Chapter 5
Use of Models by State Governments

Contents

TABLES

FIGURES

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State governments have extensive water management responsibilities, ranging from flood control to prevention of ground water contamination to comprehensive river basin management. These responsibilities have increased in recent years, due in part to Federal environmental legislation that relies on Federal-State partnerships to address a wide variety of national water resource problems. The Clean Water Act, the Resource Conservation and Recovery Act, the Water Resources Planning Act of 1965, and the Safe Drinking Water Act, in particular, assign States numerous additional obligations requiring high levels of technical expertise and highly sophisticated planning and management decisions.

Computer models can significantly aid States in undertaking these added responsibilities. While several States have sophisticated modeling capabilities, many State officials acknowledge that the use and understanding of models by State agencies is far below the level it should be. To gain a better understanding of factors affecting model use at the State level, OTA surveyed professional-level personnel at water resource agencies in all 50 States. This chapter reports the results of that survey, including the kinds of models used, the extent of their use, and the problems encountered by State water resource professionals. It contains:

- summary of survey results;
- procedure used for conducting the OTA State modeling survey;
- trends in current and potential State model use;
- major constraints to model use identified by State personnel; and
- State model use in individual water resource issue areas.

SUMMARY OF SURVEY RESULTS

State water resource professionals generally use computer models developed by others—particularly Federal agencies. The size, budget, and technical capabilities of most State water resource agencies do not permit them to develop models; consequently, State model use depends on having access to federally developed models and on the availability of federally sponsored training and technical assistance.

In many States, model use is primarily restricted to a few well-established, widely available models. State personnel are often poorly informed about the availability of models and data, and about technical assistance available to facilitate model use.

Data inadequacy was the most frequently cited constraint to effective State model use. While most State officials indicated that increased Federal funding for data collection would improve State mocieling efforts, they also emphasized the importance of improving access to Federal (and other State) data bases.

Low salary levels and high turnover rates were also stressed as hindrances to States' efforts to maintain staffs with expertise in modeling. After data needs, States placed highest priority on increased federally sponsored training in model use and applications for both technical and managerial personnel. other major State concerns included the need for Federal sponsorship of simpler models for State-level use, and improving the reliabilit, and credibility of models through Federal coordination, clearinghouse activities, and standard-setting.

PROCEDURE USED IN CONDUCTING THE OTA STATE MODELING SURVEY

OTA surveyed State agencies responsible for the supply and quality of freshwater resources in June 1980 to determine the extent of their current and potential water resource model use. State personnel were asked to identify major problems facing the States in using models and Federal policy options to improve State model use.

The survey was divided into two major sections. The first assessed existing and potential State model use in four major water resource areas: 1) surface water flow and supply; 2) surface water quality; 3) ground water; and 4) economic and social concerns. These areas were further divided into a total of 33 water resource issues. * Model use for each of these issues was assessed for three different decisionmaking functions: 1) operations and management; 2) planning and policy; and 3) other (primarily research). The respondents were also encouraged to provide additional information on the role of models for each of the 33 water resource issues—e. g., the specific regulations for which the model is applied. Detailed results of this portion of the survey are compiled in appendix E.

The second section of the survey posed three broad questions on State model use:

1. Identify the most important needs associated with water resource model development in your State, and suggest options available to the Federal Government to assist your State.
2. Identify the most important problems and needs associated with water resource model maintenance in your State, and suggest options available to the Federal Government to assist your State.
3. Summarize reasons models are or are not used by your State. Consider the reliability and credibility of models, and human/institutional problems. Suggest options available to the Federal Government to assist your State in model use.

Surveys were sent to State agencies responsible for both water quality and water supply concerns in each State. Since these responsibilities often rest with different State agencies, surveys were sent to different agency contacts for water supply and water quality issues. Names of key agency contacts were suggested by the State water resources research institutes.

Six surveys were sent to each State agency contact (two contacts from each State)—a total of612 surveys. Each contact was asked to circulate these surveys among the agency personnel familiar with the use of models in the State for the 33 listed water resource issues. Most of the surveys returned were submitted independently by individual agency personnel; some of the States, however, returned a single response that had been circulated throughout the agency.

All 50 States and the District of Columbia returned completed surveys. However, the number of surveys returned from each State varied from one to six. A total of 103 surveys were returned.

*A discussion of the modeling techniques used to analyze each of the four major resource areas, and a review of the problems and modeling capabilities associated with each of the 33 water resource issues, is presented in (h, 6

TRENDS IN CURRENT AND POTENTIAL STATE MODEL USE

Forty-eight States currently use water resource models. Collectively, the States employ these models to address problems for all 33 identified water resource issues. However, it is clear that most States use only a few of the many models available—primarily those based on well-established modeling techniques like wasteload allocation or ground water supply models.

The majority of States use models for less than 10 resource issues, and 14 States (28 percent) use them for five or fewer resource issues. Only one-fifth of the States use models for more than 15 issues (see table 5 and fig. 7).

In contrast to their current model use, a majority of the States identified potential uses for models in more than 20 of the 33 water resource issues. Nearly one-fourth of the States indicated that they could use models for over 30 issues. These statistics indicate that although models are currently used for a limited range of issues, State offcials see increased model use as important for expanding State roles in water resources management, planning, and policy (see fig. 7).

Large discrepancies between existing and potential model use can be highlighted by ranking each of the 33 resource issues according to the percentage of States indicating current or potential model use. * Table 6 lists the States' top 10 existing and potential water resource modeling uses, and figures 8-11 illustrate the percentages of States indicating current and potential use of models for each of the 33 water resource issues.

These data indicate several trends: surface water flow models are currently the most widely used—5 of the 10 top-ranked resource issues are surface water flow issues. For ground water issues as well, supply and flow models rather than quality models receive the greatest amounts of current use. Three of the top 10 issues, however, are surface water quality issues. One of them, wasteload allocation, is the issue for which the greatest number of States indicated current or potential model use. While most States do not often employ models to assess water quality problems, the few problems that have been studied most—e. g., wasteload allocation and erosion/sedimentat ion—are widely analyzed using models. States tend to be frequent users of flow and supply models, in part because Federal agencies have been active in developing and applying them. The Corps of Engineers and the U.S. Geological Survey (USGS) actively assist States in modeling efforts for flood forecasting and control, drought and low-flow forecasting, streamflow regulation, domestic water supply, ground water supplies and

*These rankings are obtained for each resource issue by totaling the percentage of States using models to address that issue over the three specified decisionmaking functions (operations and management, planning and policy, and research). This combined number better reflects model use for each issue than percentages reported for any one decisionmaking category. A State may use several different models for the same issue—one for planning and policy, one for operations and management, and another for research.

Table 5.—Number of States Indicating Existing or Potential Model Use

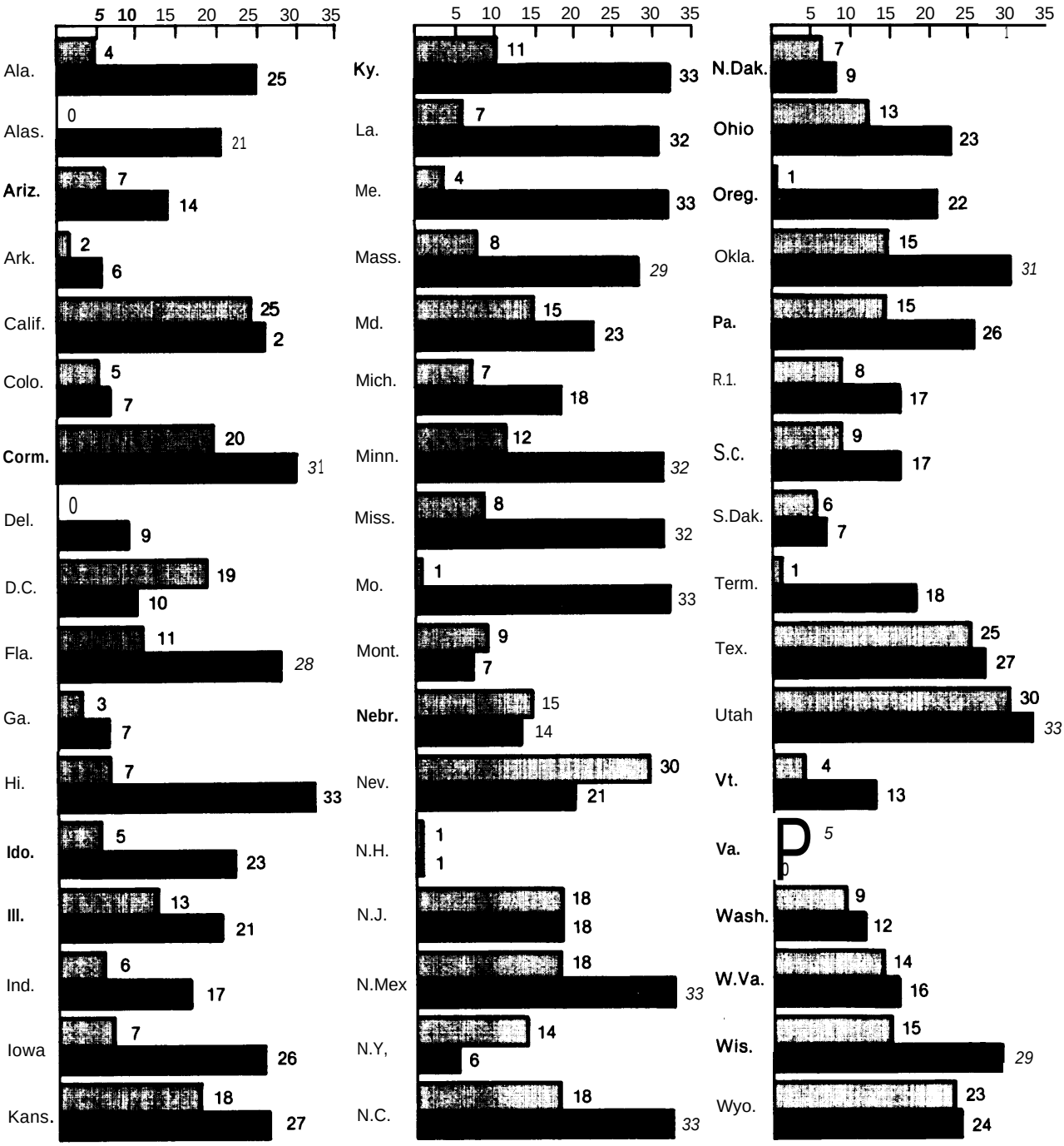
Number of issues	Existing	Potential
0 through 5	14	2
6 through 10	14	
11 through 15	12	8
16 through 20	5	7
21 through 25	3	9
26 through 30	2	8
31 through 33	0	12

SOURCE: Office of Technology Assessment,

Photo credit: Environmental Protection Agency

Water quality concerns, and the models used to analyze them, are increasingly important to State agencies. While only 3 of the States' 10 most important model use areas are currently water quality issues, OTA'S survey of State officials shows that 7 of the 10 top water modeling areas are expected to involve water quality in the future

Figure 7.—Number of Water Resource Issues for Which States Indicated Current or Potential Model Use



The number of water resource issues for which States *currently* use models.

The number of water resource issues for which States could *potentially* use models.

SOURCE: Office of Technology Assessment.

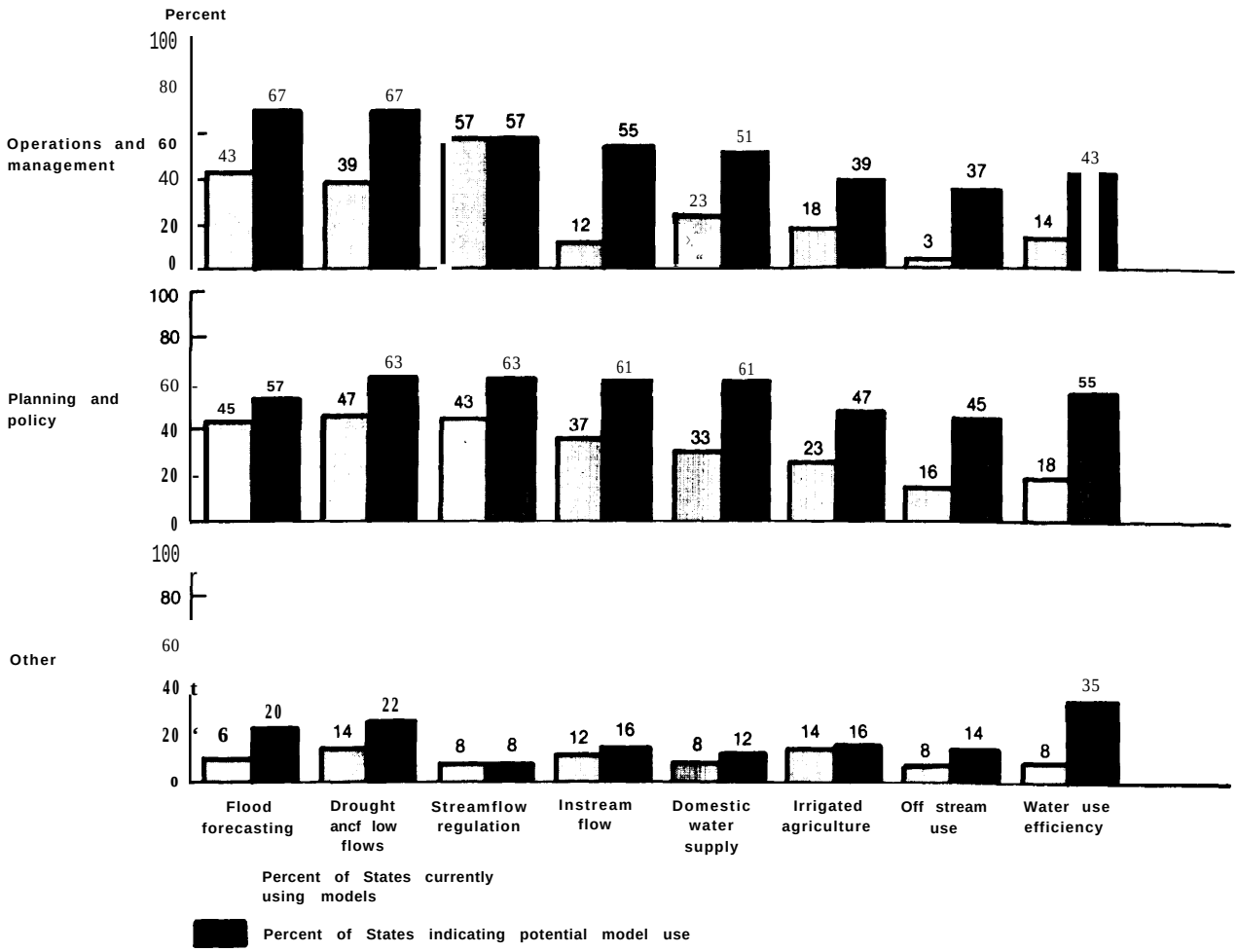
Table 6.—Rankings of State Model Use for Ail Water Resource issues (top ten)

Existing	Potential
• Wasteload allocation	• Wasteload allocation
• Ground water supplies and safe yields	• Conjunctive use
• Streamflow regulation	. Drought and low-flow forecasting
• Drought and low-flow forecasting	• Impacts on aquatic life
• Flood forecasting and control	• Ground water supplies
• Conjunctive use	• Waste disposal—ground water
• Impacts on aquatic life	• Agricultural pollution—ground water
• Erosion/sedimentation	. Urban runoff
• Domestic water supply	• Erosion/sedimentation
. Instream flow	• Accidental contamination of ground water

[a]Tied for fifth place

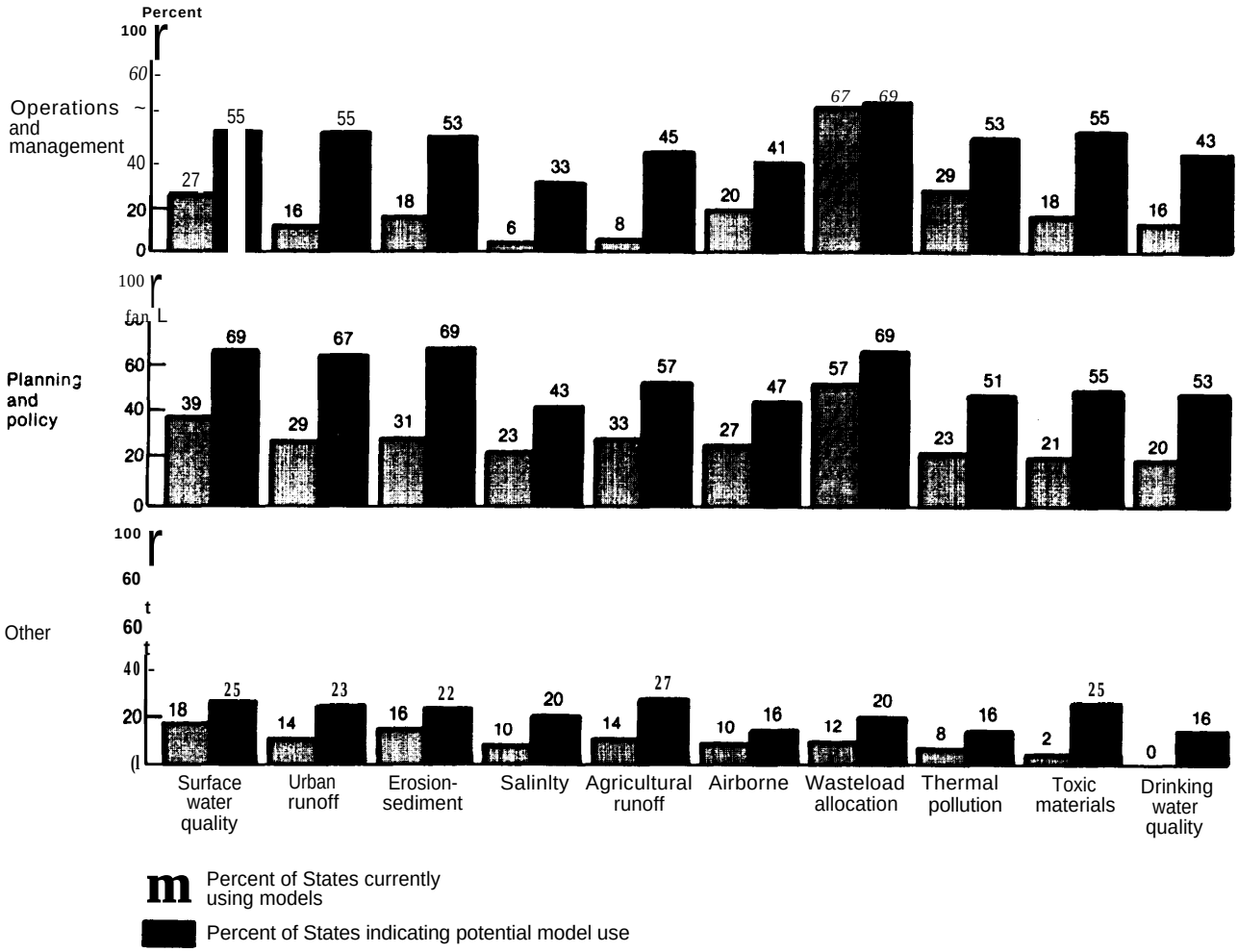
SOURCE: Office of Technology Assessment.

Figure 8.—Surface Water Fiow and Suppiy issues



SOURCE: Office of Technology Assessment.

Figure 9.—Surface Water Quaiity issues



SOURCE: Off Ice of Technology Assessment.

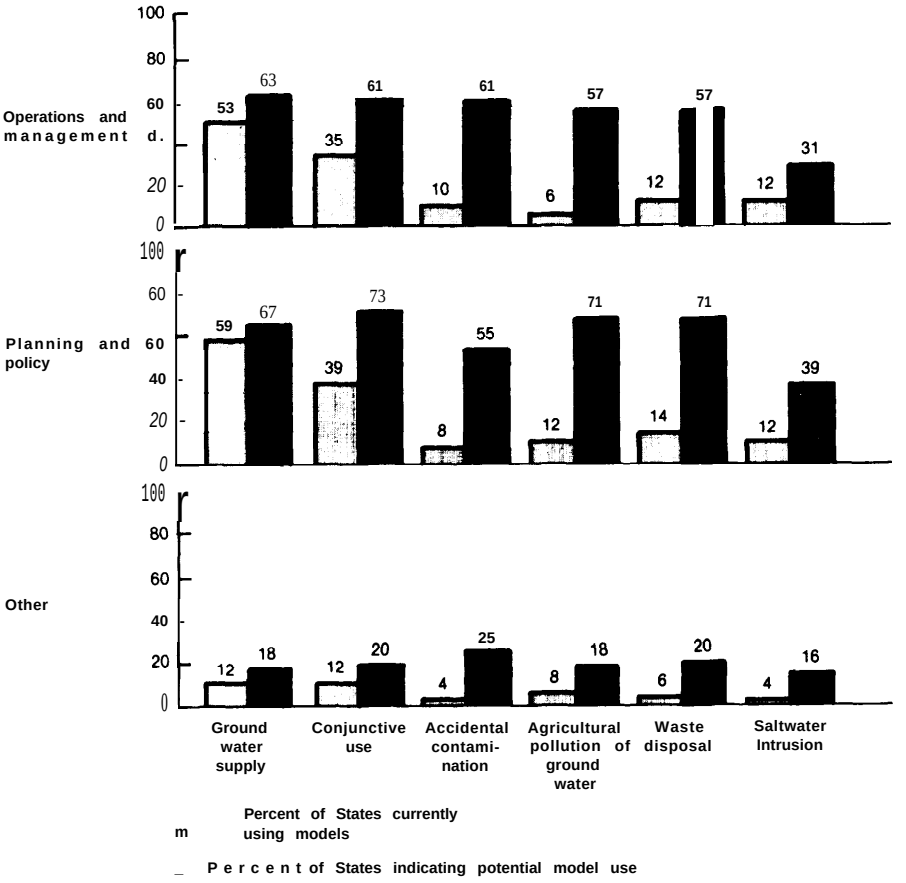
safe yields, and conjunctive use of ground and surface waters.

The characteristics of the top 10 resource issues for potential model use differ significantly from those with the highest current use. Instead of flow and supply, most of the identified problems involve ground and surface water quality concerns—7 out of 10 are quality issues. Ground water issues also stand out among potential model uses; States rank five of the six specified ground water resource issues in the top 10.

One reason for the widespread potential reported for surface water quality models is the extensive responsibilities that States have acquired for meeting national clean water goals. Models have an important role in States' compliance with numerous sections of the Clean Water Act.

Many States stress the need for ground water models because modeling techniques are often the only method of determining the characteristics of major aquifers. However, the lack of ground water data—particularly for pollutant transport within aquifers— severely limits the current use of these models. In general, deficiencies in data and lack of knowledge of physical processes are more serious constraints to the use of ground and surface water quality models than for flow and quantity models.

Figure IO.- Ground Water Issues



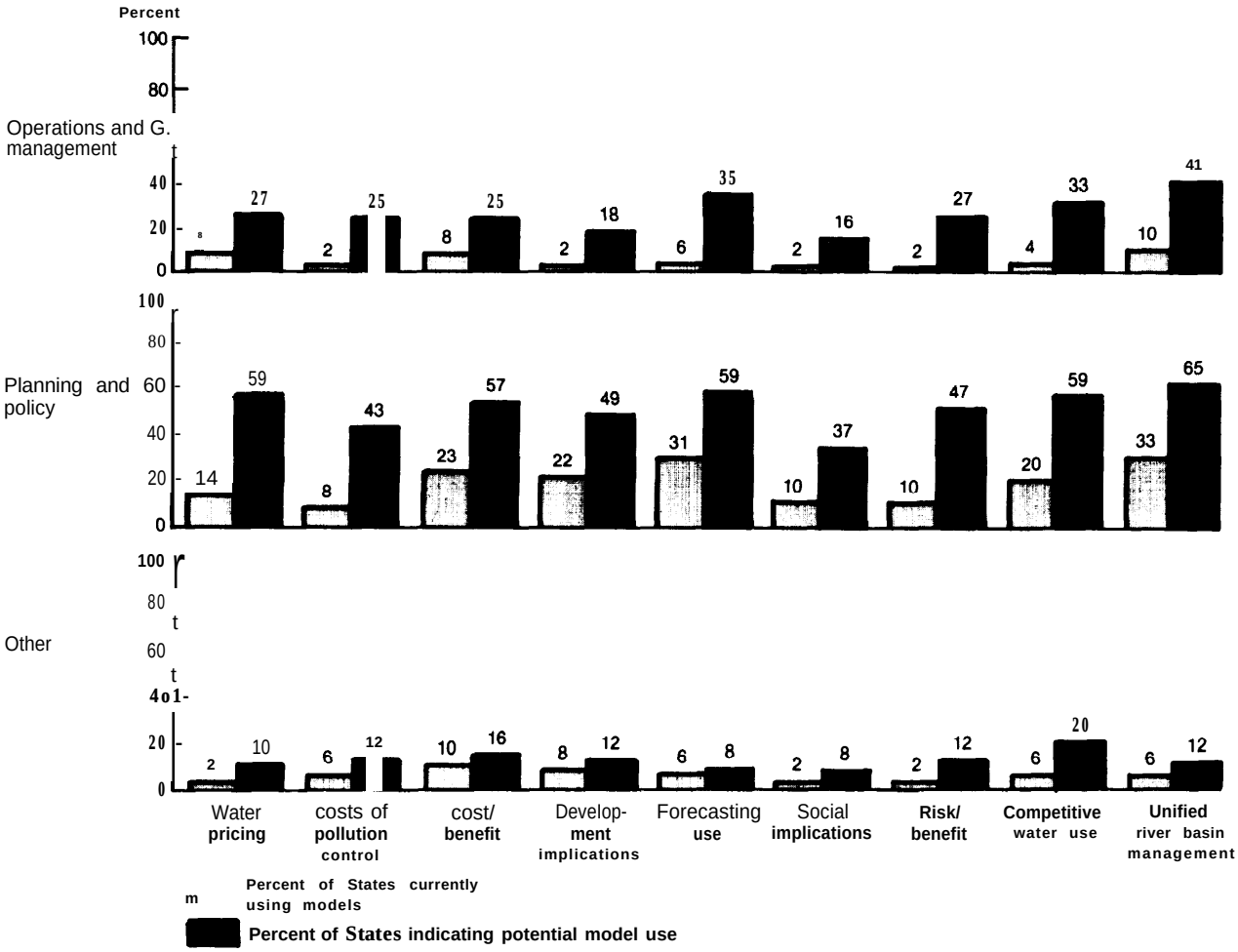
SOURCE: Office of Technology Assessment.

Photo credit: @ Ted Spiegei, 1982

State and local water quality agencies have major responsibility for designing community wastewater treatment facilities to meet Federal requirements under the Clean Water Act. Much of the current use of models—and the perceived need for additional modeling capabilities—at the State level stems from Federal requirements for State action

Large discrepancies between current and potential use for particular issues suggest that State-1evel model use is limited by some technical or institutional factor (inadequate data, lack of qualified personnel, poor reliability of the model itself, etc.). For example, 34 percent of the States currently use drought and low-flow forecasting models for operations and management, while 67 percent of the States indicate potential uses for them. Resource issue-specific assessments of the States' current and potential model use appear in the section of this chapter entitled: "State Model Use in Individual Water Resource Issue Areas.

Figure 11.—Economic and Social Issues



SOURCE: Office of Technology Assessment.

CONSTRAINTS TO MODEL USE

State agencies were asked to identify problems and needs associated with model development, use, and maintenance in their States, and to recommend ways to solve problems and meet State needs. The responses to these questions ranged from general comments, like "inadequate data' or "lack of qualified personnel, to very detailed descriptions of problems with specific models or programs. The following sections highlight trends encountered in the responses, according to nine subject areas: 1) developing models to meet State needs; **2)** data limitations; 3) lack of qualified personnel; **4) access** to Federal models; 5) reliability and credibility of models; 6) model standardization; 7) funding; 8) maintenance; and 9) documentation.

Developing Models To Meet State Needs

Respondents frequently recommended that Federal agencies develop models to meet State needs. Many of the respondents identified a need for sim-

ple models. Comprehensive models with large data requirements are of little use to States lacking the time, resources, or capability to operate them.

According to the survey, many models cannot be applied to local site-specific problems. Models are often designed to simulate an area too large for State purposes.

Data Limitations

The inadequacy of data was the most commonly identified factor inhibiting State modeling efforts. Not only does insufficient data constrain the development and application of models, but the use of unreliable data can produce inaccurate results. For example, one respondent commented on the impact of using unreliable data for planning advanced waste treatment plants (AWT):

> Millions of dollars have been expended for AWT based on models which had an inadequate data base and the resulting treatment levels required may or may not have been beneficial compared to the costs.

Many of the respondents noted that the reliability and credibility of models is only as good as the input data.

The majority of comments concerning data were general, often simply citing "insufficient data' or "lack of data. The specific responses, however, fall into several categories:

- lack of data for specific stages of modeling (i.e., development, calibration, verification, etc.);
- lack of data for specific issues (i. e., ground water supply, nonpoint source pollution);
- outdated and poorly maintained data bases; and
- unreliable or inaccurate data (e. g., data sampled at the wrong time).

Although the States rely on Federal agencies to supply a substantial part of the needed data, they are and expect to be taking the major responsibility for data collection. The major obstacle in meeting the States' data needs is insufficient funding. Along with funding problems, a shortage of manpower was another frequently mentioned factor limiting data collection.

Several respondents suggested that a central, or possibly a "national' data bank was necessary.

The States also identified four other important, though less frequently cited, data problems:

- poor access to Federal/State data banks;
- no data processing (storage and retrieval) capability;
- duplication of State and Federal data collection efforts; and
- intensive data requirements of many models.

Lack of Qualified Personnel

The States have a severe shortage of personnel qualified to develop, use, or maintain models. This limits State modeling efforts in many ways. For example, some States are unable to modify existing Federal models to suit their specific needs. Other States report that their lack of modeling expertise causes an overreliance on contractors to develop and apply models.

Part of the problem is due to the prevailing salary scales for State employees, which make it difficult to attract and retain qualified personnel. However, most States did not propose supplemental Federal funding, but strongly recommended increased technical assistance and training by Federal agencies.

One respondent wrote the following about the need for training in his State:

> The main problem of model implementation in Indiana is training. The Federal Government should provide the States with low-cost, application-oriented training opportunities . . . .

Training was considered a high priority by the respondents, second only to data needs. Specific concerns about training fell under three categories:

- general education for management-level decisionmakers to understand and appreciate models;
- advanced training for technical personnel to develop, use and maintain models; and
- recommendations for specific courses, e.g. , training to use the Environmental) *Protection* Agency's (EPA) Stormwater Management Model.

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Although a few States requested funding for training, the majority of the States currently rely on federally conducted training programs. The workshops and seminars held by the Corps of Engineers' Hydrologic Engineering Center (HEC) and USGS were praised by many respondents. One respondent said:

> There is only a handful of people in this State, including the USGS, who can use this type of model (2 D—ground water flow model). The training courses in Denver (sponsored by USGS) have been invaluable to us.

The States identified a need for technical assistance at all stages of the modeling effort, from development to maintenance, throughout the range of water resource issues. Most comments were general, like ' 'State needs model expertise assistance (Federal) to expedite solutions. " Other States expressed more specific technical assistance problems, e.g., "a lack of technical personnel at regional EPA levels to review and assist the State in model maintenance, or 'a strong technical assistance program in ground water modeling technology is needed to provide the capability to establish flexible predictive mechanisms in ground water contamination cases,

Access to Federal Models

An important modeling problem common to many States is the difficulty of obtaining information on or access to Federal models, data, and technical assistance. The States rely heavily on the Federal Government to supply such services to them; improving access to these services represents perhaps the most easily realizable opportunity for the Federal Government to contribute to State modeling efforts.

A majority of the comments on accessibility centered on the need for information about and access to state-of-the-art Federal models. Generally, States are either unaware of, or unable to obtain, models and data to help them solve specific problems.

A periodic report or newsletter was suggested as a means of informing States about Federal modeling activities. Alternatively, the State water resources research institutes could provide a means of transferring information within each State. A national clearinghouse was also recommended by many respondents as a good method to make models available to the States. These centers would inventory available models and provide descriptions to potential users. The clearinghouse could also provide computer programs and documentation to users. Respondents also suggested that a clearinghouse could serve as a center of technical expertise, model maintenance, and quality control.

Reliability and Credibility of Models

Many of the State respondents pointed out that the reliability and credibility of models strongly influences their use. Part of this influence is due to user perceptions. As one respondent stated, "Past experience with awkward models can impede future development. On the other hand, another respondent wrote, "As we use the one model we have, and gain some experience, the reliability and credibility increase.

State respondents also recognized deficiencies in technically measurable aspects of model reliability, in particular, model calibration and validation. Many respondents mentioned problems with the reliability of specific models—a typical comment was, "current ground water modeling programs are not sufficiently sophisticated to model the complex situation (especially the ground water-surface water interface) in this State.

The following concerns were reported as factors affecting the reliability and credibility of models at the State level:

- the degree of uncertainty in results is not communicated for many models;
- the reliability of many models has not been established through repeated use;
- many model parameters are of questionable accuracy;
- assumed values or calculations are sometimes used in the place of field data;
- the state of the art, in some cases, is not advanced enough to provide reliable models;
- some decisionmakers are cautious about model use due to a past history of inappropriate use; and
- model development has been overemphasized in the past, to the detriment of calibration and validation.

Although comments on model calibration, verification, and validation were not numerous, most of the responses had a common theme: the States have an insufficient amount of time, resources, and data to perform these functions.

Specific comments included:

. some Federal agencies have encouraged the use of some models without adequately calibrating or validating them with field data;
- Federal agencies should devote more attention to parameter estimation and testing model sensitivity; and
. more comprehensive data sampling program is needed for improved validation, and estimates of model accuracy should be developed and provided.

Model Standardization

Various suggestions were given for Federal actions to standardize the modeling process:

- develop standard procedures for model use (e.g., for determining wasteload allocations);
- develop standard procedures for model calibration;
- establish guidelines to govern technical development of models; and
- coordinate Federal data collection efforts to assure standardization and quality control.

When models and model use procedures are not standardized, discrepancies can result if different models are used for the same purpose. One respondent noted that several State and Federal agencies use different models to analyze the same problem—e. g., setting discharge standards. Coordination is needed to avoid conflicting results.

Funding

Many respondents reported that low funding levels limit State modeling efforts. A few States reported that models were not used at all due to low funding. States generally use available funds for adapting existing models (mainly Federal), and have little or no funds available to develop models independently. Several respondents suggested that coordinated Federal-State modeling efforts might improve the cost effectiveness of modeling.

The respondents also reported that funds are needed for:

- computer equipment;
- testing and validating models;
- data collection; and
- personnel and training.

Model Maintenance

From the States' perspective, model maintenance is a minor problem. As most of the models they use are federally built, they rely primarily on Federal agencies to maintain them. States generally seek assurance that Federal agencies will maintain the models they have developed, and will advise States of revisions and modifications.

A few respondents suggested funding States to maintain needed models if Federal agencies are unable to do so. One State cited intermittent funding for model maintenance as a problem. Several respondents recommended seminars as an effective means of informing States of model revisions or modifications.

Documentation

Few respondents reported problems with inadequate model documentation. The few that did typically made a general comment, citing poor documentation as "a barrier to model use.

Specific comments included:

- user's manuals are not written for the average user;
- documentation is not provided for modifications in models; and
- lack of documentation leads to uncertainty about the validity of model results.

STATE MODEL USE IN INDIVIDUAL WATER RESOURCE ISSUES

Surface Water Flow and Supply Issues

Flood Forecasting and Control

Flood forecasting and control models are widely used by State agencies. Most States that indicated a need for flood forecasting models (57 percent of respondents) currently use them for both operations and management decisions (43 percent) and planning and policy (45 percent). Some additional States rely on Federal agency modeling efforts to supply information needs in this area.

Major uses reported for these models include: 1) delineation of flood-prone areas and estimates of potential flood-related damage; 2) evaluation of existing spillway and dam adequacy (under the National Dam Safety Program); and 3) planning/design and operation of flood control facilities. Increased emphasis on nonstructural flood control—e.g., improved flood plain management—in State flood control strategies has made models that delineate flood plains and evaluate the impacts of land-use changes on flooding patterns increasingly important to State efforts. A number of States reported a need for flood forecasting and control models that can analyze small watersheds.

Federally developed models for flood forecasting and control are widely available to the States. Those most frequently mentioned in survey responses were flood control models developed by the Soil Conservation Service and a series of models developed by HEC. The effectiveness of the Corps of Engineers' training program for these models has been a major factor in promoting their use at the State level.

Results from the OTA survey of Federal agencies indicated that model-based information on flood forecasting and control is distributed to State authorities by the National Oceanic and Atmospheric Administration, USGS, and the Federal Emergency Management Agency.

Photo credit: @ Ted Spiegel, 1982

Ruins of an apartment building in Johnstown, Pa., testify to the destructive power of raging floodwaters. State agencies widely use flood forecasting and control models to assess the probable extent of flood inundations and to route flows in ways that minimize actual flood damages

Drought and Low-Flow Forecasting

Slightly fewer than half of the States use models for forecasting droughts and low flows, but many States acknowledged that models could be used more extensively. Forty-seven percent of the respondents saw potential applications in operations and management, and 63 percent in planning and policy—the highest reported for any surface water flow issue area. States in every region of the Nation are concerned with drought and low-flow conditions. While Western States reported use or potential use of these models to allocate water and estimate the capability to meet demands, the significance of flow to water quality and wasteload allocations has expanded the potential use of models throughout the country. Eastern States, in particular, emphasized wasteload allocation in discussing potential applications for low-flow models.

A number of Federal agencies provide appropriate models for State use—respondents identified those of the Corps of Engineers, the National Weather Service, and the Soil Conservation Service. Federal agencies also supply States with model-generated information—several States mentioned USGS in this connection. In addition, the National Weather Service provides low-flow forecasting for the States.

Streamflow Regulation

Models for streamflow regulation are currently used by more than half of the survey respondents; approximately the same percentage of States identified potential uses for these models. The State survey showed greater present use of streamflow regulation models than for any other surface water flow issue. The survey also suggested that these models are now employed by most of the States where officials have identified some use potential.

Respondents identified a broad spectrum of applications for such models, including inter- and intra-State water distribution, reservoir operations and dam safety, low-flow effects on wetlands, waste assiznihtion capacity, flood plain management/ flood insurance, and fishery management below dams.

Offstream Use

In many areas of the country, current streamflows and ground water reserves are insufficient to sustain the large withdrawals required for agricultural, industrial, and domestic uses. Projected growth in offstream demand for mining and general economic development will increase conflicts between instream and water quality requirements on one hand, and offstream withdrawals on the other.

Few States currently use models to analyze offstream uses. Those that do, concentrate on planning and policy for projecting future use. Only one State specifically mentioned planning, managing, and operating offstream facilities as an area presently involving the use of models. However, nearly half of the surveyed State officials indicated potential use for offstream models. Determining the availability of water for hydropower, mining, and industrial uses was considered a future area for model use, particularly in the context of comprehensive resource management. Eastern States as well as Western States were concerned with offstream uses.

Irrigated Agriculture

Increasing conflicts with domestic water supply and instream flow needs necessitate sophisticated planning and monitoring to ensure maximum benefits from irrigation water. State agencies employ models to determine current and future supplies and demands, and to determine optimal irrigation schedules to aid farmers in conserving water. Such models are currently used in about one-fifth of the surveyed States; slightly over twice as many States reported a potential for model use. Potential uses include assessing both quantity and quality of surface water, as well as the effects of irrigation on ground water levels. Future uses for irrigated agriculture models include determining water rights, water demands, and stream diversion.

Domestic Water Supply

Domestic water supplies have not kept pace with growing demands. In many localities, supply, treatment, and distribution systems are inadequate, resulting in shortages and reduced water quaiity. Comprehensive management for conservation, and

multiple-objective planning, will become increasingly necessary as further growth occurs in watersport areas.

Current use of models by States focuses on projecting present and future supplies and demands, and designing supply systems to meet futur~ demands. Slightly under one-third of those surveyed use water supply models. Approximately twice as many indicated potential for model use, primarily for assessing the relationship between water supplies and water quality requirements. A few States indicated a need for models to analyze the efficiency of existing distribution systems.

Instream Flow Needs

Models for assessing instream flow needs serve a variety of purposes at the State level. Their use in planning and policy to meet instream flow needs for fisheries, recreation, and hydropower was reported by 37 percent of the States—an additional 24 percent indicated the potential for such use. Fifty-five percent of the States acknowledged a potential need for operations and management models, although only 12 percent currently use such models.

Instream flow models are becoming increasingly important as tools for setting minimum instream flow requirements. The models have further application for meeting water quality standards and allocating water. A few States cited data limitations as constraints to current use. Assistance in using these models is supplied by the Fish and Wildlife Service's 1nstream Flow Group, the Corps of Engineers, and USGS.

Water Use Efficiency and Conservation

Little is currently known about the extent to which demands for water could be reduced through the use of conservation techniques or improved management and planning. However, potential benefits in reduced expenditures for supply, treatment, and distribution systems were sufficient for one-fourth of the States to indicate a potential use for models in researching these problems. This represents the greatest State interest in models for research purposes among all surf'ace water resource issues.

Under 20 percent of the States surveyed currently use models in this area, although close to half indicated potential uses for such models. State use focuses on models for predicting demand, and basic water accounting models similar to those used in determining available supplies for agricultural, domestic, and other offstream and instream uses. Greater existing and potential use was reported for planning and policy purposes than for operations and management.

Surface Water Quality Issues

Urban Runoff

State officials reported high potential for model use to determine water quality problems stemmin,q from urban runoff, despite low levels of current use: Two-thirds of the States saw continuing or possible future uses for such models in planning and policy analyses, and 55 percent envisioned uses for operations and management decisions. Several States suggested that the credibility of existing models has limited their use.

The comprehensive planning provisions of section 208 of the Clean Water Act figure largely in State reports of existing and potential uses for urban runoff models. Models are currently used to develop control measures; to plan, construct, and maintain storm overflow facilities; and to research and predict local urban runoff problems. Problems of site-specific adaptability and excessive complexity in current models were mentioned by a number of respondents. Respondents indicated that simple models for site-specific calculations could increase model use in this area, even though such models may not be suitable for complex runoff problems.

Erosion/Sedimentation

A number of States indicated the need for improved erosion/sedimentation models as a priority in water resource management. Of the State respondents, 53 and 69 percent saw potential uses for these models in operations/management and planning/policy, respectively—approximately 2 times the current level of use.

Many States reported current and potential model use under section 208 of the Clean Water Act.

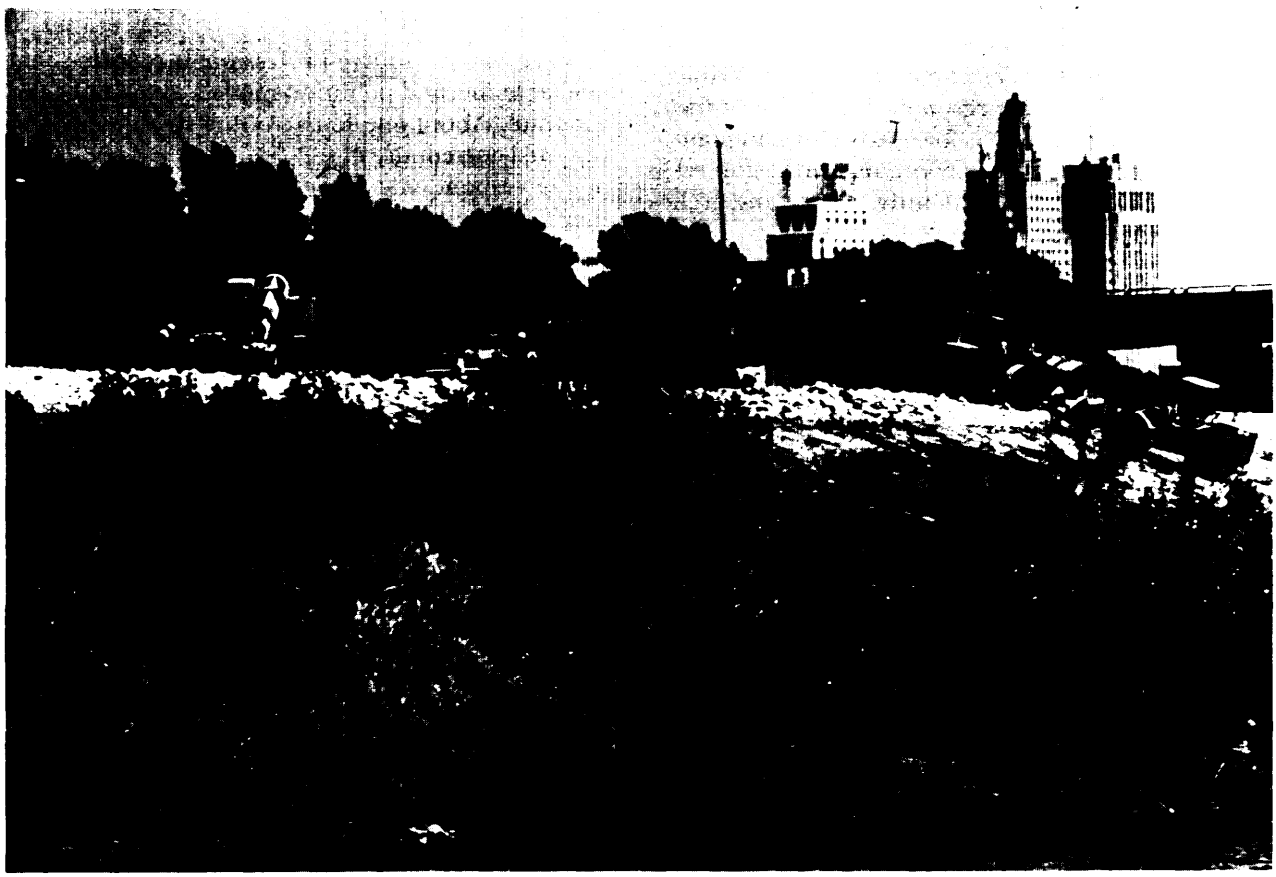


Photo credit: © Ted Spiegel, 1982

Earthmoving equipment near a riverbank in Kansas City, Mo., alters the land's contours to minimize the erosive effects of runoff from nearby highways and other urban sources

USGS and the Soil Conservation Service were repeatedly cited as providing models or working jointly with States to determine erosion and sedimentation effects.

State officials reported a wide variety of potential uses for erosion/sedimentation models; among these are evaluating erosion control measures, determining canal and reservoir sedimentation rates, evaluating irrigated and nonirrigated agricultural land uses, and planning for urban development.

Salinity

Salinity models do not appear to have a high priority in State-level water resource management. Less than half the State respondents identified potential uses for such models, and only 6 percent currently use them for operations and management decisions. Potential uses include: 1) determining the ecological benefits of salinity reduction; 2) implementing State ground water laws; 3) monitoring effects of pesticides and residuals; and 4) monitoring inland streams receiving brines from saltwater sources.

Agricultural Runoff

One-third of the States currently use agricultural runoff models for planning and policy, and nearly double that figure-57 percent—anticipate potential uses. A number of States use models in connection with section 208 of the Clean Water Act; others specified future uses in planning and regulation of animal wastes as well as in developing and implementing fertilizer and pesticide management plans.

Concern over the effects of agricultural runoff is reflected in actual and potential model use reported by States for research in this area. While only 8 percent of State respondents presently use agricultural runoff models for operations and management decisions, 14 percent use them for research, and 27 percent identify future research potential for such models.

Airborne Pollution

Several of the comments indicated that some respondents misinterpreted this question. These respondents may have identified model use for State air pollution control, rather than for the specific purpose of determining the effects of airborne pollution on water quality. However, two States identified potential use of models for acid rain abatement.

Wasteload Allocation

States use models extensively for determining wasteload allocations. Two-thirds of the State respondents indicated present use for operations and management decisions, and 57 percent reported current use in planning and policymaking—more than for any other water resource-related purpose. Survey responses suggested that the relatively long history of model use in this area has made these models widely available to States. Most States that recognize potential uses for these models are presently using them. The ubiquity of wasteload allocation problems, and the expanded State role in water pollution control, has contributed to widespread wasteload allocation model use. Model use was specifically mentioned for implementation of sections 201, 208, 303, and 402 of the Clean Water Act.

Many States, however, stated that these models need refinement. Further validation of reaction rates and other necessary parameters, standardization of models for different geographic regions of the country, and evaluations of the magnitudes of error in predictions, were among the improvements suggested. Several States also identified the need for standard wasteload allocation models for the following purposes: evaluating the effects of discharges into nontypical streams (swamps, estuaries, and intermittent streams), designing standard waste treatment facilities, and determining the need for advanced waste treatment.

Thermal Pollution

State water resource professionals reported that available thermal pollution models are simple and accurate. About one-fourth of the surveyed States reported current use of such models, and about half of the respondents recognized potential uses for them. A number of States noted that all necessary thermal modeling under section 316(B) of the Clean Water Act is performed by power-generating or other industries, and is merely reviewed at the State level. Others cited the Corps of Engineers, EPA, and USGS as providing thermal modeling services for States or in conjunction with State efforts.

Toxic Chemicals

Many States identified the development of models to deal with toxicants as a top priority, with significant potential for future applications. As with other recently recognized problems, about one-fourth of responding States identified a need for such models in research, although few of the respondents currently use them for any purpose. Potential uses, both for operations/management and policy/planning, were identified by 55 percent of the surveyed officials.

Respondents indicated that models are needed for determining sources of toxicants, toxicant transport and removal mechanisms, and for setting toxic chemical effluent standards. Some States identified data availability as a limiting factor in modeling.

Drinking Water Quality

About half the States reported potential uses for drinking water quality-related models, primarily to assist in setting standards required under the Safe Drinking Water Act. States also noted uses for improved models in determining the effects of wastewater discharges on drinking water quality, as well as for specific problems such as the effects of mining and low flows. A small number of States indicated that these models were of high priority; fewer than one-fifth of the States indicated that they are currently used.

Water Quality Impacts on Aquatic Life

Several States stressed the need for further research and improved modeling techniques to gage

the effects of changes in water quality on aquatic life. Credibility problems of current eutrophication models were specifically mentioned. Survey comments suggested that improvements to aquatic life impact models are of major concern to respondents throughout the country.

Sixty-nine percent of surveyed State officials identified potential application for these models in planning and policymaking; 55 percent identified future operations and management uses—in both cases about twice the existing level of use. Officials identified a variety of uses for aquatic life impact models, including evaluating permit applications, pollution control program planning, and comprehensive basin planning.

Ground Water Issues

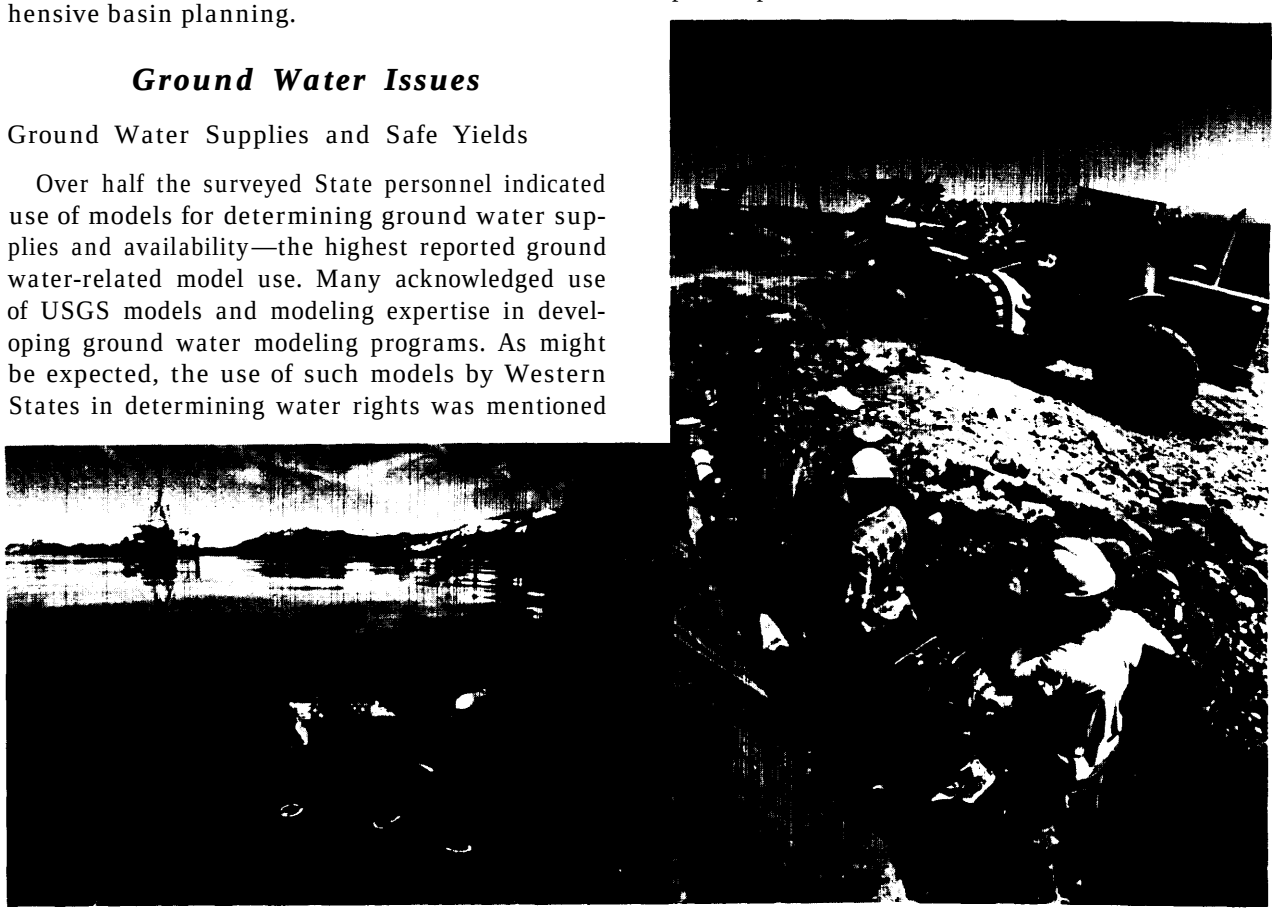
Ground Water Supplies and Safe Yields

Over half the surveyed State personnel indicated use of models for determining ground water supplies and availability—the highest reported ground water-related model use. Many acknowledged use of USGS models and modeling expertise in developing ground water modeling programs. As might be expected, the use of such models by Western States in determining water rights was mentioned frequently; however, ground water supply model use was equally evident for Eastern States.

Ground water supply models are presently employed by most of the States that reported some use potential; however, many States place a high priority on improving these models. The lack of historical aquifer performance data and the extensive current data requirements of ground water models were repeatedly cited as hindering State modeling efforts.

Conjunctive Use of Ground and Surface Water

A higher percentage of survey respondents reported potential uses for models of the interaction



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Lake Tahoe, Nev., has long been billed as one of the world's clearest bodies of water. Rapid development along shorelines, however, has greatly increased the flow of nutrients into the lake, accelerating natura{ eutrophication rates, creating nuisance algal growths, and endangering Tahoe's ecological balance. Models have been used both to assess the effects of development and to evaluate the effectiveness of centralized sewage treatment in preventing the eutrophication process. In underwater labs above, University of California biologists and hydrological scientists use radioactive trace elements to monitor nutrient levels in the water. Meanwhile, crews build sewage transport facilities to divert wastes around Lake Tahoe for treatment and release in less sensitive areas

between ground water and surface water than for any other ground water-related issue. Such models are valuable for developing comprehensive basin plans and for comprehensive water supply management. Over 35 percent of the surveyed States currently employ conjunctive use models—after supply and safe-yield models, they are the most extensively used model for ground water management. Some States reported using models developed by USGS; a number of others observed that the lack of field data constitutes a bottleneck to using these models.

Accidental Contamination of Ground Water

Although over half the States indicated potential for future use of models that predict the spread of contaminants in ground water, fewer than 10 percent currently employ them. Gaps in current knowledge about the behavior of contaminants in some types of ground water systems and data limitations upon the construction and validation of such models hinder more widespread use. Survey respondents envisioned such future applications as determining effects of various pollutants and requirements for control measures, devising warning systems for the public, and predicting longer term contamination.

Agricultural Pollution to Ground Water

Determining the effects of agricultural pollutants on ground water is also a modeling area where reported potential for State-level use is high, although a low percentage of States currently use models. Seventy-one percent of the surveyed State officials saw potential uses for such models in planning and policymaking, and 57 percent envisioned operations and management uses—current uses amount to less than one-sixth of these potential use levels. The officials specified potential uses for these models in section 208 planning, determining effects of various contaminants and corrective measures, planning allowable point source pollutant loads, and supplemental monitoring for regulatory purposes. A number of States indicated that data on pollutant movement is a limiting factor in model development and use.

Ground Water Pollution From Waste Disposal

Survey respondents indicated that lack of data and poor understanding of ground water chemistry are primary limitations on States' abilities to model the spread and effects of pollutants to ground water from waste disposal sites. Limited understanding of the reactions and diffusion of pollutants in mixed geological formations, and deficiencies of data for validation purposes, were cited as specific problems. While potential uses were reported by a high proportion of State officials-71 percent for planning and policymaking, 59 percent for operations and management decisions—these models are currently used by only one-fifth as many States. Anticipated uses include determining infiltration from sanitary landfills and mine waste disposal.

Saltwater Intrusion

Several States indicated that models for determining saltwater intrusion to ground water supplies are water resource management priorities; however, interest is naturally limited to coastal areas and States with major inland saltwater bodies.

The acquisition of sufficient data to verify such models was repeatedly cited as a significant need. State officials envisioned several management uses for these models, in particular establishing recharge areas, as well as determining acceptable pumping rates and designing well fields.

Economic and Social Issues

Effects of Pricing on Use

Models that evaluate the effects of pricing on water use were seen as having potential planning and policymaking uses by 59 percent of the State survey respondents. Respondents referred to comprehensive planning efforts under title III of the Water Resources Planning Act and section 201 facilities planning under the Clean Water Act as areas in which models are needed. Some States suggested that current models are not precise evaluation tools, and that their importance may be limited to places where strict conservation and reuse laws apply. Models are currently used by a small proportion of surveyed States, primarily in planning and research.

Costs of Pollution Control

Slightly fewer States indicated a need for models to evaluate pollution control costs than for most other types of social and economic modeling. Su~-

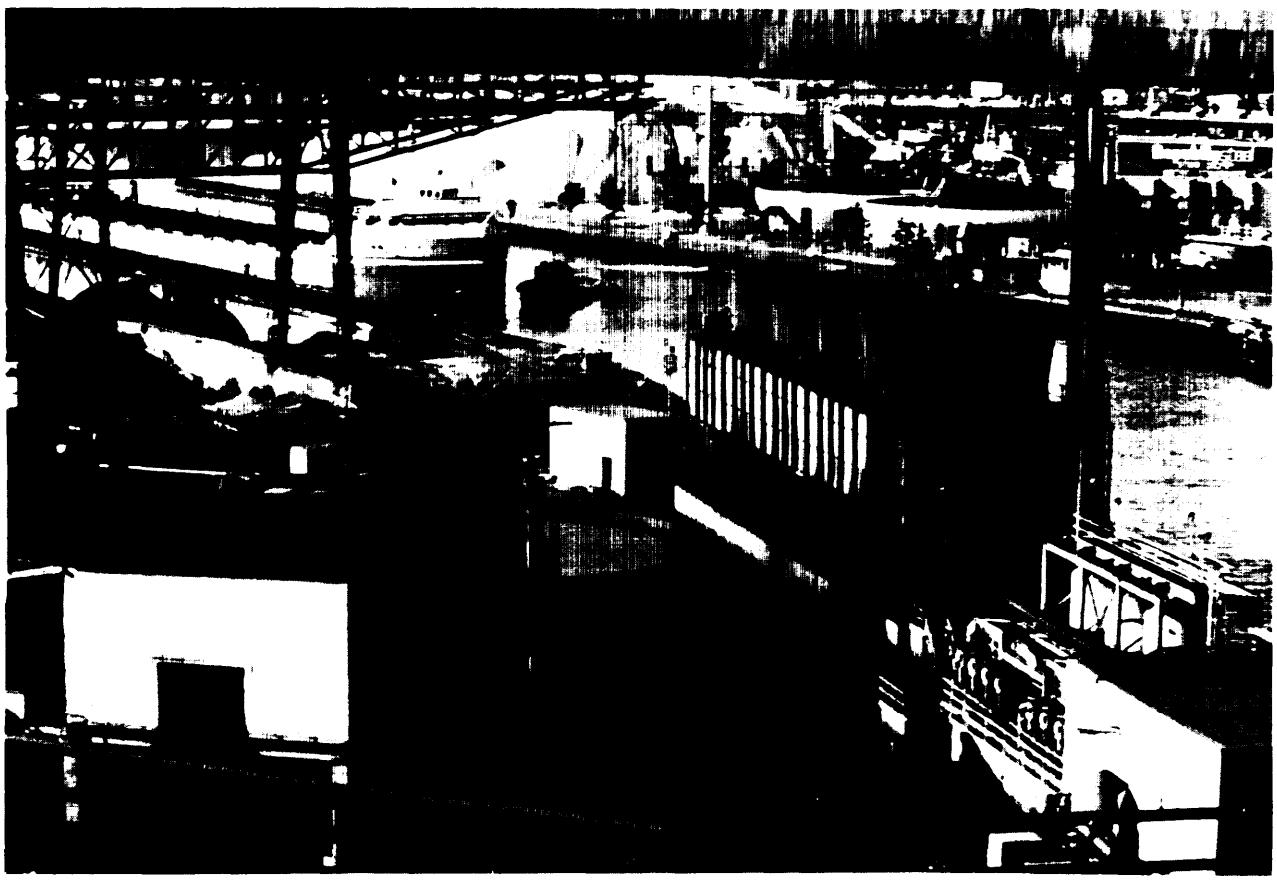
gested potential uses include assessing the effects of alternative waste treatment strategies on firm behavior, and determining the impacts of pollution control costs on individual industries. At present, such models are used in only a few States.

Cost/Benefit Analysis

Use of cost/benefit analysis models for planning and policymaking was envisioned by over half the State officials; 23 percent of those surveyed currently use such models for planning. Some current users noted, however, that models evaluating the cost effectiveness of alternative actions are more applicable than cost/benefit models. Several respondents consider the cost/benefit concept too subjective to be adequately modeled. A number of States indicated that improved models for cost/benefit analysis would be highly desirable, and one respondent specified a need for a combined hydrologic/economic model for cost/benefit studies.

Regional Economic Development Implications

Models for evaluating economic implications of water resources development and policy are used by States in the context of planning efforts under section 208 of the Clean Water Act and title III of the Water Resources Planning Act. Slightly fewer than one-half of the surveyed State personnel predicted future uses for these models; 22 percent indicated current planning uses. Officials mentioned



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such specific uses as predicting population and economic growth in water-short areas, comprehensive river basin planning, and determining the effects of ground water depletion.

Forecasting Water Use

Forecasting water use with models was considered possible at the State level by 59 percent of survey respondents; 31 percent currently use such models for planning and policy purposes. Some States doubt the reliability of these models in their current forms, and suggested that existing data are inadequate to justify sophisticated model forecasting. A variety of applications are projected for improved models; ensuring that water quality standards are not violated due to overallocation of supplies, and evaluating existing laws regulating ground and surface water use were repeatedly mentioned, as well as simple projections of future demand.

Social Impact

Relatively few States indicated a need or potential use for social impact models. While one State official suggested development of a general model that could be calibrated to local conditions, little State-level interest in such models was expressed, and some respondents questioned their reliability.

Risk/Benefit Analysis

State officials reported a variety of potential uses for risk/benefit analysis models, including dam safety analysis, flood management, and toxic waste management. Slightly fewer than half foresaw future planning and policy uses for these models in their States; 10 percent currently employ them.

Competitive Water Use

Fifty-nine percent of the surveyed officials indicated the possibility of future planning and policy-making applications for models of competitive water use; one-fifth reported that such models are currently used by their States. A few States reported that these models are a high priority for analytical work. Reported potential applications include: basinwide water supply planning, water rights determinations, and the evaluation of conflicts between water supply and water quality objectives.

Unified River Basin Management

Models for unified river basin management are currently used by a greater percentage of States than any other socioeconomic model: one-third of the survey respondents indicated that such models are currently employed for planning and policy-making, and nearly twice as many foresaw future use potential. State-level personnel mentioned such uses for these models as regional water supply planning, integrating water quality considerations with basin development, planning studies to evaluate different management options, and planning and control of development.