencies conducting research and analytical activities, but addresses none of the management concerns outlined in the 1978 act.

The differences between the two agency compilations and the 'Interim Report' suggest one of the major difficulties in creating an overall Federal

<sup>13</sup> Ibid, p. 9.

<sup>14</sup> Ibid, p. 63.

strategy for water resources R&D. From the perspective of each Federal agency or program, models and research are valuable primarily for their contribution to specific program objectives. Alternatively, an overview of national water resource problems can show areas in which lack of computer-based information prevents important advances in identifying needs, creating cost-efficient control strategies, and developing better administrative and legislative tools. Making agencies more responsive to such national-level concerns requires concerted, ongoing efforts at highest management levels to integrate overall objectives into routine agency decisions and funding allocation procedures.

The NAS evaluation of the proposed 5-year program plan also sets out to define broad problem areas in which further water resources research is needed. It focuses, however, on analyzing inadequacies in the December 1980 draft, and identifying institutional constraints to the development and implementation of a coordinated long-range Federal plan. The NAS study points out the inadequacies of a focus on research per se—rather than on a broader range of analytical and support needs—as a major defect in the DOI/OSTP coordinating effort.

The report by its title purports to cover more than 'water research'—namely, "development, demonstration, and technology transfer," although these terms are not defined. Rigorous attention is not given to distinguishing those separate activities in the program statements of the individual agencies, and no overall assessment of these activities is included in the program. The instructions to the agencies mentioned only research. 15

The NAS study further concludes that the directives of the 1978 act are insufficient in themselves to provide a basis for coordinated Federal approaches to water resource R&D.

The deficiencies noted in the draft of the five-year program report are convincing evidence that the ad hoc approach to management of the Federal water research program will not yield the results expected by Congress when it enacted the Water Research and Development Act of 1978.<sup>15</sup>

OTA'S survey of Federal water resource modelers and of related studies suggests that directives for formulating an overall Federal plan for water research and technology should specifically address the relationship between research and developing usable analytic tools. Priorities and allocation of funding and manpower need to be set for both kinds of activities, as well as for mechanisms to transfer modeling expertise and increase model availability to Federal, State, local, and private sector users.

#### Role of the State Water Resources Research Institutes in Coordinating Federal Water R&D Policy

The Water Resources Research Act of 1964, and its successor, the Water Research and Development Act of 1978, provided for the establishment of a network of State water resources research institutes at a designated land-grant college or university in each State. Under the auspices of the Office of Water Research and Technology (OWRT) in DOI, the institutes have funded a wide variety of research programs in water resources. Since its inception, the State Institute Program has involved over 35,000 professionals and students in water-related research and problem-solving studies. Funding has been provided by OWRT on a matching basis with State governments under two separate programs: 1) a basic allocation of \$110,000 per State (as of fiscal year 1980), and 2) a competitive grants program allotting a total of over \$5 million (as of fiscal year 1980). However, for fiscal year 1982, the competitive grants program has been eliminated, while the basic allocation to individual States has been reduced to the \$110,000 1980 figure. In addition, OWRT has been scheduled for elimination, and its duties and responsibilities transferred to other offices and programs, before the end of the current fiscal year.

The State Institute Program has proved to be an efficient, effective means of encouraging a wide variety of water research efforts. In fiscal year 1979, the latest year for which detailed cost statistics are available, total Federal support of slightly over \$21 million elicited a nearly equal commitment of State

<sup>15</sup>*Federal Water Resources Research*, op. cit., p. 45

<sup>16</sup>*Ibid.*, p. 58.

<sup>17</sup>There are currently 54 institutes—one per State, and additional institutions in Washington, D.C., Puerto Rico, Guam, and the Virgin Islands.

and private funds. During that year, the program supported the work of about 1,200 principal investigators and about 1,750 student research assistants. Modeling activities constitute an important component of institute efforts, and increased training opportunities in model-related skills for water resource professionals have been one of the program's major byproducts.

The 1978 act also designates the institutes as the principal source of information regarding State water research needs for use in creating the Federal 5-year program plan. Each institute is required to submit to the Secretary of the Interior for approval an annual program "developed in close consultation and collaboration with leading water resources officials within the State" and "to cooperate with the Secretary in the development of five-year water resource research and development goals and objectives."

The scope of institute activities varies greatly from State to State. Some institutes focus on analytical work in cooperation with State water agencies; others concentrate on more traditional research functions. The diversity of the activities and concerns of the 54 State institutes is highly appropriate to their research missions, but has mixed implications for relaying State agency needs in water resource R&D to Federal policymakers. The institutes are closely connected to the academic institutions at which they are housed, and are not aligned with any one State agency. Their freedom from mission-oriented concerns and priorities gives them the potential to represent the needs of all the State-level water resource agencies. However, since the institutes are staffed primarily by research scientists with professional ties to universities, they are not involved with day-to-day State agency problems.

### ***Existing Governmentwide Mechanisms for Coordinating Modeling and Model-Related Information***

#### **Office of Water Data Coordination (OWDC)**

Since water resource modeling tends to be highly data-intensive, model developers and users are particularly vulnerable to problems of data availability. Unless the collection of required data can be

planned simultaneously with model development, modeling activities must be adjusted to the available data resources. This makes coordination of water data collection extremely important to successful use of water resource models.

Hydrologic data are collected by a large number of governmental and private entities, normally in order to serve some specific informational purpose or in support of established program activities. Historically, such data were collected under methods and standards devised to suit an organization's or agency's individual purposes, and were stored away once the organization's needs for it were met. While some general-purpose data on the quality and quantity of the Nation's available water resources were routinely collected and disseminated by the Water Resources Division of the U.S. Geological Survey (USGS), potential users of water data frequently encountered difficulty in identifying and locating existing data bases. Afterwards, even when such data were located, they were often found unusable, due to collection methods and/or standards of accuracy that failed to meet user requirements.

In 1964, to aid in coordinating water resource data, the Office of Management and Budget (then the Bureau of the Budget) issued Circular A-67, assigning the role of lead agency for such activities to DOI, which assigned specific responsibility for this function to USGS. To carry out this responsibility, USGS created OWDC, and gave it the following principal responsibilities:

- exercising leadership in achieving effective coordination of water data acquisition activities;
- undertaking continuing and systematic review of water data requirements and activities;
- preparing and keeping current a *Federal Plan* to aid in coordinating agency water-data acquisition efforts;
- maintaining a central Catalog of Information on Water Data and on Federal activities being planned and conducted to acquire water data; and
- designing and operating a national network for acquiring data on the quality and quantity of ground and surface waters, including the sediment loads of streams.

Major programs of OWDC most relevant to modeling needs include:



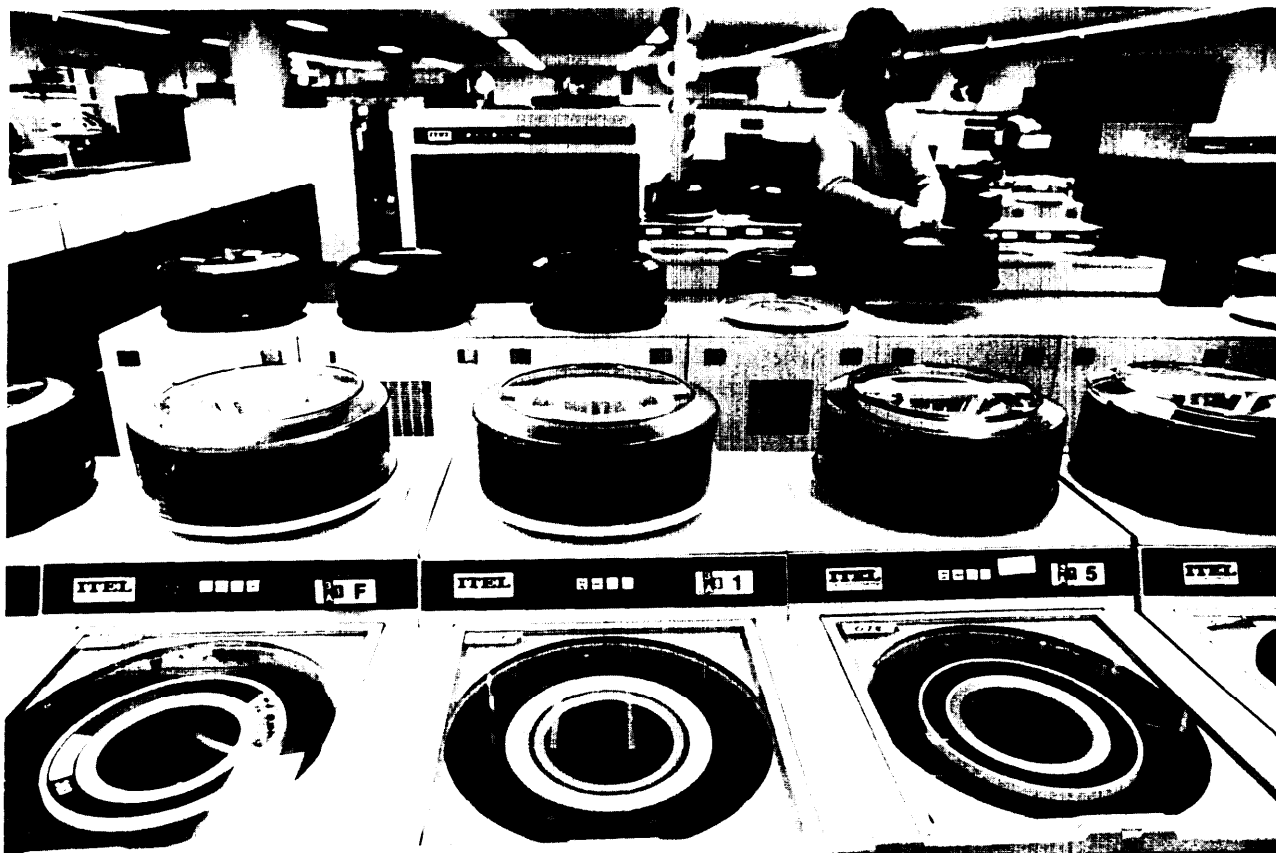


Photo credit: @ Ted Spiegel, 1982

Banks of disk-drive units retrieve and store information at USGS headquarters in Reston, Va.

**Federal Plan.**—A key coordination document, summarizes the plans and needs of agencies acquiring or using water data. It brings these plans together at the level of each of the 21 national regions of the Water Resources Council—the regional plans are then assembled as the basis for the unified Federal Plan. Ongoing field-level review and Interagency Advisory Committee oversight are employed to achieve coordination at local and national levels.

**Catalog of Information on Water Data.**—A computerized file of information about water data activities. Currently, the catalog is divided into four sections: 1) streamflow and stage; 2) quality of surface water; 3) quality of ground water; and 4) aerial

investigations and miscellaneous activities. Special indexes such as the four-volume "Index to Stations in Coastal Areas" have also been published. Another special index currently being prepared covers water data acquisition activities in the major coal provinces of the United States.

**National Water Data Exchange (NAWDEX).**—A national confederation of water-oriented organizations working together to improve access to water data. Developed by a working group of the Interagency Advisory Committee on Water Data, it has a function which the Catalog of Information on Water Data only partially fulfills—that of assisting users of water data in identifying, locating, and acquiring needed data. NAWDEX members are linked so that their several water data holdings may be readily exchanged for maximum use. Coordination and overall management for the

<sup>184</sup> "Plan for Water Data Acquisition by Federal Agencies Through fiscal year 1982, Office of Water Data Coordination, USGS, Department of the Interior, August 1980.

program is provided by a central program office within the Water Resources Division of USGS.

#### Water Resources Scientific Information Center (WRSIC)

An early priority of COWRR was the establishment of a central facility to collect and disseminate information relating to water resource analysis. In response to its recommendations, under the authority of the Water Research and Development Act of 1964, DOI created WRSIC within OWRT (then the Office of Water Resources Research) in 1966.

WRSIC is primarily a management and support unit that funds the compilation of information by other organizations. It does not collect and store published material, nor does it have a staff of abstracters, indexers, and support technicians. It contracts with a variety of governmental and private organizations to collect information under service and funding agreements, and produces publications and computerized records by arrangement with additional government organizations. Its two major information systems have been the *Selected Water Resources Abstracts* (SWRA) and the Water Resources Research in Progress File. Recent budget reduction initiatives have cut WRSIC appropriations from over \$900,000 for fiscal year 1981 to under \$600,000 in fiscal year 1982, and have eliminated WRSIC support for the Research in Progress File.

Material for SWRA is collected primarily by private centers of competence in particular water resource fields, supplemented by additional information from Federal agencies, State water resources research institutes, and a commercial abstracting service. The material is processed at the National Technical Information Service (NTIS), and made available in two forms: a journal, SWRA, published semimonthly, and computerized bibliographic retrieval services available through DOI and private sources. Approximately 15,000 new bibliographic entries are published and added to the system each year. The abstracts system currently holds over 150,000 full bibliographic references. WRSIC also uses the system to produce and publish an extensive topical bibliography series, and the OWRT research reports.

The *Water Resources Research in Progress File Catalog* is an annual compilation of about 2,500 summary

descriptions of new or substantially revised research projects in water resources. Until October 1981, the file was compiled by the Smithsonian Scientific Information Exchange (SSIE) from material voluntarily registered there by Federal and other research organizations. NTIS has recently been given responsibility for compiling the Research in Progress File, and is developing procedures to streamline the compilation process. Since file entries refer to ongoing work, the file reports projects substantially in advance of SWRA, which can reflect only published findings. File information is accessible through computer retrieval systems at NTIS and through the private sector.

Both the Research in Progress File and SWRA contain information about models and modeling activities. However, since they are designed for much broader purposes, abstracts and research projects are referenced originally by subject areas—and are cross-referenced only under the general category, “model studies. It would be extremely difficult for these general bibliographic reference services to adequately address the specialized nature of modeling needs without making substantial changes in their capabilities—such as the ability to store and distribute computer programs.

#### National Technical Information Service

NTIS of the Department of Commerce serves as the primary source for the public sale of Government-sponsored research, development, engineering reports, machine-processable data and related software. It adds approximately 70,000 new reports annually to an information collection of over 1 million titles, of which over two-thirds are computer retrievable. NTIS publishes a number of user-information reports to keep users informed of available material, including a comprehensive biweekly journal summarizing new publications, 26 weekly abstract newsletters, with annual indices, and over 2,000 bibliographies. NTIS analysts are also available to match user requests to available material, using online computerized master files.

In addition, the statutory mission of NTIS includes the collection and sale of data files and computer programs from Federal sources. These are made available to users on magnetic tape, while documentation in the form of user and program-

ing manuals is available in printed copy or on microfiche. Models must already be documented in order to be listed in NTIS files. Computer-based material is primarily indexed under the subject area(s) to which it refers—a retrieval system was developed specifically for locating computer tapes of models, but was poorly suited to this purpose. More recently, NTIS files of computer models have been combined with those of the General Services Administration (GSA) Federal Software Exchange Center (FSEC), as described below.

Following the elimination of SSIE, NTIS has recently been designated to compile the Research in Progress File, the water research portion of which was previously funded by WRSIC. As no funding was allocated to NTIS for compiling the file, the agency can only accept Notifications of Research in Progress for which submitting agencies have provided indexing and other preparatory work for computer retrieval.

Because water resource models constitute only a minute fraction of the entries in the NTIS system, proposals for increasing general NTIS capabilities to locate them and advise potential users about their functions are difficult to justify. As a general-purpose information center that is obligated by law to recover its costs from sales and distribution of product and services, NTIS cannot afford to serve as a modeling resource center. With regard to computer programs, it can be an effective mechanism for the distribution of an already-known model, but its functions are too broad to permit its effective use as a focus of modeling expertise and information.

#### GSA Federal Software Exchange Center

The Brooks Act of 1965 (Public Law 89-306) gives GSA authority to develop governmentwide guidance for automatic data-processing activities. Under this authority, GSA amended the Federal Property Regulations to create a Federal Software Exchange Program in February 1976. To implement the program, GSA created FSEC by inter-agency agreement with NTIS, using funding from the GSA automatic data-processing revolving fund.

The Federal Property Management Regulations require agencies to submit abstracts of computer programs considered usable by other agencies to

FSEC at NTIS. The regulations specify that these computer programs must have been operational for at least 90 days, and require agencies to provide particular forms of documentation with the abstracts. FSEC currently compiles the submitted abstracts into the GSA Software *Exchange Catalog*, and sets prices for Federal, State, and local government agencies wishing to use the listed computer programs. Subscriptions to the catalog are provided for a \$75 annual fee.

No mechanisms exist, however, for enforcing participation in the software exchange program. The determination of which programs are suitable for interagency use rests with each agency, and GSA has authority to do little more than persuade agencies to submit abstracts. Consequently, responses to the program have not met expectations—while GSA and NTIS officials planned for the receipt of up to 7,000 abstracts in fiscal year 1977, the first year of the center's operation, the inventory currently contains only about 1,300 abstracts, a small percentage of the software suitable for exchange.

For a program to be included in the Software *Exchange Catalog*, agencies must submit a tape of the actual program, documentation, and an information sheet specifying basic program characteristics. All software packages are routinely reviewed for completeness, but FSEC staffing levels do not generally permit the evaluation of submitted programs. Consequently, the FSEC inventory consists primarily of general submissions of unknown quality. Only a very small percentage of inventoried programs have been tested and enhanced by GSA, or are considered to be of special significance and known reliability. Moreover, to satisfy agency fears about receiving large numbers of direct inquiries regarding computer programs, software exchange program regulations further specify that the developer of submitted computer programs will not be identified to purchasers without the developer's prior consent.

Providing technical assistance to users has not been included as a major part of the FSEC mission—less than one staff-year of time was budgeted for this purpose for the first year of the center's operation. GSA's policy of recovering the costs of the program through sales of computer software appears to preclude higher levels of assistance. How-

ever, since potential users frequently have no access to developers under the program, many available models will remain unused for lack of the technical guidance required to adjust them to particular user needs. An early GAO report on FSEC activities (1978) summarizes:

The GSA Software Exchange Program, as presently operated, is primarily a catalogue sales operation. In our opinion, many agencies will not buy software from this source because adequate technical assistance is not being provided.

To enhance intra-agency software use, and expand the base for submissions to the FSEC inventory, FSEC has recently begun to offer technical assistance to Federal agencies on a reimbursable basis for establishing internal software inventories, and setting up coordination mechanisms for software development and use. FSEC is also negotiating with various specialized groups to catalogue software in topical categories, geared to specific classes of users.

### ***Existing Support Structures for Agency-Level Modeling Activities***

The majority of Federal agencies that currently use water resource models lack comprehensive strategies for developing, using, and disseminating these tools. Modeling activities and expertise are dispersed throughout most of the agencies surveyed by OTA, with little apparent coordination, communication, or sharing of resources among individual modeling projects. However, two of the major users of water resource models—the Corps of Engineers and USGS—have developed programs that integrate all major phases of modeling activity, and function as a focal point for serving the modeling needs of nonagency users.

The two organizations employ widely divergent approaches for supporting model-related activities. The Hydrologic Engineering Center (HEC) of the Corps of Engineers is a discrete organizational unit that develops and supports *a limited number of carefully selected models* for use in a wide variety of applications. By contrast, *model development is dispersed* throughout the research activities of the Water

Resources Division of USGS. A problem-solving focus is provided by the USGS Federal-State Cooperative Program, which assists State and local agencies in acquiring needed water resource information on a case-by-case basis, using analytical resources throughout the division to develop site-specific models that deal with the particular problem at hand. These two approaches are described in greater detail below to illustrate the major options available for agencywide coordination of modeling activities. In addition, a third organization—the Instream Flow Group of the U.S. Fish and Wildlife Service—is presented to illustrate the potential for advancing model use and modeling capabilities through innovative interdisciplinary, interagency analytical work.

### **Army Corps of Engineers' HEC**

Established in 1964, HEC provides assistance in applying state-of-the-art technology (primarily mathematical models) to current hydrological planning, design, and operation problems. While HEC'S initial purpose was to provide hydrological engineering services to the Corps of Engineers 52 offices, it currently supports the development and implementation of a broad range of water resource analysis and planning techniques. Services are provided extensively to non-Corps of Engineers users—private firms; other Federal, State, and local government organizations; universities; and foreign organizations—which currently account for over 80 percent of HEC model use.

HEC professionals locate, evaluate, and/or develop new procedures and techniques for analyzing water resources; develop and maintain 12 major computer models; teach currently available techniques and model use in formal training courses; and assist Corps of Engineers offices and others in applying models and techniques to current studies. To provide readily accessible user assistance, HEC assigns each of its major models to one or more engineers, who answer user questions over the telephone and handle unforeseen difficulties that may arise.

HEC has evolved a number of basic guidelines to ensure the widest possible use for the models it develops and/or maintains. Models are designed for general use, so that most problems in a field of interest can be solved with the same model, and

<sup>19</sup> *The Federal Software Exchange Program—A Small Step In Improving Computer Program Sharing*, General Accounting Office, January 1978, p. 13.

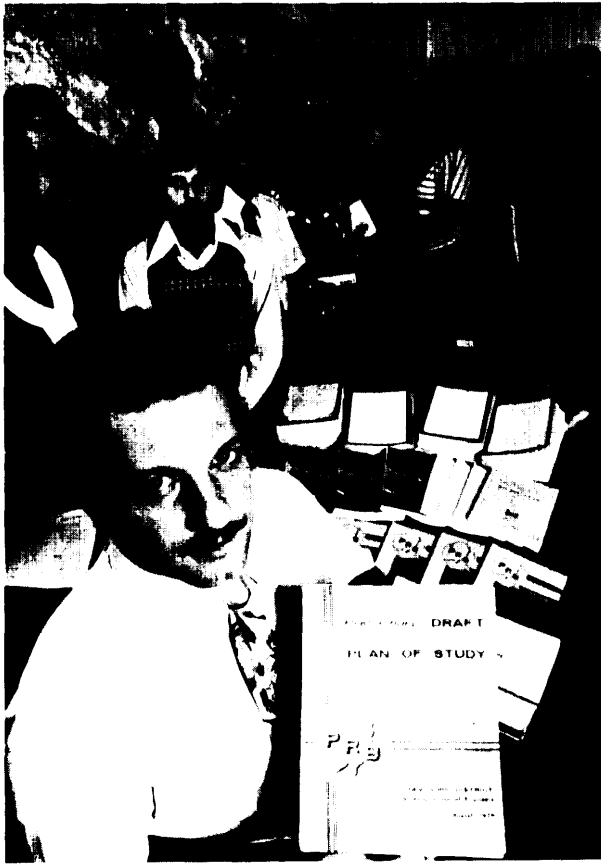


Photo credit: © Ted Spiegel, 1982

Extensive field investigations, analyses, and public participation are part of the planning process for the Army Corps of Engineers' study of the Passaic River Basin. HEC provides analytical support for Corps studies, using a wide variety of modeling and other planning techniques

require little or no program modifications. Commonly accepted techniques are used where possible, and a variety of approaches is provided within an overall modeling package to suit individual needs and preferences. All programs are written in a commonly accepted computer language (FORTRAN IV), and are also designed to be easily transportable to a wide variety of computer types.

The ease with which the model can be used is also an important design criterion. To document models, HEC develops both user's and programmer's manuals. The user's manual is written both to allow the beginner to use the model easily and to permit experienced users to employ the model for complex problems. The procedures for entering data

into the computer are designed for simplicity, and are thoroughly described in the user's manual.

HEC distributes copies of its models and documentation without charge to a variety of users; private firms are charged a nominal fee for reproduction and handling costs. A November 1976 survey showed an annual distribution of approximately 700 model copies, and found that over 2,700 copies of HEC models were still in use by the offices that received them. HEC also publishes newsletters, professional papers, computer program abstracts, and training course notebooks to promote the use of its models.

Training courses are an integral part of the HEC user assistance program. The center provides 24 weeks of training courses annually for Corps of Engineers staff, reserving approximately 10 percent of the space in these courses for non-corps of Engineers personnel. A number of the HEC-developed courses have also been adopted for use by U.S. and Canadian universities. Fifteen of the HEC courses have been videotaped; tapes and instructional material are available for loan, and may be used by visitors to HEC in conjunction with individualized instruction from center staff. Despite these efforts, however, HEC staff acknowledge that insufficient training is currently available to the non-Corps of Engineers user.

#### USGS Water Resources Division

USGS is a service-providing organization charged with collecting data on and analyzing the Nation's physical resources. Its Water Resources Division collects long-term multipurpose data on surface water, ground water, water quality, and water use; performs special interpretive studies of the physical, chemical, and biological characteristics of water; and conducts appraisals for environmental impact evaluation, energy development, coastal zone management, subsurface waste storage, waste utilization, land-use planning, flood plain management, and flood warning systems. Water resource models are used in all phases of the divisions activities, and are an integral part of its analytical capabilities.

The division undertakes a substantial amount of data gathering, resource investigation, and research for general use throughout the Federal Govern-

ment. It also carries out work to meet the analytical needs of other Federal agencies on a cost-reimbursable basis, involving funding transfers of nearly \$30 million in fiscal year 1978. Nearly half the division's budget, however—\$70 million for fiscal year 1978—was involved in activities carried out for the Federal-State Cooperative Program. The program, funded on a 50-50 basis by the division and State and local governments, provides data, information, and analyses to over 600 non-Federal agencies, concentrating on problems whose solutions are of mutual benefit to Federal, State, and local water resource professionals and decisionmakers. More requests for studies and offers of matching funds are received by the division each year than can be undertaken under current funding levels; decisions and negotiations regarding projects are made on a decentralized basis through 47 district offices. Most arrangements for undertaking studies are formalized with a simple one-page standard cooperative agreement.

Research and analytical work for the cooperative program is implemented under USGS direction, principally by Water Resources Division staff. These activities take place primarily at the division's regional centers in Reston, Va., Lakewood, Colo., and Menlo Park, Calif.; at the Gulf Coast Hydroscience Center at Bay St. Louis, Miss.; and occasionally in other sections of the country as needed. The combination of decentralized planning and coordinated interdisciplinary analysis at central locations allows the program both to be responsive to real-world problems and indications of emerging priorities, and to pool manpower and expertise in the relatively small field of hydrology.

When a model is needed to perform a particular analysis, USGS professionals develop one to suit the specific site characteristics under study. Thus, each model developed by the division is an individually tailored, single-use model, though it may often be based in part on a previously developed research prototype or an earlier modeling effort. Models and model-related activity account for between 10 and 12 percent of the Water Resources Division operating budget—from \$12 million to \$15 million was spent on applying models to specific problems, and from \$3 million to \$4 million on research, in fiscal year 1979.



Photo credit: @ Ted Spiegel, 1982

USGS investigations of water problems are often coupled with laboratory research and modeling activities to provide the information necessary for a thorough analysis. Here, a USGS research scientist demonstrates computer-controlled lab equipment used to make calculations for the study **shown in foreground**

One of the keys to the strength of the USGS effort is the reputation for impartiality enjoyed by the division's studies. Many of the projects it undertakes are associated with controversies among conflicting interests. Because the division's analyses are perceived to be relatively free from mission-oriented biases, its results tend to be accepted by all parties to interstate, intrastate, State-local, and international disputes.

USGS also provides extensive hydrological and water resource-related training. Courses are conducted primarily at the USGS National Training Center at Lakewood, Colo., and include a large number of sessions on modeling surface water,

ground water, and water quality. Open to personnel throughout the Federal Government and from State agencies and international organizations, courses are geared toward various levels of professional expertise, some of them designed for administrators, others for technicians and resource specialists. Nationally and often internationally recognized scientists and engineers from the Water Resources Division serve as the main instructional staff for training sessions. Experts from other divisions of USGS, other Government agencies, universities, and private industry also serve as lecturers and special consultants.

#### Cooperative Instream Flow Service Group

The extensive development of water resources in the Western United States over the past 15 years has had major effects on the availability of water for instream uses such as recreation, and fish and wildlife needs. During this period, concern over rapid decreases in instream water availability created broad-based expressions of need for a comprehensive source of information and expertise on standard tools for analyzing instream water needs. Such concern reached major proportions by the mid- 1970's— particularly in the Pacific Northwest, where protection of the anadromous fish resource has been an acute problem for many years.

During the early 1970's, a number of entities engaged in analyzing instream flow problems both from a technical and legal/institutional perspective. The general response of natural resource management agencies, and the U.S. Fish and Wildlife Service in particular, was to organize groups of fisheries or wildlife biologists to make suggestions to the water management community. This approach proved relatively unsuccessful, as resource managers were not inclined to give strong credence to a solely 'biological' perspective. As an alternative, the Office of Biological Services within the Fish and Wildlife Service proposed to develop an interdisciplinary, service-oriented center for instream flow analysis, drawing personnel from numerous Federal and State Government agencies. Funding to create this center—the Cooperative Instream Flow Service Group—was eventually provided through EPA for fiscal years 1976 through 1979. Funding is currently provided directly by DOI.

Potential users of Instream Flow Group (IFG) services identified two major needs: 1) information on biological and hydrological aspects of instream uses; and 2) information on institutional means currently (or potentially) available for ensuring adequate stream flows. Satisfying these needs required the creation of a team of personnel encompassing the biological, physical, and social sciences to gather, collate, and disseminate information on instream uses. Model developers and users were also considered a necessary part of the team effort, in order to create usable mathematical tools for instream analysis. Staffing for IFG was accomplished through the Fish and Wildlife Service, State agency personnel recruited under the Intergovernmental Personnel Act, and detailees from other Federal agencies.

Since its inception, the group has concentrated on transferring information on instream uses via computerized data retrieval systems, library functions, preparing information papers, training, and providing technical assistance on various aspects of stream flow protection. Two of its major analytical efforts have been in developing methods to: 1) analyze the effects of incremental changes in flow on instream uses such as fish and wildlife habitat; and 2) analyze tradeoffs between instream and off-stream uses as part of regional water assessments.

In the first area, IFG has developed the instream flow incremental methodology, an analytic approach to evaluating changes in the fish-carrying capacity of stream reaches. This methodology has been widely adopted for use in Western and Mid-western States. For the second area, work is in progress for a regional reconnaissance method to evaluate general stream characteristics within a water basin. Using the Upper Colorado River Basin as a case example, the group is attempting to develop a unified basin modeling approach as a decision-making tool to determine the cumulative effects of various water management schemes.

The group provides two types of assistance to improve the level of competency among users of its computer-based models. First, it offers an array of training *opportunities* designed to inform participants about the basic issues, develop an overview understanding of solutions to the problem, and finally,

provide instruction in using computer-based models. The group maintains an extensive training program throughout the Western United States on such subjects as western water law, strategies for protecting instream flows, and negotiating instream flows. In addition, the group offers training in the use of modeling technologies. For example, its instream flow field techniques short course and its computer analysis short course are designed to give the user the technical competence required to conduct analyses of instream flow requirements.

Second, IFG provides *technical assistance*. This entails helping users who are engaged in instream flow analysis to develop study plans, make measurements, analyze data, develop and present recommendations, and implement them. Technical assistance also involves assisting State and Federal water administrators in determining areas and opportunities for factoring instream uses into State water plans or land management plans.

IFG officials attribute the group's success to its strong interdisciplinary focus, the quality of its personnel, clear identification of the problems to be addressed, and frequent interaction among staff members and group leaders. The communication engendered among professionals in a number of disciplines is considered a vital prerequisite to devising methodologies, solutions, and recommendations credible to the wide range of interests that are party to water resource management decisions.

### ***Agency-Level Mechanisms for Providing Information on and Access to Existing Models***

A number of mechanisms are currently used in various Federal agencies for making model-related information available to users. Such services may range from simple directories of available models; to user support groups for transferring modeling technologies; to clearinghouses that match user needs to available models, test and evaluate modeling systems, and provide user training. Four major agency efforts are described below: 1) the International Clearinghouse for Groundwater Models (ICGWM); 2) the EPA Stormwater Management Model (SWMM) User's Group; 3) the EPA Center for Water Quality Modeling; and 4) the USDA Land and Water Resources and Economic Model-

ing System (LAWREMS). Each represents a substantially different approach to managing model-related information and improving user access to existing modeling systems, and addresses different kinds of user needs.

#### **International Clearinghouse for Groundwater Models**

Studies begun in 1975 at the Holcomb Research Institute indicated that, while significant progress had been made in developing and using numerical models for ground water-related resource management, major gaps existed between the need for and the existence and actual application of ground water models. Access to existing models, and identifying models designed for specific applications, were observed to be serious problems. The gulf between model developers and model users needed to be closed by developing mechanisms for transferring modeling technology from experienced modelers to others needing these important analytical tools.

Further research work, funded by EPA and the Scientific Committee on Problems of the Environment, developed guidelines for establishing a clearinghouse to assist users of ground water models, and an outline of the primary objectives and services of such a center. ICGWM became operational when EPA funded a 3-year project to staff and fulfill the clearinghouse objectives at the Holcomb Research Institute. The project is intended to test the utility of the clearinghouse approach to technology transfer using ground water models as an example.

The clearinghouse concept is based on the idea that a central information source can greatly reduce the effort normally required to acquire model information. Through the clearinghouse, the potential user can be exposed to all levels of available technologies and can expeditiously determine which is most appropriate for his purposes. Further, a clearinghouse provides a natural setting for testing and evaluating models, and for education in model applications, operations, and theory for nontechnical and technically trained personnel alike.

The first major activity of ICGWM was to develop a ground water model information search and retrieval system. A model annotation form—a detailed checklist containing both general and specific model characteristics—was circulated international-



ly to known model developers, with a request to complete the form by checking off those characteristics that apply to their models. These forms were used to develop a computer-assisted Model Annotation Retrieval System (MARS). As of February 1982, MARS had over 400 unique model annotations—and their number is constantly growing.

To access information, the same model annotation form is distributed to interested model users. The user checks off the desired model characteristics and returns the form to the clearinghouse, where MARS compares it to the stored models and identifies those that meet all or most of the desired characteristics. This retrieval system is designed to avoid the complexities that plague traditional systems controlled by key words. Its success can be gaged by the fact that user requests for model information grew from an average of 6 per week during the first 6 months of operation to 85 per week as of April 1980.

Moreover, developers have begun to recognize the commercial value of having their models included in MARS. Evidence of competition has recently been observed among developers to ensure that their works are available to potential users through the clearinghouse.

The second phase of development at the clearinghouse involves the acquisition, evaluation, and recommendation of available models. ICGWM is currently assembling a selection of functional models that: 1) are available; 2) have been tailored to current key ground water problems; and 3) have been tested for accuracy, usability, and transferability. A screening process is being developed to examine models for validation and performance, and to create documentation guidelines for model software. In the process, close attention will be given to the model user's manual compiled by the model developer.

The other major activity started during the second phase of development is a series of workshops on ground water modeling. The workshops, held annually at the Holcomb Research Institute, are structured in a stepwise fashion, beginning with a general introduction to the applications and limitations of models for policy makers and decision-makers, and progressing toward advanced mathematical theory in later workshops. The last three

sessions are "hands-on" experiences where the attendees vigorously work with computer models and developers. The first series of workshops was conducted with an enrollment of 140; indications are that the workshops have been highly successful in educating water resources professionals about the potential of models. Future plans call for presenting the general session at regular time intervals at regional centers throughout the United States, and the entire workshop series at various international locations.

The third phase of development calls for establishing formal international linkages to the center, and developing financial support to continue the expansion of the clearinghouse. To the latter end, ICGWM plans to undertake technology transfer activities to assist users, operating under an established fee structure for technical consulting work. However, charges for these services, the workshops, and the use of MARS are unlikely to cover the cost of daily operations—outside sources of funding will need to be secured to support clearinghouse activities. ICGWM officials suggest that an appraisal of the cost effectiveness of the center will only be possible once all of its major activities are fully operational. Over time, however, as demands for services grow, the clearinghouse is likely to require less financial assistance from outside sources.

ICGWM officials consider that the clearinghouse has been successful thus far in making ground water modeling information accessible, in reducing the time and effort required for model users to acquire appropriate modeling tools, and in educating interested professionals about the benefits and limitations of models. The clearinghouse approach also appears to hold major potential as an effective medium through which new technologies can be transferred.

#### SWMM User's Group

EPA's SWMM is one of the largest and most comprehensive mathematical models for simulating storm and combined sewer systems, their associated storage and treatment facilities, and their impacts on receiving waters. Its reliability and widespread availability have made SWMM the most widely used model of its type in the United States and Canada, and have been important in increasing the

use of models by engineers and planners. The SWMM User's Group has been instrumental in achieving the widespread dissemination and acceptance enjoyed by this important modeling tool.

Initially developed in the early 1970's, SWMM is a complex, computer-based model that simulates the movement of stormwater through a watershed, determines quantity and quality of runoff, routes this runoff through a combined (or separate) sewer system with specified storage and treatment facilities and operating policies, and thence into receiving waters, where resulting water quality is quantified. SWMM is modular, having five computational blocks—each of which can be used alone or with other blocks.

When the model first became operational, EPA's Office of Research and Development (ORD), which sponsored the development of SWMM, decided to organize an informal user's group as its principal means of technology transfer. ORD recognized that the model's principal users would not be EPA staff, but rather the members of the consulting engineering profession, acting on behalf of EPA, or of State, regional, or local governments, or industrial and commercial clients. These model "clients, who are normally free to select the models to be used, generally base their decision on a model's ease of use, cost effectiveness, and reliability.

To assure that SWMM would be readily usable, ORD devoted substantial attention and resources



Photo credit: @ Ted Spiegel, 19s2

Modern urban development has substantially increased both the complexity of urban runoff management and the need for adequate sewer transport, storage, and treatment of runoff. The Albany, N. Y., skyline provides a dramatic demonstration of the interactions between built-up urban areas and natural water bodies. Models such as EPA's SWMM can be used to assess the impact of Albany's runoff on flows and water quality levels in the Hudson River

to documenting and testing the model before attempting to disseminate it. All or parts of SWMM were tested in five different locations, and the results of the tests included in the original documentation. This, in the judgment of the SWMM developers, was the single most important factor in gaining acceptance for the model.

The first step in creating a technology transfer program for SWMM was to set up a mechanism for distributing the model and its documentation. Working from a small list of interested people, ORD offered to duplicate the model and documentation for anyone who sent in a blank tape. Since 1972, over 300 users have received copies of the program, and perhaps 1,000 copies of the documentation have been sent out. Test data are furnished with the program to allow each recipient to check that the model is operating correctly.

User's Group meetings were seen as the best mechanism for transferring knowledge among experienced model users and those who were new to SWMM. The meeting approach combines instantaneous communication of current knowledge with close interpersonal association and support for model users.

About 20 individuals attended the first SWMM User's Group meeting in early 1973. Since that time, meetings have been held on a semiannual basis, and the group membership has grown to almost 500, including representatives from 19 foreign countries. An informal user's bulletin, first published in 1973, has been sent out periodically, to announce meetings or other items of interest.

User's Group meetings are colloquial and informal in atmosphere, in order to allow a high degree of interaction between individuals with common interests and problems. To encourage group members to examine other models that may be made applicable to their problems, at least one presentation per meeting focuses on the use of a different water quality model. Since 1977, formal User's Group proceedings have been published to record meeting activities.

To maintain and update SWMM, ORD decided on the services of an outside contractor, rather than attempting to use in-house resources. The decision was based in part on the perception that in-house

efforts tend to become self-perpetuating and to stifle creative change. In addition, the group that maintains the model is available to users for over-the-telephone questioning or detailed consulting on a normal fee basis. This supplements the informal free advising network among users, and the availability of User's Group members to consult on a fee basis when needed. EPA has resisted requests to make minor changes in the program. Three updated versions of the model have appeared since the original; users are encouraged to make other local changes that they desire.

Initially, training in the use of the model was sponsored by EPA; since 1976, however, the only available formal training has been offered privately by various universities. The agency's experience has been that, given the support of the User's Group, model users are generally willing to train themselves. In this sense, the User's Group has evolved into an inexpensive alternative to agency-sponsored training programs.

Costs associated with the SWMM User's Group have been relatively low. The group requires about 20 percent of the time of one professional, about 10 percent of one secretary's time, and about \$5,000 per year to cover printing costs for meeting proceedings. Other costs include mailing, newsletter printing, maintaining the User's Group list on a time-sharing computer, and duplicating the SWMM program—all of which consume perhaps \$2,000 to \$3,000 per year at most. Meeting costs are minimal—since no travel expenses or honoraria are paid to speakers—and are covered entirely by registration fees.

#### EPA Center for Water Quality Modeling

ORD established the Center for Water Quality Modeling in 1980 to distribute, maintain, and provide technical assistance in the use of selected EPA-developed water quality models. The center, located at the Environmental Research Laboratory in Athens, Ga., serves as a focal point for assisting users in locating and applying models developed by EPA operating and research programs.

EPA's use of water quality models increased rapidly in the 1970's. Separate model development activities within individual EPA offices resulted in a

proliferation of seemingly different models, although many models were actually modifications and/or extensions of earlier modeling attempts. The lack of a central reference point for model use within the agency impeded the correction of initial modeling errors, so that errors tended to be propagated in successive modeling activities. Additional impetus for creating an office to support and maintain frequently used models came from the growing need to provide expert technical/analytical assistance to States and EPA regional offices. The success of EPA's own SWMM User's Group and the Corps of Engineers' HEC in encouraging widespread model use and acceptance pointed to the large potential benefits to be derived from such an office.

The center's initial support role has been limited to four widely used modeling packages: 1) QUAL-11 (a stream water quality model); 2) SWMM/RECEIV (an urban runoff model); 3) ARM (an agricultural runoff management model) and NPS (a general nonpoint source runoff model); and 4) HSPF (a multipurpose hydrologic simulation program). Center staff provide copies of model documentation and tapes of the models' computer codes to interested users, and relay information about errors or other problems back to the models' developers. Center personnel are currently evaluating a number of models for possible addition to the four packages presently being supported, and are developing a quantitative r-node] selection procedure to assist users.

A number of older EPA models are also on file at the center; however, current manpower limitations do not permit them to be supported or maintained. Computer programs, manuals, reports, etc., for these models are distributed on request on a 'use at your own risk' basis. While the center routinely receives requests for models in this category, it has not checked, corrected or updated them, and functions primarily as an archive in this area.

For its supported model packages, the center assists users by sponsoring intensive 'hands-on' workshops and technical seminars, taught by experts from the Environmental Research Laboratory and representatives of the organizations that developed the model under EPA grants or contracts. Workshops are open to all model users, and the

level of user interest dictates the number of workshops presented. For fiscal year 1980, several workshops were held on the HSPF; two sessions were held on QUAL-11. A newsletter for informing users of training opportunities, advising them of modeling errors or updates, and quickly providing additional model-related information was introduced in September 1980. Superseding and expanding on the SWMM User's Group Newsletter, the new publication has used the audience established by its predecessor as a base for informing users of the center's existence and activities. Current administration policy, however, prohibits the center from publishing the newsletter.

At present, the center's manpower resources are very limited; consequently, it does not offer routine "online" technical assistance to all model users. While limited technical assistance is available on specific agency problems, and can be provided through procedures established prior to the center's inception, even such requests are generally discouraged. To expand the availability of technical assistance in running models, the center concentrates on developing user interaction activities, based on the user group concept, in order to teach users to solve their own problems. Such an approach has in the past proved highly successful in encouraging the use of standardized, widely applicable models. However, inclusion of additional, more specialized models in the center's support role would likely call for the provision of greater levels of technical assistance by center staff.

#### USDA Land and Water Resources and Economic Modeling System (LAWREMS)

A December 1976 request from the Senate Committee on Agriculture, Nutrition, and Forestry for USDA assistance in evaluating the department's land and water conservation programs provided the initial impetus for the creation of LAWREMS. As a followup to its report to the Senate, the USDA Land and Water Conservation Task Force created a modeling team composed of representatives from major USDA agencies, giving it the responsibility to develop an information system about current data and analytical capabilities within the department, and to outline future goals and directions for integrated departmentwide modeling systems.

The LAWREMS team developed a computerized directory of data sets and models related to water and land resource analysis, relying primarily on those created by various USDA agencies. The team also established a file of related documentation and reports, arranged for ongoing computer assistance to facilitate access to and transfer of data and models, and created a small staff to maintain the directory and provide limited technical assistance to users.

The initial LAWREMS directory contained approximately 300 descriptions of models and data sets, each of which included such information as title, agency, an abstract, purpose, keywords, geographic coverage, operational status, name and address of technical contact, and basic technical information. The directory is currently housed within the Resource Systems Program of the Economic Research Service.

While LAWREMS support services include direct access to a limited number of models and data sets within USDA, its primary function is to direct users to the individuals or organizations that have developed these tools. The system is intended to

improve communication among program analysts and researchers about existing data and models, their use, limitations, and linkages. The existence of such a system is also intended to encourage the upkeep, maintenance, and use of existing data files and models. Services are provided primarily to USDA analysts working in the area of resource conservation; however, expanding access to include other USDA personnel, as well as interagency and non-Federal use, has been envisioned as part of future LAWREMS activities.

LAWREMS support staff are responsible for maintaining and updating the directory, and provide some technical assistance to USDA land and water conservation program evaluators and analysts. Provision of “hands-on” training to a limited category of users on selected data and analytic systems is contemplated as part of ongoing staff activities. Staff would also provide assistance in coordinating agency efforts to design new models or modify existing ones, along with identifying data requirements, when information is not available or accessible from existing sources.