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**WATER SCIENCE AND TECHNOLOGY BOARD
ANNUAL REPORT 1989**

Water Science and Technology Board
National Research Council

Washington, D.C. 1990

MASTER

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The Water Science and Technology Board is a unit of the National Research Council, which serves as an independent adviser to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine, brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees. The Board's objective is to improve the scientific and technological basis for resolving important questions and issues associated with the efficient management and use of water resources.

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This issue is dedicated to
Dr. Abel Wolman
1892-1989.

Engineer, Scientist, Educator,
and Advocate for Public Health
through Improved Water Supply and Sanitation.

DR. ABEL WOLMAN was born in Baltimore, Maryland, June 10, 1892, the fourth of six children of Polish immigrants. He received the Bachelor of Arts degree from Johns Hopkins University in 1913 and hoped to become a physician. Instead, his family persuaded him to enroll in the newly opened Johns Hopkins School of Engineering where he received his Bachelor of Science in Engineering with the first graduating class in 1915. His professional career had already started; he had been collecting water samples on the Potomac River for the U.S. Public Health Service in 1912. After a year he joined the Maryland Department of Health, beginning an association which lasted until 1939.

While employed with the state Department of Health, he performed some of his most distinguished scientific research in water purification. During this period in the city of Baltimore, the city's water supply sources were highly variable and of questionable quality. The Wolman family actually practiced water purification by tying a piece of cheesecloth around the water spigot in their home to filter out stones and dirt. Outbreaks of waterborne disease struck Baltimore and other American cities with alarming regularity.

Dr. Wolman and the late Linn Enslow, a chemist and former Johns Hopkins classmate, made a leap forward in public health science when they developed a method 70 years ago of making drinking water safe by putting measured amounts of chlorine in it, a procedure so common today that people either take it for granted or are simply unaware of the practice.

Dr. Wolman's capacity and enthusiasm for life and his work touched all who knew him. A member of the first delegation to the World Health Organization (WHO), he worked on water supply, wastewater and water resources throughout the world with WHO and the Pan American Organization. He advised international leaders on ways to bring a healthful water supply to their peoples, and became probably the best known consultant on water and public health in the world. Wolman chaired the committee that planned the water system for the then new state of Israel, and he helped Latin American nations to develop ways to finance their water systems. Dr. Wolman was professionally active until the time of his death on February 22, 1989.

Abel Wolman was truly a person who transcended all political and social boundaries with his caring and knowledge to make the world a healthier and safer place in which to live. A member of both the National Academy of Engineering and the National Academy of Sciences, Dr. Wolman had a long association with the Water Science and Technology Board as a friend and advisor. In memory of Dr. Wolman, The Water Science and Technology Board has initiated the Abel Wolman Distinguished Lecture Series. The first lecture, "Ethos, Equity, and the Water Resource," was delivered on February 15, 1990 by Dr. Luna B. Leopold, Professor Emeritus, University of California, Berkeley.

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Message From The Chairman

Michael C. Kavanaugh

In the July 15, 1989 issue of *THE ECONOMIST*, the editorial writers hypothesized that over the next 40 years, world leaders will be as preoccupied with the environment as they were with defense issues in the previous 40 years. Thus, some of the world's political leaders have apparently accepted what many in the scientific community have long realized, that proper management of the environment is essential for survival on the planet. Certainly one of the major environmental issues facing the United States and the world is proper management of our water resources, a formidable task that reflects many of the conflicts inherent in the word "management."

It is in this context that the activities and achievements of the Water Science and Technology Board over the past 7 years should be considered. Since its inception in 1982, the Board has produced over 50 publications addressing a wide range of complex issues, with over 400 professionals contributing their time and energy in committee work. In the past year alone, the Board has completed, initiated, or continued 14 activities ranging from government program reviews to the publication through the National Academy Press of major reports with widespread interest.*

The diversity of activities undertaken by the Board, in response to requests of federal, state and local agencies, foundations, and other institutions concerned about water resources management, is mirrored by

the makeup of the Board itself. As you will read in the pages that follow, the Board draws on experts from the varied scientific, technical, legal, and institutional perspectives involved in resolving water resource management conflicts. Its overall mission, as defined in the charter of the National Research Council, is to advise the federal government on scientific and technical issues related to water resource management in its broadest sense. The Board offers a unique forum that can provide a balanced, objective, and critical review of the actions of the federal government and other institutions as they affect the nation's water resources.

This annual report provides a glimpse into the workings of the Board, including both current and past activities. What you will find makes interesting reading. The Board has shown a willingness to take on some tough problems, and to provide unique and global perspectives on resolving some of these problems. A number of recurring issues can be seen and it is instructive to extract some of these to best illustrate what the Board does.

One theme is the compatibility of science and public policy, illustrated in both the Board's fifth colloquium concerning remediation of contaminated soil and ground water and in a new and challenging undertaking to evaluate urban coastal wastewater management issues. Committees on Western Water Management Change and Irrigation-Induced Water Quality Problems address the

*Examples: Irrigation-Induced Water Quality Problems, Managing Coastal Erosion, and Ground Water Models: Scientific and Regulatory Applications.

thorny issue of equity in water resources allocations. The Board provides a unique retrospective evaluation of regulatory strategies and risk management decisions through several committees, including the Committee on Coastal Erosion Zone Management and on hazardous waste and flood management. A number of the Board's committees have addressed the dilemma of managing water resources in the face of poorly defined uncertainty, including an earlier committee on drought management and the current committee advising the Bureau of Reclamation on the impact of possible climate variability on their operations. The Board often addresses the diffuse interfaces among science, and technology, and the legal, institutional, and economic constraints so critical in resolving water resource issues, as demonstrated in the recent report of the Committee on Ground Water Modeling Assessment. Finally, research and educational needs for improving water

resource management are the focus of several undertakings, including the Committee on USGS Water Resources Research and the Committee on Opportunities in the Hydrologic Sciences.

An annual report can be a useful summary of an extensive activity, but it may not convey the tremendous dedication of the Board members, committee volunteers, the federal agency representatives and others with whom we interact, and the outstanding staff of the WSTB. It is personally very gratifying to work with such a distinguished and hard working group of people, who contribute so much of their time to make the activities of the Board a success, and assure that the reports produced by the Board are of the highest quality and have the maximum impact on all parties involved in water resource management. Thank you all for your contributions.

Overview

This report summarizes the activities of the Water Science and Technology Board (WSTB) and its subgroups during 1989, its seventh year of existence. It describes current and recently completed projects, new activities scheduled to begin in 1990, and plans for the future. The report also includes information on Board and committee memberships, program operational features, and reports produced during the past several years.

This annual report is an introduction to the WSTB and its program for the year. Many of our readers are people about to become involved in WSTB activities, either as appointed volunteers, recipients of advice, or sponsors of WSTB efforts. Others are individuals who know only pieces of the program but are generally interested in other aspects.

The WSTB is intended to be a dynamic forum, a mechanism by which the broad community of water science, technology, and

policy professionals can help assure high quality national water programs. As such, the Board considers outreach and communications of much importance. We welcome inquiries and suggestions concerning our activities and will provide more detailed information on any aspect of Board projects.

The WSTB is a unit of the National Research Council, the operating element of the National Academy of Sciences and the National Academy of Engineering, which exist by virtue of an 1863 act of Congress requiring the National Academy of Sciences to provide scientific and technological assistance to the federal government upon request. While the WSTB works closely with executive agencies of the federal government in a scientific advisory capacity, it is not a part of the government. The intellectual resources and expertise available to the Board extend across many disciplines and types of organizations concerned with water and related natural resources. These resources and the Board's independence afford a unique forum for addressing various issues of importance to the nation.

The WSTB was organized in 1982 as the focal point for water-related activities within the National Research Council (NRC). It was created out of recognition of the increasing importance of water resources to our nation and the expectation that a standing unit within the NRC could be a prominent and valuable resource. The Board's scope covers the traditional scientific and engineering aspects of water resources and the economic, legal, institutional, educational, and social aspects as well.

The WSTB generally meets three times

each year, and its nineteenth meeting was held in September 1989. Twenty-one volunteers from universities and industry served as WSTB members during 1989, with collective interest and expertise that covered a wide range of subjects. Several hundred others served on study committees, as report reviewers, as government agency representatives to the program, and in other important capacities. At WSTB meetings, ongoing projects are monitored, new initiatives are developed, and research needs and other issues are considered.

In addition to these "business" aspects, meetings of the WSTB foster communication within the water resources community. Most agencies with water-related responsibilities have liaison representatives who regularly attend and actively contribute at WSTB meetings. Additional communication occurs among the liaison members, who occasionally meet as a group to address WSTB-related and other matters, and through a quarterly **WSTB NEWSLETTER**, produced by the WSTB staff. In addition, in 1989 WSTB members and staff met informally on several occasions with agency representatives and others to discuss various aspects of the program and plan activities. In 1989, the Board hosted its fifth colloquium on emerging issues in water science and technology and launched a new distinguished lecture series in honor of Dr. Abel Wolman, who passed away in February 1989.

Studies undertaken by the WSTB can be initiated in either of two ways. Most commonly, topics are chosen for study after a request by a government agency or other body. At times, the WSTB will develop plans for a study it considers especially important, seeking financial support from appropriate organizations. Board members play an important leadership role in all WSTB studies, and they are responsible for activities such as project development, committee nominations, and report reviews. WSTB studies, however initiated, address research, science, engineering, and technology related to the development and management of water and related resources, especially in relation to national objectives and priorities.

The Board's principal products are its reports (see Appendix A). They range from "letter" reports, generally focused on particular agency programs and read by a limited, but important, audience of government managers, to major publications distributed by the thousands by the National Academy Press that address more general areas of science, technology, and policy. In all cases, the reports have had and are having important effects, and the WSTB's visibility and credibility have increased with each successive project.

Most WSTB reports are written by special committees and panels of experts. These committees are supported by a small staff which is critical to the effective and timely performance of all committee activities. The staff helps ensure that the group's tasks are carefully formulated and clearly understood, that all NRC policies and procedures are followed, that the professional community has been surveyed in the selection of committee members, and that expert technical assistance and logistical support is available through the critical Academy peer review, process and publication, and dissemination processes.

In 1989, financial support for the WSTB's general program and specific project activities was provided by many sponsors, including: the U.S. Environmental Protection Agency, U.S. Geological Survey, Bureau of Reclamation, Federal Emergency Management Agency, U.S. Department of Energy, National Science Foundation, U.S. Nuclear Regulatory Commission, the State of California, Electric Power Research Institute, Mobil Corporation, the Soil Conservation Service, National Aeronautics and Space Administration, the Metropolitan Water District of Southern California, Ford Foundation, East Bay Municipal Utility District, the Office of Surface Mining, Living Lakes Inc., Chevron USA, Inc., the Agency for International Development, and the National Research Council itself. The total WSTB budget for 1989 totaled about \$1.2 million, four times greater than in 1983 (its first full year of operation).

Activities Completed in 1989

MANAGING COASTAL EROSION

Much of the population of the U.S. now lives within a two-hour drive of a coast and millions of inlanders travel much farther to spend vacations or transact business in coastal locations. Since the advent of the Interstate Highway System in the 1960's, increasing demand for coastal resources has expanded and changed settlement patterns along accessible tidal and Great Lakes shorelines. These population and economic pressures have transformed the lightly developed shorelines of earlier years into high density resorts and urban complexes. An increasing number of these structures are built on erosion-prone shorelines where the continual danger of their collapse presents the potential for substantial property loss.

In response to growing concern about this problem, the U.S. Congress gave the Federal Emergency Management Agency (FEMA) responsibility for incorporating coastal erosion into its National Flood Insurance Program (NFIP). In 1988 an NRC committee was appointed (with oversight by the Marine Board and the WSTB) to provide advice to FEMA on appropriate erosion management strategies, and supporting data and analytic methods, to be administered through the NFIP.

A report completed in November 1989 (available from the National Academy Press in 1990) explores major questions surrounding a national policy on coastal erosion: Should the federal government be in the business of protecting developers and individuals who build in erosion-prone areas?

Is government involvement an intrusion on private enterprise? How should such a program be implemented? Can such a program prompt more responsible management of coastal areas? The report provides valuable information about the natural processes of coastal erosion and erosion's interaction with human activities--such as the critical balance between environmental concerns and the substantial pressure for continued shoreline development.

The report also reviews aspects of the National Flood Insurance Program and the Upton-Jones Amendment. This Amendment adopts an approach that encourages retreat from eroding shorelines. Included in the committee's reviews are lessons to be learned from state shoreline management programs and experiences, with detailed views of programs in four coastal states; the potential for predicting future shoreline changes, with details on sources of data and predictive models; and the research and development that will be necessary to develop a national erosion policy.

Committee

William L. Wood, *Chairman*, Purdue University
 Robert G. Dean, University of Florida
 Martin Jannereth, Michigan Department of Natural Resources
 Judith T. Kildow, Massachusetts Institute of Technology
 Stephen P. Leatherman, University of Maryland
 Bernard LeMehaute, University of Miami

An increasing number of structures built along the nation's vast coastlines are on erosion-prone shores, where they face the danger of collapse or damage. In response to mounting property losses, Congress gave the Federal Emergency Management Agency responsibility for incorporating coastal erosion into its National Flood Insurance Program. The WSTB was asked to help in this task, and the report Managing Coastal Erosion is an example of the Board's ability to provide focused program assessments for federal agencies. (Photo from Michigan Department of Natural Resources.)

David W. Owens, University of North Carolina
Rutherford H. Platt, University of Massachusetts
Robert L. Wiegel, University of California

IRRIGATION-INDUCED WATER QUALITY PROBLEMS

Irrigation brings many benefits to society, but it also can bring problems. The irrigation-induced selenium contamination at Kesterson National Wildlife Refuge and the ongoing problems with irrigation drainage throughout California's San Joaquin Valley illustrate the conflicts that can arise between the interests of agriculture and the environment. The phenomenon, according to the WSTB's recently released report "Irrigation-Induced Water Quality Problems," is one that should not be dismissed as an aberration because selenium at these sites is just one example of a trace element being concentrated to problematic levels as a result of irrigation. The underlying issue is clear: irrigation, like many other uses of water, degrades water quality. The contaminants and the impacts may vary, but similar episodes are already being discovered at other sites throughout the West.

The committee's final report looks at this type of problem broadly--its causes and consequences as well as how economic, legal, and other factors impede our ability to respond--and suggests ways to study the complex issues involved. Together with some 15 letter reports issued over the 5 years of the committee's existence, this report attempts to warn federal and state policymakers about the difficulties inherent in resolving irrigation-related water quality problems. It represents a synthesis of the committee's advice to the San Joaquin Valley Drainage Program and the National Irrigation Water Quality Program. This effort was sponsored by the Department of the Interior and the State of California.

Committee:

Jan van Schilfsgaarde, *Chairman*, Agricultural Research Service

Ernest E. Angino, University of Kansas
Magriet F. Caswell, University of California, Santa Barbara
Edwin H. Clark II, Delaware Department of Natural Resources and Environmental Control
Charles T. DuMars, University of New Mexico
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Rolf Hartung, University of Michigan
Charles D.D. Howard, Charles Howard and Associates, Consultant
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Merlyn B. Reeves, League of Women Voters
Daniel E. Willard, Indiana University
G. Richard Marzolf (*ex officio*, WSTB member), Murray State University
Gordon G. Robeck, (*ex officio*, WSTB member), Laguna Hills, California

GROUND WATER AND SOIL CONTAMINATION REMEDIATION: TOWARD COMPATIBLE SCIENCE, POLICY, AND PUBLIC PERCEPTION

Since 1985, the WSTB has conducted an annual colloquium to provide a forum for discussion of a current issue, identified by the Board, that might not otherwise receive adequate attention.

The Board's fifth colloquium, held in Washington, D.C., April 20-21, 1989, focused on how science influences policy and public perceptions where cleanup of ground water and soil contamination is concerned. The public, press, and Congress are often unfamiliar with the scientific constraints involved in soil and ground water cleanup policy, given the complex scientific questions underlying these issues. With this in mind, the authors of the papers presented and other participants were invited not only for their technical knowledge concerning cleanup levels of contaminated soil and ground water, but also for their experience with

public perception of such contamination issues and the statutes and laws that regulate how state and government agencies respond.

A steering committee of Board members and others, working closely with the WSTB staff, organized the colloquium program. Twelve papers were presented by recognized experts affiliated with federal and state regulatory agencies, environmental and public interest groups, private industry, consulting firms, universities, the U.S. Air Force, and law firms. The presenters included scientists and regulators involved in setting cleanup levels, as well as the affected parties.

The final report, issued in 1990, has two major sections: an overview and the papers prepared by individual authors. Colloquium Chairman, Richard A. Conway and the steering committee prepared the overview based on the background papers, the presentations, and discussion generated at the colloquium.

Steering Committee:

Richard A. Conway, *Chairman*, Union Carbide Corporation

Stephen Cordle, U.S. Environmental Protection Agency
James W. Mercer, Geotrans, Inc.
David W. Miller, Geraghty & Miller, Inc.
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Principal Contributors:

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William J. Walsh, Pepper, Hamilton, & Scheetz
Stephen R. Wassersug, U.S. Environmental Protection Agency
Marcia E. Williams, Browning-Ferris Industries, Inc.

CURRENT PROGRAM

OPTIONS FOR WESTERN WATER
MANAGEMENT CHANGE: THIRD
PARTY EFFECTS

As the West grows and its population becomes more urban, it faces increasing conflicts over how best to allocate and manage water supplies. Water transfers are a much-discussed water management approach. Yet important questions about the effects of water transfers remain unanswered. Of particular concern in this study are the effects on third parties--those interests beyond the direct sellers and buyers. One often overlooked third party, for instance, is the environment (e.g., the impact of water transfers on water quality or on habitat availability).

Environmental values are increasingly important to society but it is uncertain whether the institutional setting--the combination of laws, policy, and tradition--has kept pace with this change in societal values. Water transfers are becoming more common, but mechanisms to put into practice our broadened understanding of the inherent costs and benefits, and incorporate a heightened sensitivity to the third party effects, often are lacking.

This WSTB study is using a case study approach to improve our understanding of the nature, purpose, and consequences of water transfers, with special emphasis on possible impediments and third party effects. The Truckee-Carson basin in Nevada, the Arizona experience, conflicts in Colorado's Front Range region, and other examples exploring the role of transfers in western water management will be exam-

ined in an attempt to draw out some broader insights to guide the federal role in such transfers. A variety of sponsors support this work, including the Ford Foundation, the Bureau of Reclamation, the Environmental Protection Agency, the Metropolitan Water District of Southern California, and East Bay Municipal Utility District.

Committee:

A. Dan Tarlock, *Chairman*, Chicago Kent College of Law
D. Craig Bell, Western States Water Council
Bonnie Colby, University of Arizona
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Richard Trudell, American Indian Lawyer Training Program
Henry J. Vaux, Jr., University of California-Riverside
Susan Williams, Gover, Stetson, Williams, and West
Jan van Schilfgaarde, Agriculture Research Service

In the 20 years since the first Earth Day was celebrated, the nation's values have undergone an evolution, and many citizens now place more emphasis on environmental protection. The WSTB's activities reflect this trend--some current studies with an environmental management focus deal with the impacts of water transfers in the West, the restoration of aquatic systems, and the National Water Quality Assessment Program. (Photo from D. Schuhart, Soil Conservation Service.)

ASSESSMENT OF OPPORTUNITIES IN THE HYDROLOGIC SCIENCES

In late 1987 the WSTB began an important study of opportunities in the hydrologic sciences. The study includes a review of the current status of the subfields of hydrology and of their coupling with related geosciences and biosciences, the identification of promising new frontiers and opportunities for the hydrologic sciences to help improve water and environmental management, and the development of a framework for hydrologic education and research. This study results from an increased awareness by the hydrologic community of the need for fundamental advances in hydrologic science to generate solutions to emerging complex problems of water technology, and from the realization that the time has come for hydrology to become better established as a science alongside other recognized geosciences.

The study is assessing our understanding of the natural reservoirs and fluxes involved in the global hydrologic cycle. The focus is on continental water and the physical, chemical, and biological processes interacting with the continental water, such as erosion, sedimentation, vegetation growth, and chemical weathering. Oceans, lakes, the atmosphere, glaciers, and ice sheets are considered to the extent that they interact with the hydrologic cycle. The spatial scales of concern vary from the micro-processes of soil moisture to the global scale of hydroclimaticological change. The time scales of concern also vary broadly.

The committee's product will be a report, currently undergoing external peer review and expected to be published by the National Academy Press in the summer of 1990. The report will provide guidance for the development of the hydrologic sciences and attempt to secure acceptance for hydrology within the science establishment on a par with other geosciences. Although the book is being written for a broad audience, from the informed lay public to research scientists and university educators, the principal audience will be science policymakers and research managers in government agencies and other organizations having geoscience programs.

Support for this project was provided

by the National Science Foundation, National Aeronautics and Space Administration, U.S. Geological Survey, National Research Council, U.S. Forest Service, National Weather Service, Army Research Office, and the Mobil Corporation.

Committee:

Peter S. Eagleson, *Chairman*, Massachusetts Institute of Technology
Wilfried H. Brutsaert, Cornell University
Samuel C. Colbeck, U.S. Army Cold Regions Research and Engineering Laboratory
Kenneth W. Cummins, University of Pittsburgh
Jeff Dozier, University of California, Santa Barbara
Thomas Dunne, University of Washington
John M. Edmond, Massachusetts Institute of Technology
Vijay K. Gupta, University of Colorado
Gordon C. Jacoby, Lamont-Doherty Geological Observatory
Syukuro Manabe, National Oceanic and Atmospheric Administration
Sharon E. Nicholson, Florida State University
Donald R. Nielsen, University of California, Davis
Ignacio Rodriguez-Iturbe, University of Iowa
Jacob Rubin, U.S. Geological Survey
J. Leslie Smith, University of British Columbia
Garrison Sposito, University of California, Berkeley
Wayne T. Swank, Coweeta Hydrologic Laboratory
Edward J. Zipser, Texas A&M University
Stephen J. Burges, *ex officio*, WSTB member, University of Washington

USGS WATER RESOURCES RESEARCH

Since 1985, the Committee on USGS Water Resources Research has provided advice to and worked with U.S. Geological Survey (USGS) scientists and managers on a variety of matters. Originally established to provide guidance relating to the institutes and grants provisions of the Water Resources Research Act of 1984 (Public Law 98-242), the committee's activities have expanded to cover both intramural and ex-

tramural research programs of the USGS and many of the agency's other programs.

In addition to the institutes and grants programs, the committee's attention has focused on various aspects of the National Water Quality Assessment Program, the agency's National Research Program in water resources, climate change and water resources, and other topics.

In 1989, the full committee met twice in addition to meetings of smaller work groups. The committee began planning a report that will highlight a variety of issues relevant to future USGS roles and programs. The report will be future looking, addressing the "right mix" of program elements in USGS district offices in coming decades, the role of research in the agency, the agency's data networks, and relation with other entities, including, universities.

Committee:

Walter R. Lynn, *Chairman*, Cornell University
James W. Biggar, University of California, Davis
Edward J. Bouwer, The Johns Hopkins University, (through 12/89)
Lenore S. Clesceri, Rensselaer Polytechnic Institute
Thomas Dunne, University of Washington, (through 12/89)
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Philip C. Kearney, USDA, Agriculture Research Service
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Clifford S. Russell, Vanderbilt University
Philip Singer, Stanford University
Hugo F. Thomas, Connecticut Department of Environmental Protection, (through 12/89)
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GROUND WATER RECHARGE IN SURFACE-MINED AREAS

The availability of coal as a source of energy is important to our modern style of living and economy. The production of coal is a complex, heavy industry that can have many impacts on the environment, especially on the hydrologic functions of the areas in which mining occurs, such as water quality and rainfall-runoff-ground water recharge relationships. Presently, approximately 60 percent of the coal production in the United States is by surface mining.

To consider and minimize the potential negative impacts of surface mining, Congress passed the Surface Mining Control and Reclamation Act (SMCRA) of 1977, which contains requirements relative to the hydrologic character of mined areas. Among these is a requirement that, in the restoration of the landscape, mining operators restore the "recharge capacity" of mined areas to approximate pre-mining conditions. To get guidance for interpreting and implementing this requirement, in 1988 the Office of Surface Mining Reclamation and Enforcement (OSM) of the U.S. Department of the Interior asked the WSTB for assistance.

In response, in March 1989 the WSTB formed a committee to assess of technologies for ground water recharge evaluation. The scope of work included:

- (1) definition of the term "recharge capacity;"
- (2) identification of methods for estimating ground water recharge in mining areas;
- (3) a critique of the strengths and weaknesses of existing approaches with respect to their hydrologic validity;
- (4) recommendations for preserving ground water recharge in comparable terms for pre-mining "natural" and post-mining "restored" conditions;
- (5) identification of considerations that are relevant to analysis of hydrologic functions of mined locales;
- (6) identification of any research required to strengthen the recommended

approach; and

(7) recommendations of policy change, if warranted.

The assignment was difficult owing to a number of factors, not the least of which is the paucity of accurate historical data on hydrologic functions in the often remote areas where surface mining occurs. Further, there was the aspect that the impact of mining might be less than the magnitude of uncertainty associated with the ability to quantify recharge. Nonetheless, recommendations are provided in the committee's report that should allow relevant parties to comply with the spirit of the Act, i.e., to assure minimum negative disturbances to the hydrologic system in surface mined areas.

This committee's report, available in March 1990, includes chapters on regulatory aspects of the issue, the hydrology of ground water recharge, pre-mining conditions in coal mining regions, methods and impacts of mining, and techniques for quantifying ground water recharge rates. Although not the major charge of our report, a discussion of the relevant water quality issues is included.

Committee:

Herman Bouwer, *Chairman*, Water Conservation Laboratory, USDA

Robert E. Beck, Southern Illinois University

Corale L. Brierley, Salt Lake City, Utah

C. Thomas Haan, Oklahoma State University

George M. Hornberger, University of Virginia

Robert J. Luxmoore, Oak Ridge National Laboratory

John C. Sencindiver, West Virginia University

James R. Wallis, IBM Watson Research Center

William W. Woessner, University of Montana

INTERNATIONAL SOIL AND WATER RESEARCH AND DEVELOPMENT

Early in 1990, after nearly a year of pre-project planning, a new Committee on

International Soil and Water Research and Development was appointed jointly by the WSTB and the Board on Science and Technology for International Development (BOSTID) of the NRC's Office of International Affairs. This new committee was established at the request of the U.S. Agency for International Development (AID). AID is active world-wide in developing countries in the general area of soil and water science and technology. Some of the issues with which AID soil and water programs are concerned include: erosion, deforestation, salinity, water supplies, public health, water quality, impacts of potential climate change, and others. The agency is in the process of reorganizing and bringing more focus to its programs oriented to problems in these areas through establishment of a new Soil and Water Agricultural Collaborative Research and Development Network (SWAN).

The new committee will provide both technical and policy advice to the SWAN "network" through senior AID staff. The committee will operate somewhat in the continuing advisory style of the WSTB's existing Committee on USGS Water Resources Research. It would also conduct more in-depth deliberative studies of technical topics.

The committee's initial activity of the committee is likely to be an assessment of the scientific, technological, and management needs of the network. This will involve a general review of natural resources problems in developing countries, identification of the most pressing problems, and an evaluation of AID's capability to respond to these problems in countries where financial assistance is being considered.

The committee will meet several times each year, including one major meeting including most "network" representatives. This project has the potential to bring the expertise of a broad community of scientists and engineers to bear on some of the world's major environmental problems.

Committee:

Leonard Berry, *Chairman*, Florida Atlantic University

Susanna B. Hecht, University of California,
Los Angeles
Charles C. Howe, University of Colorado
Jack Keller, Utah State University
Charles B. McCants, Raleigh, North Carolina
Hugh Popenoe, University of Florida
Paul P. S. Teng, University of Hawaii
Goro Uehara, University of Hawaii
P. Suresh C. Rao, *ex officio*, WSTB member,
University of Florida

GLEN CANYON ENVIRONMENTAL STUDIES

Management of water resources has been and will remain a critical issue for the western United States. The Bureau of Reclamation originally was created to reclaim the arid west and provide economic stability in the newly annexed portion of the nation. Subsequently, additional goals were added to the Bureau's mission, such as providing municipal water supplies and supplying energy through the operation of hydroelectric generating facilities.

New trends and changing circumstances have required a reevaluation of the Bureau's mission and its priorities. More attention is being given to alternative means of supplying water through improved system management and reevaluating allocation priorities. Water conservation and environmental protection have become major public concerns.

In 1986, the Bureau of Reclamation, recognizing these changing circumstances, requested assistance in evaluating and interpreting the Glen Canyon Environmental Studies (GCES) being conducted concerning the impacts on the environment of the lower Colorado River and operation of the Glen Canyon Dam. The WSTB saw this request as a special opportunity to examine a set of investigations designed to evaluate the effects of storage and power dam operation on basic earth science phenomena. Furthermore, the WSTB saw an opportunity to examine the integration of science and technology with economic, political, and legal institutions, and to bring thinking from diverse disciplines to

bear on procedures used to investigate large rivers.

The committee produced its first report, River and Dam Management, in December 1987. Although the committee concluded that the Bureau of Reclamation could not make any long-term decisions concerning the management of Glen Canyon Dam based on the GCES, it concluded that the studies have produced some excellent information, and many research results represent new knowledge that will contribute to the information base about the Colorado River. The committee has continued to provide scientific advice to the researchers and to review future study plans for Phase II. Two letter reports were issued in 1988.

As the committee continues advising the GCES team until January 1991, it has undertaken a new responsibility to organize a symposium to review existing information about the Colorado River downstream from Glen Canyon. Approximately ten background papers will be presented by scholars known for their experience with water science issues in the southwestern United States and with the Grand Canyon/Glen Canyon in particular. A published proceedings from the NRC will be produced in 1990.

Another charge to the committee is to review the draft final plan for future research below Glen Canyon Dam. A formal letter report should be issued on this review in 1990.

Committee:

G. Richard Marzolf, *Chairman*, Murray State University, Murray, Kentucky
David Dawdy, Consulting Hydrologist, San Francisco, California
William Graf, Arizona State University
W. Michael Hanemann, University of California, Berkeley
Trevor C. Hughes, Utah State University
William M. Lewis, University of Colorado, Boulder
A. Dan Tarlock, Chicago Kent College of Law
Duncan T. Patten, *ex officio*, Arizona State University

One recurring theme among WSTB projects is the management of water resources. As priorities have shifted over time, there have been increased calls for more careful balancing in federal water management policies. The WSTB's review of the Bureau of Reclamation's Glen Canyon Environmental Studies deals with this need for balance between the needs for hydropower and the maintenance of the natural ecology of rivers. (Photo from the U.S. Department of the Interior).

RESTORATION OF AQUATIC SYSTEMS: SCIENCE, TECHNOLOGY, AND PUBLIC POLICY

In 1934 Aldo Leopold said that "The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to begin with." The concept expressed here--restoration--has been defined in an ongoing WSTB study as "the return of an ecosystem to the closest approximation to its previous condition prior to the disturbance of concern." This study is particularly relevant as society is increasingly concerned with correcting some of the environmental mistakes of the past.

The committee is reviewing many restoration activities involving lakes, wetlands, and rivers. They also are looking at several large aquatic systems to show how these water bodies interact. The scope of work includes: (1) formulating criteria by which to choose the restoration projects to be reviewed; (2) evaluating selected restorations with respect to their scientific basis, performance over time, the technologies were fulfilled, and why it was a success or failure, taking into consideration the political and regulatory aspects; (3) identifying common factors of successful restoration projects, and based on this review, providing a recommended list of criteria for successful restoration efforts to serve as a model for future efforts at restoring aquatic systems; and (4) identifying federal policy, policy conflicts, and responsible agencies that contribute substantially to the continuing degradation of lakes, rivers, and wetlands in the United States.

After a two-year evaluation, the committee will issue a final report. The study is sponsored by seven organizations, both federal and private, including Chevron USA, Inc., U.S. Army Corps of Engineers, Living Lakes, Inc., the U.S. Environmental Protection Agency, the Bureau of Reclamation, the Soil Conservation Service, and the National Research Council.

Committee:

John Cairns, *Chairman*, Virginia Polytechnic Institute

G. Ronnie Best, University of Florida
John J. Berger, Consultant, El Cerrito, California
Patrick L. Brezonik, University of Minnesota
Stephen R. Carpenter, University of Wisconsin
G. Dennis Cooke, Kent State University
Donald L. Hey, Wetlands Research Inc.
Jon A. Kusler, Association of State Wetland Managers
Claire L. Schelske, University of Florida
Leonard Shabman, Virginia Polytechnic Institute
Rebecca R. Scharitz, University of Georgia
Richard E. Sparks, Illinois Natural History Survey
Soroosh Sorooshian, University of Arizona
James T.B. Tripp, Environmental Defense Fund
Daniel E. Willard, Indiana University
Joy B. Zedler, San Diego State University
Betty H. Olson, *ex officio*, WSTB member, University of California at Irvine
M. Gordon Wolman, *ex officio*, WSTB member, The Johns Hopkins University

EVALUATION OF THE USGS NATIONAL WATER QUALITY ASSESSMENT PILOT PROGRAM

Human health and environmental health are inextricably linked to our nation's water quality. As our population grows and our water resources become more developed and stressed, water quality becomes a more important component of our political, economic, social, and environmental decisionmaking. Such decisionmaking should not proceed without adequate information and understanding.

In 1986, the USGS proposed and initiated the pilot National Water Quality Assessment program to evaluate national trends in both surface and ground water quality. Subsequently, the Board was asked to undertake a two-year evaluation of the pilot program and to make recommendations concerning implementation of a full-scale program, including its technical design and potential usefulness for establishing and evaluating national policies. A committee was established which has been engaged in studies since mid 1988.

In September 1989, the committee issued an interim report to the USGS. The committee stated that it was convinced that a national-scale, long-term water quality assessment is in the best interest of the nation and that the USGS is well qualified to implement the proposed NAWQA program.

A final reporting concerning full-scale implementation of the program and a critique of its design should be issued in summer 1990.

Committee:

Richard S. Engelbrecht, *Chairman*, University of Illinois
K. C. Bishop, Chevron USA, Inc.

Sandra L. Blackstone, University of Denver
College of Law

Michael E. Campana, University of New Mexico

Margaret Conaitt, The Procter & Gamble Company

Robert C. Cooper, University of California, Riverside

David L. Freyberg, Stanford University

James Geraghty, Geraghty & Miller, Inc.

Judy L. Meyer, University of Georgia

Donald J. O'Connor, Manhattan College

Susan Stafford, Oregon State University

James Heaney, *ex officio*, WSTB member, University of Florida

Kenneth Potter, *ex officio*, University of Wisconsin

New Activities Beginning in 1990

CLIMATE UNCERTAINTY AND WATER RESOURCES MANAGEMENT

The possibility of global climate variability, whether natural or human-induced, is a topic of great concern among both scientists and the public at large. Although there is growing acknowledgement that mechanisms are in place that might bring about significant warming of Earth's surface, there is little agreement as to the specific impacts that might result and thus what actions we might need to take to adapt to changed conditions.

In late 1989, a new committee was appointed to help the Bureau of Reclamation improve its capability to manage its extensive system of water projects in the 17 western states in light of the possible hydrologic uncertainty posed by prospects of global climate change. It is an effort to assist them in the initial development of alternative operating strategies--to be anticipatory rather than reactive. And whether significant human-induced climate changes occur or not, such preparation should provide guidance useful in coping with the more normal perturbations that occur within climatic cycles.

The committee will first convene a substantive colloquium on climate uncertainty and water management. There, the committee and other scientists, engineers, and Bureau of Reclamation staff will share current information and debate the ranges of management responses that might be possible. The committee will prepare a report designed to help the agency as it develops a work plan for a comprehensive research program to investigate further the

issues and problems related to climate change and water management. Other activities relevant to the matter of improving water management may follow. This effort is supported by the Bureau of Reclamation.

Committee:

Stephen J. Burges, *Chairman*, University of Washington
 Robert E. Dickinson, National Center for Atmospheric Research
 Kenneth D. Frederick, Resources for the Future
 Roger E. Kasperson, Clark University
 Bruce A. Kimball, USDA/Agricultural Research Service
 Daniel P. Sheer, Water Resources Management, Inc.

OPPORTUNITIES TO IMPROVE WASTEWATER MANAGEMENT FOR URBAN COASTAL AREAS

As is happening in many areas of environmental management, decisionmakers responsible for wastewater management in coastal areas are facing difficult judgements when trying to balance environmental effectiveness and economic efficiency. As part of this debate, the WSTB has recently begun a new study of considerable public interest with the appointment of its Committee on Wastewater Management for Urban Coastal Areas.

Whether because they have failed to modernize their sewage systems, identified new pollution problems, or outgrown the capacity of their current systems, coastal

urban centers around the country--and in fact the world--face the same general need to set priorities for wastewater management and choose technologies that are most effective and appropriate for long-term conditions. The experience gained in science and engineering during the past two decades since passage of the Clean Water Act in 1972 provides the nation the opportunity to open new horizons in the decision making process.

The study will aid in the development of needed waste management strategies for the future that maximize innovative, flexible, and cost-effective options for coastal environments. The study is timely not only because of experience gained in recent years, but due to a high level of public commitment to improving the ocean and coastal environment, the availability of better tools to assess and manage risk, and the fact that governments at all levels are faced with difficult allocations of scarce financial resources.

The study will examine issues such as the balance of costs and environmental benefits, and the degree of flexibility needed to account for regional conditions, and new information regarding system performance.

Sponsors include the U.S. Environmental Protection Agency, National Science Foundation, National Academy of Engineering, the City of San Diego, and the Freeman Fund of the Boston Section of the American Society of Civil Engineers.

Committee:

John J. Boland, *Chairman*, The Johns Hopkins University

Blake P. Anderson, County Sanitation Districts of Orange County

Norman H. Brooks, California Institute of Technology

William M. Eichbaum, The Conservation Foundation

Lynn R. Goldman, California Department of Health Services

Donald R. F. Harleman, Massachusetts Institute of Technology

Robert W. Howarth, Cornell University

Robert J. Huggett, College of William and Mary

Thomas M. Keinath, Clemson University

Alan J. Mearns, National Oceanic and Atmospheric Administration

Charles R. O'Melia, The Johns Hopkins University

Larry A. Roesner, Camp, Dresser, & McKee, Inc.

Joan B. Rose, University of South Florida

Jerry R. Schubel, State University of New York, Stony Brook

Richard A. Conway, *ex officio*, WSTB member, Union Carbide Corporation

PLANNING FOR AND REMEDIATING IRRIGATION-INDUCED WATER QUALITY PROBLEMS

Although salinity problems have long been known to be associated with irrigated agriculture, the problems caused by trace element accumulations have only recently been recognized. The bird deaths and deformities at Kesterson National Wildlife Refuge in 1982 provided the first clearly identified example of this type of problem, and sparked a broad west-wide research effort to identify similar problem sites. This multiagency effort, the National Irrigation Water Quality Program, has to date reviewed more than 600 sites and identified more than 22 sites in 13 states as having high potential for such problems. Further site identification and evaluation efforts are underway, and planning activities for how to deal with the problems identified are beginning.

Until recently, the NIWQP received some guidance from the WSTB's Committee on Irrigation-Induced Water Quality Problems. At this committee's termination, the Department of the Interior requested the WSTB to form a new committee to give guidance specifically to the NIWQP. The new committee will, in part: host a joint meeting with NIWQP's field staff and management where the preliminary results of the ongoing site identification research will be shared; critique NIWQP plans and approaches; write a concise final report assessing the strengths and weaknesses of the NIWQP strategy. The Department of the Interior will sponsor this activity.

Committee:

(To be appointed)

Looking to the future, the WSTB hopes to continue to provide an objective perspective on the nation's most important water resource issues. The Board will maintain a blend of both broad and focused studies, and will continue to deal with both the technical and institutional issues that arise. (Photo shows a channel network formed by the ebbing tide in the Gulf of California.) (Photo from Anne Griffiths Belt for the National Geographic Society.)

Future Plans: 1990 and Beyond

EMERGING TECHNOLOGIES IN WATER TREATMENT

With the arrival of 1990 and the 20th anniversary of Earth Day, the nation and the world are committed more than ever before to protecting environmental values. In some areas, however, it appears that technology is unable to meet increasingly stringent standards. Water treatment is one such area--including the treatment of municipal, industrial, and agriculture wastewater; the remediation of water resources at hazardous waste sites; and the treatment of water sources.

Some experts argue that progress is being slowed by barriers that discourage technologically innovative companies and the people who invest in them. Yet the nature of these barriers is not well understood because they represent a mix of technical and institutional factors that are not easily separated. Should this study be pursued, it would evaluate the status of water treatment technologies, assess the adequacy of technological development in this sector, and consider whether this sector will be able to achieve the environmental requirements that are likely to be set in the future. It would pay special attention to the nation's international competitiveness in this field. The WSTB might elect to pursue this topic via a series of focused symposia or other formats. Both federal and private sources of funding are being investigated.

ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM

In September 1987, at the initiative of

then Administrator Lee Thomas, the Environmental Protection Agency's Office of Research and Development (ORD) directed its scientists to develop an integrated strategy to improve the agency's ability to assess the risks to natural ecological systems at the regional scale from current and emerging environmental pollutants.

The first proposed step in the development of the integrated ecological research strategy is creation of the Environmental Monitoring and Assessment Program (EMAP). This program has been proposed to begin in FY 1990 to compliment EPA's Acid Deposition, Global Climate Effects, and Stratospheric Modification Research Programs. The goal of EMAP is to identify, collect, organize, and analyze environmental monitoring data and report periodically to the Administrator on the current status and trends in indicators of the condition of the nation's ecosystems.

In late 1989, the WSTB received a request from ORD to provide a scientific review of EMAP's surface water quality assessment program. EMAP's surface water component shares certain broad goals with the USGS's proposed National Water Quality Assessment Program (NAWQA) currently under review by the WSTB.

Since the EMAP program will cover much more than water quality, the NRC's Board on Environmental Studies (BEST) has also been requested to play a role, by providing a review of the terrestrial (forests, deserts and range, and agroecosystems) and wetlands portion of EMAP. Thus, the study project will be developed jointly by the WSTB and BEST to insure appropriate integration among the reviews.

It is envisioned that a joint BEST/

WSTB oversight committee will be established to oversee two committees reviewing different components of the EMAP. The study committees will most likely be appointed and begin their review in the fall of 1990.

REGIONAL ASSESSMENT OF POTENTIAL FOR GROUND WATER CONTAMINATION: EVALUATION OF CURRENT TECHNIQUES AND FUTURE OPPORTUNITIES

In February 1990, the WSTB hosted a planning conference to help develop plans for a new study of techniques for assessing ground water vulnerability which may be underway before the end of 1990. The idea for this study arose out of the WSTB's tradition of looking ahead in the broad field of water resources, anticipating topics of future importance.

Ground water quality protection has become a major national environmental concern as discoveries of contamination due to hazardous waste disposal or pesticide use have resulted in the closure of drinking water wells and highlighted the importance of this vital resource. A number of techniques have been developed to assess the potential for contamination of ground water on an areal basis in order to make decisions regarding land use.

Use of simulation models and various empirical numerical rating techniques have been proposed for evaluating ground water vulnerability at both local and regional scales. For example, EPA uses the numerical ranking scheme DR_ASTIC to assess contamination potential on the basis of the physiographic and hydrogeologic. Similar Delphi

rating schemes are being developed and used by several state environmental agencies to regulate pesticide use. The relative merits of models versus rating schemes have been debated in the literature and by EPA in deciding registration of Aldicarb pesticide use. The Aldicarb case is seen as a template for all future decisions made by the agency on pesticide registration.

The use of Geographic Information Systems (GIS) is becoming popular for inventorying, archiving, retrieving, and displaying spatial data needed in these approaches for evaluating vulnerability. GIS coupling to numerical rating schemes and to simulation models allows the production of computer-generated thematic maps displaying contamination potentials or vulnerability of land areas (at county-level or higher spatial scales). However, the varying levels of data quality and scales of the spatial data bases supporting GIS introduce great uncertainty in the reliability of these vulnerability maps. Questions as to how to validate the predictions (i.e., the GIS thematic maps) through sampling or monitoring also need to be resolved.

This WSTB initiative would examine the scientific basis for and the relative merits or limitations of various schemes for evaluating vulnerability of soils, surface waters, and ground waters. Recommendations could be made on the appropriateness of the schemes within the regulatory framework. Technical issues on data quality and uncertainty of vulnerability assessments could also be addressed.

Support for this initiative will be sought from EPA, USGS, and the Department of Agriculture. This study is likely to be underway by the fall of 1990.

Appendix A
**Reports Issued by the Water Science
and Technology Board
(1982-1989)***

MANAGING COASTAL EROSION

1990, 160 pp.

This report provides information about the natural processes of coastal erosion and the effect of human activity on those processes. The committee chairman was William L. Wood, Purdue University. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: \$24.50.

**GROUND WATER MODELS:
SCIENTIFIC AND REGULATORY
APPLICATIONS**

1990, 300 pp.

This report addresses scientific aspects and the use of ground water flow and contaminant transport modeling in the regulatory process. The committee was chaired by Frank W. Schwartz, Ohio State University. The report is available for \$29.95 from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**IRRIGATION-INDUCED WATER
QUALITY PROBLEMS**

1989, 104 pp.

This report addresses how irrigation can endanger water quality, and how eco-

nomic, legal, and other factors impede our ability to respond to water quality problems. It explores how to study these problems, unraveling complex issues and clarifying the varying perspectives of farmers, environmentalists, scientists, and other key figures. The chairman of this committee was Jan van Schilfgaarde, Agricultural Research Service. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. Cost: \$24.95.

**INTERIM REPORT OF THE COMMITTEE
ON NATIONAL WATER QUALITY
ASSESSMENT PILOT PROGRAM
(September 25, 1989)**

1989, 8 pp.

The first report from the committee provides USGS with an interim summary of its evaluation of the NAWQA program. It concludes that a national, long-term water quality assessment is necessary and that the USGS is well qualified to implement the proposed program. A final review of the NAWQA program will be issued by June 1990. The committee chairman is Richard S. Engelbrecht, University of Illinois.

**GREAT LAKES WATER LEVELS:
SHORELINE DILEMMAS**

1989, 149 pp.

This is the fourth report from the

*Two reports completed in 1989, published in 1990.

WSTB series of colloquia on emerging issues in water science and technology. It addresses hydrometeorological, engineering, and land management and policy issues related to fluctuations in Great Lakes water levels. John J. Boland of The Johns Hopkins University, chaired the colloquium. The report is available in limited quantity at no cost from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(June 9, 1989)**

This letter report addresses the U.S. Department of the Interior's NIWQP and contains comments in response to a briefing of preliminary data from the NIWQP's second set of reconnaissance studies. It provides suggestions to improve data uniformity and identification of the causes of identified problems, and it calls for the NIWQP to synthesize the myriad data into a comprehensive analysis with systematic conclusions.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(September 11, 1989)**

This letter report from the Subcommittee on Economics, Policy, and Systems Analysis to the SJVDP discusses the continued development of the WADE computer model and the need to be frank about both its strengths and weaknesses. The necessity of outside peer review is stressed. The letter also comments on the SJVDP's progress in conducting legal and sociological analyses.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(October 5, 1989)**

This letter report expresses strong dissatisfaction with the political influences

that have directed the SJVDP to look for solutions only within the confines of the San Joaquin Valley. This committee sees this as a short-sighted approach and again urges policymakers to address the long-term impacts of irrigated agriculture.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(December 30, 1988)**

1988, 3 pp.

The third letter report from the Subcommittee on Quality Assurance/Quality Control stresses the continued importance of quality assurance and quality control activities to the San Joaquin Valley Drainage Program (SJVDP). The subcommittee was chaired by Robert R. Meglen, University of Colorado at Denver. The report is available at no cost from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON GLEN CANYON
ENVIRONMENTAL STUDIES
(July 11, 1988)**

1988, 8 pp.

The first letter report from the committee recommends the Bureau of Reclamation establish a science research advisory group to be placed at the Department of the Interior level. G. Richard Marzolf of Murry State University in Kentucky chairs this committee. The letter report can be obtained at no cost from the Water Science and Technology, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON GLEN CANYON
ENVIRONMENTAL STUDIES
(December 19, 1988)**

1988, 2 p.

This is the second letter report from the committee emphasizes the recommendation that the Department of the Interior establish a senior science advisory group and that the chief scientist or principal investigator be retained through an Inter-agency Personnel Agreement to provide long-term continuity for the investigation. The committee is chaired by G. Richard Marzolf, Murray State University, Kentucky. The report is available at no cost from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON USGS WATER RESOURCES
RESEARCH (August 1, 1988)**

1988, 3 pp.

The third letter report from the committee concerns funding for and reauthorization of the Water Resources Research Act of 1984, P.L. 98-242 which enables the extramural institutes and grants programs administered by the U.S. Geological Survey. The committee chair was Betty H. Olson of the University of California Irvine. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**HAZARDOUS WASTE SITE
MANAGEMENT: WATER QUALITY
ISSUES**

1988, 224 pp.

This report, a collection of papers from a colloquium sponsored by the WSTB, discusses ground and surface water cleanup

levels at hazardous waste sites. Michael Kavanaugh, James M. Montgomery Consulting Engineers, chaired the colloquium and authored an overview. The report is available for \$24.50 from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**ESTIMATING PROBABILITIES OF
EXTREME FLOODS: METHODS AND
RECOMMENDED RESEARCH**

1988, 144 pp.

This report provides scientific examination of a variety of techniques available for characterizing very rare floods. It includes both a general overview and looks in detail at statistical and runoff model techniques. The committee was chaired by Jared L. Cohon of The Johns Hopkins University. The report is available for \$15.95 from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**RIVER AND DAM MANAGEMENT:
A REVIEW OF THE BUREAU OF
RECLAMATION'S GLEN CANYON
ENVIRONMENTAL STUDIES**

1988, 203 pp.

This report provides recommendations to the Department of the Interior concerning the performance and results of the Glen Canyon Environmental Studies (GCES). It reviews the Bureau of Reclamation's planning and management of this project; the integration of the GCES results into a decisionmaking report; and the utility of the GCES results for management of the Colorado River, the Grand Canyon, and the operations of the Glen Canyon Dam. The committee is chaired by G. Richard Marzolf, Kansas State University. The report is available in limited quantities from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(July 28, 1987)**

1987, 3 pp.

In its fourth letter report, the Committee on Irrigation-Induced Water Quality Problems describes some signs of progress, including the program's effort to better define goals and objectives; initial steps taken to consider economic, legal, and institutional factors; and the establishment of a Citizens Advisory Committee. The committee chairman was Jan van Schilf-gaarde, USDA-ARS, Fort Collins, Colorado. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(July 28, 1987)**

1987, 7 pp.

In its first letter report, the Subcommittee on Economics and Policy of the CIIWQP reports it was encouraged that the San Joaquin Valley Drainage Program (SJVDP) had begun to consider economic, social, legal, and institutional issues in their evaluation of alternative solutions. The subcommittee chairman was Margriet Caswell, University of California-Santa Barbara. The report is available from the Water Science and Technology, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON USGS WATER RESOURCES
RESEARCH (July 13, 1987)**

1987, 2 pp.

The second letter report from the committee contains a current assessment of the Section 105 extramural research grants

program. The committee chairman was Betty H. Olson of the University of California, Irvine. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(March 30, 1987)**

1987, 3 pp.

In its second letter report, the Subcommittee on Quality Assurance and Quality Control (QA/QC) of the CIIWQP to the San Joaquin Valley Drainage Program (SJVDP) recommends that the SJVDP acquire a knowledgeable and experienced QA/QC manager. The subcommittee chairman was Robert R. Meglen, University of Colorado. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(February 17, 1987)**

1987, 1 p.

This is a one-page supplement to the first letter report of the Subcommittee on Public Health (dated June 9, 1986) of the CIIWQP. It recommends that as the San Joaquin Valley Drainage Program evaluates the feasibility and desirability of potential actions to resolve agricultural drainage problems in the San Joaquin Valley, it should explicitly address the public health concerns that might be raised by such actions. The subcommittee chairman was Edwin H. Clark of the Delaware Department of Natural Resources and Environmental Control. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

NATIONAL WATER QUALITY MONITORING AND ASSESSMENT

1987, 108 pp.

This report, based on the second WSTB colloquium, discusses the need for a national water quality monitoring and assessment program for the United States. The colloquium chairman was Richard S. Engelbrecht of the University of Illinois. This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS Accession Number: PB 87-157467. List price: \$18.95.

A REVIEW OF THE U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY PROGRAM FOR RECYCLING AND REUSE OF A LAUNDRY AND SHOWER WASTEWATER

1986, 104 pp.

This study evaluated the U.S. Army's Construction Engineering Research Laboratory (CERL) program on recycling and reuse of field laundry and shower wastewater. It looks at technical and scientific merit, and recommends additional research needs necessary to achieve the goals of the program. The chairman was Richard S. Engelbrecht, University of Illinois at Urbana-Champaign, Illinois. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS Accession Number: PB 87-151726. List price: \$19.95.

LETTER REPORT OF THE COMMITTEE ON IRRIGATION-INDUCED WATER QUALITY PROBLEMS (September 5, 1986)

1986, 2 pp.

The third letter report issued by the committee reviews research and related programs addressing the agricultural drain-

age problems in the San Joaquin Valley, California. The study committee was chaired by Jan van Schilfgaarde, USDA-ARS, Fort Collins, Colorado. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

LETTER REPORT OF THE COMMITTEE ON IRRIGATION-INDUCED WATER QUALITY PROBLEMS (July 8, 1986)

1986, 6 pp.

This is the first letter report issued by the Subcommittee on Quality Assurance and Quality Control of the CIWQP. The subcommittee chairman was Robert R. McGlen, University of Colorado. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

LETTER REPORT OF THE COMMITTEE ON IRRIGATION-INDUCED WATER QUALITY PROBLEMS (June 12, 1986)

1986, 4 pp.

The first letter report issued by the Subcommittee on Public Health of the CIWQP reviews the research proposed by the Ad Hoc Committee on Public Health of the San Joaquin Valley Drainage Program (SJVDP). The subcommittee chairman was Edwin H. Clark of the Conservation Foundation. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

GROUND WATER QUALITY PROTECTION: STATE AND LOCAL STRATEGIES

1986, 309 pp.

This report reviews ground water protection strategies in ten states and three

local areas of the United States. The report provides a model for those looking to establish or improve ground water quality protection programs. The committee chairman was Jerome B. Gilbert, East Bay Municipal Utility District, Oakland, California. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: \$24.50.

**DROUGHT MANAGEMENT AND ITS
IMPACT ON PUBLIC WATER
SYSTEMS**

1986, 127 pp.

This report--the first in the WSTB's series of colloquia to focus attention on emerging issues in water science, technology, and policy--addresses drought management and its impact on public water systems. The colloquium chairman was Robert L. Smith of the University of Kansas. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: \$7.50.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(April 2, 1986)**

1986, 3 pp.

The second letter report from the Committee on Irrigation-Induced Water Quality Problems responds to briefings provided by the University of California research program about irrigation drainage problems in the San Joaquin Valley. The committee chairman was William H. Allaway of Ithaca, New York. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**THE GREAT LAKES WATER
QUALITY AGREEMENT: AN
EVOLVING INSTRUMENT FOR
ECOSYSTEM MANAGEMENT**

1985, 224 pp.

This report reviews the 1978 Great Lakes Water Quality Agreement between the United States and Canada. The report covers four major areas concerning the Great Lakes and the agreement: enrichment, toxic contaminants, institutional arrangements and the ecosystem approach, and sustainable development. The committee co-chairmen were Orie Loucks of the Holcomb Research Institute, and Henry Regier of the University of Toronto. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS Accession Number: PB 87-186292. List price: \$24.95.

**LETTER REPORT OF THE COMMITTEE
ON USGS WATER RESOURCES
RESEARCH (November 26, 1985)**

1985, 9 pp.

This report recommends a focus for the research grants program administered by the U.S. Geological Survey and authorized by section 105 of the Water Resources Research Act of 1984. The committee chairman was James J. Morgan of the California Institute of Technology. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE COMMITTEE
ON IRRIGATION-INDUCED WATER
QUALITY PROBLEMS
(October 10, 1985)**

1985, 11 pp.

This report, the first in a series pro-

viding guidance to the San Joaquin Valley Drainage Program, calls for improved research coordination, better management, and public participation. The committee chairman was William H. Allaway of Ithaca, New York. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**LETTER REPORT OF THE WSTB
WORKING GROUP TO REVIEW PLANS
FOR A NATIONAL WATER QUALITY
ASSESSMENT PROGRAM
(October 7, 1985)**

1985, 3 pp.

This report was written by an ad hoc work group, consisting of Water Science and Technology Board members and members of the Committee on USGS Water Resources Research, in reaction to documents and briefings on the proposed National Water Quality Assessment Program. The workgroup chairman was Walter R. Lynn of Cornell University. The letter report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

**WSTB REVIEW OF U.S. DEPARTMENT
OF ENERGY (DOE) REPORT
"TRANSPORT OF ENERGY-RELATED
ORGANIC COMPOUNDS AND
MIXTURES IN SUBSURFACE
ENVIRONMENTS"**

1985, 6 pp.

In response to a request from the U.S. Department of Energy (DOE), an ad hoc subcommittee of the WSTB reviewed a DOE report titled "Transport of Energy Related Organic Compounds and Mixtures in Subsurface Environments" (November 1984). The DOE document was a "concept paper" describing a research plan to be adopted by the department. The subcommittee chair was Mary P. Anderson of the University of Wisconsin-Madison. The letter report is available from the Water

Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20481.

**SAFETY OF DAMS: FLOOD
AND EARTHQUAKE CRITERIA**

1985, 321 pp.

The report concerns the levels of safety to be provided at new and existing dams to withstand extreme floods and earthquakes. The report includes a thorough inventory of safety criteria for dams in use in the United States and internationally. The committee chairman was George W. Housner of the California Institute of Technology. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: \$16.50.

**REVIEW OF THE GREAT LAKES
WATER QUALITY AGREEMENT:
WORKING PAPERS AND DISCUSSION**

1984, 174 pp.

The William H. Donner Foundation, in consultation with the staff of the International Joint Commission (IJC), asked the WSTB to study the Great Lakes Water Quality Agreement. This report contains five formal papers, the discussion that followed each presentation, and a final summary chapter prepared by the Conference Advisory Panel. The conference chairman was Orie Loucks of the Holcomb Research Institute. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS Accession Number: PB 85-110807. List price: \$17.50.

**WATER FOR THE FUTURE OF THE
NATION'S CAPITAL AREA - 1984**

1984, 71 pp.

This report reviews the Army Corps of Engineers methods investigating the fu-

ture water resources needs of the metropolitan Washington area and to report the scientific bases for the conclusions reached. The committee chairmen were Daniel A. Okun of the University of North Carolina, and Walter R. Lynn of Cornell University. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, and the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS Accession number: PB 84-195585. List price: \$11.50.

THE POTOMAC ESTUARY EXPERIMENTAL WATER TREATMENT PLANT

1984, 135 pp.

This report was the culmination of an eight-year review of the U.S. Army Corps of Engineers study to determine the feasibility of using the Potomac estuary waters as a source of water supply for the metropolitan Washington area. The committee chairman was Perry L. McCarty of Stanford University. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, and the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS Accession number: PB 84-195643. List price: \$16.00.

THE LAKE ERIE-NIAGARA RIVER ICE BOOM: OPERATIONS AND IMPACTS

1984, 74 pp.

This report responds to a request from the International Joint Commission (IJC)--United States and Canada--to the NRC to assist in resolving issues associated with the ice boom located at the entrance to the Niagara River, New York and Ontario. The chairman was Harry L. Hamilton, Jr. of the State University of New York--Albany. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA

22161. NTIS Accession number: PB 84-129-709. List price: \$11.50.

SAFETY OF EXISTING DAMS: EVALUATION AND IMPROVEMENT

1983, 384 pp.

This text book-like report is to enhance dam safety and to provide guidance for achieving improvements in the safety of existing dams. The committee chairman was Robert B. Jansen, consulting engineer. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. List price: \$19.95.

LETTER REPORT: MAY 31, 1983 TO U.S. DEPARTMENT OF INTERIOR, U.S. GEOLOGICAL SURVEY AND OFFICE OF WATER POLICY

This letter report responds to a USGS request for comments on an outline for the proposed National Water Summary 1983--Hydrologic Setting of Water-Related Issues. The chairman was Walter R. Lynn of Cornell University. The report is available from the Water Science and Technology Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

COOPERATION IN URBAN WATER MANAGEMENT, CONFERENCE PROCEEDINGS

1983, 187 pp.

The WSTB held a conference in 1982 to assess the barriers to efficient management of urban water supplies, titled "Cooperation in Urban Water Management" and produced this report. The conference chairman was David H. Marks of the Massachusetts Institute of Technology. The report is available from the National Technical Information Service, 5285 Royal Road, Springfield, VA 22161. NTIS Accession number: PB 83-217992. List price: \$17.50.

**A LEVEE POLICY FOR THE
NATIONAL FLOOD INSURANCE
PROGRAM**

1982, 107 pp.

This report provides recommendations for integrating structural and non-structural flood mitigation in the National Flood Insurance Program. The committee chairman was L. Douglas James of Utah State University. The report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Accession number: PB 83-134619. List price: \$13.00.

**SAFETY OF NONFEDERAL DAMS:
A REVIEW OF THE
FEDERAL ROLE**

1982, 53 pp.

The recommendations in this report concern the enhancement of state dam safety programs. The committee chairman was Robert B. Jansen, a consulting engineer. The report is available from the National Technical Information Service, 5282 Port Royal Road, Springfield, VA 22161. Accession number: PB 82-188855. List price: \$9.00.

Appendix B

Meetings of the Water Science and Technology Board and its Subgroups During 1989

JANUARY

5-6 Committee on Coastal Erosion
Zone Management Committee,
Washington, D.C.

19 Planning Session for Study of
Emerging Technologies in Water
Treatment, Washington, D.C.

19 Planning Session for Study of
Wastewater Management for Ur-
ban Coastal Areas, Washington,
D.C.

FEBRUARY

16-17 Committee on National Water
Quality Assessment Pilot Program,
Washington, D.C.

20 Water Science and Technology
Board, Washington, D.C.

20-21 Colloquium V-Ground Water and
Soil Contamination Remediation:
Toward Compatible Science, Pol-
icy, and Public Perception

MARCH

2-4 Committee on Opportunities in
the Hydrologic Sciences, Beckman
Center, Irvine, California

23-25 Committee on National Water
Quality Assessment Pilot Program,
Washington, D.C.

8-10 Committee on Irrigation-Induced
Water Quality Problems, Albu-
querque, New Mexico

MAY

23-24 Committee on Coastal Erosion
Zone Management, Beckman Cen-
ter, Irvine, California

8-9 Committee on Coastal Erosion
Zone Management, Washington,
D.C.

28-29 Committee on USGS Water Re-
sources Research, Reston, Virginia

25-26 Committee on Western Water Man-
agement Change, Beckman Center,
Irvine, California

APRIL

6-7 Committee on Ground Water Re-
charge in Surface-Mined Areas,
Pittsburgh, Pennsylvania

JUNE

19-21 Committee on Ground Water
Recharge in Surface-Mined Areas,
Lexington, Kentucky

6-7 Subcommittee on Economics and
Policy and Systems Analysis, San
Francisco, California

26 Committee on Glen Canyon En-
vironmental Studies, Denver, Col-
orado

JULY

- 6-7 Committee on Irrigation-Induced Water Quality Problems, Beckman Center, Irvine, California
- 20-22 Committee on Opportunities in the Hydrologic Sciences, Beckman Center, Irvine, California

AUGUST

- 21-22 Committee on Coastal Erosion Zone Management, Washington, D.C.

SEPTEMBER

- 7-9 Committee on Ground Water Recharge in Surface-Mined Areas, Billings, Montana
- 7-8 Committee on USGS Water Resources Research, Boulder, Colorado
- 14-15 Water Science and Technology Board, Woods Hole, Massachusetts
- 25-26 Committee on National Water Quality Assessment Pilot Program, Beckman Center, Irvine, California

OCTOBER

- 5-6 Committee on Restoration of Aquatic Systems: Science, Technology, and Public Policy, Washington, D.C.
- 26-28 Committee on Western Water Management Change, Reno, Nevada

NOVEMBER

- 10-11 Committee on Opportunities in the Hydrologic Sciences Editorial Group, Cambridge, Massachusetts
- 16-18 Committee on National Water Quality Assessment Pilot Program, Beckman Center, Irvine, California
- 20-21 Committee on Ground Water Recharge in Surface-Mined Areas, Washington, D.C.

DECEMBER

- 4 Committee on Glen Canyon Environmental Studies, Washington, D.C.

Appendix C

Terms of Reference Water Science and Technology Board (Adopted November 29, 1982)

INTRODUCTION AND PURPOSES

The Water Science and Technology Board (WSTB) was established in the National Research Council to provide a single focal point for studies related to water resources accomplished under the aegis of the National Academy of Sciences and the National Academy of Engineering. The Board's objective is to improve the scientific and technological basis for resolving important questions and issues associated with the efficient management and use of water resources.

In carrying out its responsibilities and to serve the national interest, the Board responds to requests for evaluations and advice concerning specific and generic issues in water resources; influences action by initiating studies of issues that merit consideration by public agencies and others; identifies issues and topics of research related to water resources; and cooperates with other units of the National Research Council and groups with mutual interests outside the National Research Council.

The Board's scope covers the traditional scientific and engineering aspects of water resources and the economic, institutional, legal, educational, and social aspects, as well.

AREAS OF INTEREST

To pursue its objectives, the Board is concerned with:

- Basic hydrologic and related sciences and their applications in water resource systems, including analyses of ground water movement and the hydrologic cycle, measurement of water quantity and quality, data analysis, and forecasting.

- Planning, analysis, and operation of water systems, including resource management, water quality and quantity for all uses, public health and environmental protection, aquifer and watershed protection and management, economic analysis, design standards, modeling methods, risk assessment, system analysis techniques, and management systems.

- Nonstructural water resources issues, such as floodplain management, supply-demand relationships, water reallocation and reuse, effects of human activities on water resources, legal-institutional issues, ecosystem effects, and cultural and aesthetic values.

- Structural and traditional engineering aspects of water projects, such as dams, levees, renovation-retrofit technologies, and treatment processes.

- The health and vitality of the nation's water-related science and engineering establishment, including its educational aspects.

GENERAL ACTIVITIES

The Board strives to accomplish its purposes through the following means:

1) Responding to specific requests by government agencies and others;

2) Reviewing and evaluating water-related research and scientific, engineering, and technological developments;

3) Initiating investigations of issues considered to be appropriate by the Board, its parent Commissions, and the Governing Board of the National Research Council;

4) Reviewing research and the state-of-the art in science, engineering, and technology related to the development and management of water and related resources, especially in relation to national objectives and priorities;

5) Projecting future needs for and capabilities of multi-disciplinary water-related research and education in the sciences, engineering, and technology;

6) Disseminating the results of its studies, serving as a repository of scientific and engineering knowledge, and providing a forum for the exchange of information on water science and technology;

7) Fostering communication among members of the professional community in the United States on national and international water resources issues; and

8) Articulating water-related educational issues, including undergraduate, postgraduate, continuing education, and public-education programs and the related needs for equipment and facilities.

ORGANIZATION AND MANAGEMENT

Governance and Relationship with Parent Bodies

The Board, although responsible for its own immediate governance, is accountable to and supported by two Commissions of the National Research Council--the Commission on Engineering and Technical Systems (CETS) and the Commission on Physical Sciences, Mathematics, and Resources (CPSMR)*. CETS is primarily concerned with the development and applica-

tion of engineering disciplines to technological systems and their relationship to societal problems, while CPSMR is primarily concerned with basic sciences and their relation to resource identification and development and environmental management. For each of its specific technical, project, or administrative activities, the Board or its study groups will be responsible to and supported by either CETS or CPSMR.

The Board may undertake activities related to its mission such as conferences, seminars, and meetings. It may collaborate with professional associations and other groups as may be necessary to fulfill its goals.

The Board may recommend to the Chairman of the National Research Council and to the Commissions such changes in the purposes, responsibilities, size, and functions of the Board as it believes desirable.

BOARD MEMBERSHIP

To meet its broad need for expertise, the Board consists of not fewer than 15 and not more than 18 members in addition to its Chairman. Members are chosen for their background and experience as well as for their familiarity with appropriate scientific, technological, and policy issues. While serving on the Board, each member, insofar as possible, participates in at least one study conducted under the auspices of the Board.

Terms of appointment are normally for three years. Members are not eligible for more than two consecutive three-year terms. The Board Chairman is appointed by the Chairman of the National Research Council for a period not to exceed three years. The Board nominates individuals for its own continuing membership.

When appropriate, the Board may invite federal agencies and organizations to nominate individuals to serve as non-voting liaison representatives to the Board.

*Note: In February 1990 the CPSMR was disestablished. A new Commission on Geosciences, Environment, and Resources (CGER) was created. The WSTB was thenceforth responsible to the CGER and CETS. WSTB terms of reference will be modified accordingly.

STUDY GROUP ACTIVITIES

The principal operating units of the Board are its separately appointed and individually mandated study groups. The Board, assisted by its staff, manages the activities of these units.

The Board exercises its oversight responsibility for ongoing studies by receiving reports from the chairpersons or staff and meeting with them as it deems appropriate.

The Board originates or reviews and approves nominations for membership on the study group committees and transmits its recommendations to the appropriate Commission.

The Board Chairman, with the approval of the Chairman of the appropriate Commission and the Chairman of the National Research Council, appoints chairmen and members of committees of the Board.

In recommending nominations for its committees, the Board seeks advice from both within and outside the National Research Council. Normally, members of committees or panels serve for the duration of a given study.

REPORT REVIEW

The Board reviews all reports that develop from its program in accordance with procedures and requirements established by the appropriate Commission and by the Report Review Committee of the National Research Council.

BOARD MEETINGS

The Board normally meets three times each year, twice at the NRC headquarters in Washington, D.C., and once elsewhere in the United States. Additional meetings are held as the Board deems necessary to carry out its responsibilities for planning, oversight, and review including, but not limited to, review and assessment of current activities; consideration and approval of new projects, proposals, and proposed memberships; technical and programmatic brief-

ings; and discussions with government decisionmaking and policy personnel.

PROGRAM PLANNING

The Board, with the aid of WSTB staff, annually prepares a general plan of its proposed program of activities and projects for submission to the two Commissions, accompanied by a request for authorization to receive outside funds for the support of these activities. The Board prepares reports on its activities as may be requested or required by the Commissions or the Governing Board of the National Research Council.

The Board Chairman and Staff Director present the Board's program plan and budget to the Commissions. New projects, approved by the Board, that do not appear in the approved plan and authorized budget are brought to the appropriate Commission for action. The Chairman and Director also report periodically to the Commissions on any issues and problems of particular concern to the Board and any issues of broader scope that may require a response of the National Research Council.

The Board formulates programs and requests funds in support of undertakings deemed to be logical, appropriate extensions of its approved program plan, subject to appropriate approvals.

The Board reviews all proposals for new activities that require the use of outside funds. Proposals must be approved by the Board before a request for authorization to receive funds is submitted to the appropriate Commission.

Proposed projects are evaluated by the Board according to the following criteria: (a) the importance of the issue to the nation relative to its water needs; (b) the availability of expert volunteers who can ensure that the Board's contribution will be appropriate, effective, and timely; (c) the relevance of the work to the Board's areas of interest and competence, and (d) the involvement of policymakers of sufficient stature to ensure that the Board's response will have a significant impact.

STAFF

The Board Director is responsible to the Chairman for the general management of the Board's program and to the executive Directors of CETS and CPSMR. The Director has the authority to hire additional staff members and or consultants necessary to assist in the overall management of the Board's program, subject to the constraints

and approvals of National Research Council policies and the administrative budget of the Board.

EXPENSES

Expenses of the Board and its study groups, including support of its staff and meetings, are ordinarily financed by grants or contract funds.

- END -

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