

## IN THIS ISSUE

### Feature

*Water Disinfection  
Issues and Alternatives*

### New Reports

*Natural Attenuation for  
Groundwater  
Remediation, p. 3*

*Research in Subsurface  
Science at the DOE, p. 4*

**Current Projects, p. 5**

**Future Projects, p. 9**

**WSTB Reports, p. 10**

**National Research  
Council Meetings, p. 13**

Find us at the web:  
[nationalacademies.org/wstb](http://nationalacademies.org/wstb)

Printed on recycled paper

## Water Disinfection Issues and Alternatives

By Laura Ehlers

Disinfection of drinking water has had a tremendous positive impact on public health in the twentieth century, eliminating massive waterborne outbreaks of typhoid fever and cholera. It is important in industry, healthcare, home hygiene, drinking water, and wastewater applications and is accomplished by the use of chemicals or by ultraviolet radiation. Despite the proven benefits of disinfection, however, there are mounting concerns regarding the use of disinfectants because of their role in the creation of harmful disinfection byproducts (DBPs) and other environmental impacts. The common disinfectants chlorine, chloramine, chlorine dioxide, and ozone all form DBPs or chemical degradation products subsequent to their interaction with water sources containing natural organic matter. Many DBPs have potential adverse health effects, and the majority of DBPs have yet to be identified. Public health authorities have recognized the need to control levels of DBPs in drinking water by establishing standards for trihalomethanes and haloacetic acids, which are likely to become stricter in the near future.

Striking the proper balance between rigorous disinfection for microbial pathogens and control of DBP formation has been a difficult undertaking for EPA and for the drinking water industry. Although prevention of waterborne microbial disease remains the primary purpose of disinfection, greater care must now be used during the application of chemical disinfectants in order to mitigate the formation of DBPs. The question of how to provide the greatest amount of affordable health protection in the context of drinking water has been very difficult to answer, and continues to pose challenges to regulators, researchers,

### Envisioning the Agenda for Water Resources Research in the 21<sup>st</sup> Century

At several of its meetings during the past year and a half, the WSTB held discussions about water management challenges of the twenty-first century and the adequacy of water research arrangements to meet those challenges. The board members are now engaged in writing a report based upon those discussions. The report is intended to (1) delimit key water resource challenges of the next two decades; (2) identify broad areas that should receive immediate emphasis in the water resources research planning; and (3) describe ways in which the setting of water research agendas, the conduct of water research, and the levels of investment devoted to such research might be improved in the next decade or so. Projected population growth and its implications for land and natural resource use; economic growth and the quickening pace of introduction of new technologies with potentially unknown side effects; the pressures of the globalizing economy; more widespread recognition of the need to preserve and enhance aquatic-based ecosystems; and the prospects of global warming will likely combine to make the problems of managing water resources a more significant challenge in the twenty-first century than they have been in the past. The board intends to complete this project and publish its report, useful to those with roles in water research management, in mid-2000. For information, contact Laura Ehlers at 202-334-3422 or [lehlers@nas.edu](mailto:lehlers@nas.edu).

public health experts, and water utilities. In response, the WSTB is proposing a new study to evaluate the efficacy, benefits, and environmental costs of disinfectants and to explore alternative disinfectants. The results of such a study will be equally vital for both industries and governments.

A major public health challenge is to assess the efficacy of disinfection procedures in destroying microbial pathogens. Determining the efficacy of disinfection is dependent on a specified protocol for measuring concentrations of organisms and determining their viability and infectivity following disinfection. Current methods for determining viability and infectivity include culturing on growth media for bacteria, cell culture techniques for viruses, and vital dye or stain, excystation, and animal infectivity for protozoa—all of which are imperfect to some extent. In addition, new methods are being devised but have not yet been standardized across the country—a necessity if they are to be used regularly to determine disinfection efficacy. Methodological problems with determining disinfection efficacy are even more daunting for new and emerging disinfectants, such as UV irradiation. Approaches for comparing the tradeoffs and the benefits from one disinfection technique to another are needed.

Microorganisms that can maintain viability and replicate in the presence of low levels of disinfectants are “tolerant,” while those that can maintain viability and biological functions at practically applied levels of disinfectants are “resistant.” Microbial resistance to disinfection is of particular relevance for bacteria and, unlike bacterial resistance to antibiotics, has received very limited study. Numerous field studies have shown that indicator bacteria and human pathogens can persist in water systems, despite the effectiveness of disinfectants in laboratory settings. Little is known about the mechanisms of bacterial resistance to disinfectants, and no genetic determinants for resistance have been isolated. Given the importance of disinfection processes in protecting public health, a greater research investment in this issue is clearly warranted.

Maintaining a disinfectant residual in water distribution systems is common practice in the United States, and it is required by federal regulations for systems treating surface water. Many health authorities contend that a disinfectant residual in the distribution system provides a measure of protection in the event of fecal contamination of the distribution system. Maintaining a disinfectant residual may also be important in suppressing the growth of bacterial biofilms within the distribution system. In general, though, our understanding of the role of disinfectant residuals and their overall importance at concentrations typically used is limited. As new disinfectants and combinations of disinfectants are developed, it will be imperative to assess their persistence within distribution systems under a variety of environmental conditions and to develop strategies for managing disinfectant residuals to minimize bacterial

regrowth.

The disinfection of wastewater has received limited attention, mainly in connection with the Clean Water Act. The Act sets conditions on the quality of discharged effluent in order to prevent waterbodies from violating water quality standards. These standards are inconsistent from state to state and are usually based on controlling fecal bacterial indicators rather than on risk-based or performance-based approaches for controlling pathogenic bacteria, viruses, and protozoa. Ambient water quality criteria for most microbes have not been established, making it difficult to determine how effective the disinfection of discharged effluent should be. Only in the reclaimed water arena has further evaluation of the disinfection barrier been undertaken. Seasonal disinfection, coliform recovery, and the impact of chlorine residuals on ecological systems have initiated much discussion on the role and type of disinfection needed for dischargers of wastewater. Resolving these issues requires a better understanding of disinfection practices, alternatives, and efficacy.

The WSTB hopes to confront these issues by establishing an expert committee to undertake the following activities:

- Summarize the universe of current and emerging disinfectants and their applications;
- Review mechanisms of inactivation and inactivation kinetics for different disinfectants;
- Evaluate the methods used to quantify inactivation via disinfectants, considering both killing and elimination of the organism’s capability to reproduce;
- Evaluate microbial resistance to disinfectants vs. microbial tolerance;
- Examine how well emerging and existing disinfectants provide for residual maintenance within the distribution system; and
- Examine approaches for assessing the benefits and costs of disinfection, including the formation of disinfection byproducts.

A workshop will be held March 28 in Washington DC to bring together public and private stakeholders, generate interest in the study, and identify potential sponsors and committee members.

---

*Laura Ehlers is a Senior Staff Officer with the Water Science and Technology Board*

## New Reports

### Natural Attenuation for Groundwater Remediation

By Jacqueline MacDonald and Laura Ehlers

At tens of thousands of sites around the United States, contaminated groundwater and soil are being treated with natural processes—a site remediation strategy called “natural attenuation.” Such processes can transform contaminants to less harmful forms or immobilize them, and they result from biological, chemical, and physical reactions that take place in the subsurface. Regulatory definitions of natural attenuation include not only contaminant degradation by subsurface microbes, reactions with naturally occurring chemicals, and sorption onto geologic media, but also other natural processes that dilute contaminants or transfer them from water to air. At an increasing number of sites, responsible parties and environmental regulators are relying on natural attenuation to control contamination, in part because of the high costs of engineered cleanup systems. The WSTB sheds new light on this important issue with the release of its report *Natural Attenuation for Groundwater Remediation*. The report examines public concerns about natural attenuation, the scientific bases for natural attenuation, and the criteria for evaluating the potential success or failure of natural attenuation.

Community representatives often express significant reservations about using natural attenuation as a formal cleanup remedy. Often viewed as a “do-nothing” approach, natural attenuation is perceived by many affected communities as allowing responsible parties to save on cleanup costs while exposing the community to undue health and environmental risks. For this reason, public involvement in decision making is especially important at sites where natural attenuation is proposed as a remedy. The report recommends that environmental agencies and responsible parties provide communities with clear evidence indicating which natural attenuation processes are responsible for the loss of contaminants (when natural attenuation is proposed as a formal remedy for groundwater contamination). In addition, federal and state environmental regulations and guidelines for cleaning up contaminated sites affecting communities should be changed to allow community involvement as soon as the presence of contamination is confirmed. Current regulations provide for community involvement only after a list of potential remedies has been proposed. A central repository of all data concerning the contamination and potential remedies at sites is essential to the success of natural attenuation.

The report discusses the likelihood that natural attenuation will succeed as the key part of a site cleanup strategy. In general, natural attenuation is well established as a remediation approach for only a few types of contaminants, primarily benzene, toluene, ethylbenzene,

and xylene (BTEX). For other contaminant classes, it is not as likely to succeed or not well established. In some cases, the likelihood of success is low because of the possible production of toxic intermediate compounds. In other cases, the presence of contaminant mixtures can influence natural attenuation of any one component of the mixture. Natural attenuation processes cannot destroy metals but only immobilize them. Finally, potential for success is low because our scientific understanding is limited. For these reasons, the report recommends that natural attenuation never be considered a default or presumptive remedy.

The report discusses the criteria necessary for documenting that natural attenuation is occurring at a waste site. These include not only data showing a decrease in contaminant concentration in groundwater samples, but also a site model and “footprints” of the underlying mechanisms. Footprints are concentration changes in reactants (other than contaminants) or products of the biogeochemical processes that transform or immobilize the contaminants. When coupled to an observation of the loss of a contaminant, footprints help to establish which processes are responsible for attenuation. The report recommends long-term monitoring of waste sites to ensure that documented attenuation processes continue to occur.

Within the past few years, many organizations have issued documents providing guidance on evaluating natural attenuation; 14 of these documents were reviewed by the report’s authoring committee. A comprehensive natural attenuation protocol should cover community concerns, multiple scientific and technical issues (e.g., determining which natural attenuation processes are responsible for observed decreases in contaminant concentrations), and implementation issues. For a variety of reasons, none of the reviewed documents fulfilled all these criteria. The existing protocols are silent on when and how to involve the public in site decisions and when and how to implement institutional controls. Discussion of contingency plans in case natural attenuation does not work also is inadequate in many of the protocols. Guidance on how to conduct long-term monitoring to ensure that natural attenuation remains protective of public health and the environment is limited. Because EPA does not officially endorse any protocols other than those developed by the agency, it is unclear which protocols are appropriate for use in various regulatory programs. The report recommends that EPA develop national consensus guidelines for protocols on natural attenuation as soon as possible.

In summary, natural attenuation processes that degrade or transform contaminants can work well in controlling risks from groundwater contamination when the right combination of contaminants and environmental conditions exists. Natural attenuation is most likely to be effective for contaminants that are readily degraded or immobilized under a wide range of environmental conditions such as BTEX. For most other commonly encountered

environmental contaminants, natural attenuation may work in some cases only under very specific site conditions. Regardless of how simple or complex the contaminant and its environment are, documenting natural attenuation requires evidence that natural processes at the site are immobilizing or destroying the contamination to an extent that is sufficient to protect public health and the environment. Footprints of the attenuation reactions should serve as the basis for this evidence, and rigorous protocols are needed to ensure that the evidence is sufficient.

The committee was chaired by Bruce E. Rittmann of Northwestern University. Funding was provided by EPA, USGS, DOE, DOD, the American Petroleum Institute, the Chemical Manufacturers' Association, Chevron, Lawrence Livermore National Laboratory, the National Mining Association, and the Nuclear Regulatory Commission. To order a prepublication copy of the report, contact the National Academy Press at 800-624-6242 or www.nap.edu.

## Research Needs in Subsurface Science at the DOE

By Patricia Jones

The Board on Radioactive Waste Management and the WSTB have just released a new report, *Research Needs in Subsurface Science: U.S. Department of Energy's Environmental Management Science Program*. The report provides an overview of subsurface contamination problems across the DOE complex, using experiences from the six largest DOE sites (Hanford, Idaho Engineering and Environmental Laboratory, Nevada Test Site, Oak Ridge Reservation, Rocky Flats, and Savannah River) to demonstrate how advances in scientific and engineering knowledge can improve the effectiveness of cleanup efforts.

Nuclear weapons production has resulted in the widespread contamination of DOE sites, ranging from contaminated waste burial grounds to contaminated soil, sediment, rock, and groundwater. Subsurface contamination is a difficult cleanup problem that represents an enormous liability for the nation. Its solution is partially dependent on the development and application of new and improved cleanup technologies. Such development will require advances in our basic understanding of the complex natural systems at DOE sites and DOE contaminants. Given the long-term nature of the DOE's cleanup mission and its projected cost—the program is planned to last until 2070 and cost on the order of \$200 billion—the report states that DOE has sufficient time to do the basic research required to support the development and deployment of new cleanup technologies.

DOE's Environmental Management (EM) Science Program is one of the largest environmental research efforts in the federal government. The program has supported research projects relevant to many aspects of DOE's cleanup program, including subsurface contamination, high-level waste, and plant deactivation

and decommissioning. The report concludes that there is a critical mass of projects covering remediation of subsurface contamination, especially treatment and destruction of organic contaminants through physical, chemical, and biological processes, but that there are research gaps in the areas of containment, model validation, and monitoring of treatment effectiveness. These are significant problem areas in the DOE complex, as it is inevitable that DOE will have to manage much of its subsurface contamination in place. In addition, there are relatively few projects that address radionuclide and metal contamination.

The major recommendations of the report focus on a long-term basic research program for subsurface contamination and address program vision, research emphases, and implementation. First, the report recommends that a vision for the program be supported both programmatically and financially by DOE upper management. The program should generate new knowledge to support DOE's mission to clean up its contaminated sites, it should be well connected to DOE's difficult cleanup problems; and it should have a long-term, multidisciplinary focus on resolving DOE's subsurface contamination problems.

Second, based on the analysis of DOE's subsurface contamination problems, the report recommends that the subsurface component of the EM Science Program have four research emphases. The first program component should be to better locate and characterize subsurface contaminants. Basic research that supports advances in capabilities to locate and characterize subsurface contamination and elucidate relevant subsurface conditions will help DOE to better assess the potential hazards of its contamination problems and design and implement appropriate corrective action strategies. The second program component is conceptual modeling. Basic research on the fundamental approaches and assumptions underlying conceptual model development could produce a "tool box" of methodologies that can be applied to contaminated sites both inside and outside the DOE complex. Third, the research program must emphasize containment and stabilization. There is a need to develop new waste containment and stabilization technologies to lower the cost, accelerate regulatory approvals, and increase public confidence in solving subsurface contamination problems. Finally, the program must include long-term monitoring and validation of treatment effectiveness. Improvements in capabilities to monitor and validate contaminant locations and perform remedial actions will greatly enhance the technical success of DOE's efforts. Within these four emphases, the EM Science Program should encourage research on metals and radionuclides, which are generally not receiving attention in other federal research programs.

To be successful, the program must be structured so that research results can be handed off to technology developers and problem holders at DOE sites. In

particular, the report encourages program managers to support program-wide integration activities that optimize the impacts of advances in subsurface science on DOE site cleanup. It recommends that program managers examine the feasibility of developing field research sites as one program component. Such sites could attract new researchers to the program, encourage both formal and informal multidisciplinary collaborations among researchers, and facilitate the transfer of research results into application. The current level of program funding was determined to be insufficient to support the research emphases outlined in the report, especially because subsurface research is just one of many research areas supported by the program.

The report concludes that basic research supported by the EM Science Program and other relevant federal research programs will have little if any impact on DOE cleanup unless research results are transferred into technology development programs and to problem holders at DOE sites. Strong scientific, technical, and management leadership is needed at all levels, from the EM Science Program to the assistant secretary for environmental management, if significant progress in the DOE cleanup program is to be made in the next decade.

The committee was chaired by Jane C. S. Long of the University of Nevada, Reno. This project was funded by the U.S. Department of Energy, Office of Environmental Management. To obtain a copy of this report, contact the National Academy Press at 800-624-6242 or [www.nap.edu](http://www.nap.edu).

---

## Current Projects

### **NRC Takes on New Fast-Track Study of Corps of Engineers' Upper Mississippi River-Illinois Waterway Navigation Improvement Planning Studies**

Since 1993, the U.S. Army Corps of Engineers has been conducting a planning study of the feasibility of improvements (primarily larger locks on select dams) to the navigation system on the Upper Mississippi River. Based on economic analyses conducted by an economics work group in the Corps's St. Louis district office, preliminary (1998) results suggested that large-scale structural improvements to the navigation system would not be economically feasible. But in recent allegations prominently featured in the national media, the Corps stands accused of later improperly adjusting some key economic assumptions and methods in order to reach a conclusion supporting expanded capacity (through larger locks) of the Upper Mississippi-Illinois navigation system. One result of these allegations is that the Department of Defense has arranged for the NRC to conduct an independent review of the navigation study's economic analysis.

This project will be organized jointly by the WSTB and the Transportation Research Board. (The committee was not yet appointed when this item went to press.) The study will focus mainly on the Corps' economic analysis regarding proposed improvements, including economic assumptions, methods, and forecasts regarding barge transportation demands on the Upper Mississippi River-Illinois Waterway. A committee of about ten members with expertise in transportation economics, natural resource economics, water resources planning and analysis, econometrics, and cost-benefit analysis will be appointed. It is expected that the committee will meet three times between May and October. At its first meeting, the committee will likely be briefed by various participants involved in the Corps' economic analysis. Members of the public, along with representatives of environmental and transportation interest groups, will have the opportunity to express their perspectives on the analysis. Subsequent meetings will be spent preparing the committee's report and hearing from interested stakeholder groups. For questions about this study, please contact Jeffrey Jacobs at 202-334-2899 or [jjacobs@nas.edu](mailto:jjacobs@nas.edu).

### **Bioavailability of Contaminants in Soils and Sediments**

The first meeting of the new committee on bioavailability of contaminants in soils and sediments is scheduled for May 15–16 in Washington, DC. The committee will study processes that affect availability of contaminants in soils and sediments to humans and ecosystems. A variety of mechanisms—from sorption on solid materials to biological and chemical transformations—can render contaminants present in the environment virtually harmless to human and ecological systems. Yet existing risk assessment tools do not adequately account for these mechanisms. This study will assess broadly the current scientific understanding of processes—both in the environment and in the human body—that affect whether chemical contaminants present in soils and sediments at contaminated sites are bioavailable to humans, animals, and plants. The committee will also evaluate existing tools for measuring bioavailability. It will analyze how treatment with different remediation technologies affects bioavailability and how bioavailability impacts treatment processes that rely on microbial degradation of contaminants.

Committee members include Richard G. Luthy, *chair*, Stanford University; Richelle M. Allen-King, Washington State University; Sally L. Brown, University of Washington; David A. Dzombak, Carnegie Mellon University; Scott E. Fendorf, Stanford University; Joseph H. Graziano, Columbia University; Joseph B. Hughes, Rice University; John P. Giesy, Michigan State University; Samuel N. Luoma, USGS; Linda A. Malone, College of William and Mary; Charles A. Menzie, Menzie-Cura and Associates, Inc.; Michael V. Ruby, Exponent; Terry W. Schultz, University of Tennessee; Barth F. Smets,

University of Connecticut; and Kimberly M. Thompson, Harvard University. Sponsors include EPA, the Strategic Environmental Research and Development Program, the National Institute of Environmental Health Sciences, the Army, the Air Force, the Agency for Toxic Substances and Disease Registry, and the Department of Energy. For more information, contact Laura Ehlers at 202-334-3422 or lehlers@nas.edu.

### **Opportunities to Improve the National Water Quality Assessment (NAWQA) Program**

The WSTB recently convened a new committee to review the USGS National Water Quality Assessment (NAWQA) program. This eight-year-old, \$70 million/year perennial program was designed to describe the status of, trends in, and factors affecting surface water and groundwater quality throughout the United States. The committee will suggest methodologies to improve understanding of the causative factors affecting water quality conditions; it will assess whether information produced in the program can be extrapolated to areas not studied intensively under NAWQA; it will examine the current national synthesis topics; and it will make recommendations on aggregation and presentation of information.

The committee held its first of four meetings February 3–4, 2000, in Washington, DC. At the meeting, the committee heard presentations from key USGS representatives and from representatives of EPA, USDA, and the Maryland Geological Survey, which routinely use NAWQA data and reports and closely interact with NAWQA personnel. The committee also developed an outline and strategy for completing its report. The second meeting, to be held May 1–2 in La Jolla, CA, will include additional presentations by USGS/NAWQA personnel and others. The committee membership includes George R. Hallberg, *chair*, Cadmus Group, Inc.; Michael E. Campana, University of New Mexico; Daniel B. Carr, George Mason University; Lorraine L. Janus, New York City Department of Environmental Protection; Judith L. Meyer, University of Georgia; Kenneth H. Reckhow, Duke University and the Water Resources Research Institute of the University of North Carolina; Marc O. Ribaud, U.S. Department of Agriculture; Paul V. Roberts, Stanford University; Kenneth K. Tanji, University of California, Davis; Richard M. Vogel, Tufts University; and Marylynn V. Yates, University of California, Riverside. For more information, contact Mark Gibson at 202-334-3422 or mgibson@nas.edu.

### **Mitigating Wetland Losses**

The joint BEST/WSTB Committee on Mitigating Wetland Losses held its first meeting in Washington, DC on January 19–20. At the request of EPA, the new study is evaluating the effectiveness of wetland restoration and

mitigation practices in replicating predisturbed wetland functions and ecological attributes. The study will review the scientific and technical literature on wetlands structure and functioning and Clean Water Act Section 404 regulatory program options for mitigating wetlands loss through project specific mitigation, mitigation banking, and, where applicable, in-lieu fee programs. The committee will evaluate the current ability of practitioners to restore various wetlands in a variety of environments and evaluate the factors associated with success and failure of mitigating for wetlands loss. The committee will analyze an illustrative set of wetlands mitigation projects, including individual projects, mitigation banks, and in-lieu fee programs to the extent that they have ecological goals.

At its first meeting, the committee heard presentations from EPA and a number of interest groups and discussed study strategy, including the next meeting to be held March 26–28. The committee includes Joy Zedler, *chair*, University of Wisconsin; Victoria Alvarez, California Department of Transportation; Robert Evans, North Carolina State University; Royal Gardner, Stetson University; James Gilliam, North Carolina State University; Karen Prestegard, University of Maryland; Ann Redmond, Florida Wetlandsbank, Inc.; Leonard Shabman, Virginia Polytechnic and State University; Charles Simenstad, University of Washington; and Eugene Turner, Louisiana State University. For more information, contact David Policansky at 202-334-2540 or dpolican@nas.edu or Stephen Parker at 202-334-3422 or sdparker@nas.edu.

### **Missouri River Ecosystem Science**

The U.S. Army Corps of Engineers constructed and operates six mainstem dams on the Missouri River. Due partly to drought in the basin in the late 1980s and early 1990s, and due partly to concerns over aquatic habitat degradation, the Corps considered many options for revising its Missouri River dam operations policies. One recommendation (from the Missouri River Basin Association) to the Corps was that a solid scientific knowledge base was essential for improved river management. This WSTB committee will characterize the historical and current ecological status of the Missouri River and floodplain ecosystem and review scientific research on the river-floodplain ecosystem. The committee will also identify appropriate institutional arrangements for improving ecosystem monitoring and research, and identify institutional arrangements that can enhance adaptive management of the river-floodplain ecosystem.

The committee held its first meeting in Omaha, NE on December 13–14, 1999. The committee heard from study sponsors EPA and Army Corps of Engineers, who were represented by Dennis Grams (EPA) and Rosemary Hargrave and Larry Cieslik (Corps). Gene Zuerlein from the Nebraska Game and Parks Commission gave a presentation on Missouri River ecology and river

management. During an open public comment session, the committee also heard from Jim Becic (Papio-Missouri River Natural Resources District); Chad Smith (American Rivers); John Sowl (National Park Service); and Nick Stas (WAPA). The committee will hold its second meeting in Columbia, MO, on April 25–26. Steve Gloss of the University of Wyoming serves as chair. For more information, contact Jeffrey Jacobs at 202-334-3422 or jjacobs@nas.edu.

### Restoration of the Greater Everglades

The Committee on the Restoration of the Greater Everglades Ecosystem (CROGEE), formed at the request of the Secretary of the Interior, Bruce Babbitt, has now held two meetings. The first was held on December 2–4, 1999 in Hollywood, FL. The meeting was attended by a broad spectrum of scientists, engineers, and other interested citizens from governmental, educational, business, and environmental institutions and the Miccosukee and Seminole Tribes. The committee heard presentations on topics including descriptions of the natural and altered systems, overviews of the proposed restoration process and the science underlying it, and the relationships of the Everglades to the urban and agricultural sectors.

The second meeting was held on February 28–March 1, 2000 in River Ranch, FL. Detailed briefings were given on Restudy features such as hydrologic and quantitative ecological modeling, and local planning and growth management issues. Committee members and other meeting participants then organized themselves into small groups to accommodate their interests in social science, and hydrological and ecological issues. One important outcome of the meeting will be the formation of a more detailed work plan for the year. Meeting schedules and agendas are posted on the National Academies web site (<http://www.national-academies.org>). For more information contact Stephen Parker or William Logan at 202-334-3422 (sdparker@nas.edu or wlogan@nas.edu).

### Committee on Drinking Water Contaminants

The joint WSTB/BEST Committee on Drinking Water Contaminants held the first meeting of its second phase of study on December 2–3, 1999, in Washington, DC. EPA's Office of Ground Water and Drinking Water has requested that the committee develop and recommend a process to prioritize all types of potential drinking water contaminants (including microbiological contaminants) for inclusion on future Drinking Water Contaminant Candidate Lists (CCLs). The process must also include a simple semi-quantitative prioritization tool as recommended by the committee in their first two reports, *Setting Priorities for Drinking Water Contaminants* and *Identifying Future Drinking Water Contaminants*. At its meeting, the committee heard a presentation from EPA representatives

and developed an outline and strategy for completing its report, which is due in the fall of 2000. The second meeting, held March 6–8 in Irvine, CA, included a short workshop and presentations on the development and use of mechanisms for grouping related microbial pathogens for research and regulation. Deborah Swackhamer of the University of Minnesota chairs the committee. For more information, contact Mark Gibson at 202-334-3422 or mgibson@nas.edu.

### Privatization of Water Services in the United States

Water supply and sewerage services were initially owned and operated by the private sector in many U.S. cities. With the growth of large cities and strong governments, local government entities eventually assumed ownership and operation of most of the nation's water service companies. But during the past 15–20 years, a range of factors has driven many municipalities to consider the benefits of privatization. Many U.S. cities today lease various parts of their water supply and wastewater treatment systems to private operators. While it holds great promise for improving water service delivery, the long-term consequences of U.S. water service privatization are not clear. This committee is reviewing water service privatization in the U.S. in light of its economic and fiscal, regulatory, public service and public health, environmental, and water quality implications. The committee held its second meeting in Irvine, CA, on February 21–22. Guest speakers included Paul Gagliardo, City of San Diego Water Department; Michael Gritzuk, Phoenix Water Services Department; and Paul Reiter, Seattle Public Works. The committee will hold its third meeting in Indianapolis, IN, on June 8–9. Charles Howe of the University of Colorado chairs the committee. For more information, contact Jeffrey Jacobs at 202-334-3422 or jjacobs@nas.edu.

### Riparian Zones: Functions and Strategies for Management

The joint WSTB/BEST Committee on Riparian Zones held its second meeting outside Albuquerque, NM, on January 30–February 1, 2000. At the meeting the committee heard from the US Forest Service and the Bureau of Land Management about their riparian management programs; from scientists Jonathan Friedman (USGS), Julie Stromberg (Arizona State University), and Robert Ohmart (Arizona State University) about riparian conditions in the arid Southwest; and from Patrick McCarthy (The Nature Conservancy) and David Seery (NRCS) about local riparian management programs and concerns. On January 30, committee member Manuel Molles hosted a half-day field trip through the Sevilleta Wildlife Refuge and surrounding lands to observe perennial and ephemeral riparian areas, the invasion of exotic vegetation in riparian zones, and the impacts of grazing on the condition of public lands. The committee's charge is to describe the nature and functioning of riparian

zones and assess the condition and trends of riparian habitats with respect to water quantity and quality. It will also review criteria for the improved management of riparian lands and for mitigation of impacts on such habitats by identifying conflicting policies or objectives and suggesting methods for resolving them. The third committee meeting, which will focus on agricultural activities in semi-arid and humid riparian areas, is scheduled for June 4–6 in Ames, IA. For further information, contact Laura Ehlers at 202-334-3422 or lehlers@nas.edu.

### Studies in Hydrologic Science

The joint WSTB/Board on Atmospheric Sciences and Climate Committee on Hydrologic Science, which last met in Washington on January 6–7, is currently making plans to hold a series of workshops on scientific challenges in the hydrologic sciences. Members of the committee are presently drafting white papers that will define the scopes of inquiries and lay out issues to be explored during the workshops. Three such workshops are planned over the next five to eight months and relate to (1) better integration of hydrological and ecological sciences, (2) groundwater fluxes across interfaces, specifically estimation of groundwater recharge and discharge, and (3) predictability of hydrologic systems and opportunities that might be exploited due to advances in computation. The first workshop topic stems from an initiative developed by WSTB members at a recent strategic planning meeting.

The committee's first report, *Hydrologic Science Priorities for the US Global Change Research Program [USGCRP]: An Initial Assessment*, published in September 1999, appears to have already had a positive impact on the USGCRP. Two key research priorities for the program were identified in the report—predictability and variability of regional and global water cycles and coupling of hydrologic systems and ecosystems through chemical cycles. These themes are clearly recognizable in the recommendations of the recently convened Water Cycle Study Group, charged with the task of developing a science plan in this field for the USGCRP. Dara Entekhabi of the Massachusetts Institute of Technology chairs the committee. For more information, contact William Logan at 202-334-3422 or wlogan@nas.edu.

### Environmental Remediation at Naval Facilities

The WSTB will be continuing the activities of the Committee on Environmental Remediation at Naval Facilities. The purpose of this committee is to advise the Navy as it proceeds with the cleanup of contaminated soils, sediments, and groundwater at naval bases and other relevant defense facilities. The first phase of the project evaluated the use of new risk-based methods for cleaning up contaminated groundwater and soil at Navy facilities. The second phase of work will focus on the latter stages of

hazardous waste site management. First, the study will define a decision-making framework for site cleanup that is iterative, nonlinear, and consists of combinations of technologies. Second, the study will review the state of development of technologies for cleanup of groundwater, sediment, and soils, including those that are not traditionally “economically viable.” The committee will consider how innovative (both new and alternative) technologies can be introduced by the Navy after the remedy has been selected. Finally, the committee will define logical endpoints and milestones in site cleanup, including a consideration of the role of long-term monitoring in deciding when to “turn off” a remedy. A new committee is currently being formed to address these issues. Edward J. Bouwer of the Johns Hopkins University chairs the committee. For more information or to nominate new committee members, contact Laura Ehlers at 202-334-3422 or lehlers@nas.edu.

### Risk-Based Analyses for Flood Damage Reduction Studies

The U.S. Army Corps of Engineers is the federal agency primarily responsible for constructing the nation's flood damage reduction projects. To account for uncertainties in fundamental data, statistical relationships, and natural hydrologic and climatic variability, in the early 1990s the Corps began using risk analysis techniques in its flood damage reduction studies. This committee reviewed the Corps' use of risk analysis methods and its implications regarding levee project formulation, economic justification, value added, and engineering and safety implications. It also conducted a detailed review of two Corps flood damage reduction studies that used risk analysis, examining the scientific validity of risk analysis and its implications for Corps policies, procedures, and projects. The committee's draft report is currently undergoing external review. Prepublication copies of the committee's report should be available in mid-June. Gregory B. Baecher of the University of Maryland chairs the committee. For more information, contact Jeffrey Jacobs at 202-334-3422 or jjacobs@nas.edu.

### Committee on USGS Water Resources Research

The Committee on USGS Water Resources Research met February 7–8 in Washington, DC. This was the 38th meeting of the committee, which was originally formed in 1985 to advise the USGS on research questions and issues of emerging water science and technology. Approximately 60 distinguished individuals have served on the committee over the years. This was the first meeting for four new members who were appointed in January: Benedykt Dziegielewski, Southern Illinois University; David Maidment, University of Texas; Karen Prestegard, University of Maryland; and Vernon Snoeyink, NAE, University of Illinois. They join current members Kenneth Bradbury, *chair*, Wisconsin Geological and Natural

History Survey; Victor Bader, University of Arizona; Ana Barros, Harvard University; Michael Campana, University of New Mexico; Stuart Schwartz, Consultant, San Diego, CA; Donald Siegel, Syracuse University; Mary Stoertz, Ohio University; and Kay Thompson, Washington University in St. Louis.

The committee is currently engaged in two projects. First, it will soon complete its report *Investigating Groundwater Systems on Regional and National Scales*. The committee will then take on an assessment of the national water use information program managed by the USGS, which will be its focus until about mid-2001. For more information about the activities of this committee, contact Stephen Parker at 202-334-3422 or [sdparker@nas.edu](mailto:sdparker@nas.edu).

### **Committee on Eutrophication, Coastal Processes, and Watershed Management**

This joint WSTB/Ocean Studies Board effort assesses how coastal and watershed processes affect nutrient over-enrichment of coastal ecosystems and recommends ways to improve research, monitoring, and management at the federal, state, and local levels. The committee's report has been through outside review and the committee is now making changes in response. Release of a prepublication copy of the report is expected by April 1. The report deals with the causes, symptoms, and impacts of nutrient over-enrichment; nutrient sources; estuarine susceptibility; monitoring and assessment; modeling; source reduction and control; policy design and goal setting; and other related issues. It has sections tailored to managers needing general information and technical specialists needing more detailed information. The study is chaired by Robert Howarth of Cornell University. Sponsors include NOAA, EPA, USGS, and the Electric Power Research Institute. For more information, contact study directors Dan Walker (OSB) at 202-334-1798 or Chris Elfring (WSTB) at 202-334-3422.

### **Site (Seeing Into the Earth)**

A committee overseen by the Board on Earth Sciences and Resources (BESR), with assistance from the WSTB, has recently completed its long-awaited study of noninvasive methods for characterizing the shallow subsurface of the earth. The ability to characterize the shallow subsurface is essential for many environmental and engineering concerns. The study examined new and improved noninvasive characterization methods as well as addressing technical and institutional barriers to implementing new methods. The committee's report *Seeing Into the Earth: Characterization of the Shallow Subsurface for Environmental and Engineering Applications*, recently received clearance following review and should be available from the National Academy Press this spring. Phillip Romig of the Colorado School of

Mines chaired the committee. For information, contact BESR director Anthony de Souza at 202-334-2744.

---

## **Future Projects**

### **Services and Values of Aquatic Ecosystems**

Aquatic ecosystems perform numerous environmental functions, such as recycling nutrients, purifying water, attenuating floods, recharging groundwater, and providing habitats for wildlife. They often form the basis of economic livelihood and are widely used for recreational purposes. However, while ecosystem functions may be useful markers for the physical, biological, and chemical processes at work in aquatic resources, they are seldom experienced directly by users of the resource. In contrast, economists find it more helpful to think of the "services" of a resource which create value for human users. In aquatic ecosystems, hydrologic services typically include flood risk reduction, lake-level maintenance, and water supply. Biological services affect productivity of fisheries, waste assimilation, and the protection of endangered species.

The WSTB held a planning workshop on November 3, 1999, in Washington, DC to identify major issues, important literature, potential experts, and sponsors for a potential study on aquatic ecosystem services and values. Representatives from academia, the USGS, USACE, USDA, and EPA participated in the one-day workshop, with John J. Boland of the Johns Hopkins University serving as moderator. The workshop participants agreed that a full-scale NRC study focusing on the value of aquatic ecosystem services, rather than functions, was both warranted and timely. A proposal will be written soon by WSTB staff. The proposed study will identify and assess existing methods for defining and assigning economic values to the services of aquatic ecosystems. It will also include consideration of the errors and biases characteristic of such methods and whether their increased use will lead to improved environmental decision-making. To suggest sources of funding or nominate committee members, contact Mark Gibson at 202-334-3422 or [mgibson@nas.edu](mailto:mgibson@nas.edu).

### **Evaluating the Impacts of Removal of Existing Dams**

With approval by the NRC's Governing Board Executive Committee on January 26, the WSTB will be pursuing development of a project concerning a topic of considerable national interest and importance—the removal of existing dams. The planned study would focus on hydrologic and ecological issues associated with dam removal, including the redistribution of contaminated sediments; water quality and temperature change issues; hydrogeomorphic changes; channel and riparian area re-establishment; instream flow-change considerations; and

removal of structures so as to maximize the natural stream valley and channel functions. The study would aim to (1) define the likely physical, chemical, and biological impacts to the river and riparian system that result from dam removal; (2) determine the likelihood that dam removal can reverse the negative effects brought about by dam installation; (3) estimate the length of time that is likely to be required to restore pre-dam conditions to river reaches upstream and downstream from dams that are removed; and (4) assess the adequacy of relevant science, research, and monitoring programs to provide information needed to evaluate the effects of dam removal. The report resulting from this study would address decision makers, researchers, and educated laypersons in order to inform agencies and groups deciding the future of dams and trying to assess the likely impacts of removal. The report will include selected studies of cases where dams have already been removed as a way of understanding the consequences, including socioeconomic consequences, of dam removal. Presently, the WSTB is developing sponsorship for the study, which might be underway by the summer of 2000. To suggest sources of funding or nominate committee members, contact WSTB director Stephen Parker at 202-334-3422 or [sdparker@nas.edu](mailto:sdparker@nas.edu).

### **Assessment and Control of Nonpoint Source Pollution**

Nonpoint source (NPS) pollution has become the major threat to water quality in the nation's waterbodies, both coastal and inland. NPS pollution is associated with a wide variety of human activities that involve changes in vegetative cover, disturbance of soil, or alteration of hydrology. The consequences of NPS pollution range from minor to very severe, depending on the intensity of activity, the vulnerability of the natural systems where the activity occurs, and the technologies that are used to mitigate the adverse effects on water quality and aquatic ecosystems. This proposed study would investigate (1) the sufficiency of knowledge about sources of NPS pollution, including land use change and other factors, (2) the state of modeling to predict pollutant loads from these sources, and (3) the effectiveness of regulatory and management approaches in controlling NPS pollution. The study would complement the ongoing efforts of the Committee on Eutrophication, Coastal Processes, and Watershed Management by focusing more on inland nonpoint sources of pollution and considering a broader range of pollutant types. A verbal commitment of funding has been made by EPA, and additional contributions are being sought. To suggest funding sources or possible committee membership, contact Laura Ehlers at 202-334-3422 or [lehlers@nas.edu](mailto:lehlers@nas.edu).

## **WSTB Reports**

### **Natural Attenuation for Groundwater Remediation** 2000

This report examines important natural attenuation issues about such as public concerns, scientific bases, and the criteria for evaluating its potential for success or failure. The prepublication form of the report is available from the National Academy Press for \$45.00 (*see order form*).

### **Watershed Management for Potable Water Supply: Assessing the New York City Strategy** 2000

This report evaluates the New York City Watershed Memorandum of Agreement, a comprehensive watershed management plan that is allowing the City to avoid filtration of its large upstate surface water supply. A broad range of conclusions and recommendations are made, many of which are applicable to surface water supplies across the country. Available for \$56.00 (*see order form*).

### **Ecological Indicators for the Nation** 2000

The report provides a framework for selecting ecological indicators, and also provides recommendations on several specific indicators for gauging the integrity of the nation's ecosystems. Available for \$39.95 (*see order form*).

### **Hydrologic Science Priorities for the U.S. Global Change Research Program: An Initial Assessment** 1999

This report makes recommendations regarding important hydrologic processes for the U.S. Global Change Research Program. Two broad science areas—predictability and variability of regional and global water cycles and coupling of hydrologic systems and ecosystems through biogeochemical cycles—are identified that could augment the current hydrologic sciences content of the USGCRP. Available from the WSTB at 202-334-3422.

### **Downstream: Adaptive Management of Glen Canyon Dam and the Colorado River Ecosystem** 1999

This report comments on the Long-Term Monitoring and Research Plan of the Grand Canyon Monitoring and Research Center. It evaluates the effectiveness and weaknesses of the Plan in promoting the Center's research and monitoring programs. Available for \$41.50 (*see order form*).

### **Identifying Future Drinking Water Contaminants**

1999

This report summarizes a workshop based on prioritizing potential drinking water contaminants for inclusion on future Drinking Water Contaminant Candidate Lists. Available for \$45.00 (*see order form*).

### **Water for the Future: The West Bank and Gaza Strip, Israel, and Jordan**

1999

This report recommends that Israel, Jordan, and the Palestinian Authority work together to preserve aquatic ecosystems in the Middle East to ensure that an adequate supply of fresh, high-quality water is available for future generations. The report offers a range of findings and observations on water resource management options for this area. Available for \$35.00 (*see order form*).

### **New Directions in Water Resources Planning for the U.S. Army Corps of Engineers**

1999

This report identifies several ways in which the Corps might reduce the time required in water project planning. The report also recommends that the federal Principles and Guidelines for Water and Land Resources Implementation Studies be thoroughly reviewed and modernized. Available for \$39.00 (*see order form*).

### **Hydrologic Hazards Science at the U.S. Geological Survey**

1999

This report provides advice to the U.S. Geological Survey with respect to its research, interpretive studies, and data collection efforts in the area of hydrologic hazards, which includes droughts, flooding, and related phenomena. Available from the WSTB at 202-334-3422.

### **Improving American River Flood Frequency Analyses**

1999

This report is a followup study on flood frequency relationships for the American River. It evaluates the usefulness of various kinds of data, including historical and paleoflood data; recommends flood flow frequency distribution for the American River; and reviews recent scientific literature on climate variability and flood frequency. Available from the WSTB at 202-334-3422.

### **New Strategies for America's Watersheds**

1999

This report provides a timely and comprehensive look at the rise of "watershed thinking" among scientists and policymakers and recommends ways to steer the nation toward improved watershed management. The volume defines important terms, identifies fundamental issues, and discusses why now is the time to bring watersheds to the forefront of ecosystem management. Available for \$49.00 (*see order form*).

### **Setting Priorities for Drinking Water Contaminants**

1999

This report provides a phased decision process for determining which contaminants on the Contaminant Candidate List are appropriate for regulatory decisions and which will require research or monitoring. Available for \$35.00 (*see order form*).

### **Environmental Cleanup at Navy Facilities: Risk-Based Methods**

1999

This report reviews and critiques risk-based cleanup methods, including those developed by the EPA and the American Society of Testing and Materials, and identifies eleven criteria that must be part of any risk-based methodology adopted by the Navy, a responsible party with a large number of complex and heavily contaminated waste sites. Available from the WSTB at 202-334-3422.

### **Issues in Potable Reuse: The Viability of Augmenting Drinking Water Supplies With Reclaimed Water**

1998

This report looks at the issues involving the use of reclaimed water to supplement drinking water supplies. It discusses issues of water treatment technology, monitoring, and testing of reclaimed water to ensure public safety. Available for \$44.95 (*see order form*).

### **Hydrologic Sciences: Taking Stock and Looking Ahead**

1998

The WSTB used the opportunity of its 1997 Abel Wolman Distinguished Lecture to assess the vitality of the hydrologic sciences by the hydrologic community. This report is a compilation of the Wolman Lecture and four invited papers, preceded by a summarizing overview. Available for \$35.00 (*see order form*).

### **Innovations in Ground Water and Soil Cleanup**

1997

This report provides a comprehensive review of the status of innovative technologies for subsurface cleanup. It also recommends strategies for increasing market demand for innovative remediation technologies, standardizing the collection of pilot and field test data on these technologies, and evaluating cost data. Available for \$44.95 (*see order form*).

### **Valuing Ground Water**

1997

This report examines approaches for assessing the economic value of groundwater and the costs of contaminating or depleting this resource. It suggests a framework for policymakers and managers to use in evaluating tradeoffs when there are competing uses for groundwater. Available for \$39.95 (*see order form*).

**Building a Foundation for Environmental Research**  
1997

This report outlines a new framework for organizing the research program at EPA's Office of Research and Development (ORD). The report calls for the establishment of two kinds of research at ORD: *problem-driven* research and *core* research. In addition, recommendations are made about how EPA can leverage its limited resources by working with the other agencies and organizations involved in environmental research. Available from the WSTB at 202-334-3422.

**Watershed Research in the U.S. Geological Survey**  
1997

This report is intended to assist the USGS in improving its overall strategy for watershed research. The report identifies opportunities for further scientific research and emphasizes the importance of collaboration with others in maximizing the effectiveness of the agency's research efforts. Available from the WSTB at 202-334-3422.

**Safe Water from Every Tap: Improving Water Service to Small Communities**  
1997

This report assesses the quality of drinking water in small communities and recommends a three-part strategy for improving it. Available for \$44.95 (*see order form*).

**Alluvial Fan Flooding**  
1996

This report provides an updated regulatory definition of alluvial fan flooding, presents criteria for assessing whether an area is or is not subject to such flooding, and provides examples of applying the definition and criteria to real situations. Available from the WSTB at 202-334-3422.

**Freshwater Ecosystems: Revitalizing Educational Programs in Limnology**  
1996

This report provides an overview of the status of inland waters, reviews the history of limnology, describes the key future problems that may face water resource managers, and recommends changes in limnology education and research funding to meet the needs of water resource management. Available for \$54.95 (*see order form*).

**A New Era for Irrigation**  
1996

This report explores the impacts of changing supply and demand conditions, assesses current and potential technologies that might help water users adapt to changing conditions, and considers how to mitigate short- and long-term problems associated with irrigation. Available for \$39.95 (*see order form*).

**Hazardous Materials in the Hydrologic Environment: The Role of the U.S. Geological Survey**  
1996

This report attempts to help shape the overall framework of the U.S. Geological Survey's research in hazardous materials science and technology and identifies general areas of scientific opportunity. Available from the WSTB at 202-334-3422.

**River Resource Management in the Grand Canyon**  
1996

This report assesses the achievements and shortcomings of the Bureau of Reclamation's Glen Canyon Environmental Studies and reviews the final research done under the program. Available for \$35.00 (*see order form*).

**Use of Reclaimed Water and Sludge in Food Crop Production**  
1996

This report reviews the current state-of-the-practice, public health concerns, existing guidelines and regulations, and implementations issues of using municipal wastewater and sludge in food crop production. Available for \$34.00 (*see order form*).

**Wetlands: Characteristics and Boundaries**  
1995

This report analyzes present regulatory practice related to wetlands delineation and recommends changes that should bolster the objectivity and scientific validity of wetlands delineation and identification. Available for \$42.95 (*see order form*).

**Flood Risk Management and the American River Basin: An Evaluation**  
1995

This book reviews the U.S. Army Corps of Engineers' investigations of flood control options for the American River basin and evaluates flood control feasibility studies for the watershed. Available for \$29.00 (*see order form*).

**Mexico City's Water Supply: Improving the Outlook for Sustainability**  
1995

This bilingual report addresses the technical, health, regulatory, and social aspects of groundwater withdrawals, water use, and water quality in the Mexico City metropolitan area and recommends ways to improve the balance of water supply, demand, and conservation. Available for \$30.00 (*see order form*).

**Review of EPA's Environmental Monitoring and Assessment Program: Overall Evaluation**  
1995

This final review of EPA's Environmental Monitoring and Assessment Program (EMAP) evaluates whether

EMAP's goals of assessing the status of and trends in the nation's ecosystems are achievable, given the difficult scientific, practical, and management challenges of implementing them. Available for \$35.00 (*see order form*).

#### **Alternatives for Ground Water Cleanup**

1994

This report provides guidance on how the nation can balance public health and technological realities when addressing groundwater contamination. Included is a listing of nearly 80 contaminated sites that the committee reviewed and detailed case studies for several of the sites. Available for \$64.75 (*see order form; print on demand*).

#### **Ground Water Recharge: Using Waters of Impaired Quality**

1994

This report examines the use of waters of less-than-ideal quality, such as treated municipal wastewater and urban stormwater runoff, as sources for artificial groundwater recharge projects. Available for \$59.25 (*see order form; print on demand*).

#### **Managing Wastewater in Coastal Urban Areas**

1993

This report examines the problems of wastewater and stormwater management in coastal urban settings, recommending a system of integrated coastal management. Available for \$54.95 (*see order form*).

#### **In Situ Bioremediation: When Does It Work?**

1993

This report provides direction for decision-makers and offers detailed explanations of the processes involved in *in situ* bioremediation, circumstances in which it is best used, and methods for evaluating the results of bioremediation projects. Available for \$34.95 (*see order form*).

#### **Water Science and Technology Board**

The Water Science and Technology Board (WSTB) is a unit of the National Research Council, which serves as an independent advisor to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, brings the resources of the scientific and technical community to bear on national problems through its volunteer advisory committees.

This newsletter is produced three times a year and is distributed at no charge to subscribers in March, July, and November each year. Editorial office: National Research Council, Water Science and Technology Board, HA 462, 2101 Constitution Avenue., N.W., Washington, D.C. 20418, 202-334-3422.

Editor: Laura Ehlers

Associate editor: Ellen de Guzman

## **National Research Council Meetings**

**March 26–28, 2000** Committee on Mitigating Wetland Losses, Orlando, FL

**March 28, 2000** Workshop on Water Disinfection Issues and Alternatives, Washington, DC

**April, 3–4, 2000** Water Science and Technology Board Meeting, Washington, DC

**April 25–26, 2000** Committee on the Missouri River Basin, Columbia, MO

**May 1–2, 2000** Committee on NAWQA Program, La Jolla, CA

**May 15–16, 2000** Committee on the Bioavailability of Contaminants in Soils and Sediments, Washington, DC

**June 4–6, 2000** Committee on Riparian Zone Functioning and Strategies for Management, Ames, IA

**June 8–9, 2000** Committee on Privatization of Water Services in the United States, Indianapolis, IN

**July 17–18, 2000** Committee on Drinking Water Contaminants, TBA