

## **Making and Breaking the 1999 Mid-Atlantic Drought**

*by Robert M. Hirsch and Harry F. Lins*

The mid-Atlantic drought of 1999 displayed many of the classical features of drought in the eastern United States: it started gradually, it had different effects on different sectors, and it ended rather quickly due to an influx of tropical moisture. It was unique in its extraordinary level of media coverage and in its use of newly developed information products that provided an unprecedented ability to observe the growth and termination of the drought on a daily basis.

The 1999 drought actually began in early summer 1998 when, after a relatively moist winter and spring, precipitation dropped to below-normal levels and remained there throughout the summer and autumn. Precipitation increased to near normal levels during January and March of 1999, but then declined again during the spring. Thus, the cold season recharge needed to recover from the hydrologic deficit that accumulated during the last six months of 1998 did not occur, and the region was poised for serious drought conditions by late spring of 1999.

Below-normal streamflow and groundwater conditions prevailed over most of the mid-Atlantic region by the end of May 1999, and in July the region was firmly in the grip of hydrologic drought. Streamflow values were between the lower 10<sup>th</sup> and 24<sup>th</sup> percentiles at more than 200 stations in the region and groundwater levels were in the lower quartile at most of the region's observations wells. The drought was most severe for the agricultural community; precipitation over the crucial April through July growing period was the lowest on record for several states.

Water quality was also affected. At the end of July, the salt front in the Hudson River reached river mile 75, just two miles below the Poughkeepsie water supply intakes. In early September, it actually reached the intakes for several days. Groundwater and surface-water supplies were severely stressed in many communities dependent on small reservoirs or on small streams (especially in northern Delaware). Small communities and individual homes supplied by wells faced crisis conditions, and well drillers were working overtime

drilling new wells and deepening existing wells throughout the region.

However, the situation in some of the larger metropolitan areas was distinctly different. The Washington metropolitan area has multiple sources of surface water: Jennings-Randolph Lake on the North Branch of the Potomac River, the Occoquan Reservoir in Northern Virginia, and Little Seneca Lake and two reservoirs on the Patuxent River in Maryland. During the most severe hydrologic drought in early August, this system of reservoirs remained relatively full. This interconnected set of supplies had been designed in the aftermath of the severe droughts of the 1960s and in anticipation of the rapid population growth that has taken place in the region since that time. The 1999 drought was the first time this coordinated system had been put to the test, and the system proved more than capable of meeting the challenge. For the first time in its history, Jennings-Randolph Lake was called upon to supplement the flow of the Potomac River near Washington. Simulations of the regional system showed a probability of less than one percent that the system would fail to meet regional demands in the next several months.

Nonetheless, the public policy response to the drought did not distinguish between agricultural impacts and water supply impacts. In Virginia, the governor announced that any decisions to restrict water use were the responsibility of local authorities after assessing their specific conditions. Meanwhile, in Maryland, which faced similar hydrologic conditions, the drought was considered a statewide emergency, and water users were required to behave in shortage mode, with severe water use restrictions, regardless of the status of their jurisdiction's supplies. In other words, communities that had made long-term investments in reliable supplies had to act as if they had not made these wise investments. The different responses highlight the contrast between emphasizing engineering analyses vs. emphasizing political equity.

These different approaches were never put to the ultimate test, however, as a six-week sequence of weather events beginning in mid-August completely eliminated the precipitation deficits that had accumulated since July

## 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.

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1998. The wet period began with the passage of several cold fronts through the region between August 13 and 25. Stream flows, although benefiting briefly from each cold front, still remained below normal (Fig. 1) and groundwater and baseflow conditions made no real recovery. During the first week in September, the remnants of Hurricane Dennis and another cold front moved through the mid-Atlantic bringing more substantial rainfall (as much as 9 inches). This brought streamflow briefly up to normal levels before returning to below-normal levels within several days.

The turning point in the drought episode occurred on September 16 when Hurricane Floyd tracked up the eastern seaboard dropping from 2 to more than 16 inches of rain across the region. Many areas went from drought to flooding within 24 hours, and rainfall amounts finally exceeded the 14-month cumulative deficit. Notably, 45 percent of the 222 real-time streamgages in the mid-Atlantic region recorded new record high flows for September 17. This did not mark the end of the drought recovery, however. Another cold front brought more rain to the region on September 30, and Hurricane Irene dropped several inches of rain on the southeastern parts of the mid-Atlantic region on October 18 as it moved offshore past the Carolina Capes.

The region has now entered the time of year when water demands, including evapotranspiration, decline significantly. It is very unlikely, therefore, that hydrologic drought will reappear in the mid-Atlantic at least until the spring or summer of 2000. The drought has been a significant learning experience for the water scientists and engineers in the region. We recognize now, more than ever, that presenting comprehensive and accurate information on current conditions, and predicting future conditions, is an important obligation. The public needs to know about, and distinguish between, the many faces of drought, including meteorological and agricultural conditions as well as streamflow, groundwater, water quality, and reservoir storage. Technologies such as data telemetry, the Internet, and simulation modeling now make it possible for the water science and technology community to better fulfill this important obligation.

In an effort to enhance the provision of drought information, the U.S. Geological Survey (USGS) has developed a web-based *Daily Streamflow Conditions Map of the U.S.* ([http://water.usgs.gov/dwc/national\\_map.html](http://water.usgs.gov/dwc/national_map.html)). This new product depicts streamflow as a percentile of its long-term value for each day at more than 2,000 real-time streamgage locations. At each gage, flow is classified into one of seven percentile categories and conditions are updated every three hours. This map affords a unique look at the spatial and temporal variability of surface water conditions nationwide, and it is especially useful for tracking the progress of the drought and floods of 1999.

Figure 1. Percentage of streamgages (out of approximately 220) in the Mid-Atlantic Water Resources Region recording normal to above-normal streamflow for each day from June 22–October 30, 1999. The dashed line represents the percentage of streamgages expected to record normal to above-normal flows on any given date.

Because no single definition or index of drought works in all circumstances, other agencies—the National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, and the National Drought Mitigation Center in conjunction with USGS, U.S. Bureau of Reclamation, and others—have recently developed a new information product called the “Drought Monitor.” Designed to assist resource managers, this product is a weekly synthesis of multiple indices, outlooks, and news accounts and represents a consensus of federal and academic scientists on the current status of drought in the United States. It is available online at <http://enso.unl.edu/monitor/monitor.html>.

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## NEW REPORTS

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### **New York City’s Watershed Management Strategy** by Laura Ehlers

January 21, 1997 marked an important event in the history of American water management, namely the signing of the mammoth New York City Watershed Memorandum of Agreement (MOA) as a legal framework to protect the drinking water supply of nine million people. The culmination of years of negotiation between upstate and downstate interests, the MOA commits New York City to a long-term watershed management program that combines land acquisition, new watershed rules and

regulations, and financial assistance to watershed communities to promote environmental quality and their local economies. Most important for New York City, the agreement currently satisfies provisions of the EPA’s Surface Water Treatment Rule that will allow the City to avoid filtering its upstate Catskill/Delaware water supply until at least 2002.

Immediately following the signing of the MOA, the National Research Council’s Water Science and Technology Board was asked by the New York City Comptroller’s Office to provide a scientific evaluation of the watershed management program. The goal of the NRC study was to determine whether the MOA is based on sound science and to recommend improvements to strengthen watershed management for this large unfiltered supply. A new WSTB report, *Watershed Management for Potable Water Supply: Assessing New York City’s Approach*, is the culmination of this two-year study.

The NRC committee was asked to address many provisions of the MOA including (1) the use of setback distances to protect bodies of water from nonpoint source pollution; (2) the Total Maximum Daily Load (TMDL) program; (3) siting and technology requirements for wastewater treatment plants and septic systems; (4) the phosphorus offset pilot program; (5) the enhanced monitoring program; and (6) antidegradation policy. The role of active disease surveillance in watershed management was explored and a microbial risk assessment was conducted. Finally, the committee considered the potential impact of future changes in federal regulations regarding safe drinking water.

The NRC committee found the MOA to be a good template for proactive watershed management that, if properly implemented, will maintain high water quality in the Catskill/Delaware system. However, it warned that the MOA is not a guarantee of permanent filtration avoidance because of changing regulations, uncertainties regarding sources of pollution, advances in science that may improve treatment technologies, and natural variations in climate, streamflow, and watershed conditions. The committee recommended that New York City place the highest priority on pathogenic microorganisms in the watershed and direct its resources towards (1) improved methods for detecting pathogens, (2) identifying the sources of pathogens, (3) understanding pathogen transport and fate, and (4) demonstrating the ability of best management practices (BMPs) to reduce pathogens in stormwater. Currently, the main focus of New York City’s watershed management strategy is phosphorus because of its role in eutrophication and its contribution to the creation of disinfection byproducts. Considerably less effort has been expended developing monitoring and modeling tools for microbial pathogens, which pose a more significant and direct threat to public health.

The report states that the concept of balancing

watershed rules and regulations with targeted financial support of watershed community development is a reasonable strategy for New York City and possibly other water supplies. The report acknowledges that resulting economic development in the watershed region may affect water quality. However, existing information convinced the committee that population growth in the Catskill/Delaware watershed is very limited and that increased economic activity can be offset by careful planning, directed development, more extensive environmental regulation, and improved wastewater management, as provided in the MOA. Such measures should maintain high water quality in the reservoirs over the next several years, assuming growth rates do not increase substantially. Highlights from some of the other conclusions and recommendations found in the report are presented below.

- Monitoring of all parameters in streams, subsurface flow, and wastewater treatment plant effluent should be based primarily on flow proportional sampling rather than on fixed-frequency sampling.
- The MOA requires setbacks or “buffer zones” between some polluting activities and waterbodies to help protect the water supply. The report states that setbacks in the watershed must be actively managed in order to achieve the pollutant removals ascribed to buffer zones and gives suggestions for such management. The City is urged to not rely upon setbacks as the sole protection from nonpoint source pollution.
- Stormwater BMPs are limited in their ability to remove pollutants from runoff. Performance monitoring of these BMPs will be critical to the success of many MOA programs including the TMDL program, the phosphorus offset pilot program, the Watershed Agricultural Program, and Stormwater Pollution Prevention Plans.
- Planned upgrades to wastewater treatment plants will be sufficient to counter pollutant increases with population growth for 40 to 100 years. However, failing and new septic systems should be upgraded/constructed using best available control technology—aerobic treatment units coupled with a rigorous inspection and maintenance program.

The committee was chaired by Charles R. O’Melia of the Johns Hopkins University. Funding was provided by the New York City Comptroller’s Office. To order a prepublication copy of the report, contact the National Academy Press at 800-624-6242 or <http://www.nap.edu>.

**Ecological Indicators for the Nation**  
*by Jeffrey Jacobs*

In the realm of environmental sciences and

policymaking, indicators are useful in monitoring conditions and changes in the nation’s ecosystems and in measuring the effects of environmental policies. There have been multiple efforts to developing ecological indicators for the United States. However, the complexities and uncertainties of ecosystems and their behavior present significant challenges in developing a concise and comprehensive set of national-level indicators. Although no current indicators of environmental conditions or trends have the stature of influential economic indicators, the environmental indicators of global mean atmospheric temperature, sea surface temperatures, and atmospheric carbon dioxide concentrations are attracting considerable attention. The development of indicators of comparable power for ecological processes will help focus attention on ecosystem conditions, providing clues that could help guide and improve environmental policy decisions. The recently released report from the WSTB and BEST, *Ecological Indicators for the Nation*, represents an important step forward in the country’s development of ecological indicators.

To avoid some of the pitfalls common to ecological indicator development (e.g., lack of clear linkages between an indicator and underlying ecological processes), the report recommends use of the following criteria to evaluate potential indicators:

**General importance:** Does the indicator provide information about changes in important ecological and biogeochemical cycles?

**Conceptual basis:** Is the indicator based on a well understood and generally accepted conceptual model of the system to which it is applied?

**Reliability:** Has the indicator proven reliable?

**Temporal and spatial scales:** Does the indicator provide information about local, regional, or national processes? Are the changes measured by the indicator likely to be short- or long-term?

**Statistical properties:** Is the indicator sensitive enough to detect important changes, but not so sensitive that signals are masked by natural variability?

**Data requirements:** How much and what kinds of information are necessary to permit reliable estimates of the indicator to be calculated?

**Skills required:** What technical and conceptual skills must the collectors of data for an indicator possess?

**Data quality:** Are the data reasonably accurate?

**Robustness:** Is the indicator likely to be relatively insensitive to expected sources of interference or changes in measurement technologies?

**International compatibility:** Is the indicator compatible with indicators being developed outside the United States?

**Costs, Benefits, and Cost-Effectiveness:** How do the indicator costs compare to its benefits? Is there a less

costly way to obtain information from this indicator?

According to the report, national-level indicators should be developed for three major categories: (1) land cover and land use, (2) ecological capital, and (3) ecosystem functioning. It was recommended that these indicators be implemented sequentially, with the land cover indicator implemented first. The land cover indicator includes aquatic and dryland ecosystems and records the percentage of land in each of many land cover categories. A similar land use indicator should be developed when sufficient information is available.

Ecological capital refers to physical components, such as soil, and to the species that drive and maintain ecosystem processes. As an indicator of soil condition, the NRC committee recommended that *soil organic matter* be used. It was also recommended that *nutrient runoff* be used to indicate the loss of essential nutrients from the soil. As indicators of biotic capital, two indicators were recommended: *total species diversity* and *native species diversity*.

Regarding ecosystem functioning, the report describes three indicators of terrestrial productivity and two indicators of aquatic productivity. The recommended indicators of terrestrial productivity are *production capacity*, measured by total chlorophyll per unit area, *net primary production*, a direct measure of the amount of energy and carbon that has been brought into an ecosystem, and *carbon storage* of ecosystems, a direct measure of the amount of carbon sequestered or released by ecosystems. The two indicators recommended for aquatic ecosystems are *stream oxygen* and the *trophic status of lakes* (the latter can be developed from a few key characteristics that determine lakes' functional properties and their ability to provide ecosystem services).

Because agriculture represents a large and important percentage of the nation's overall land use, it merits additional indicators, according to the report. *Nutrient use efficiency* and *nutrient balance*, for both nitrogen and phosphorus, are described as important indicators in agricultural settings. Similarly, the report provides indicators of forested ecosystems and notes that similar indicators can and should be developed for other vegetation types. Indicators to evaluate the "diversity status" of a local area are described: *independence of an area*, *species diversity*, and *deficiency of natural diversity*, all of which provide unique information on various aspects of diversity.

The NRC committee was chaired by Gordon Orians of the University of Washington. The report was prepared in response to a request from the U.S. Environmental Protection Agency. To obtain a prepublication copy of the report, contact the National Academy Press at 800-624-6242 or <http://www.nap.edu>.

### Hydrologic Science Priorities for the U.S. Global

## Change Research Program: An Initial Assessment

By Stephen D. Parker

During the past decade, an in-depth understanding of the water cycle, especially at regional scales, has emerged as a major scientific challenge within the U.S. Global Change Research Program (USGCRP), a federal effort to enhance understanding of the global environment and assess its possible evolution. As water is a critical component of other systems and critical to humankind, it has emerged as a cross-cutting theme in the USGCRP. The global water cycle, now one of USGCRP's six fundamental program elements, offers two primary research challenges: (1) land-surface interactions and (2) atmospheric processes. Research in hydrologic science is primarily in the first area, an area that includes land surface-atmospheric coupling over a range of spatial and temporal scales and includes the role of the land surface state in climate variability and change. According to the new WSTB/BASC report *Hydrologic Science Priorities for the U.S. Global Change Research Program: An Initial Assessment*, these challenges are important but limited. Broader challenges for hydrologic sciences that address cross-disciplinary research and recognize the integrative nature of terrestrial hydrology could strengthen the USGCRP.

This first report by the Committee on Hydrologic Science states that terrestrial hydrologic processes, specifically the storage and movement of water on land and within the terrestrial biosphere, are important across all of the USGCRP elements and should serve as a unifying physical process within the USGCRP. To meet these additional challenges, this report identifies two broad science areas that augment the current hydrologic sciences content of the USGCRP: (1) predictability and variability of regional and global water cycles and (2) coupling of hydrologic systems and ecosystems through biogeochemical cycles.

Predictability directly addresses the USGCRP priority of identifying possible future environmental change. The report recognizes current plans within the climate variability element but recommends additional research topics that can strengthen the long-term research goals of USGCRP. These additional topics include enhanced understanding of linkages in variability of global and regional hydrologic systems as the basis for producing improved predictions. The emphasis on variability and predictability, particularly in regional hydrologic systems, is designed to link the understanding of the global water cycle with emerging regional and local water resources issues.

According to the report, cross-disciplinary research involving hydrologic science is key to addressing challenges identified under both the USGCRP global carbon cycle and global water cycle elements. For example, terrestrial ecosystems exert a strong influence

on the global water cycle through evaporation processes. Also, ecosystem disturbances are likely to be a major pathway for any changes and shifts in water and chemical cycles resulting from human activity. The foundation for this research must be a better understanding of the water and chemical pathways and of hydrologic–ecosystem linkages and a new means of achieving this understanding. It is then possible to address the combined influences of climate change and land use change, which occur in the context of natural variability, on hydrologic systems and ecosystems.

The USGCRP should give high priority to developing effective measurement and data strategies specifically for the terrestrial component of the global water cycle. The strategies should address multiple needs, ranging from the detection of change to process studies to operational applications. Future planning for remote sensing and ground-based measurement networks should be integrated to give measurement strategies that are responsive to the priorities discussed above. This will require a high degree of interagency and international collaboration, and it will require new approaches to planning hydrologic measurements. Considerable attention also needs to be given to recovering and archiving hydrologic data and making the data available through effective data and information systems. These strategies need to integrate remote sensing and ground-based data, and they must be sustained over the long term.

Water issues are central to the USGCRP emphasis on global change and its impacts. Therefore water issues can help guide the evolution of new initiatives within the USGCRP. To yield effective results, concerted efforts need to be made to improve connections between hydrologic research and its applications.

As noted on page 9, this report was released in early September. Copies can be obtained at no charge by sending an e-mail request to [sdparker@nas.edu](mailto:sdparker@nas.edu).

## UPDATE: CURRENT PROJECTS

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### **Restoration of the Greater Everglades**

The Committee on the Restoration of the Greater Everglades Ecosystem, approved in late September, will function as an independent scientific review panel to give advice on the implementation of the Central and Southern Florida Comprehensive Review Study (Restudy) and the restoration of the South Florida Ecosystem. This committee was formed at the request of the Secretary of the Interior, Bruce Babbitt.

The Florida Everglades is the largest single wetland in the contiguous United States. Since the mid-1880s, the historical Everglades has been drained and half of the

area devoted to agriculture and other development. The remaining wetland areas have been altered by human disturbances, chiefly by diverting water for human uses, lowering water flows to protect against floods, and greatly increasing the nutrient supply to the wetlands by runoff from agricultural fields and urban areas. The present management system of canals, pumps, and levees will not be able to provide adequate water supplies to agricultural and urban areas, or sufficient flood protection, let alone to support the natural ecosystems remaining as wetlands.

The committee will provide a scientific overview and technical assessment of the many complicated, interrelated activities that are occurring at the federal, state, local, and non-governmental levels. In addition to strategic assessments and guidance, the committee will provide more focused advice on technical topics of importance to the restoration efforts.

Members of the new committee are James M. Davidson, *Chair*, University of Florida (Ret.); Jean M. Bahr, University of Wisconsin; Linda K. Blum, University of Virginia; Patrick L. Brezonik, University of Minnesota; Robert W. Burchell, Rutgers University; Frank W. Davis, University of California, Santa Barbara; Wayne C. Huber, Oregon State University; Stephen R. Humphrey, University of Florida; Daniel P. Loucks, Cornell University; Scott W. Nixon, University of Rhode Island; Gordon H. Orians, University of Washington; Kenneth W. Potter, University of Wisconsin; Larry Robinson, Florida Agricultural and Mechanical University; Steven E. Sanderson, Emory University; Rebecca R. Sharitz, Savannah River Ecology Laboratory; and John Vecchioli, U.S. Geological Survey (Ret.). The committee's first meeting will be December 2–4 in Ft. Lauderdale, FL. Meeting schedules and agendas will be posted on the National Academies website (<http://www.national-academies.org>). For more information contact Stephen Parker at 202-334-3422 or [sdparker@nas.edu](mailto:sdparker@nas.edu) or Tricia Jones at [pjones@nas.edu](mailto:pjones@nas.edu).

### **Privatization of Water Services in the United States**

Private development of water services was the initial approach taken by many U.S. cities for drinking water supply and wastewater services. With the growth of large cities and strong governments, however, local government took over most of the private water supply and sewerage companies. During the past 15–20 years, there has been a renewed interest in privatizing water services, with many cities leasing various parts of water supply and treatment systems to private operators. While the privatization of water services holds much promise, the long-term consequences of privatization are not clear.

A newly appointed WSTB committee will provide a comprehensive review of water service privatization in the United States and its economic and fiscal, regulatory,

public service and health, environmental, and water quality implications. The committee will hold its first meeting in Washington, D.C. on November 18–19. Committee members include Charles W. Howe, *Chair*, University of Colorado; Jean E. Auer, American States Water Company; Janice A. Beecher, Beecher Policy Research, Inc.; Charles A. Buescher, Jr., Washington University, St. Louis; Larry Chertoff, Water Industry Council; Jerome B. Gilbert, J. Gilbert Inc.; Richard Howitt, University of California, Davis; Daniel A. Okun, University of North Carolina; David E. Rager, Cincinnati Water Works; William G. Reinhardt, Public Works Financing; and William N. Stasiuk, New York City Department of Environmental Protection Bureau of Water Supply. For more information, contact Jeffrey Jacobs at 202-334-3422 or [jjacobs@nas.edu](mailto:jjacobs@nas.edu).

### **Riparian Zones: Functions and Strategies for Management**

The joint WSTB/BEST Committee on Riparian Zones held its first meeting in Washington, DC on October 21–22. At the meeting the committee heard from its five sponsoring agencies—EPA, USGS, USDA, the Bureau of Reclamation, and the National Science Foundation—and it devised a strategy for completing its tasks. This study will 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 second committee meeting is scheduled for January 30–February 1, 2000, in Albuquerque, NM.

The committee membership includes Mark M. Brinson, *Chair*, East Carolina University; Lawrence J. MacDonnell, *Vice-Chair*, Stewardship Initiatives; Douglas J. Austen, Illinois Department of Natural Resources; Robert L. Beschta, Oregon State University; Theo A. Dillaha, Virginia Polytechnic Institute and State University; Debra L. Donahue, University of Wyoming College of Law; Stanley V. Gregory, Oregon State University; Judson W. Harvey, U.S. Geological Survey; Manuel C. Molles, Jr., University of New Mexico; Elizabeth I. Rogers, White Water Associates, Inc.; and Jack A. Stanford, University of Montana. For further information, contact Laura Ehlers at 202-334-3422 or [lehlers@nas.edu](mailto:lehlers@nas.edu).

### **Drinking Water Contaminants**

The joint WSTB/BEST Committee on Drinking Water Contaminants is beginning work on a second phase of study that will extend through February 2001. EPA's

Office of Ground Water and Drinking Water has requested that the committee develop and recommend a process for prioritizing all types of potential drinking water contaminants (including microbiological contaminants) for inclusion on future Drinking Water Contaminant Candidate Lists. The process must include a simple, semiquantitative prioritization tool as recommended by the committee in its first two reports, *Setting Priorities for Drinking Water Contaminants* and *Identifying Future Drinking Water Contaminants*. In addition, the committee will provide further guidance on the development of mechanisms for grouping microbial contaminants into categories for research and regulation.

The committee membership was revised to include three new members: Jeffrey Griffiths, Tufts University; Charles Haas, Drexel University; and WSTB member Rebecca Parkin, The George Washington University. Deborah Swackhamer, University of Minnesota, was appointed to chair the committee. The next committee meeting is scheduled for December 2–3, 1999, in Washington, DC. For more information, contact Mark Gibson at 202-334-3422 or [mgibson@nas.edu](mailto:mgibson@nas.edu).

### **Missouri River Basin: Improving the Scientific Basis for Adaptive Management**

The U.S. Army Corps of Engineers operates six mainstem dams on the Missouri River. Due partly to drought in the basin in the late 1980s and early 1990s and partly to concerns over degradation of aquatic habitat, the Corps has been considering options for revising its Missouri River dam operations policies. At the same time, it was suggested by the Missouri River Basin Association that better scientific knowledge was needed to support management decisions for ecosystem restoration. Thus, a new WSTB committee has been formed to review scientific research and characterize the historical and current ecological status of the Missouri River and floodplain ecosystem. The committee will also identify existing scientific information and identify information needs for improved river management, including dam operation. The committee will hold its first meeting in Omaha, NE on December 13–14, 1999.

Committee members include Steven P. Gloss, *Chair*, University of Wyoming; John H. Davidson, University of South Dakota School of Law; Robert Davis, University of Colorado; David Ford, David Ford Consulting Engineers; Gerald E. Galloway, Jr., International Joint Commission; Larry W. Hesse, River Ecosystems, Inc.; W. Carter Johnson, South Dakota State University; Peggy A. Johnson, Pennsylvania State University; Kent D. Keenlyne, Biological Services, Inc.; Steven Light, Institute for Agricultural & Trade Policy; Ernest T. Smerdon, National Science Foundation; and Robert G. Wetzel, University of Alabama. For more information, contact Jeffrey Jacobs at 202-334-3422 or

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

The WSTB has raised approximately 65 percent of the funding needed to launch a new study of 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 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.

Funding has been acquired from EPA, SERDP, NIEHS, Army, Air Force, and ATSDR. Additional funding is being sought from both government and private organizations. The study will be chaired by WSTB member Richard Luthy of Carnegie Mellon University. If you are interested in sponsoring this project or would like to nominate committee members, contact Laura Ehlers at 202-334-3422 or *lehlers@nas.edu.*

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

The NRC will soon be convening a committee to review the USGS National Water Quality Assessment Program (NAWQA). This seven-year-old, \$70 million/year national program was designed to describe the status of, trends in, and factors affecting surface and groundwater quality in the U.S. The WSTB has provided advice to the USGS regarding NAWQA on three occasions in the past. The current effort would focus on four particular areas of NAWQA and make suggestions for improvement. First, it will suggest methodologies to improve understanding of the causative factors affecting water quality conditions. Second, it will assess whether information produced in the program can be extrapolated to areas not studied intensely under NAWQA. Third, the project will examine current priority pollutants (e.g., pesticides, nutrients, volatile organic compounds, and trace elements) selected for broad investigation under NAWQA for completeness. Finally, the project will make

recommendations on aggregation and presentation of information generated at the study unit scale so that it is meaningful at the regional and national levels.

The study will be carried out over a 16-month period, during which the committee will meet three to four times. The committee slate should be approved shortly. For more information, contact Mark Gibson at 202-334-3422 or *mgibson@nas.edu.*

### **Mitigating Wetland Losses**

With sponsorship from EPA, WSTB and BEST are launching a new study that will evaluate the effectiveness of wetland restoration and mitigation practices in replicating pre-disturbed wetland functions and ecological attributes. Under Section 404 of the Clean Water Act, compensatory mitigation of wetlands is required to offset any unavoidable adverse impacts on wetlands that cannot otherwise be minimized. Compensatory mitigation usually consists of restoration, enhancement, or creation of new wetlands, where practicable. However, it is not certain how well such mitigation efforts compensate for existing, naturally functioning wetlands. As a result, the degree to which progress is being made in achieving the goal of no net loss of wetland resources is uncertain.

The study will be undertaken by a multidisciplinary committee that 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 main criterion for the evaluation will be the degree to which the structure and functioning of the mitigated wetland match those of naturally occurring wetlands in the same region. 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.

It is expected that the study committee will be appointed soon and that work will be underway in early winter. For more information or to nominate committee members, contact David Policansky at 202-334-2540 or *dpolican@nas.edu* or Stephen Parker at 202-334-3422 or *sdparker@nas.edu.*

### **Studies in Hydrologic Science**

Early in 1999, in cooperation with its sister Board on Atmospheric Sciences and Climate, the WSTB launched a program of studies to review and provide advice on scientific activities of U.S. federal agencies and U.S.

contributions to international programs in hydrologic science including research, observation systems, and data collection. In these studies, the NRC hopes to (1) help assure the best and most appropriate hydrologic input to U.S. and international programs with hydrologic components and (2) guide the proper development of the field of hydrologic science to be of maximum value to the national and international scientific enterprise.

The committee was appointed in December 1998 and subsequently held three meetings. The committee released its first report, *Hydrologic Science Priorities for the U.S. Global Change Research Program: An Initial Assessment*, in late August (see New Reports section). The committee has begun to craft a second report on strategic directions in hydrologic science, which will be the focus of the next meeting January 6–7, 2000, in Washington, DC. Dara Entekhabi of the Massachusetts Institute of Technology chairs the committee. For information, contact Stephen Parker at 202-334-3422 or [sdparker@nas.edu](mailto:sdparker@nas.edu).

### **Environmental Remediation at Naval Facilities**

The WSTB will likely be continuing the activities of the Committee on Environmental Remediation at Naval Facilities, pending approval from the Navy for the second phase of this project. 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. In order to identify the Phase 2 study topic and draft a work statement, a planning meeting was held in Washington, DC on August 25, 1999, including NRC staff, some committee members, and Navy personnel from all levels. A proposal was subsequently developed that focuses on the latter stages of hazardous waste site management, including remedy selection, remedy operation, implementation and maintenance of institutional controls, long-term monitoring, and site closure. The proposal is currently undergoing review by Navy personnel, after which a new committee will be formed and a first committee meeting will be scheduled. 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](mailto: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. In order to account for

uncertainties in fundamental data and statistical relationships, the Corps has begun using risk-based analysis to make decisions regarding project performance and design parameters. This committee is reviewing the Corps's use of risk analysis methods and its implications regarding project formulation, economic justification, value added, and engineering and safety implications. It is also reviewing Corps studies that have used risk analysis, examining both the scientific validity of risk analysis and implications of its use for Corps policies and procedures. The committee held its fourth meeting in Woods Hole, MA on September 13–14, 1999. The committee will hold its fifth and final meeting in Washington, DC on December 6–7, 1999. Greg Baecher of the University of Maryland chairs the committee. For further information, contact Jeffrey Jacobs at 202-334-3422 or [jjjacobs@nas.edu](mailto:jjjacobs@nas.edu).

### **USGS Water Resources Research**

The Committee on USGS Water Resources Research is nearing completion of a study that will lead to publication of the report *Investigating Groundwater Systems on Regional and National Scales* in the spring of 2000. The report will provide guidance to the USGS on direction, scope, and emphasis of future regional and national groundwater studies carried out by the Water Resources Division. Questions such as the following are forming the basis for the study. What are the nation's major emerging groundwater problems and research needs? What constitutes a regional assessment and how can it best be presented?

The committee is chaired by Kenneth Bradbury, Wisconsin Geological and Natural History Survey, University of Wisconsin. The committee last met in Washington, DC, on September 27–28, 1999, to work on the report and to hear briefings relevant to the next project to be taken on by the committee—the USGS national water use information program. Review of this new topic will commence at the committee's next meeting, scheduled for February 7–8, 2000. For more information, contact Stephen Parker at 202-334-3422 or [sdparker@nas.edu](mailto:sdparker@nas.edu).

### **Subsurface Contamination at DOE Complex Sites**

The Committee on Subsurface Contamination at DOE Complex Sites: Research Needs and Opportunities was tasked with advising the U.S. Department of Energy (DOE) on a science plan for subsurface contamination research sponsored by the DOE's Environmental Management Science Program. The committee's final report describes the significant subsurface contamination problems at DOE sites that cannot be addressed with current technologies, identifies the knowledge gaps relevant to these problems, and suggests elements of a

research plan to help fill these gaps. The study was jointly conducted by the WSTB and the Board on Radioactive Waste Management (BRWM).

The committee held its final meeting on July 1–2, 1999, in Woods Hole, MA, and the final report is currently undergoing external review. A prepublication copy of this report is expected later this Fall. The committee published an interim report in December 1998, which offered advice to the DOE on the technical content of their FY99 call for proposals. For additional information, contact BRWM director Kevin Crowley at 202-334-3066 or [kcrowley@nas.edu](mailto:kcrowley@nas.edu).

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

The coastal regions of the United State are economically vital areas, and they support diverse industries and more than 141 million people. But increased use of coastal regions has led to increased environmental problems. One of the most significant problems is eutrophication—the process of increasing organic enrichment in bodies of water that can lead to excessive (and sometimes noxious) production of algal biomass, seagrass loss due to light reduction, changes in marine biodiversity, and, ultimately, depletion of dissolved oxygen and associated fish kills.

This joint WSTB/Ocean Studies Board effort has assessed how coastal and watershed processes affect eutrophication of coastal ecosystems; recommended ways to improve coordination and effectiveness of research, monitoring, and management being conducted at the federal, state, and local levels; and identified means to remove barriers that impede implementation of techniques to reduce coastal eutrophication. The committee has held all of its regular meetings and its report is currently undergoing outside review; one final meeting is scheduled for November 1999 to respond to the external reviews. The draft report deals with the causes, symptoms, and impacts of eutrophication, nutrient sources, estuarine susceptibility, monitoring and assessment, modeling, source reduction and control, policy design and goal setting, and other related issues. The final report is expected in early 2000. For additional information, contact Dan Walker (OSB) at 202-334-1798 or Chris Elfring (WSTB) at 202-334-3426.

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

The Committee on Intrinsic Remediation has sent its report, *Natural Attenuation for Groundwater Remediation*, to external review. The final version, which will document the current scientific evidence pertaining to the natural attenuation of contaminants in groundwater at waste sites, should be available in December 1999.

The committee's report assesses the likelihood that

natural attenuation will succeed for a wide variety of contaminants, including petroleum hydrocarbons, oxygenated hydrocarbons (such as fuel oxygenates), halogenated aliphatics (such as chlorinated solvents), halogenated aromatics (including PCBs), nitroaromatics (such as TNT), heavy metals, and radionuclides. The report recommends data collection and evaluation strategies for assessing the natural attenuation potential at specific contaminated sites.

The report also explores related community concerns and policy issues. It recommends mechanisms for involving communities near contaminated sites in decisions concerning use of natural attenuation. It also reviews the adequacy, from both technical and policy perspectives, of more than two dozen existing technical protocols and policy documents for the use of natural attenuation. The committee chair is Bruce Rittmann of Northwestern University. For more information, contact Jackie MacDonald at [jmacdona@nas.edu](mailto:jmacdona@nas.edu).

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

A committee overseen by the Board on Earth Sciences and Resources (BESR), with assistance from the WSTB, should soon be completing its 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 committee is evaluating new and improved noninvasive characterization methods as well as addressing technical and institutional barriers to implementing new methods. The committee's report, titled *Seeing Into the Earth: Characterization of the Shallow Subsurface for Environmental and Engineering Applications* is presently awaiting clearance following review and should be distributed early this winter. Phillip Romig of the Colorado School of Mines chairs the committee. For information, contact Thomas Usselman at 202-334-2744.

## **PREVIEW: FUTURE PROJECTS**

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### **Functions and Values of Aquatic Ecosystems**

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 full NRC study to assess the functions and associated economic values of aquatic ecosystems. Aquatic ecosystems perform numerous valuable environmental functions, such as recycling nutrients, purifying water, attenuating floods, recharging groundwater, and forming

habitats for wildlife. In some cases, these functions provide services that benefit people, making them valuable to society. Unfortunately, increasing use and demands on aquatic ecosystems have often resulted in their devaluation through pollution, channelization, and development.

Representatives from USGS, USACE, NSF, USDA, and EPA participated in the one-day workshop. The moderator was John J. Boland of the Johns Hopkins University and former chair of the WSTB. The workshop deliberations indicated that a full committee-based NRC study is warranted and timely. The WSTB will use the findings of the workshop to develop a proposal and begin seeking sponsorship. For more information, or if you are interested in sponsoring the study, contact Mark Gibson at 202-334-3422 or [mgibson@nas.edu](mailto:mgibson@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. 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. Although several federal agency representatives have expressed interest in funding the study, no firm commitments have been made. To suggest funding sources or possible committee membership, contact Laura Ehlers at (202) 334-3422 or [lehlers@nas.edu](mailto:lehlers@nas.edu).

### **Integrating Hydrologic and Ecologic Sciences**

An internal grant from the Academies has recently been received to conduct a planning workshop to identify major issues, important literature, potential experts, and sponsors for a study of integrating hydrologic and ecosystem science and modeling. It is hoped that the planning workshop will develop a short discussion paper of issues, a proposal, and funding for such a study.

Water and ecosystems are inextricably linked. Water and the materials and energy that it transports affect the distribution and function of ecosystems. In turn, ecosystems affect water, material, and energy transport. Research on the effects of riparian buffer strips on water and nutrient fluxes provides an illustration of how a

problem necessitates input from both disciplines. Hydrologists have the tool and skills to provide accurate information on surface and subsurface movement of water and nutrients, and ecologists are equipped to accurately determine the effects of plant uptake on nutrient cycling. Because these two disciplines are linked, it is essential that scientists from the two disciplines work together to effectively solve important ecohydrological problems.

The workshop will be organized to consider the following questions:

1. What types of scientific and engineering questions require integration of hydrologic and ecologic sciences? In what areas do the greatest opportunities currently exist?
2. What case studies illustrate the successful integration of ecologic and hydrologic sciences? What were the benefits of that collaboration to scientific and/or management outcomes?
3. What factors influence the feasibility for integrating hydrologic and ecologic sciences? What are barriers to integration, e.g., scientific compartmentalization, different funding sources, hot issues, and compartmentalized goals?
4. What advances in technology will expedite the process of integration?
5. What types of models are most suitable for integration of ecosystem and hydrologic considerations?
6. What infrastructure changes will be needed to facilitate integration, e.g., educational curricula, research funding?

For information, or if you are interested in participating in the planning conference or in sponsoring the study, contact Stephen Parker at 202-334-3422 or [sdparker@nas.edu](mailto:sdparker@nas.edu).

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## **WATERMARKS**

### **Paul Busch**

The WSTB sadly notes the passing of Dr. Paul L. Busch on July 27, 1999, of complications from non-Hodgkin's lymphoma. Paul was 61. A much-admired member of the WSTB from 1984 to 1987, Paul's involvement in NRC work began in the late-1970's as a member of the pre-WSTB Committee to Review the Metropolitan Washington Area Water Supply Study and continued until his untimely death when he was a member of the Board on Environmental Studies and Toxicology. Paul earned his doctorate at Harvard University in 1966 and then spent his entire career as a consulting engineer

with Malcolm Pirnie, serving the firm as president since 1988 and CEO since 1990. A leading authority on the management and treatment of industrial and toxic wastes and an expert in water and wastewater treatment processes, Dr. Busch had been much honored for his achievements, including election to the National Academy of Engineering in 1996 for his "significant contributions to the quality of the world's environment." Particularly interested in the education of tomorrow's engineers, he served as guest lecturer, visiting professor, mentor, and advisor at over two dozen universities.

### **WSTB Staff Changes**

As the WSTB prepares for several new activities and the new millennium, a number of changes are occurring with the staff. Recently, associate director Jackie MacDonald left to join RAND in Washington, DC. Concurrently, the board has filled one of two staff officer vacancies with William S. Logan. Logan, a recent assistant professor at George Washington University, holds a Ph.D. from the University of Waterloo. An expert in the hydrologic problems of coastal areas and expanding urban centers, he will be initially assigned to the new study of restoration of the Greater Everglades Ecosystem and other projects. Also joining the Everglades study team is Patricia Jones. Tricia is a staff/research associate who has worked at the NRC since 1994, primarily with the Board on Radioactive Waste Management and the Board on Natural Disasters. In addition to her position with the NRC, Tricia is pursuing a masters degree in urban and environmental planning at the University of Virginia, Northern Virginia Center.

In August, Anike Johnson came on board as a new project assistant. Anike recently received a B.S. in biology from Salisbury State University. Her project assignments include the Missouri River Basin study, the bioavailability study, the drinking water contaminants study, and the Navy study. Also among staff changes is the recent promotion of Jeffrey Jacobs to senior staff officer. With these various changes (and until further additions) the current WSTB staff roster is as follows:

Stephen D. Parker, Director  
Laura Ehlers, Senior Staff Officer  
Chris Elfring, Senior Staff Officer (part time)  
Jeffrey Jacobs, Senior Staff Officer  
William Logan, Staff Officer  
Vacant, Staff Officer  
Jeanne Aquilino, Administrative Associate  
Mark Gibson, Research Associate  
Patricia Jones, Staff Associate (part time)  
Anita Hall, Administrative Assistant  
Ellen De Guzman, Senior Project Assistant  
Anike Johnson, Project Assistant

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## **WSTB REPORTS**

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### **Watershed Management for Potable Water Supply: Assessing New York City's Approach**

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. The report is available in prepublication form from the National Academy Press for \$52.00 (*see order form*).

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

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. The report is available in prepublication form from the National Academy Press for \$39.95 (*see order form*).

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

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. The report is available from the WSTB at 202-334-3422.

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

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**

This report is a result of a workshop to prioritize potential drinking water contaminants (including chemical and microbiological 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**

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**

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**

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 in limited quantities from the WSTB at 202-334-3422.

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

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 in limited quantities from the WSTB at 202-334-3422.

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

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**

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. The report is guided first and foremost by concerns about public health and concludes that there is no replacement for policy judgments by the EPA. Available for \$35.00 (*see order form*).

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

The fiscal and technological limitations associated with cleaning up hazardous waste sites have prompted responsible parties to turn to risk-based methods for environmental remediation. This report reviews and critiques risk-based 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.

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

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*).

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

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*).

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

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**

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**

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**

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.

#### **Alluvial Fan Flooding**

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.

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

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*).

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

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**

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**

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**

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**

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**

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**

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**

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**

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**

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**

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**

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?**

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*).

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**NATIONAL RESEARCH COUNCIL MEETINGS**

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- November 18-19, 1999** Committee on Privatization of Drinking Water Supplies, Washington, DC  
**December 2-3, 1999** Committee on Drinking Water Contaminants, Washington, DC  
**December 2-4, 1999:** Committee on Restoration of the Greater Everglades Ecosystems, Ft. Lauderdale, FL  
**December 6-7, 1999** Committee on Risk-Based Analysis, Washington, DC  
**December 13-14, 1999** Committee on the Missouri River Basin, Omaha, NE  
**January 6-7, 2000** Committee on Hydrologic Science, Washington, DC  
**January 30-February 1, 2000** Committee on Riparian Zones Functioning and Strategies for Management, Albuquerque, NM  
**February 7-8, 2000** Committee on USGS Water Resources Research, Washington, DC

