WATER

FOR A SUSTAINABLE AND SECURE FUTURE

A Report of the
Fourth National Conference on Science,
Policy and the Environment

January 29-30, 2004 • Washington, DC

Craig M. Schiffries and Amanda Brewster, Editors

National Council for Science and the Environment
Improving the scientific basis for environmental decisionmaking

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The National Council for Science and the Environment (NCSE) has been working since 1990 to improve the scientific basis of environmental decisionmaking and has earned an impressive reputation for objectivity, responsibility, and achievement.

The Council envisions a society where environmental decisions are based on an accurate understanding of the underlying environmental science, its meaning, and its limitations. In such a society, citizens and decisionmakers receive accurate, understandable, and integrated science-based information. They understand the risks, uncertainties, and potential consequences of their action or inaction.

Endorsed by over 500 academic, scientific, environmental, and business organizations, and federal, state, and local government, NCSE works closely with the many communities that create and use environmental knowledge to shape environmental decisions.

The Council conducts a range of innovative activities in the following areas:

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The Council brings stakeholders together through its Center for Science Solutions to develop and implement science-based solutions to specific environmental problems. The first program under the Center, the National Commission on Science for Sustainable Forestry, supports research to develop a better scientific foundation for assessing and improving forest management practices.

WATER

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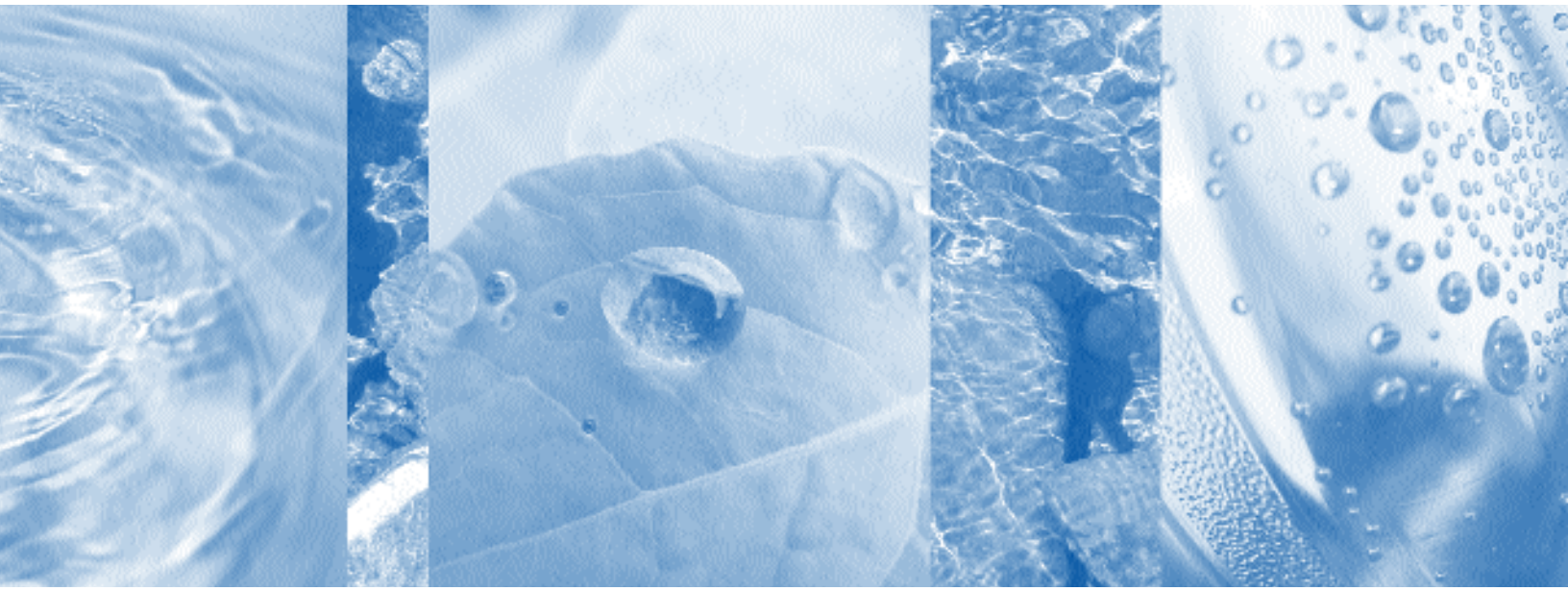

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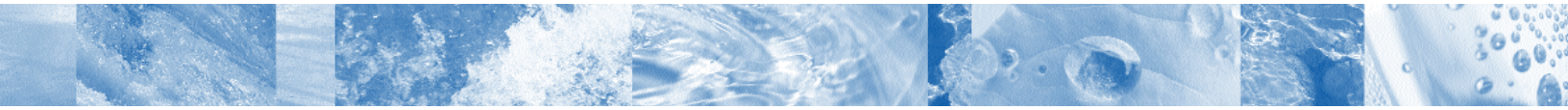

Water for a Sustainable and Secure Future
4th National Conference on Science, Policy and the Environment

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"...[O]ur country is blessed by abundant land and water resources. But they will provide for us only if we manage them wisely — something a century ago President Theodore Roosevelt embraced when he championed the cause of conservation. We are still figuring it out but we do know, as one of our founding fathers, Benjamin Franklin, put it succinctly in Poor Richard's Almanac, 'When the wells run dry, we know the worth of water.' "

William K. Reilly
President and Chief Executive Officer, Aqua International Partners
Chairman, World Wildlife Fund
Former Administrator, U.S. Environmental Protection Agency

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EXECUTIVE SUMMARY

"Water issues have become one of the top priorities of the international system," United Nations Environment Programme (UNEP) Executive Director Klaus Toepfer said in a statement at the 4th National Conference on Science, Policy and the Environment in Washington, DC, in January 2004. More than 800 scientists, policymakers, business executives, and civil society representatives from 46 states and 14 countries came together to discuss how science can help promote sustainable water management in the United States and globally. Some 80 experts spoke in plenary sessions and smaller topical panels.

Conference participants addressed the many essential roles water plays in our lives today — maintaining human health and survival, protecting sensitive ecosystems, producing an ample food supply, promoting overall economic prosperity, enhancing recreation and aesthetics, and providing for the long-term security of individuals and nations.

The urgent need to reform water management policies both in the United States and abroad emerged as a major theme of the conference. Bruce Babbitt, former Secretary of the Interior, noted that there is no absolute shortage of water in most areas of the United States. However, providing enough water for human needs is challenging water policymakers, especially in the American West, largely because water has been viewed as a free commodity. For this reason, it has been delivered at vastly below cost and used inefficiently.

William Reilly, former Administrator of the U.S. EPA, stressed the need to modify U.S. water policies that have become remnants of a bygone era — when water was plentiful. Now population growth and other factors are straining water resources and creating conflict, such as in the controversy over water allocation in the Pacific Northwest's Klamath basin. Even when water is relatively scarce, it is often wasted through inefficiency, which can reach 50 percent in some places. The United States had the worst water efficiency of 147 countries ranked by the World Water Council, a status that Reilly linked to low water prices. The price of water in the United States averages $0.54 per cubic meter, compared to $1.23 for the United Kingdom and $1.78 for Germany.

A number of speakers called for water pricing reforms. Mohamed El-Ashry, former Chairman and CEO of the Global Environment Facility, recognized that water pricing is contentious, but "you won't get far without addressing it." Toepfer called pricing "perhaps the most important management issue regarding water and sanitation, the one that could have the most benefit for the poor..." He recommended progressive pricing — "charging more per unit the more water is used" — to ensure that people can afford enough water to live healthfully and still provide incentives for efficient use.

Jeremy Pelczer, President of American Water, which has 21 million customers in the United States, and Deputy CEO of RWE Thames Water, which has 70 million customers worldwide, said that the water industry has a responsibility to improve the water situation for the world's poor. He suggested a role for the private sector that would include very low-risk, low-return investments to provide water more effectively in the developing world.

Peter Gleick, President of the Pacific Institute for Studies in Development, Environment and Security, said that the world is in "a water crisis" that is getting worse. Population is growing most rapidly where water is least available, and water will be among the first resources affected by rising global temperatures and the resulting climate change. However, Gleick said that the water crisis can be alleviated by pursuing solutions that involve community-scale water systems, open and decentralized decisionmaking, and greater efficiency.

Several speakers identified important opportunities for closing the gap between water science and water policy. Robert Glennon, author of *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters*, said that a profound misunderstanding of water science has been institutionalized in many states, where groundwater and surface water are legally two unrelated entities. This gap

has led to practices of unsustainable groundwater withdrawal in some areas and ineffective water management policies that do not take a holistic approach. Ground water and surface water are inextricably linked through the hydrologic cycle, and we need to reform the governance of surface and ground water to reflect actual hydrologic linkages.

Brian Richter of The Nature Conservancy said that the challenge of 21st century river management is to better balance human water needs with the water needs of rivers themselves. Meeting this challenge may require a fundamentally new approach to valuing and managing rivers. Richter argues that each component of a river's flow pattern — the highs, the lows, and the levels in between — is important to the health of the river system and the life within it. He is optimistic that new policies will be based on a growing scientific consensus that restoring some degree of a river's natural flow pattern is the best way to protect and restore river health and functioning.

Hydrological and ecological linkages, rather than political boundaries, should form the basis for water management. Governance structures should be designed to facilitate a watershed, basin or ecosystem approach to water management. For example, researchers are increasingly attributing coastal pollution problems, such as nutrient over-enrichment, dead zones, and toxic contamination, to diffuse sources far inland from coastal environments. Therefore, effective solutions to these issues must be holistic, entering at the watershed level and connecting coastal pollution with inland sources.

Good science is critical to sensible water management policy, emphasized Robert Hirsch, Associate Director for Water of the U.S. Geological Survey. Focusing on the role of scientists in improving water policy, William K. Reilly said he believes strongly in the need to engage scientists in helping to make environmental policies and setting environmental priorities. He urged scientists to avoid becoming "truants from the policy process."

Pulitzer Prize-winning author Jared Diamond offered a cautionary example of the results of poor environmental management practices as he delivered the John H. Chafee Memorial Lecture, *Lessons from Environmental Collapses of Past Societies*. Drawing upon his natural science research to understand why some environments are more fragile than others, Diamond explained how inadvertent environmental degradation led to the demise of the isolated civilization on Easter Island in the South Pacific.

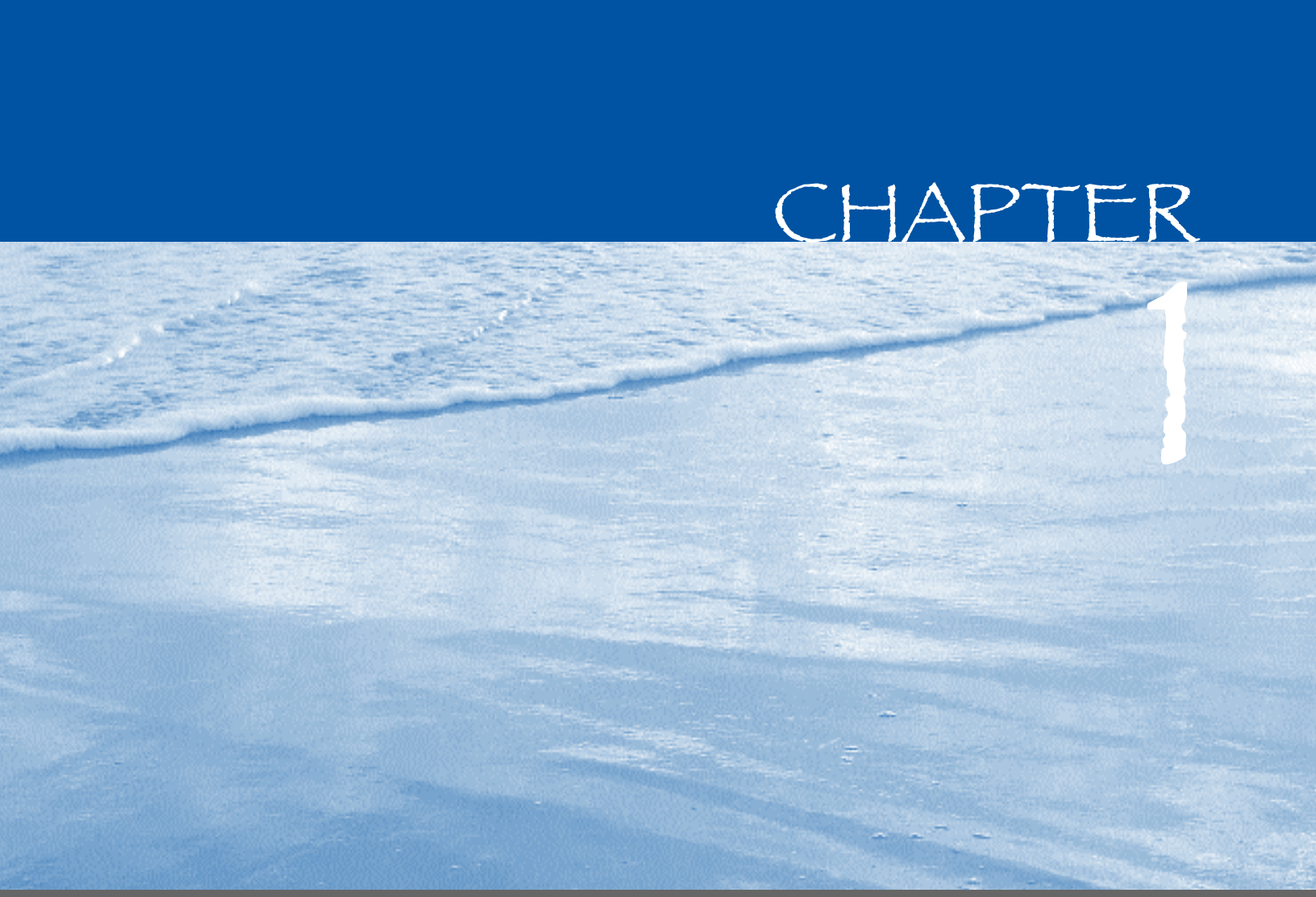
This report contains the recommendations of the many conference participants, who brought experience as scientists, federal, state and local policymakers, and civil society representatives.

Conference attendees participated in one of 16 simultaneous breakout sessions, each addressing a different aspect of water sustainability. Targeted recommendations were developed to address each of these aspects of water sustainability. A set of nine primary recommendations were distilled from the targeted recommendations. The primary recommendations are as follows:

1. Develop a Robust Set of Indicators for Sustainable Water Management.
2. Improve Data and Monitoring Systems for Sustainable Water Management.
3. Advance Interdisciplinary Scientific Research on Sustainable Water Management.
4. Integrate Social Science and Natural Science Research on Sustainable Water Management.
5. Close the Gap Between Water Science and Water Policy.
6. Develop a Broad Spectrum of Technologies to Advance Sustainable Water Management.
7. Improve Education and Outreach on Sustainable Water Management.
8. Promote International Capacity Building on Sustainable Water Management.
9. Establish a National Commission on Water Sustainability.

From the 4th National Conference on Science, Policy and the Environment: Water for a Sustainable and Secure Future, clockwise from top left: William Reilly, former U.S. EPA Administrator, gives the opening plenary lecture. Exhibitions featured innovative water resource programs, products, and technologies, as well as research on water science and water policy. Attendees at the opening address in the Ronald Reagan Building and International Trade Center. From left: Dr. Stephen Hubble, NCSE;

Hon. Russell Train, former EPA Administrator; Dr. Thomas Lovejoy, Heinz Center; Amb. Richard Benedick, NCSE; Dr. Jared Diamond, UCLA; Senator Lincoln Chafee; and Dr. Craig Schiffries, NCSE, gather before Dr. Diamond's featured lecture. Former Interior Secretary Bruce Babbitt speaks at a roundtable discussion on sustainable water use; fellow panel members Amb. Richard Benedick, Mohamed El-Ashry, and Barbara Sheen Todd are seated behind him. Participants attend a luncheon.



CHAPTER 1

INTRODUCTION

The National Conference on Science, Policy and the Environment is built on the idea that stakeholder-informed science is a powerful tool for building consensus necessary to solve the serious environmental problems that face the United States and the global community. The 1st National Conference, held in December 2000, introduced the concept of sustainability science, which is a synthetic, interdisciplinary approach used to understand the complex interactions between society and nature. The 2nd National Conference focused on the role of science in achieving sustainable communities. The 3rd National Conference addressed education for a sustainable and secure future.

INTRODUCTION

The 4th National Conference on Science, Policy and the Environment explored the role of science in achieving sustainable relationships among water, people, and the environment. It engaged more than 800 participants from 46 states and 14 countries. This multi-stakeholder meeting brought together leaders from academic institutions, business, government, and non-profit organizations. It included elected and appointed officials at local, state, and national levels of government, as well as leaders of international organizations and civil society.

The 4th National Conference addressed the many essential roles water plays in our lives today—maintaining human health and survival, protecting sensitive ecosystems, producing an ample food supply, promoting overall economic prosperity, enhancing recreation and aesthetics, and providing for the long-term security of individuals and nations.

Water issues are diverse and complex. Different water needs compete with one another — the needs of ecosystems vs. the needs of human communities and the needs of upstream vs. downstream users, for example. Population growth is exerting increased pressure on freshwater, estuarine and coastal water resources, while water supplies are often contaminated with microbial and chemical agents that impact human health. Additional complications arise when these issues cross political boundaries, as is often the case.

The conference was organized around four major themes:

1. Sustainable Water Management and Institutions. How can we make watershed management work? How can we better align water policy with water science?

2. Water Quality and Sanitation. Have we turned the corner on water pollution? How safe is our water? How should priorities be set, and who should set them?

3. Water Technologies. How can technology help meet U.S. and international water supply and sanitation needs? How can we bring new water technologies to the marketplace?

4. Estuaries and Coastal Resources. How can we manage estuaries and coastal resources more comprehensively?

The conference included plenary sessions, symposia, and breakout sessions (see agenda, Appendix A). The plenary sessions set the context of the major topics and provided an opportunity to learn from leading scientists and policymakers, including former Interior Secretary Bruce Babbitt, former EPA Administrator William K. Reilly, and U.N. Environment Programme Executive Director Klaus Toepfer. The symposia addressed the four themes listed above and included presentations and discussions from balanced panels of experts. The breakout sessions generated recommendations about specific topics under each of the four themes. Speakers provided diverse perspectives on water issues, and their remarks establish a solid body of background information on water sustainability.

Pulitzer Prize-winning author Jared Diamond delivered the Fourth Annual John H. Chafee Memorial Lecture, *Lessons from Environmental Collapses of Past Societies,* at NCSE's 2004 National Conference. Diamond explained how inadvertent environmental degradation led to the demise of the isolated civilization on Easter Island in the South Pacific. NCSE has published the text of Jared Diamond's lecture in a separate report, which is the fourth in a series of books documenting the annual John H. Chafee Memorial Lecture on Science and the Environment.

Chapter 2 of this report contains the text of selected plenary lectures. Chapters 3 and 4 contain summaries of plenary roundtable sessions and the four simultaneous symposia.

The conference featured 16 breakout sessions on specific topics related to water. In each session, participants generated recommendations for improving water sustainability in the context of their session's focal topic; these appear in Chapter 5. Some overarching recommendations were distilled from these diverse sessions; these have been synthesized into nine general conference recommendations, which can be found in Chapter 6.

The stakeholders gathered at this conference made it clear that sustainable water management will present serious challenges for policymakers in the future. They also made it clear that there are many individuals and institutions striving to meet these challenges. We hope that connections made and information shared at the 4th National Conference on Science, Policy and the Environment will lead to the new ideas and partnerships needed to manage water resources sustainably — for the people and ecosystems of today, and for generations to come.

CHAPTER 2

PLENARY LECTURES AND AWARDS

SELECTED PLENARY LECTURES

William K. Reilly, *The Worth of Water*

Klaus Toepfer, *Water and Sustainable Development*

Jeremy Pelczer, *Water Partnerships and Social Responsibility*

LIFETIME ACHIEVEMENT AWARDS

Ruth Patrick, *Unity of Water, Land, and Air*

M. Gordon "Reds" Wolman, *Mars, Two Worlds, and Rhetoric*

The Worth of Water

William K. Reilly
President and CEO, Aqua International Partners
Chairman, World Wildlife Fund
Former Administrator, U.S. Environmental Protection Agency

I'm very pleased to see that the National Council for Science and the Environment has as a stated priority to establish science as the basis for making environmental policy decisions and for the integration of scientific research and realities into regulations, particularly. I compliment you on your concept and on these conferences, which I understand have become increasingly well-attended by those from the various sectors who make policy in this town.

The theme of water, the theme of science — both have been priorities of mine. They were important themes during my time at the Environmental Protection Agency. Our efforts to craft a new Clean Air Act received more attention during my day, although water issues probably occupied more of our time and resources.

I look back on what we did with respect to water. We increased funding for the Great Lakes and for our estuaries and great water bodies about eightfold. We vigorously pursued a policy of no net loss of wetlands, which had originated at The Conservation Foundation when I was president there. At The Conservation Foundation we organized a task force, chaired by Governor Kean of New Jersey, that made the "no net loss" recommendation, and that proposal became an environmental commitment of the Bush campaign and of the Administration, which it fell to me at EPA then to implement, and we did that as aggressively as we could. We set new limits on lead in drinking water and on other contaminants, and exercised three vetoes under Section 404c of the Clean Water Act: Big River, Rhode Island; Ware Creek, Virginia; and, more famously, Two Forks, Colorado.

No vetoes have been issued since my time. My successors must have learned from my experience. The aggressive concern for wetlands, however, did make me famous in certain quarters. I was on an airplane flying back from Europe while I was in office and my seatmate happened to be reading a magazine about golf. The article listed the 25 most important people in the world of golf and I was ranked fourteenth. I don't play golf. My ranking was said to be attributed to the fact that I had personally intervened to block the location of more new golf courses in the United States than anyone else. You may applaud. But Republicans play golf! What you find, however, is there is something irresistible about a wetland to a golf course developer: it's flat, it's cheap, and it typically has good views of the water.

Well, we threatened more vetoes than in fact we carried out. I remember one, Old Cutler Bay in Florida, where there was a proposal to take a substantial number, 70-some acres, I think, of mangroves. Of course, Florida had already lost more than 90 percent of its mangroves. This was going to be for a Jack Nicklaus golf course development. I remember at the time hearing that the lawyer for the development firm had said, "This is traditional. This is accepted in our culture." To which my public response was, "Well, so was selling horse meat once." The proposal was abandoned, the project redesigned to protect the wetlands, and I lost some friends.

We engaged the issue of whether the city of New York should be required to have a filtration plant. Since the city relied on surface water bodies for its drinking water, it seemed likely over time that that moment would come. But we gave New York a period of time during which it could attempt to protect the watershed in the area that contributes water to New York City, to see whether land use interventions could obviate the need

for a multibillion-dollar investment in filtration. That was an interesting engagement of the land use issue as it relates to water. Land use is an issue in which I began my career. Engaging land use in that way is always sensitive and difficult, and so it was with those upstate communities since the implications were for some constraints on development — if not the aggregate growth they would accommodate, then the way that it would be sited.

The application of science to environmental policy has been an important concern and personal priority of mine. Before even taking up our positions at EPA, we asked the Science Advisory Board, a group of scientists and engineers, largely distinguished professors from around the country, to advise us on what were the most important threats to the health and the ecology of the American people and to what extent the priorities, the budget priorities, particularly, of this Agency conformed to their sense of what's important. This group was chaired by Ray Loehr, a distinguished engineer from the University of Texas. Wetlands, habitat loss, and deterioration of estuaries were cited as three critical concerns in the ecological portion of their report.

We did everything we could during our time to respond to the priorities as the scientists saw them and to remind the Congress and others as frequently as we could both of the significance of the risks cited by the scientists and of the equally clear message we got that some of the risks, particularly with respect to hazardous waste, had been overstated and were not as serious in the minds of the experts as in the minds of the Congress and the public.

I believe very strongly in the need to engage scientists in helping make environmental policies and setting environmental priorities. But I have to say that I was somewhat disappointed during my time in government at the reluctance that some of the best scientists often displayed about engaging in the mudbath of politics. I frequently had conversations with scientists who would say to me privately what they thought in the most clear-cut way with respect to a controversial question or decision, yet then found, when I made the recommended decision, that they were miles behind me and very often silent.

There is a particular concern today, I think, a tendency on the part of some partisans to characterize data as advocacy, and scientists as activists, when they are merely conducting research and reporting on it. Allegations of partisanship or advocacy have caused some scientists to obscure the clear implications of their research and it's caused others, I believe, to become truants from the policy process, an unfortunate consequence, one I fully understand, of becoming a target, the object of criticism. And yet we will not succeed in creating sound environmental policies without the involvement of serious scientists.

Well, I now run the only private equity fund exclusively devoted to investing in water in developing countries, and we have deployed about a quarter of a billion dollars in Colombia, India, Israel, Mexico, and Poland. We have invested in new metering technologies and filtration, in water storage for the home, in drip irrigation equipment and technology, and have become exposed to the severity of water problems, particularly in the developing world, which is the only place that I'm now investing.

It's interesting to me that over the past 10 to 15 years we have seen a transformation in the thinking of development economists with respect to water. There was a time when World Bank economists and others considered that there were essentially three priority investments for developing countries: power, communications, and transport. Those, it was thought, were the determinants of economic take-off. That philosophy has changed. There is now an increasing regard among international economists, development economists, for water. And the reasons for this are essentially the acknowledgement that in order to accommodate the urbanization and industrialization that is occurring in the developing world, very significant amounts of water must be found.

Typically, about 15 percent of water use in the developing world goes for industry, for example. The comparable percentage in OECD countries is about 45 percent. To sustain the rate of urbanization and industrialization in the developing world, the proportion of water that must be assigned to those uses will have to increase about threefold. Where is that water to come from? Well,

it requires 100,000 gallons of treated water to produce one car, 150 to 300 ultra-pure gallons of water to make one microchip, 100 gallons for a ream of paper. The water cannot come from new dams and reservoirs. The sites have been taken. International finance is no longer so freely available for large dams, so the water must come from more efficient use — efficiency improvements in staffing, in collecting water, in storing it, delivering it, then charging, and collecting money from billpayers, from water users.

Water services in developing countries are notoriously inefficient. It is possible, through efficiencies, in places that waste 50 percent or more of their water (which is not an uncommon figure in the developing world), to get substantially more water.

The current situation in many developing countries with respect to water is really heartbreaking in its human dimensions. I can recall some years ago leading a delegation to St. Petersburg, then Leningrad, in Russia, and being warned not to drink the water. It contained, I was told, giardia, fecal coliform, and heavy metals in significant quantities. In our delegation was a young man who had been a Fulbright scholar in that city and I asked him, "What do the locals do about this problem? Do they boil the water? Do they confine what they drink to tea or beer?" He looked very serious and said, "Everybody I knew well enough to know such things — my girlfriend, the family I lived with — had chronic diarrhea and considered it normal."

A physician who does work in Mexico told me that after 20 some years of going to the same village in Mexico, during his most recent visit there he had seen a transformation in the health and vitality of the people. It turned out that all that had happened was the upstream village had put in wastewater treatment, so that downstream users were no longer getting sick from drinking contaminated water, a condition they had considered a fact of life. Well, for so many human and important economic reasons, we simply must do a better job of improving water services and supply around the world. Water is the world's number-one environmental health determinant and dirty or scarce water the number-one environmental health problem.

Turning to North America, which is the focus today, I note certain similarities with water use in developing countries and also certain disturbing trends. We don't have the tools available that, for example, exist in China, which is giving a very high priority to improving its water. China is now a place where rivers no longer reach the sea, where water is very often unusable if it's available at all. The Prime Minister of China recently threatened the mayor of Beijing. The Prime Minister castigated the mayor for Beijing's failure to use water more efficiently and to reform its water practices. And he threatened, if this situation did not improve, to move the capital. Now, I thought, there was a time when we at EPA were very concerned about management practices at the Blue Plains plant here in Washington. It did not occur to us to move the capital. It did occur to us to put the mayor in jail. But that had already occurred to somebody else, so it was not original. The Chinese have tools that were not available to us.

One of the trends that is relatively new in our country is that we have begun to experience water conflicts in the absence of droughts — over recreation versus consumption in the Dakotas, over stream impairments from surface mining and mountaintop removal in West Virginia, between Front Range and Western slope communities in Colorado, between Imperial Valley farmers and urban users in California, between ranchers and mining companies over mining water for methane in Wyoming, between fishers and Indians and environmentalists on the one hand and farmers in the Klamath Basin in the Northwest on the other, between buyers of land with unlimited rights to underlying water in Texas versus their neighbors.

Now, in EPA's gap analysis in 2002, there was an estimated range of capital needs for drinking water over the next 20 years — $154 to $446 billion. And for clean water — combined sewer overflow, collection, and the like — the estimate for capital investment needs for that period was between $330 and $450 billion. This is versus the $10 and $13 billion, respectively, that we currently spend each year for those two problems. The estimated numbers, by their very size, suggest a daunting problem. Interestingly, however, need for major new cap-

ital infusions drops quite significantly if you assume an annual rate increase averaging about 3 percent for water as greater revenues would become available to water utilities to meet these needs.

In the United States water rates, incidentally, have been increasing in the recent past at about 4 percent a year. The World Water Council, based in Marseilles, France, has ranked 147 countries according to the efficiency of their water use and ranked the United States dead last as the most wasteful and least efficient. Well, one explanation for that may be that water in the United States historically has been cheap. The Germans pay $1.78 for a cubic meter of water, the French $1.08, the British $1.23. What do you suppose we pay? Fifty-four cents. Now if that cost were buried in the monthly bill for cable TV, the basic service bill, a lot of consumers might not even notice it, since basic cable costs $45 a month or more; for an average American family of four, a water bill is about $14 or $15.

I recall learning some years ago that in a particular state a 100 percent increase in water availability for urban use could be accommodated by a 10 percent reduction in the total use of water by agriculture, which points to the huge magnitude of irrigation water. It points, I think, also to the opportunity to use it more efficiently and to avoid encountering those very large numbers in the EPA gap analysis. Incidentally, water use per capita in the United States *has* improved over the last 20 years, largely as a consequence of more efficient use of technology in irrigated agriculture.

Well, my strong expectation is that a reasonable and progressive adjustment in water pricing will lead to a significant reduction in water scarcity and thus water conflicts. For that to occur, however, we will need a heightened priority for water efficiency and a cultural and political acceptance of certain water realities.

I mentioned earlier my veto of the Two Forks Dam. Two Forks was a huge project. It entailed at the time over $500 million in estimated development and construction costs. There was not a cent of federal money in that project, which made the exercise of the veto particularly controversial. The project would have involved altering thirty-some miles of a free-flowing river and impounding over a million acre-feet of water. There would have been a routine rise and fall of the water around the lip of that reservoir in excess of 15 feet, and 500 acres of pool and riparian wetlands would have been lost.

Before commencing the veto process I consulted Senator John Chafee, the ranking Republican member of the Environment and Public Works Committee. "Senator, just speculating, if I were to make a fairly aggressive use of the Clean Water Act, do you think that I would be putting the Act or any key parts of it at risk politically, in Congress?" I well remember John Chafee's response. He said, "I don't need to know what you're thinking about doing. But whatever you're planning to do, do it when Congress is not in town." So the following Good Friday morning I initiated the process. I had scarcely finished signing the order before my chief of staff, Gordon Binder, who is here today and whom many of you know, came into my office looking very concerned and said, "There's been an oil spill in Alaska. It looks like a big one." It was a busy weekend. That was, by the way, the sixth week of my tenure at EPA.

We were told that the initiation of a veto on the part of the United States government with respect to western water indicated a misunderstanding of the culture and civilization of the West, which was largely built on free water, subsidized water, and on significant water development projects. We were said to be putting civilization and culture at risk.

I remember a private session with Senator Bill Armstrong and President Bush (the first President Bush), and not a pleasant conversation. Senator Armstrong said pointedly and precisely, "I won't argue that you are putting the economy or the civilization of the West at risk. What I will say you are doing is altering the nature of our green city of Denver. It will no longer be a city of elms and lush shrubs and plants if this becomes the new mode of dealing with water." That probably is correct, for Denver was a Midwestern city planted in the arid foreplain of the Rocky Mountains.

Denver, incidentally today, has done what the city had not done in 1989. They have implemented metering. They have undertaken serious conservation. They have dealt with various water shortages, with restrictions on

water use, and they have begun to encourage the planting of shrubs and trees and plants that are endemic, appropriate to their surrounding natural environment.

I once watched a television piece in which the police in Las Vegas, in a period of particularly heightened water concern and restriction, were making the rounds looking for people who were violating the prohibition on lawn watering. The police with television crew in tow encountered some poor fellow blatantly watering his front lawn, and they arrested him. He was heard to say as he was being hauled off, "You'd think we were living in a damned desert out here the way they're behaving!"

Well, my object in commencing that veto was to initiate the process of considering whether or not we ought to shift, particularly in the West, from an era of development and construction to solve our water problems to an era of conservation and efficiency. One Congressman, whose name you would recognize, said after I made that decision that he was pleased as he had voted so often for water projects holding his nose because they were so costly, so inefficient and unnecessary.

Well, along with a greater acceptance, I think, of the need to price water more realistically will come greater recognition of the value of water trading. We have seen trading in California. T. Boone Pickens has bet more than $30 million that it will come to Texas. He's bought up surface rights with their pertinent groundwater rights. Some difficult realities are involved in trading. Farmers may prosper but then have nothing to do. Some areas that sell their water may dry up and see their agricultural economies, their cultures transformed.

Two Forks was a proposal of the Denver Water Board. The Denver Water Board had the reputation in Colorado, certainly among the surrounding communities and especially those on the West Slope, of expanding its jurisdiction and taking over more and more prime water resources in canyons and valleys. The *Denver Post* once ran a famous cartoon, around the time of the moon landing, showing one of our astronauts on the moon planting a flag declaring "Claimed for the Denver Water Board."

The decision to force more conservation on the part of the suburbs of Denver arguably did have the impact of causing those communities to buy up water from surrounding areas that had it and were then using it for agriculture. And that entailed a certain tradeoff, one that was quite acceptable to the farmers and to others who had the water rights, but it also has resulted in changes in their economy.

Incidentally, one argument against pricing more realistically for efficient use is that it will disadvantage the poor. We have, certainly in the developing world and elsewhere, learned about lifeline rates that protect a minimum guarantee of water for families. We've learned from studies by the World Bank in Jakarta, Mexico City, Delhi, Tijuana, and other places that the very poor typically get their water from truck vendors. The middle class tends to be hooked up to centralized water systems. And the truck vendors charge the poor 10, 15, even 20 times more than water costs the middle class with their access to public water connections.

It's the subsidies, incidentally, that do the damage typically in much of the world in which I have been investing. In India, in Mexico, in Saudi Arabia, water for farmers — in Mexico water also for mining — is provided essentially free.

The consequence in India, with which I am most familiar, in Maharashtra, for example, is a 12- to 15-foot annual drop in the groundwater table, which is causing new subsidies to be developed for micro-irrigation, which can result in a 30, 40, 50 percent reduction in water use once it's installed. Poorly designed subsidies often create problems and do much inadvertent damage.

Pricing will accelerate the introduction of new technologies. Metering results in a 30 percent drop in water use among even the wealthy when it's introduced. Nobody's foolish when it comes to spending money. The positive effects of drip irrigation I already mentioned. Desalination costs have come down to between $2 and $4 a thousand gallons in the last 15 or so years, a rate that is still probably in excess of typical surface or groundwater costs, but getting close. Israel now has 12 desalination plants on the drawing boards.

Well, our history in this country has resulted in a patchwork of laws, precedents, and practices from a time when people were fewer and water was more readily

available, there for the taking. We have inherited a practice of water entitlements, ongoing subsidies to lower the cost of water to farmers and consumers without which the arid West would not have been settled. Yet today, these very institutions seriously hinder how we manage water resources. Given population and economic growth, I think, more conflicts over use of water supply seem inevitable.

I'm struck by the Klamath situation — a massive fish kill attributed there by many observers to low flows when farmers who are entitled to the water got their share. It's apparent the allocations were made at a time when water supply seemed endless. Today, the conflict is framed, for political purposes I expect, as a clash between people and fish, between farmers and environmentalists. That plays well in certain quarters. But it's far from the whole story: it's really a story about people on both sides, some winning, some losing. Farmers may need the water, but Native Americans depend on the fishery, so do commercial fishermen, and the recreational fishing industry. They lost out. Available water is oversubscribed, and trying to sort out a fair and equitable solution that works for all of the people of the region has proved tough, though those efforts are underway. In part it's difficult because there are not the mechanisms that help us, that force us, to make necessary tradeoffs.

So, in sum, the future likely will see water prices rise, and agriculture reduce its share. Prices will mediate shortages and new institutions will be fashioned to reform priorities and entitlements. Species, I fear, will disappear and vast areas may become drier. And we'll see more conflicts as this unfolds.

In a cover article the London *Economist* recently heralded the end of the oil age. They might equally proclaim the arrival of the water age.

Valuing water more realistically, fashioning new institutions, introducing new technologies — these are three needed directions for water policy.

There is another one. I can recall, and probably many of you can, as a youth marvelous associations with certain water areas. For me it was Narragansett Bay, Tiverton, and Newport, Rhode Island. I remember as Administrator attending the annual meeting of Save the Bay, in Rhode Island. As I looked out over the attentive crowd and spoke about our priority for improving the health of places like Narragansett Bay, it struck me what a powerful motivation it is when people treasure a resource like the Bay. We needed to tap into that concern.

We tried to respond to that in my time in government by creating geographic initiatives and convening people to consider the resource itself — Corpus Christi Bay, Narragansett Bay, Chesapeake Bay — to gather without pointing fingers but merely to begin by assessing the condition of the resource, the causes of pollution and contamination, the sources of deterioration, and then gradually beginning to get a fix on what it would take to do something about these problems. That, which was essentially a communications and consensus-building exercise, proved marvelously effective at engaging people in looking realistically at a resource everyone loved. And I think that in dealing with any environmental problem, I would advise people to focus on what it is people love and care about, because for those resources they will make sacrifices, they will make the effort.

Restoration and prevention of deterioration are not just an economic or environmental matter. This leads us to land use. I wonder if any of you in this audience remember back far enough to the proposal of the Nixon Administration for a National Land Use Policy Act. It came close to passing. It passed in the Senate twice but failed in the House. It ran afoul, finally, of ideological concerns, though the Coastal Zone Management Act largely includes many of the land use bill's provisions. Today I think we face the prospect of having to recognize the interconnections between water and land use to a degree that in an earlier generation we were not prepared to do. We may have to recognize that in some areas water itself will prove to be the constraint on growth and development.

Let me say something about climate. If the Intergovernmental Panel on Climate Change is correct in its forecast of a potential for a drop in soil moisture in the American West of a third, then we will first encounter severe climate change as a water crisis. An entire culture and economy then could have to be transformed.

The problems of managing water resources and restoring water bodies are vastly complicated by the

prospect of a changing climate. We don't know with precision how much change will come, when it will come, nor what the impacts locally will be. But the weight of evidence is mounting, from temperature records to retreating glaciers, to melting tundra, to sea level rise, to changes in the behavior of wildlife. And if, as projected, there are significant changes in patterns of drought and precipitation, we could witness dramatic impacts and be called upon to make costly fixes.

If the snowpack in the Sierras, for example, diminishes and what's there melts earlier, what will Californians, two thirds of whom depend upon that resource for their water, do for drinking water? If the Midwest and Southeast experience more torrential rains, which themselves have been associated with climate change, with a warming climate, are we prepared for the massive flooding we saw a decade ago? Are we prepared to deal with sea level rise in Florida and other coastal communities?

We need to know more about these potential impacts and we need to do more to begin seriously addressing the growing levels of greenhouse gases we are pumping into the atmosphere. Climate change is a global problem, and I recognize that even if the Untied States were to stop all carbon dioxide emissions tomorrow, the problem would not go away, for emissions in a number of countries in the developing world are projected to grow substantially over the next few decades. But we must as a nation re-engage in the international debate. And to do that we need a credible domestic program that might usefully start with mandatory reporting of emissions so that we can better track and monitor and ultimately reduce our large contribution to the problem. I was heartened to see last fall that the Senate's first serious debate on U.S. responses to the problem drew 43 votes for the bill sponsored by Senators McCain and Lieberman — a modest, though important, first step. Perhaps the momentum is swinging over to favor those who are prepared to tackle the problem.

Well, in conclusion, our country is blessed by abundant land and water resources. But they will provide for us only if we manage them wisely — something a century ago President Theodore Roosevelt embraced when he championed the cause of conservation. We are still figuring it out but we do know, as one of our founding fathers, Benjamin Franklin, put it succinctly in *Poor Richard's Almanac,* "When the wells run dry, we know the worth of water." The truth of that proposition is being tested, as nations, communities, and people the world over come to terms with the relentless thirst for more decent-quality water for all of its many needs and purposes.

Water is a good window, a surrogate for much else in life. It can be a measure of health for people, as for plants and animals. Now we're going to Mars. Why are we going to Mars and what are we looking for? We're looking for water. That's worth pointing out. I've been accused of seeing the world through a water glass. Nevertheless, water! Because if it's there, then there could be life. Water equals life!

Thank you.

Water and Sustainable Development

Klaus Toepfer, Executive Director
United Nations Environment Programme (UNEP)

Water issues have become one of the top priorities of the international system — last year was the United Nations International Year of Freshwater and this year is the International Year of Oceans and Seas. This April's discussions at the U.N. Commission on Sustainable Development in New York City will focus on the practical implementation of international goals related to water, sanitation and human settlements. And environment ministers meeting in Jeju, South Korea, in March at the UNEP Global Ministerial Environment Forum (GMEF) will discuss the environmental dimensions of these issues and help to move them forward by presenting success stories from their own countries.

WATER AND POVERTY

Why do we accord water policy such high importance? First of all, access to adequate supplies of fresh water and sanitation is fundamental to the alleviation of poverty. Water is often not perceived as a luxury, and people who live without access to clean water, or who have no access to adequate sanitation, are, almost invariably, the poor. They are caught in a vicious circle. Their poverty denies them the basic necessities of clean water and basic sanitation. And their lack of these necessities condemns them to continued poverty. Poor people pay vastly more — between ten and a hundred times more — for water and sanitation services than their wealthy neighbors — more than farmers, more than industrialists, more than you and me.

Not only do the poor pay more in financial terms, they also pay more in terms of physical effort — whether it be queuing at a standpipe in a city slum or walking for kilometers to collect water from a rural well or stream. That cost is usually borne by women, who could be more profitably employed, or children, who should be in school.

The poor also pay an enormous price in health. It is estimated that 80 percent of illness and death in the developing world is water related. Half the world's hospital beds are occupied by people with water-related diseases. Lack of clean water or adequate sanitation kills 1.7 million people a year, 90 percent of them children. Infant mortality in low-income countries is more than 13 times higher than in wealthier countries.

These statistics represent major roadblocks on the path to sustainable development; the failure to address water issues is a critical threat to its realization.

My organization, the United Nations Environment Programme (UNEP), is trying to help solve these problems. We offer a number of tools — including assessments, policy options, technology transfer, and capacity building — to address water and sanitation issues and the global decline in freshwater quantity and quality.

At the heart of UNEP's water strategy is the principle of a fair share of water — for all users and for all uses, including key ecological services. We believe that the following three issues are central to achieving sustainable use and equitable distribution of the world's water resources:

- Good water governance and management,
- Sustainable finance, and
- Sound science.

1. GOOD WATER GOVERNANCE AND MANAGEMENT

Good governance is perhaps the most important requirement for solving problems of freshwater and sanitation. Governance includes policy, institutional struc-

tures, and decision-making processes. An essential requirement is political will.

Governance is a particularly important and complex issue with respect to shared water resources. At the 3rd World Water Forum in Kyoto, Japan, in March of 2003, UNEP and the Food and Agricultural Organization of the United Nations launched the Atlas of International Freshwater Agreements, which shows how the issue of shared water resources is generally a spur to cooperation rather than conflict. Despite tensions over water resources, only 37 incidents of acute conflict have occurred since 1948, of which around 30 were in the Middle East. Meanwhile, over the same period approximately 295 international water agreements were negotiated and signed. So water can be a source of valuable international cooperation.

Governance is, of course, closely tied to management. Poor water management causes most of the water crises in the world today. This recognition is long-standing. For example, forty years ago the Berlin Conference on Water Development in Less Developed Areas found that "the main problems in the field are not technical, but are of an organizational, administrative, political or managerial nature." Despite this recognition, current efforts to address water management and policy issues are inadequate to the task at hand. The international community and national governments share responsibility for this. More emphasis must be placed on capacity development for management, institutional reform, and governance reform.

One prominent area I'd like to mention is the need for integrated river basin and ecosystem management. Managing water systems holistically allows us to improve environmental services and therefore to improve the lives and livelihoods of the people who depend on those systems. It is essential for the sustainability of water resources and all the services they provide. Crucially important is the maintenance of upstream habitats — especially forests, riparian zones, wetlands, floodplains, and estuaries.

Another essential component of the good management package is community participation. Water security is found where the whole community — including the poor and the marginal — has some control over water resources and services. Poor people and communities — especially women — need to be consulted about the most appropriate solutions to their needs, rather than having unsustainable higher-tech solutions thrust upon them — which they can't maintain because they either don't have the know-how or can't afford the spare parts.

Perhaps the most important management issue regarding water and sanitation, the one that could have the most benefit for the poor — yet is proving to be the most controversial — is the issue of water pricing. It is plain to anyone working in the development or environmental field that the sustainable use and management of water resources demands that users must pay the true costs of the services they receive, with the provision that the poor majority receive a basic needs supply at a price they can afford. Currently, agriculture's use is heavily subsidized, while the poor pay too much — financially and in terms of health and labor.

The over-use of water resources can be curbed by demand management approaches that include improved irrigation practices, less-water-consuming crops (especially in water-scarce areas), and more efficient industrial processes. Weighted pricing structures and the withdrawal of perverse subsidies can encourage all these things — without harming the poor.

Consider, for a minute, the costs of subsidizing water to larger users.

When water is subsidized it tends to be wasted. Subsidies impose a direct cost on taxpayers and an indirect cost through encouraging inefficient water use. The funds used for subsidizing water might be better used by society for other purposes — for instance, providing better services to the poor.

Another type of subsidy is when people pollute water and do not pay. This transfers the costs of pollution to other users. In some cases these costs are enormous — to the economy, to human health, and to the environment. The people who pay the highest price are, again, usually the poor. It is they who have to live closest to polluting industries, and they who have to use untreated, polluted water because they do not have access to the clean piped water that so many of us take for granted.

But, if everyone has to pay the true cost of water, how do we supply the poor? Despite the fact that the poor already pay a disproportionately high price — if they have the money — for water and sanitation services, and despite the fact that studies show that the poor are willing, when they can, to pay for what they know is their single most important necessity, there are both moral and practical problems in trying to make the poor pay more for water.

The answer I propose to this dilemma is progressive pricing. Progressive pricing means charging more per unit the more water is used. A basic needs amount of water should be sold at a low price, subsidized if necessary, so that poor people can afford the minimum needed for a healthy existence. Increasing levels of consumption are billed at progressively higher tariffs per unit. This provides an incentive for more efficient water use. The money saved on infrastructure investment and wasted water can then be re-invested into supporting the uptake of water-efficient technology by larger users, thus alleviating the perceived financial burden of paying for the true cost of the resource — a win-win situation for the poor, for industry and agriculture, and for the environment.

2. SUSTAINABLE FINANCE

If current water and sanitation commitments are going to be attained, investment — both at the macro and the micro level — will have to increase to as much as double current levels.

The Water Supply and Sanitation Collaborative Council and the Global Water Partnership have estimated that meeting the Millennium Development Goals on water coverage could require between $14 and $30 billion dollars a year on top of the roughly $30 billion already being spent.

However, the dividends should be vastly greater. For example, a cholera epidemic in 1991 cost the Peruvian economy $1 billion in combined emergency health expenditures and lost revenue from exports and tourism. This figure is more than four times what Peru spent on water supply and sewerage between 1981 and 1988.

There are a number of ways of financing the investments needed in improving water and sanitation services — international and bilateral funding, debt relief, privatization schemes, community-level resource mobilization, and so on. What is important is that investment solutions must benefit developing countries in the long-term, address the needs of the poor, and be consistent with the environmentally sustainable management of water resources.

Unfortunately, however, major investors are still rarely interested in investing in small-scale projects at the neighborhood level. The amount of aid currently allocated to low-cost water and sanitation programs is abysmally low. The OECD's Development Assistance Committee reported in 2000 that only 1.7 percent of all sector-allocable aid is earmarked for this purpose. Most of the money available for development is for large-scale projects of $100 million or more. Yet perhaps the most cost-effective investment for public health — and therefore for poverty alleviation — is simple education in basic hygiene practices. This reduces mortality more than just the provision of safe water or sanitation alone.

Let me add a few words about privatization. Water as such should not be privatized, as this resource is a sacred good in many societies. But selling water utilities and contracting out water revenue collection have advantages — such as improvements in service delivery, improved revenue collection, and financing for expansion.

But there are also disadvantages. Developing-country utilities sold in a poor management and financial state are worth much less than if their management is efficient and they are financially sound. Furthermore, privatized or commercialized utilities require regulation. Sophisticated regulatory authorities to monitor privatized water utilities do not exist in most developing countries.

A suggested preferred approach for donor support is to help improve the management of developing country water utilities. Improved revenue streams can then finance service delivery and infrastructure improvements, enhance the environmental sustainability of water supply and use, and improve the delivery of clean water and sanitation to the poor.

3. SOUND SCIENCE

We are fortunate that there is a lot of good science available to support management and policy decisions. 2003 was marked by some of the best and most authoritative water assessments ever compiled, including the U.N. World Water Development Report and UNEP's groundwater assessment.

In the past, the lack of hard facts has precluded action. But this is increasingly no longer the case. For instance, a monitoring and early warning project in seven West African cities including Abidjan, Niamey, and Dakar is now helping to pinpoint pollution "hot spots" and threats to aquifers, with the scheme extending to the eastern African countries of Ethiopia, Kenya, and Zambia.

But although a lot of good science exists, it is not always used. The tools are available and the technologies have been developed or are in development. But the problems are in many cases worsening — in our ever-expanding cities, in rural areas, in rivers, lakes, and groundwater aquifers.

Turning this situation around will require focusing on what works. Particularly, we need to address the issue of the wasteful and unsustainable use of water in agriculture, which commands the lion's share of available freshwater resources — over 70 percent globally — and which in many cases wastes 60 percent or more of the water it uses. Agriculture's use is leading not only to water scarcity in many areas, but to salinization, soil degradation, and desertification — all major contributors to poverty and obstacles to sustainable development.

We also need to address the waste of water in urban areas. For example, in African cities, up to 50 percent of the population — the poorest, of course — lack adequate water supplies, and 60 percent lack adequate sanitation. The figures are similar for urban Asia. Yet up to 50 percent of the water supply is wasted through leakage or is otherwise unaccounted for.

Technologies already exist to remedy many of these problems, but information about them needs to be more widely disseminated before it will be adopted. UNEP's International Environmental Technology Centre in Osaka, Japan, is doing its best to address this need by compiling a database of water-saving tips, technologies, and policies drawn from both the developed and developing world. Examples range from technologies such as drip irrigation, which can reduce water consumption by as much as 60 percent, to rainwater harvesting, dual supply systems in coastal areas, and dual flush lavatories.

SIGNS OF HOPE

There have been numerous international conferences and special events related to water issues in recent years, including three World Water Forums, last year's International Year of Freshwater, and the annual World Water Day. The question is, are all of these gatherings making a difference on the ground?

Political will to tackle the water crisis has been lacking for many years. But I believe this is no longer the case. Late last year, African ministers responsible for water supplies met in Addis Ababa, Ethiopia. The ministers committed themselves to establishing National Task Forces aimed not only at meeting the Millennium Development Goals but also at going beyond them to deliver safe drinking water and sanitation for all 300 million Africans in need by 2025. I believe that the new Regional Water Facility, established this year in Tunis with a plan to raise $650 million for low cost loans and grants, will play an important role. Meanwhile water sector reforms are now also being assessed or are underway in 16 African countries including Uganda and Kenya.

The European Commission, building on commitments made at the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, has also been active this year. For example, it announced commitment of 50 million Euros to help Chad carry out its new Water and Drainage Strategy. This will help provide reliable drinking water supplies for more than 2,200 villages, new or improved supplies in more than 70 towns, and 280 "water supply points" for nomadic herdsmen and women.

The United States Government has expanded its Safe Drinking Water Partnership, which aims to reduce diarrheal diseases in children under five years old and in other vulnerable populations by providing locally-pro-

duced water disinfectant and safe water storage containers and by advocating behavioral changes that lead to improved hygiene. Recent months have seen these activities introduced into Malawi and expanded in Madagascar and Kenya, and new initiatives are in the process of being launched in both Afghanistan and Nigeria.

Recent encouraging evidence suggests that the collective efforts of the international community may be beginning to bear fruit. A new report, using the "World Urbanization Prospects: 2001 Revision" by the U.N. Population Division and based on new data, particularly from Africa, indicates that more people are receiving reasonable levels of safe drinking water than had previously been supposed. In other words, far more was achieved from investments by organizations like the World Bank during the 1990s than may have been realized when the internationally agreed upon development goals were established.

In closing, water management is a difficult endeavor, with an increasing potential for conflict as pressures on water resources increase. But the history is one of cooperation or at least co-existence. The challenge is to increase the benefits from sharing water resources in an environmentally sustainable manner and to share them equitably. This will require both scientific input and political will so that available knowledge can be applied to securing a sustainable future for the many who depend on our precious water resources.

Water Partnerships and Social Responsibility

Jeremy Pelczer
President, American Water
Deputy CEO, RWE Thames Water

American Water is a company of some 8,000 water professionals. Our vision is to be your trusted water resource company, dedicated to delivering innovative solutions. Our job is to provide water and wastewater services safely, reliably, and efficiently to our 21 million customers in 27 states. We are part of a larger international company, RWE Thames Water, which has more than 20,000 employees serving 70 million customers.

We serve all those customers to the best of our ability — that is our job. But as professionals, we can't fail to notice and be concerned by the emerging water crisis caused by unsustainable water use in so many countries, including parts of the United States. And as human beings, with a strong sense of pride in the public service we provide, we can't fail to be touched by the plight of the 1.1 billion people around the world without access to safe water and the 2.4 billion without safe sanitation.

Financial analysts list water services companies as utilities, and treat them accordingly. I understand why they do that, but utility means something is useful, and water is far more than that. As U.N. Secretary General Kofi Annan has said, "water is life; sanitation is dignity." The fact that so many of the world's citizens have neither of those things isn't something we can easily ignore — particularly when relatively simple and inexpensive solutions do exist.

Human health and welfare lie at the heart of sustainable development. I believe we need to find ways to ensure that everyone on Earth has clean water and safe sanitation. Yet in many parts of the world the situation, at the beginning of the 21st century, has been largely unchanged for hundreds of years. And the situation is going to get worse. Population numbers in the developed world — the OECD countries — will be stable or decline over the next hundred years. But in the rest of the world — the developing world — the sheer scale of the challenge is daunting. Achieving the U.N.'s Millennium Development Goals of halving the number of people without service by 2015 will require some 300,000 clean water connections every day of the week, 7 days a week, throughout that period, and the figure for sanitation is more than 400,000.

As a company equipped with many of the required skills, and a commitment to taking our social responsibilities seriously, the question we have to ask is what, if anything, can we do to help? I believe there are things we can do, and I want to describe some of them, but first I must answer the question we are all addressing in this session. Why have past water policies failed or succeeded? And is water too important to leave to the experts alone?

In my view there are three reasons why some water policies have failed in the past.

First, measures have been taken in isolation, without recognizing that the apparently simple questions of water supply and resource allocation are immensely complicated, involving all sorts of environmental and social considerations and raising multiple issues. Dealing with one part of the water cycle in isolation, failing to plan and operate on a watershed basis, and not making an effective link between water supply and sanitation are frequent causes of failure. Even here in the United States we have real difficulties in reconciling the requirements of the Clean Water Act with those of the Safe Drinking Water Act.

Second, every human and geographical situation is different. Water policies have too often revolved around the technical and engineering aspects of water supply, with the human dimension virtually ignored. Perhaps

because of the 'utility' listing I mentioned earlier, there is a tendency to concentrate on merely finding a supply of water and then providing connections to those who need it. But the situation is always more complicated than that. In supplying water, there is always some form of existing social infrastructure in place to provide and allocate water. This needs to be given proper consideration in designing any new water policy. Even the most competent engineering solutions, if imposed from the outside without extensive research and community consultation, are doomed to failure.

Third, in many developing countries, water policies have given insufficient attention to ensuring that the needs of the poorest in society are met. There are many reasons for this, including political unwillingness to give any priority to those who are unlikely to vote or pay taxes, and fear of legitimizing informal settlements. But the consequences are clear. Middle class areas end up paying low prices for a networked service, while the poor pay much higher prices for poorer quality water from street vendors. There are ways around this problem, but it does have to be made a priority from the start — by all the agencies concerned.

Having made those points, I expect my reply to the question about leaving water to the experts will be predictable. Yes, by all means leave water to the experts, but not just to the water and wastewater service providers and their regulators. There is a need to involve experts in a wide variety of scientific and social disciplines. They also need to be wise enough to see the big picture, and prepared to work with all the people who will be affected by any decisions. I suspect such a group drafted South Africa's Water Policy, which is a model of clarity and sound thinking. And I want to quote just one section, which I think applies equally well to the United States and to Europe: "The use to which we, as a society, put our water will come under increasing scrutiny and intensifying management as we move into the 21st century. We will have to stretch our understanding, and apply our wisdom ever more creatively if our aspirations for the growth and development of our society are not to be constrained as a result of limited water resources."

I said earlier that I would talk about ways in which my company is contributing to solutions in the developing world. One way we do this is through the support our employees and customers provide to two excellent non-governmental organizations, WaterAid and Water for People. These are organizations working at the grass roots, using the simplest of technology to provide clean water and safe sanitation, mainly in rural areas of Africa, South Asia, and South America. We admire their dedicated work and their remarkable ability to provide a person with clean water for life at a cost of less than $30.

We also provide skilled employees to assist, at our expense, on various projects in countries including South Africa, Iraq, and East Bali. The payback comes in the experience and personal development gained by those who take part. I was immensely proud that when RWE Thames Water was approached by the Save the Children Fund to provide humanitarian assistance with water and wastewater in Iraq, in the immediate aftermath of the conflict, we immediately had 23 volunteers, almost half of them from American Water. After an initial reconnaissance visit, the security situation has prevented us from having people on the ground, but we are still assisting the Baghdad Water Authority, through UNICEF, to source portable water treatment plants.

I also want to mention a major project, funded by the Japanese Bank for International Co-operation, we are engaged on in Bangalore, in the south of India — because I think it demonstrates the importance of good infrastructure in achieving sustainability.

Bangalore is one of the most rapidly growing cities in the world, and an international center for Information Technology. The population of 5.5 million, more than 20 percent of whom currently live in more than 400 urban slums, is expected to double during the next 20 years. The main water supply comes from the River Cauvary 60 miles away and has to be pumped uphill four times on the way. Yet when this precious liquid reaches Bangalore, more than half is lost through leaks and unbilled connections.

Bangalore has an excellent Water Supply and Sanitation Board, and they are determined to tackle this problem, with our help. So we are systematically tracing every main, replacing old and leaking pipes, mending

leaks, and installing meters throughout the system. It is a painstaking process, but it is saving the city both money and water, with which they will be able to extend the network and work towards a 24-hour supply.

We are also looking at developing a whole new approach that we believe could enable a significant private sector contribution to achieving the Millennium Development Goals. Our starting point is the realization that the scale of the challenge is so great that corporate philanthropy and consultancy projects of the sort I have just mentioned won't be sufficient. And our traditional approaches won't be appropriate. We are going to have to develop a new business model and — if we succeed in making it work — persuade other companies to join us in adopting it.

It is clear to us that the biggest obstacle, for us, to working where the needs are greatest is business risk. Only by reducing those risks can we reduce the required rate of return sufficiently for it to be affordable.

We believe we can reduce risks significantly in three ways. First, by working in partnerships in which each partner does only those things they do best. Following that principle, the second point is that we will invest our most precious commodity, expertise and human resources. And the third point is that we will identify organizations that have the local knowledge and community links to make a success of the billing and collection function. Our aim is to work in this way with international NGOs, willing municipalities, other companies, community based organizations, and anyone who wants to work with us. In doing so we, and our partners, will seek to achieve a rate of return in the range of 7 percent to 10 percent.

Our first public discussion of this concept took place last July and provoked a remarkable level of interest and enthusiasm. Since then we have been working with three international NGOs and a number of other interested parties, including the Kenan Institute here in Washington, to develop a workable model. This will involve an international alliance of partners working on a not-for-profit basis and providing a brokerage function to establish for-profit projects to deliver on the ground. Projects will focus on ensuring economic, social, and environmental sustainability and will work with municipalities in management partnerships of three to seven years' duration. The international alliance will assist in locating sources of funding, but particularly international aid and local capital. An output-based aid approach will be adopted, and there will be a strong emphasis on local capacity building.

There is still some way to go, but I am optimistic that we will be able to make a formal announcement of the partnership in the middle of the year and to announce the location of two pilot projects by the end of the year. In the meantime, we welcome suggestions, advice, constructive criticism, and all offers of help, so please feel free to contact me afterwards or send me an e-mail.

I just want to end with another quote from the South African Water Policy, because it sums up for me why water is more than "useful" and why water service companies are more than utilities:

"The scale of deprivation is clearly visible in the lack of...safe water and...adequate sanitation. This impacts most heavily on women and children in rural and peri-urban areas. African women in these areas have no choice but to walk long distances to collect water, a heavy burden which impacts directly on their health. The time spent doing this could be better spent working, studying, growing food or taking part in other activities. There is a similar impact on children. Thousands of children die annually, of avoidable diseases related to poor sanitation and the lack of clean water."

I hope that goes some way toward explaining why my colleagues and I — in addition to our principal task of providing the best possible service to all our existing customers — are so determined to try and make an impact on the global water problems.

Thank you very much.

NCSE LIFETIME ACHIEVEMENT AWARD PRESENTED TO:

Ruth Patrick

Francis Boyer Chair of Limnology at the Academy of Natural Sciences in Philadelphia
Adjunct Professor at the University of Pennsylvania

From introduction by Thomas Lovejoy, President, H. John Heinz III Center for Science, Economics and the Environment:

"...for literally one generation of graduate students after another, Ruth has provided an extremely important role model of a scientist...who knows how to talk to policymakers, talk to the public."

"In 1945, Ruth Patrick invented team research in ecology. She discovered what I refer to as the Patrick principle, namely, that if you look at the biodiversity of a river or a landscape, it will give you a measure of the human impact."

"...what the Patrick principle gives us is one very important way of measuring whether we're having any success at all in this great quest for sustainable development. It's an absolutely extraordinary piece of work. The Patrick principle will be guiding those of us working on the environment and the human condition for millennia to come."

UNITY OF WATER, LAND, AND AIR

My interest in water started at the age of 4, when my father would take my sister and me for walks in the woods in Kansas City. My sister and I each had our baskets and we would collect the earthworms, and the snails, and the plants, the flowers, the fruits and so on. And after this trip, my father, who had been carrying, like Tom Sawyer, a fishing rod with a tin can on the end of it, would scrape the water from the streams, put it in a bottle, and we would go home.

After my sister and I had had our milk and cookies we would go into the library where Father had a roll-top desk, and in this desk were four microscopes. And he would pull out the one that was most appropriate for what he wanted to show us. And I would climb on his knees and peer through, and I saw a whole new world that I did not know existed. And so my interest in water and diatoms started. The more I studied, the more I realized that air, water and land form one world on the planet Earth, the only planet that we know that has life.

The purity of the air is maintained by the process of photosynthesis, in which plants produce pure oxygen. And it is this pure oxygen in the atmosphere that enables you and I and all mankind, and all the animals of the earth, to live. This purity of the water that is part of photosynthesis and part of our life-forms is maintained by the process of evaporation of water from our seas, rivers, and lakes. In the atmosphere water forms rain, snow, ice, and fog, that precipitates onto planet Earth and improves the quality of our rivers, lakes, and ponds. Some of it sinks into the earth and forms groundwater. Precipitation and other processes are essential to improve the quality of the air, water, and land. Because of these complex rela-

tionships, in order to evaluate the effects of man's activities, one must study the whole ecosystem. In this way, we can begin to evaluate what man is doing to our biosphere and what is necessary to maintain the purity of air, water, and the beauty of our landscape. Thank you.

Ruth Patrick is the Francis Boyer Chair of Limnology at the Academy of Natural Sciences in Philadelphia and Adjunct Professor at the University of Pennsylvania. Dr. Patrick's illustrious career spans more than seven decades, during which she has been a pioneer in the field of interdisciplinary environmental study.

While her early research focused specifically on enhancing our understanding of aquatic ecosystems, Dr. Patrick's work has profoundly influenced the entire field of ecology. She was the first person to use biodiversity as a measure of ecosystem health — a method that is now used to assess a wide variety of ecosystems. Dr. Patrick has written a number of books, including, most recently, a five volume series called Rivers of the United States. *She is author of more than 200 scientific papers.*

In 1970 Dr. Patrick became the 12th woman elected to the National Academy of Sciences. She has served on the Board of Directors for the Dupont and Pennsylvania Power and Light companies. She received the John and Alice Tyler Prize for Environmental Achievement in 1975 and was awarded the National Medal of Science by President Bill Clinton in 1996.

Dr. Patrick earned her bachelor's degree from Coker College in South Carolina in 1929 and her Ph.D. from the University of Virginia in 1934. She has received 25 honorary degrees.

NCSE LIFETIME ACHIEVEMENT AWARD PRESENTED TO:

M. Gordon "Reds" Wolman

B. Howell Griswold Jr. Professor of Geography and International Affairs
The Johns Hopkins University

From introduction by Deborah Knopman, Associate Director of RAND R&D:

"For us as graduate students in the department, Reds was our model — of how to put the pieces of our education together to form productive careers in the sciences or engineering while also making active contributions to public policy."

"Reds' visionary leadership in science, education and citizenship is truly a national treasure. He made contributions to the field of geomorphology that changed the course of the discipline. He conceived and implemented a new model of engineering education that has become a model for other schools. These contributions alone merit the highest recognition, but to also have served with the highest distinction as a citizen-scientist adds even more strength to his worthiness for national recognition."

MARS, TWO WORLDS, AND RHETORIC

I am deeply honored to receive this lifetime achievement award from the National Council for Science and the Environment. It is a particularly special and — I can only use one appropriate word I think — delightful opportunity to share the stage and the event with Dr. Ruth Patrick. It is also humbling, as it is to find myself in the company of Maurice Strong and Senator Nelson.

I was offered the opportunity to make a few remarks. I can assure you that in this enormously comprehensive two days of sessions, there is not a single thing I can think of to say that has not been said. There is also the likelihood that it has already been said, better. Now I turn to the audience and simply say to you: I am going to say it anyhow.

I have just three observations, if you will, notes — they are not even as much as chords — that I want to touch upon. They are the following: Mars, two worlds and rhetoric.

Let me start with Mars. It turns out that this is an exciting several weeks in that apparently those in government have decided that water on the globe is inadequate and that we should search for it on Mars. The point I would like to make here is that Earth is a very well-watered planet. There is an enormous amount of water, as everyone in this room is aware. Coleridge is partially right though, in that it takes effort to provide the drinking water. What I want to emphasize is the notion that perhaps sometimes too much is said about the scarcity issue, which may grab the attention of people, but I think also diverts them from recognizing that the characteristic of water which is important is its spatial and temporal variability.

The problem of dealing with this spatial and temporal variability is likely to be intensified with climate change, whatever one thinks about the nature of its occurrence now and in the foreseeable future. Those who have to deal with the issue of spatial variability are in a very difficult bind if their sources are dispersed. And by

that I mean, for example, the dependence on wells widely spaced in many areas of Sub-Saharan Africa. On the other hand, the ability to cope with variability and uncertainty — if you add that as part of the climate change scene — is enhanced by the degree of connectivity that exists in many parts of the urban world in the United States and in many parts of Europe and elsewhere.

In each case, everyone is searching, regardless of where they are, for more efficient and productive use of water. This involves, on the one hand, the technological and the scientific, but equally important, what I'll call the social and economic. As everyone is aware now, one of the panaceas for the issue of efficient distribution and use is, of course, the market. I simply want to say that I doubt that there are any panaceas in the game at which everyone here is engaged, and that the issue of equity and its balance with economic efficiency is a really difficult and important one with which we have to grapple.

Let me turn to two worlds. Perhaps, in describing the world water scene, the most important message to convey to people is the fact that there are really two worlds to water. One is in the developing world, where there are unimaginable numbers of people who are without adequate water and sanitation, that is billions of people, not millions of people, where the infant mortality rates are in some instances 20 times higher, in some instances 50 times higher, than what we would consider even reasonable in this country. Then there is the other world, that is the developed world, for lack of a better word, which I would characterize because of time constraints as fat, dumb, and happy — maybe not so happy; I'm not sure. These are very different worlds, and it's important to recognize that where we are is where billions of people in the world want to be.

It does not mean, however, that the suggestions for water policy, for an illustration — water quality for drinking water — should in fact be precisely those that we have decided, sensibly or not so sensibly in some cases, are appropriate here. I know there's a kind of heresy to say there is a distinction to be made here, saying there are those who have and those who haven't and they don't need what we have. What I mean to say is that the imposition of certain ideas from our society is not necessarily appropriate where there are some very, very fundamental needs to be met and where there are no questions of what is needed, technically at least, to do it. The real questions are matters of will. The United States has a water bottling industry, which I understand is worth about 6 to 7 billion dollars per year. For the world as a whole, the bottled water industry is more on the order of 20 to 21 billion dollars per year. That happens to be about the amount of foreign investment needed to provide water and sanitation for all of the developing world. I find something obscene in that relationship.

There is one commonality of course, between these two worlds, and that is that both worlds need the same things: money, human power, and management. And to that extent, we're all in it together and the expectations of how to behave directed at those objectives are the same. The real issue, I think, and we need to be careful, is not to mix things up.

Let me conclude with rhetoric. By rhetoric I mean speaking at two levels. One rhetoric, which is bothersome to me, but may be necessary, is the level at which we draw the attention of the citizens and of the political world by calling things a crisis. As far as I can see, that seems to work. However, what we're dealing with is not within the definition of crisis. Crisis implies a reaction, a relatively instantaneous, quick event of some kind, and presumes sometimes that there is a solution that goes with that. Everything in the resource and environmental field is not like that. As everyone in this room knows, the kinds of issues with which we are grappling in the water field are forever. While there are momentary crises everywhere on the earth for people who have no water, what is needed is a long, long term view, that is, the sustainable view. And I think it's vital that we try to figure out what sort of language is appropriate at the public level to convey the message we want to convey.

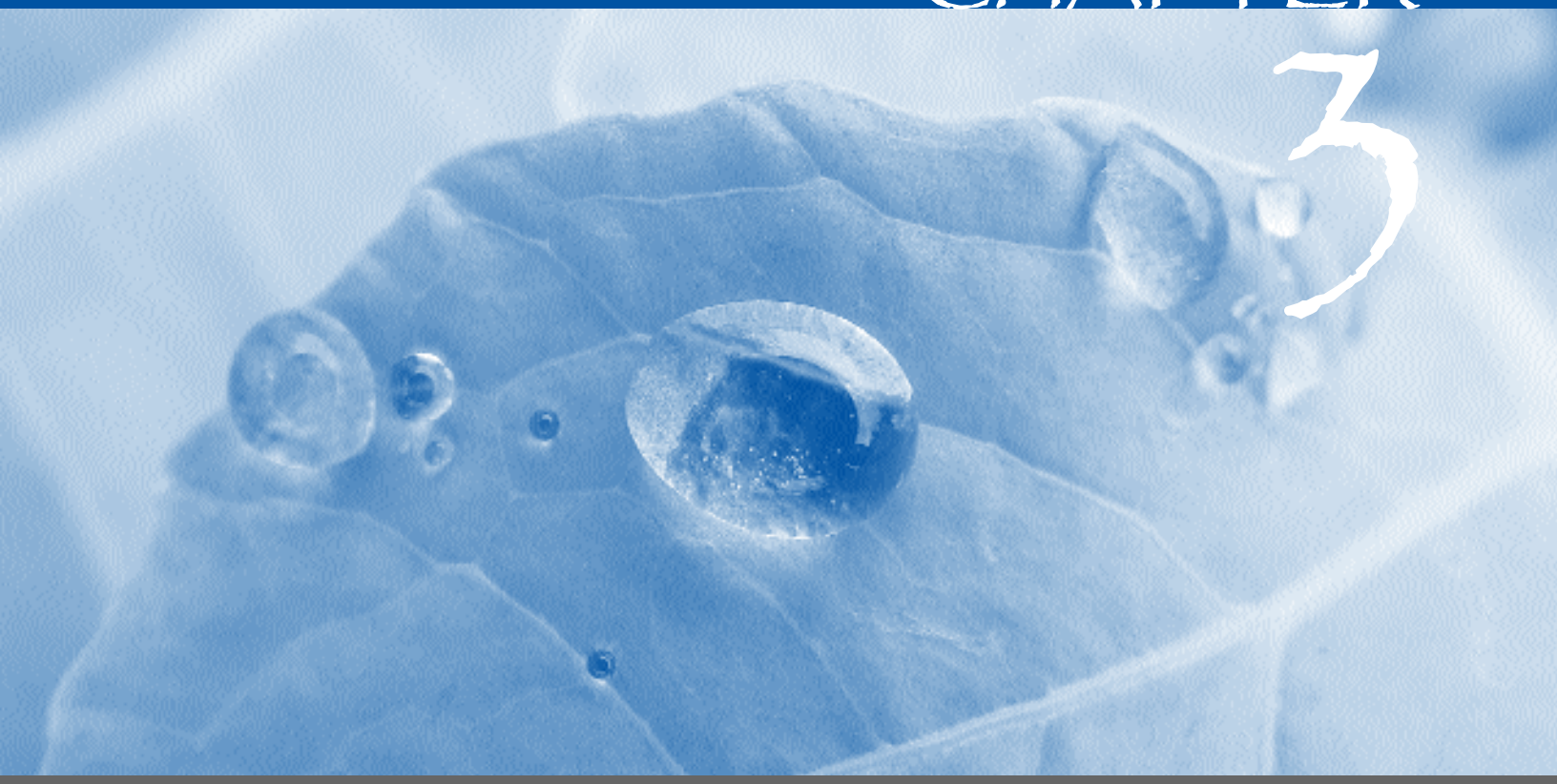
The other level of rhetoric has to do with the way in which one communicates information from the scientific community, not to, but with, the decision-making community. This is a vital area, though not one that some of my colleagues at the university — at least 20 to 25 years ago — thought that we needed to worry about. We came to worry about it because we came to realize

that if nobody could speak to the Congress we had no money. Now, that's not the best incentive for this higher democratic instinct, but I would like to close by emphasizing the importance of communication, particularly of what we know, what we don't know, how it should influence policy, and how we convey uncertainty, but not in such a way that we get stalled in the water. It seems to me that this organization, the National Council for Science and the Environment, represents the kind of idea which is essential and vital to the hopes of providing adequate water for those who need it, when they need it, around the planet. My thanks to the Council.

M. Gordon "Reds" Wolman is B. Howell Griswold Jr. Professor of Geography and International Affairs at The Johns Hopkins University. Dr. Wolman's groundbreaking contributions to the study of watershed and river processes have helped structure international discussions on landscape evolution and sustainable development. He was among the first scientists to seriously consider how human activity combines with natural processes to affect the environment, and his work has been extremely valuable for informing policymakers. Dr. Wolman has also advanced water science through his remarkable teaching, which has inspired generations of students who have become leaders in the field.

Dr. Wolman was inducted into the National Academy of Sciences in 1988 and the National Academy of Engineering in 2002. He has served as President of the Geological Society of America, Chairman of Resources for the Future, and Chairman of the Commission on Geosciences, Environment, and Resources of the National Academies. Dr. Wolman has been recognized with numerous awards, including the 1989 John Wesley Powell Award from the U.S. Geological Survey, the 1993 Distinguished Career Award from the Association of American Geographers, the1997 Ian Campbell Medal from the American Geological Institute, and the 2000 Robert E. Horton Medal from the American Geophysical Union. His book Fluvial Processes in Geomorphology, *which he co-authored with Luna Leopold and John P. Miller, remains a classic text in the field. Originally released in 1965, it was republished in 1995 and is required reading for a new generation of scientists.*

Dr. Wolman received his bachelor's degree from The Johns Hopkins University and his Ph.D. in geology from Harvard University.



CHAPTER 3

ROUNDTABLE DISCUSSIONS

ROUNDTABLES

Sustainable Water Use:
Overcoming Barriers to Change

Managing Water in the 21st Century:
Towards a Comprehensive Water Vision

Learning from Experience:
Designing Water Policy for the Future

Plenary Roundtable

Sustainable Water Use: Overcoming Barriers to Change

PANEL DISCUSSION

The Honorable Bruce Babbitt, *Former Secretary of the Interior; Former Governor of Arizona*
Dr. Mohamed El-Ashry, *CEO and Chairman Emeritus, Global Environment Facility*
The Honorable Barbara Sheen Todd, *Commissioner, Board of Commissioners, Pinellas County, Florida; Past President, National Association of Counties*

MODERATED BY

Amb. Richard Benedick, *President, National Council for Science and the Environment*

Bruce Babbitt, Mohamed El-Ashry and Barbara Sheen Todd discussed how science can help us surmount barriers to sustainable water use at the national, international and local levels.

Bruce Babbitt pointed out that there is no absolute water shortage in most areas of the United States, only inefficient use. Once scientists define the rational, sustainable boundaries of a regional water supply, stakeholders will have to negotiate ways to divide that finite quantity among themselves. This will create demand for water-saving technologies and pricing systems.

Babbitt used his experience in Arizona to illustrate his point. During the 1970s, excessive groundwater pumping led to a precipitous decline in the state's groundwater reserves. There was no sign that pumping would stop until there was no more water left to pump. Though local groundwater sources were being drawn down quite significantly, the Central Arizona Project buffered human users from the effects of groundwater depletion by bringing water from the Colorado River into the state's central population centers. Then, in 1982, the federal government cut funding for the Central Arizona Project. People had to face the reality of their limited water supply and figure out how to meet their needs within its bounds. And they did. The crisis caused by drawing a baseline led to the development of the highly regarded Arizona Groundwater Law.

Mohamed El-Ashry said that scientists can help promote water sustainability in developing countries by quantifying the value of ecosystem services for decision-makers. In places where severe poverty is a primary concern, environmental protection must fit into poverty alleviation strategies. Demonstrating the economic benefits of preserving natural resources can facilitate this.

El-Ashry called the world-wide water crisis one of a set of linked environmental crises, which include land degradation, soil erosion, ecosystem damage, and problems in coastal zones. Among these, water sustainability is especially challenging, because over 60 percent of water bodies are shared by two or more nations. He warned that the Millennium Development Goals for water cannot be achieved without major investments — not only up front, in terms of building dams and other infrastructure, but also in developing new technologies. According to El-Ashry, barriers to sustainable water management include weak institutions, weak laws, and, most importantly, pricing.

Barbara Sheen Todd said that cooperation and coordination, on many levels, will be needed to achieve water sustainability. Scientists, policymakers, businesspeople, and citizens have interconnected goals, she said, and they must work together to achieve them. Different jurisdictions need to cooperate too, since water management decisions made in one area often affect the water

resources of other regions. Todd endorsed use management as a promising strategy for achieving water sustainability. Use management involves promoting efficiency, using reclaimed water, and conducting public education efforts. A Florida campaign to teach people why water conservation is important and how they can personally contribute led to a drop in average daily water use from 153 gallons to 96 gallons per person.

Plenary Roundtable

Managing Water in the 21st Century: Towards a Comprehensive Water Vision

PANEL DISCUSSION

Gen. Gerald Galloway, *Vice President, Titan Corp.; Chair, National Water Policy Dialogue; Past President, Universities Council on Water Resources*
Peter Gleick, *President, Pacific Institute for Studies in Development, Environment and Security*
William Graf, *University Professor, University of South Carolina; Past President, Association of American Geographers*
Robert Hirsch, *Associate Director for Water, U.S. Geological Survey; Co-Chair, National Science and Technology Council Subcommittee on Water Availability and Quality*
Harry Ott, *Director for Environment and Water, The Coca-Cola Company; Co-Chair, Water Sustainability Working Group, Global Environmental Management Initiative*
Jane Valentine, *Associate Professor, UCLA; Past President, American Water Resources Association*

MODERATED BY

Jerry Delli Priscoli, *Senior Policy Analyst, Army Corps of Engineers*

To establish context for the discussion of water management in the 21st century, Peter Gleick provided an overview of the world's water situation and Robert Hirsch summarized the water situation of the United States.

Gleick noted that 1 billion people worldwide are without access to safe and reliable drinking water and 2.4 billion are without access to sanitation services. Between 2 million and 5 million people die each year from preventable water-related diseases. The environment is suffering in places where human water use overwhelms the natural system. Factors such as climate change and human population growth will exacerbate the water crisis. Ultimately, meeting basic human and ecological needs for water, improving water quality, eliminating overdraft of groundwater, and reducing the risks of political conflict over shared water require fundamental changes in water management and use. Gleick suggests that we pursue a "soft path" to water sustainability by rethinking how we use water and ultimately improving efficiency and conservation.

Hirsch said that in the wetter eastern half of the United States, any water supply problems are easily solved.

But in the dry western half, water use has drained groundwater supplies and severely strained surface waters. Major conflicts over irrigation, urban use, hydropower, and the natural environment have ensued. He stressed that ecosystem needs for water must be addressed and are one of our biggest challenges. Hirsch emphasized that while national assessments of water availability and use are crucial, there have been no organized efforts to do such assessments since the demise of the congressionally mandated Water Resources Council more than 20 years ago.

Jane Valentine called on scientists to improve water purification technologies, noting that many of the technologies used today date back to the early 1900s. The practice of adding chemicals to remove impurities from water is especially overdue for change. She said we should develop methods of purifying water without introducing additives that must eventually be removed themselves. Valentine suggested that we pay careful attention to where research and teaching funds are going, to make sure that we are building the capacity we will need to deal with water issues that will arise in the future.

Gerald Galloway outlined weaknesses in the current U.S. infrastructure and policies to deal with flooding. According to Galloway, the United States experiences more flood damage now than at the beginning of the century, and climate change could make flooding a greater problem in the future. He encouraged policymakers to plan for today with the challenges of tomorrow in mind. In particular, our crumbling water infrastructure will have to be improved, having recently received a "D" grade from the American Society of Civil Engineers. In terms of policy Galloway recommended that we revisit the decision to use 100 year flood plains. He said this became standard in the U.S. only because it was politically feasible in the 1970s — not because it is the optimal policy. We have new ideas and technologies, said Galloway; social scientists need to help us facilitate their implementation.

William Graf said that we need to make better use of the science we have available. He acknowledged that the influence of climate change deserves attention, but he pointed out that putting water into the ground in infrastructure has already had five times the predicted effect of climate change. Sustainable water management will involve reversing some infrastructure decisions, he said. For example, about half of the 75,000 dams in the U.S. are obsolete. Graf predicted that the 21st century will be the century of biology, with endangered species becoming increasingly important drivers of science and policy. He observed that the Endangered Species Act has already been a significant influence on science and policy for water and rivers.

Harry Ott recommended that we focus more attention on social aspects of water sustainability. While working with the Global Environmental Management Initiative (GEMI) to develop a water sustainability tool, Ott observed that the social side of water sustainability had not received enough attention in the past. Dealing with the social component of water sustainability, as well as the economic and environmental components, will require collaboration between industry, NGOs, and government, he said. The water we share needs to be balanced between users, and balance can only be achieved by working together.

Plenary Roundtable

Learning from Experience: Designing Water Policy for the Future

PANEL DISCUSSION

Thomas F. Caver, *Deputy Director of Civil Works, U.S. Army Corps of Engineers*
Robert Glennon, *Morris K. Udall Professor of Law and Public Policy, University of Arizona*
Benjamin Grumbles, *Acting Assistant Administrator for Water, U.S. EPA*
Karin Krchnak, *Senior Associate, World Resources Institute; Co-Chair, UN Commission on Sustainable Development Water Caucus*
Jeremy Pelczer, *President, American Water; Deputy CEO, RWE Thames Water*

MODERATED BY

Thomas E. Lovejoy, *President, The H. John Heinz III Center for Science, Economics and the Environment*

Jeremy Pelczer said that meeting the Millennium Development Goal on water (to halve the worldwide proportion of people without access to adequate water by 2015) would require 300,000 new connections to be completed every day. Ambitious as it is, Pelczer said that all leaders in the water field must take responsibility for meeting this goal. The private sector could contribute through a low-return business model in which private companies would provide know-how rather than capital. Since they would assume little risk, it would be feasible for the companies to accept low returns (about 7 percent). Pelczer emphasized private-public collaboration must rest on a foundation of trust. He recommended that, to build trust in their communities, companies should increase transparency and openly acknowledge past environmental weaknesses.

Benjamin Grumbles said that we need to gather stakeholders together to incorporate their shared interests into water management, even when stakeholders disagree. Solving future water challenges will require more attention to source water protection and conservation, and Grumbles noted that EPA is already encouraging these approaches. Seventy-four percent of water systems have completed source water assessments in accordance with the 1996 Amendments to the Safe Drinking Water Act, and a new EPA product labeling program will help consumers identify water-efficient products and appliances. According to Grumbles, scientific water monitoring will be crucial if regulatory tools such as the Clean Water Act are to improve water quality.

Karin Krchnak pointed out that fair, participatory governance is a prerequisite for sustainable water management. "Science and technology tell us what's effective; economics tells us what's efficient; governance tells us what's fair," she said. Policymakers often fear that citizen involvement will complicate the decision processes, said Krchnak, but the benefits of this approach outweigh any potential difficulties. Involving citizens leads to more equitable and sustainable decisions that are less likely to generate conflict; moreover, surveys have shown that people are interested in becoming more informed and involved in decisions that affect their water. Despite this, environmental decisionmaking is actually becoming less transparent in the U.S. by some measures. In the immediate future, Krchnak recommended facilitating civil society input into the integrated water resource management plans agreed to in the Johannesburg Plan of Implementation.

Robert Glennon explained that we need to modify the U.S. laws that govern groundwater use, to bring them into accord with our knowledge of hydrology. Currently U.S. laws allow anyone to drill a well and pump as much groundwater as they want. Like a milkshake with an unlimited number of straws, groundwater reserves fall quickly with the unregulated insertion of new wells, leading to increased pumping cost, salt water intrusion, and subsidence. Additionally, depleting a region's groundwater harms the region's rivers and lakes since they are all connected through the hydrologic cycle. Glennon suggested establishing a system of water rights to stop groundwater overuse. Such a system would limit total groundwater withdrawals, requiring new users to buy an existing user's water rights before beginning to pump.

Thomas F. Caver said that we must learn how to deal with Congress more effectively if we are to implement a sustainable system for water management. According to Caver, Congress works with unique constraints and we need to consider that as we develop water policies. Caver recommended increasing emphasis on planning and incentives relative to regulation and punishment. He said that integrated water resource management planning would be valuable for coordinating water management across the many agencies involved.

CHAPTER 4

SYMPOSIA

Sustainable Water Management and Institutions

Water Quality and Sanitation

Water Technologies

Estuaries and Coastal Resources

Symposium

Sustainable Water Management and Institutions

How can we make watershed management work? How can we better align water policy with water science?

PANELISTS

Peter Gleick, *President, Pacific Institute for Studies in Development, Environment and Security*
William Graf, *Professor, University of South Carolina; Past President, Association of American Geographers*
Brian Richter, *Director, Freshwater Initiative, The Nature Conservancy*
Ethan T. Smith, *Coordinator, Sustainable Water Resources Roundtable*

The institutional habits of science and the institutional structures of water management must be changed if we are to manage water resources sustainably, according to panelists at this symposium. As the session progressed, it became apparent that the definition of sustainable water management is a primary issue to be resolved. "We need to talk about a goal... What are we shooting for?" asked Brian Richter.

Ethan Smith emphasized the need for indicators to guide us toward water sustainability, but he acknowledged that identifying a set of appropriate indicators will be a formidable challenge. "What is needed for a national picture, to legislate public law, might be different than what the mayor of a town needs when he worries about water supplies for his community," explained Smith. Once a useful set of indicators is identified, fitting them together into a rational framework will require serious deliberation.

William Graf noted that the scientific establishment is not optimized for generating science that can easily be applied to policy decisions, saying, "Most of us who were trained in the mid-to late part of the century, we were trained to do good science. We weren't trained to do useful science. Most scientists are very well trained to talk to each other. They are not trained to talk to the normal person or communicate their results to policymakers. Although scientists may have good and useful answers, they are trapped in the scientific community." A number of obstacles make it difficult to translate water science to effective water decisionmaking. According to Graf, "Most scientists don't have a connection to management. Our theories don't focus on how to make good decisions using what we know." Furthermore, scientists are trained to investigate the natural world free from human interference — to reach understandings of natural systems divorced from human interaction. Conveying scientific uncertainty to policymakers is usually problematic, said Graf, though scientists could improve this process by providing qualitative assessments of uncertainty.

Brian Richter found a way to effectively deal with uncertainty while working on water management in South Africa. "We engaged the water managers and decision-makers at key points in the scientific deliberations, with workshops...Then the managers got to see first hand the uncertainties scientists were grappling with. They understood it and became contributors to the additional work to reduce uncertainty." Engaging decision-makers in the scientific process helps obviate the communication difficulties that so often stand between good science and good decisions. The reverse is fruitful as well. Richter encouraged scientists to participate more actively in the water management process — not just preparing recommendations, but making sure they are implemented properly.

Peter Gleick explained that we need to rethink traditional assumptions that structure water management

institutions. In the past, finding enough water for human uses has been about finding more water to use. According to Gleick, we should really be finding ways to use less water. This requires an institutional shift, from focusing on increasing water supply to reducing water demand through efficiency. He calls this the "soft-path" to water sustainability. "I don't want to leave you with the impression that it'll be easy," cautioned Gleick. "It's relatively easy for the World Bank to spend one million dollars on a water supply project. It is really different to use a million dollars in a thousand village-level projects. It is a different institutional problem."

Symposium

Water Quality and Sanitation

Have we turned the corner on water pollution? How safe is our water? How should priorities be set, and who should set them?

PANELISTS

Marcia Brewster, *Task Manager, United Nations Interagency Gender & Water Task Force*
G. Tracy Mehan, *Environmental Stewardship Counselor for the G8 Summit; Former EPA Assistant Administrator for Water*
Erik Olson, *Senior Attorney, Natural Resources Defense Council*
Harry Ott, *Director of Global Environmental Assurance, The Coca-Cola Company; Co-Chair, Water Sustainability Working Group, Global Environmental Management Initiative*
Robbi Savage, *Executive Director, Association of State and Interstate Water Pollution Control Administrators*

While water quality and sanitation services have gotten better in the U.S. and around the world, significant work remains to be done. In 2000, 1.1 billion people lacked access to fresh water, and nearly 40 percent of the world's population lacked basic sanitation services, began Marcia Brewster. She explained that the Millennium Development Goals adopted at the 2002 World Summit on Sustainable Development commit to halving these proportions by the year 2015, which would cost about $20 billion per year. Although serious inadequacies remain, there has been progress. For example, deaths from gastrointestinal diseases, mostly arising from inadequate sanitation, have dropped from 4.8 million in 1982 to 2.2 million in 2002.

Besides the clear health implications, Brewster pointed out that developing better sanitation systems is also a gender issue; the benefits of sanitation service are especially important for girls. Oftentimes girls can only attend school if latrines are available there, and having latrines close to home means that girls are not forced to venture outside in the dark, where they may be vulnerable to violence.

Tracy Mehan focused on water quality in the United States. He described our current situation as something of a plateau. After a period of tremendous water quality improvement that immediately followed the Clean Water Act, advances have become more incremental. The Clean Water Act has difficulty addressing many of the pollution problems that remain, especially when water contaminants come from other media. For example, some lakes in Michigan are contaminated by mercury from air pollution, but since it arrived by air, the Clean Water Act cannot be used to regulate it. The fact that authority to enforce pollution standards in a single watershed is often

divided among different groups can also slow water quality improvements.

Paying for the infrastructure needed just to maintain current water quality standards will also be a challenge, said Mehan. He cited a recent EPA gap analysis, which predicted that if there is no new investment in water infrastructure over the next 20 years, the gap between what we have and what we need to provide clean water will grow to $122 billion. Who should pay for water — rate payers or tax payers — is still a policy discussion, according to Mehan. He noted that currently, Americans spend an average of $474 each year on water and sanitation services and $707 each year on soft drinks. Mehan suggested that changes in water pricing, coupled with subsidies for low income people, may be a promising solution.

Erik Olson said that although we have made significant progress on water quality in the United States, eliminating widespread cholera, typhoid, and much microbial contamination, we have more work to do. Arsenic, heavy metals, and radioactive materials are still found in some municipal water supplies, and contamination from chemical runoff remains a problem. Olson called for a third water revolution, which would consist of meaningful investment in watershed protection. (The first and second water revolutions came with piped water and modern water treatment systems, respectively). The reason we are hesitating before this third revolution is not inadequate science, in Olson's view. Rather, it is inadequate political will. To generate the political atmosphere needed to bring about change, the public must be informed and involved, said Olson, because people who are constantly reassured that their water is fine will be unlikely to support the $1 trillion needed to make it safer.

Roberta Savage spoke about the importance of engaging the public in efforts to improve water quality. She described the success of World Water Monitoring Day, which is a culmination of a month-long program in which people monitor their local watersheds and then enter the data into a large database. Individual behavior changes will be an important part of reversing unsustainable water use, so individual participation is crucial.

Harry Ott spoke about the Coca-Cola Company's concern for water quality and the company's efforts to improve it. As a main ingredient in their products, and with bottled water the company's fastest growing product, water is an important part of Coca-Cola's business. To work toward more sustainable water use, Coca-Cola has adopted the water sustainability strategy developed by the Global Environmental Management Initiative (GEMI) — a 45-member business sustainability group of which Coca-Cola is a member. Ott acknowledged that his company has faced some challenges in its progress toward water sustainability, including difficulties convincing their independent bottlers and joint venture franchises to adopt water conservation practices. But Coca-Cola has succeeded in reducing the amount of water needed to make their products. While it once took 22-30 liters of water to make a liter of product, it now takes just 3 liters of water per liter of product.

Symposium

Water Technologies

How can technology help meet U.S. and international water supply and sanitation needs? How can we bring new water technologies to the marketplace?

PANELISTS

Shannon Cunniff, *Director of Research and Development, U.S. Bureau of Reclamation*
A. Judson Hill, *Aqua International Partners*
Allan Hoffman, *Winrock International*
E. Timothy Oppelt, *Director, U.S. EPA Homeland Security Research Center*
David Zoldoske, *Director, California State University-Fresno Center for Irrigation Technology*

Panelists discussed the role of technology in achieving water sustainability and ways to encourage the adoption of useful technological solutions.

To make human water use more sustainable, we can change demand patterns, increase efficiency, and find new sources or reuse water, said Shannon Cunniff. Her talk focused on technology to develop new sources of freshwater by desalination, and particularly on desalination research being conducted by the U.S. Bureau of Reclamation. To make desalination a feasible source of freshwater will require more investment in research and development investment, she explained. To facilitate its implementation we will have to decrease the financial, environmental, technological, and political risks. Cunniff suggested that a consistent national policy, possibly in the form of EPA guidelines, would be useful in accomplishing this goal.

Water and energy are inextricably linked, pointed out Allan Hoffman, because to use water we must use energy to lift it from the ground, pump it, possibly desalinate it, and manage our wastewater. There is no substitute for water, and while there is no absolute shortage of water or energy, there is a shortage of cheap water and energy. Finding energy efficient ways to desalinate brackish water can benefit communities with scarce potable water resources, such as a village in Qatar, Jordan that Hoffman described. Though it lacked fresh water and access to the power grid, the village sat upon a source of brackish water 50 m below ground and had potential to capture solar energy. A solar powered desalination system was successfully installed. The concentrated brine left over from desalination was trucked to the already salt-rich Dead Sea, but disposing of this type of waste can pose difficulties in other places, Hoffman noted.

Timothy Oppelt spoke about the use of water technologies for homeland security. He described the EPA Homeland Security Research Program, which focuses on detecting and mitigating biological, chemical and radiological threats to the water supply. Developing new technologies and verifying their effectiveness are both important parts of the program. Detection, prevention, containment, decontamination, residue disposal and risk assessment are also components of the homeland security research program.

Adam Skolnik of Senninger Irrigation discussed how we can use technology to improve irrigation efficiency in the agricultural sector, which uses 60 to 75 percent of freshwater in the United States. Currently, irrigation systems must deliver far more water than plants actually need, because much of the water is wasted. This unnecessarily diverts water from other uses, and the excess water that diffuses back into the ground may or may not be contaminated. Skolnik said that existing technologies could make irrigation more efficient but are

still very expensive. As more farmers adopt them, their prices will decrease, making the efficient technologies more accessible.

There are already initiatives to advance irrigation technologies, said David Zoldoske. For example, the International Center for Water Technology, with 375 members representing 50 to 60 companies, gathers business competitors to collaborate on addressing common needs. To promote new technologies, the center helps small companies coordinate R&D, collaborate with other agencies, and export their products for use abroad. Certifying that technologies perform what they claim is another important function of the center, as is educating the public and policymakers.

Jud Hill spoke about how venture capitalists can help bring water technologies to the market by investing in desalination, disinfection, and other water-related projects. Hill pointed out that we consume only 2 percent of the water we use, leaving tremendous room for efficiency improvements.

Symposium

Estuaries and Coastal Resources

How can we manage estuaries and coastal resources more comprehensively?

PANELISTS

Darrell Brown, *Chief, U.S. EPA Coastal Management Branch*
Mark Castro, *University of Maryland Center for Environmental Science*
Barry Costa-Pierce, *University of Rhode Island; Director, Rhode Island Sea Grant College Program*
Chris Dionigi, *Assistant Director, Interagency Invasive Species Council*
Mark Van Putten, *ConservationStrategies; Past President, National Wildlife Federation*

Panelists discussed the status of efforts to protect estuaries and coastal resources in the United States, reviewing current management programs and suggesting improvements.

Darrell Brown described the National Estuary Program, which was established in a 1987 Amendment to the Clean Water Act to identify, protect, and restore nationally significant estuaries in the United States. Working with farmers and homeowners in 28 sites, this initiative has saved approximately 118,000 acres of habitat by curbing polluted runoff, upgrading sewage treatment plants, and improving septic systems. Brown drew several lessons from the program's success, including the importance of sustained, dependable funding, measurable goals with indicators, and community involvement.

Mark Castro offered a case study on linking science and decisionmaking in efforts to reduce nitrogen enrichment of estuarine and coastal areas. Increased nitrogen concentrations lead to habitat loss, lower dissolved oxygen content, algal blooms, fish kills, adverse human health effects, and lost tourist revenue. In a study of 34 watersheds, 10 were found to have human nitrogen input. The predominant source varied by region, with most nitrogen in the northeast coming from imported foods and most in the mid-Atlantic coming from agricultural fertilizer. Long Island was unique in that 70 percent of nitrogen input came from sewers.

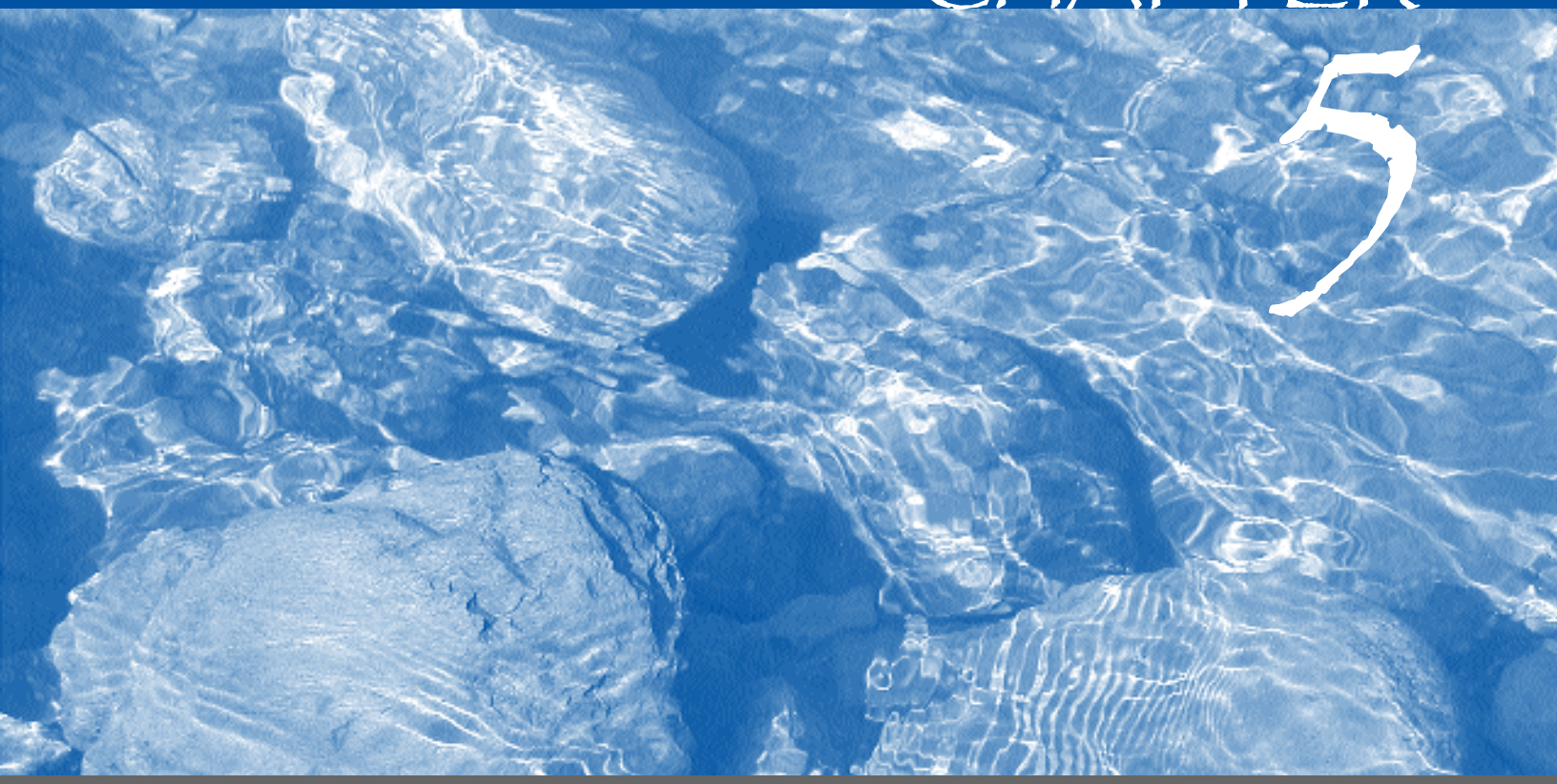
To manage coastal and marine resources more effectively, Barry Costa-Pierce said we need to gather targeted scientific information to answer specific questions — such as sources of pollution and ecosystem impacts of particular human activities like recreational boating. Finding out how the ecosystem functions of estuaries resume as ecosystem structures are restored is also important. When it comes to community-based restora-

tion programs, Costa-Pierce advises us to take lessons from developing countries, where these programs have been most effective.

Invasive species pose a serious threat to all types of ecosystems, including coastal ecosystems, explained Chris Dionigi. Invasive species are plants, animals, or micro-organisms that are not native to an ecosystem and can or are likely to cause ecological or economic harm to the ecosystem once they are introduced. The proliferation of zebra mussels, which have spread throughout the Mississippi watershed since 1988, shows how damaging an introduced species can be. Zebra mussels have cost water users $300 million per year in the Great Lakes region alone. The Eurasian watermilfoil is another costly invasive species. It has reduced property value an average of $12,000 per lot in Vermont lakeside communities where it has been introduced. The total cost of invasive species in the United States has been estimated at $100 billion per year, and the damage they cause is often permanent. Since estuaries frequently span multiple jurisdictions and are valued for their environmental, economic, and social resources, they have a diverse group of stakeholders. Dionigi suggested that coordinating estuary stakeholders around invasive species projects could help promote broader efforts to protect and restore estuaries.

Managing watersheds requires creating constituencies within them, said Mark Van Putten, and this can be done by promoting citizen science. Teaching citizens about ecosystems and involving them in monitoring programs builds community support for protection efforts while expanding monitoring capacity. It can be difficult to gather initial funding to spur community involvement, but local media with a genuine commitment to the community can be a helpful resource.

CHAPTER 5



TARGETED RECOMMENDATIONS

Attendees at the 4th National Conference on Science, Policy and the Environment, *Water for a Sustainable and Secure Future,* engaged in one of 16 simultaneous breakout sessions, each addressing a different aspect of water sustainability. Conferees generated a set of science-based recommendations for each topic. The recommendations are grouped under four themes that correspond to the symposia in Chapter 4.

SESSIONS ON SUSTAINABLE WATER MANAGEMENT AND INSTITUTIONS

Allocating water for people and ecosystems

When making policies to manage water, the needs of humans and ecosystems can come into conflict. Decisionmakers must seek to balance human demands with the water needs of rivers and ecosystems.

Targeted Recommendations

- Encourage federal agencies to jointly organize a pilot effort in a specific location to examine hydrology, ecology, water management, and water use. It would serve as a virtual "sustainability laboratory" to test scientific understanding of the consequences of various water management scenarios.

- Create conventions for data on water and ecological conditions and establish a national database to facilitate broad sharing of existing data on watersheds, including long-term trends. The database should be designed to facilitate understanding of how flow conditions influence ecological conditions. In addition, there should be an organized effort to collect watershed data to fill recognized data gaps, particularly in the area of biology.

- Encourage federal agencies to restore funding for "extension" activities, with a focus on improving the public understanding of the consequences of water management on ecosystem conditions and services. These activities should include innovative use of technology to convey complicated concepts (e.g., graphics, dynamic visualizations, interactive simulation).

- Recognizing that there is no single "bright line," have scientists develop a range of ecological conditions and services associated with various levels of human use of the resource.

- Convene a group of scientists to survey existing indices and identify successes and remaining research gaps in the use of indices.

- Encourage federal agencies to conduct research on (1) how people use water and (2) how social science can be used to better inform public choices about water use.

SESSIONS ON SUSTAINABLE WATER MANAGEMENT AND INSTITUTIONS

Integrating surface and ground water management

Though surface and ground water issues are interconnected in nature, these water resources are often managed separately. This has led to practices of unsustainable ground water withdrawals in some areas and water management policies that fail to consider water holistically.

Targeted Recommendations

- Improve the scientific understanding of surface and ground water linkages, use, and management.
  - Promote scientific efforts to better define and quantify surface and ground water resources.
  - Support efforts to better define and quantify surface and ground water consumption (not just diversion).
  - Strengthen monitoring of water availability and use.

- Improve education about surface and ground water linkages, use, and management through both formal education systems (kindergarten through higher education) and public education.
  - Strengthen understanding of the linkages between surface and ground water.
  - Strengthen understanding of options for, and the necessity of, sustainable water use.

- Strengthen understanding of the hydrologic cycle.
- Develop and promote water curricula in kindergarten through higher education.
- Develop and promote innovative teaching materials, including 3-D visuals, to spur the conceptualization of watersheds and aquifers.

- Promote reform of the governance of surface and ground water to reflect actual hydrologic linkages and address environmental impacts.
  - Develop and implement national ground water monitoring standards.
  - Create science-based model legal frameworks, regulations, and rules as recommendations for states and municipalities.
  - Improve and promote the use of decisionmaking toolkits for management of surface and ground water.
  - Capture and disseminate "best practice" examples of integrated surface and ground water management.
  - Regulate water consumption, not just diversion.

- Strengthen the communication between decisionmakers, scientists, and engineers regarding the interactions between surface and ground water and between water quality and quantity.

SESSIONS ON SUSTAINABLE WATER MANAGEMENT AND INSTITUTIONS

Water sustainability indicators

As we pursue sustainable water management, we must be able to measure our progress toward this goal. Indicators of water sustainability can help us assess and improve our management of water resources, but they must be carefully selected.

Targeted Recommendations

- Develop a linked set of indicators at multiple spatial and temporal scales that encompass the ecological, economic, and social conditions and processes that are relevant to sustainable management of water resources. The set of indicators and the measurements from which they are produced should reflect scientific knowledge of the conditions, trends, processes, and phenomena relevant to the sustainability of water resources, as they are linked to public policy issues. Reporting of indicators should include measures of their precision or uncertainty.

- Involve scientists, resource managers from governments and the private sector, and interested members of the public in the selection of indicators and the development of institutional capacities to produce and use them to describe water issues. The Sustainable Water Resources Roundtable is an example of the type of collaborative process that is intended. One objective of these processes should be to increase the consistency and compatibility of the indicators and measures produced and used by different types of institutions.

- Ensure that the set of indicators is appropriate for use by people in a variety of institutions including local communities, watershed groups, corporations, and state and federal governments. Basin and watershed groups should be organized to utilize the indicators. More consistency in measurement programs should be developed among industry, academic, NGO, and government data initiatives. Pilot tests of new indicator systems should be carried out to determine better ways of describing water issues; pilot studies should include, for example, cost/benefit evaluation and comparison between output and outcome indicators. Universities should conduct research into the nature of water resources sustainability and publish papers in the professional literature to aid in the improved definition of the necessary statistics and data collection programs.

- Ensure that the set of indicators addresses peoples' values and concerns. Methods and processes for using indicators should provide ways for peoples' values to be represented or expressed. Cultural values should be used as a way to determine priorities to help promote a balance between human and ecosystem needs.

SESSIONS ON SUSTAINABLE WATER MANAGEMENT AND INSTITUTIONS

Managing demand for water

To achieve water sustainability, we need to bring our water use in line with water availability. One way is to reduce demand for water, through such methods as conservation and recycling.

Targeted Recommendations

- Conduct additional research to improve understanding of the risks, costs, and benefits of water reuse and recycling technologies and to identify governmental (local, regional, etc.) mechanisms that facilitate the adoption of reuse/recycling technologies. Emphasis should be placed on disseminating existing and future research findings to relevant entities and organizations.

- Quantify the full costs of providing water for various user classes. Specific emphasis should be placed on identifying who is deriving the benefits and who is paying the costs. From a permit or allocation standpoint, a focus should be placed on investigating methodologies for determining optimal use of potential water users.

- Encourage local governments to evaluate building codes and work with the scientific community to incorporate efficiency and water conservation measures into building codes and other policies.

- Investigate means to establish baseline ecosystem requirements as part of total water use characterization of particular communities/regions. Particular emphasis should be placed on using a watershed as the fundamental planning unit.

- Conduct research to identify impediments to adopting progressive rate structures (i.e., conservation-oriented) and publicize successful applications of such. Emphasis should be placed on wide dissemination of these successful examples. In addition, conduct research to determine the effectiveness of incentives such as pricing to change water use behavior.

- Encourage local entities, nongovernmental organizations, public interest groups, and governmental organizations to educate communities about where their water comes from, how much they use, the resource limits, ways to conserve, and the intrinsic value of water. This education should occur community-wide and with cultural sensitivity. Special emphasis should be placed on educating elementary school children on these fundamental issues.

- Compile existing information on efficiency of water-saving technology. Additional analysis is needed to continually develop more efficient technologies for saving water in all water use classes, including "unaccounted-for" water. Articulate the full range of costs of new technologies.

- Develop strategies for transferring efficient technological information to where it is needed or desired.

- Conduct research to identify good examples of existing and/or potential institutional mechanisms that allocate water efficiently and equitably, including the concept of intergenerational equity.

SESSIONS ON SUSTAINABLE WATER MANAGEMENT AND INSTITUTIONS

Economics of sustainable water use

Water has an ambiguous status — priced and traded as a commodity in some cases and considered a universal right in others. This session explored how water fits into the economy and how water can be managed as both a social and economic good.

Targeted Recommendations

- Provide support for research that yields:
  - Better methods to value ecosystem services.
  - Ways to capture and equitably distribute costs of environmental degradation.
  - Improved understanding of the life cycle cost of decisions and metrics (rigorous and transparent) to measure this.
  - More accurate measurement of the impacts of subsidies (e.g., Arizona Project)
  - Opportunities to create enforceable and transferable rights to water.
  - Understanding of the importance of water availability to national economic development and international competitiveness.
  - Economic methodologies to determine the total costs and benefits of water use except for drinking and sanitation services.
  - Pricing schemes that best establish market incentives for environmental sustainability and equitable and efficient water use, noting the importance of considering population growth and location choice.

- Introduce green accounting into national income accounts.

SESSIONS ON WATER QUALITY AND SANITATION

Water, sanitation, and human health

Most Americans have ready access to an adequate supply of water. But problems remain. Infrastructure for water delivery is aging, allowing toxins to leech into the water supply. Water purification systems do not remove all contaminants. Outbreaks of water-borne disease still occur. This session examined how water quality affects human health in the United States, identified the health issues most in need of attention, and developed strategies for addressing these issues.

Targeted Recommendations

- Apply multibarrier protection in a watershed and groundwater basin approach that will integrate environmental and public health issues. The multibarrier approach should be multidisciplinary and include strong source water protection, advanced water treatment, and modernized water distribution systems. This approach should include adequate seed capital, investment in information resources, and emphasis on technology and infrastructure. Strategies must be economically sustainable, and efforts must be supported by political will.

- Ensure that the following are top priorities:
  - A vigorous program of monitoring, surveillance, research, and assessment, including the following:
    - An independent organization, such as the National Academies, should identify research needed to create a robust monitoring program.
    - Research on appropriate technologies should be conducted, including distributed wastewater treatment facilities and improved methods for measuring population health and vulnerability.
    - The prevalence of water related diseases should be scientifically evaluated and estimat-

ed. This evaluation should include microbial diseases and chronic diseases caused by non-microbial contaminants.
    - Monitoring of pollution sources, water quality, and water distribution sources should be increased.
- Research to investigate the most effective methods for deploying U.S. financial resources to significantly improve drinking water quality around the world. This research should aim to identify methods for funding financially sustainable, low cost water treatment systems.
- Education efforts targeted to all levels of society, including local communities and key local constituencies, including women. People should be educated on the benefits of source water protection and natural water purification.
- Programs for developing low cost hygiene technologies.
- Research and development efforts to develop technologies and practices to reduce pollutants and improve source water protection.

SESSIONS ON WATER QUALITY AND SANITATION

Water infrastructure needs for the 21st century

The water treatment systems, dams, and water transportation infrastructure of the United States are deteriorating. Participants in this session discussed the most pressing water infrastructure needs for the 21st century.

Targeted Recommendations

- Encourage Congress to establish a mechanism supported by dedicated revenue, such as a National Clean and Safe Water Trust Fund, to provide grants and loans for construction of core drinking water and wastewater infrastructure and related science and technology research.
- Develop principles and guidelines for federal water project development that include state-of-the-art economics, science, and decision tools as well as full consideration of environmental and social benefits.
- Encourage USDA and EPA, in cooperation with the states, to support research to identify barriers to funding programs for disadvantaged communities and pockets of poverty and recommend methods to overcome these barriers.
- Encourage USDA and EPA to fund research in methods to prevent pollution as opposed to treat pollution in order to meet environmental and health regulations.
- Encourage the federal government to support research to both identify and treat newer pollutants (e.g., drugs, endocrine disruptors) and biological agents and to identify the effects of these pollutants and agents on humans and animals.
- Encourage the federal government to support research into the identification of impacts of water and wastewater treatment processes through their life cycle, including impacts of the operation of these treatment facilities on the local environment.
- Encourage Congress and the President to appoint a National Commission to identify a sustainable source of funding for the nation's water infrastructure.

SESSIONS ON WATER QUALITY AND SANITATION

Control of non-point source pollution

Non-point source (diffuse) water pollution comes from a variety of sources — particularly agricultural and urban runoff. Participants in this session discussed the factors that contribute to non-point source pollution and strategies for minimizing its harmful effects.

Targeted Recommendations

- Develop a better understanding of ecosystem processes with respect to maximizing nutrient recycling in agriculturally dominant ecosystems while sustaining profitability.
- Evaluate the relationship between hydrologic regimes and ecosystem consequences.
- Evaluate and develop source-tracking technology in large complex watersheds.
- Improve estimates of best management practices and their effectiveness at the watershed level (including consideration of social, behavioral, and cultural factors).
- Develop research models and tools to implement a no-net-runoff policy and to make associated changes in planning and zoning requirements.
- Study effects of emerging contaminants such as antibiotics, hormones, etc., and assess their impacts.
- Develop information on the effectiveness of various riparian area management techniques in reducing pollutant impacts in various contexts.
- Research the effectiveness of various source minimization techniques.
- Evaluate the effectiveness of non-point source education programs in promoting behavior that reduces non-point source pollution.
- Analyze the cost of manure treatment using full-cost accounting methods to reflect savings in societal costs.

SESSIONS ON WATER QUALITY AND SANITATION

Community-based watershed restoration

Community-based watershed restoration projects are important for improving water quality and maintaining ecological integrity. This session examined how such efforts can be most effective and considered the roles of forests, wetlands, and riparian areas. Local watershed organizations and partnerships were also discussed.

Targeted Recommendations

- Recast environmental regulations to incorporate a science-based watershed perspective.
- Ensure that federal regulations provide a minimum national standard that can be augmented by local regulations and standards.
- Create a federal environmental restoration program to make small grants to sets of local governments within federally identified watersheds in response to general proposals from at least two local government units to implement on the ground restoration projects involving the community.
- Focus community-based restoration on strategic goals that incorporate biological, social, and economic indicators. For example, restore rivers to a swimable and fishable condition. This encompasses water quality, recreation, aesthetics, and associated economic benefits in a manner individuals can relate to.
- Recognize the importance of scientific information for communities to make sound environmental decisions. The utility of this information is best when:
  - Community members and leaders know where to get information and how to use it.
  - Data are in a standard recognizable format, ideally in a single portal, electronic data clearinghouse.

- Emphasize ecological economics and a watershed perspective. Make an effort to quantify and disseminate the value of water-based ecological assets at the community level. In addition, consider cultural, aesthetic, and recreation values of water.

- Promote place-based environmental education. It will naturally build student excitement, interest, and action in their local watersheds and communities through study and participation in local watershed restoration projects. Funding should be provided for teacher training to connect local watershed projects and education to standards. In addition, agency research should involve local teachers and local media as part of the public outreach.

SESSIONS ON WATER QUALITY AND SANITATION

Research and data needs for better decisionmaking on water quality

People who develop water policy must draw on research from a variety of disciplines, including environmental science, health science, behavioral science, and economics. Participants in this session discussed areas in which research and data are lacking as well as strategies for filling these gaps.

Targeted Recommendations

- Make better use of existing data by:
  - Building cyber-infrastructure systems to make data available across agencies, academics, and voluntary monitoring organizations.
  - Encouraging and providing consistent methodologies across states and data-collection initiatives and including geo-reference in all data collection.
  - Focusing on watersheds to unify data from disparate sources and scales.

- Expand data collection and monitoring projects by:
  - Ensuring inclusion of human driver monitoring — demographic information, land use, management practices, etc. — to identify source linkages.
  - Gathering data on all types of water resources, including wetlands, reservoirs, ground water, etc.
  - Ensuring hydrologic context concurrent with water quality data collection.

- Provide more research and science by:
  - Connecting environmental conditions to human health research.
  - Considering scale in going from small watersheds to large watersheds of policy interest.
  - Making models flexible to incorporate emerging science and targeted to key management decisions.
  - Developing remote sensing technologies for the study of water quality.

- Provide synthesis and interpretation by:
  - Providing visualization — presentation of results that have meaning for non-specialists.
  - Providing summaries for policy makers and the public.
  - Including a "molecule to watershed" scale sensibility in approaching research and policy.

SESSIONS ON WATER TECHNOLOGIES

Technologies for water monitoring and homeland security

Secure water sources are critical components of a secure homeland. Participants in this session discussed methods for protecting and monitoring our nation's water supply from a homeland security perspective.

Targeted Recommendations

- Establish a mechanism for funding long-term (greater than five years) interdisciplinary work through open competition to develop technologies for water monitoring and homeland security. Such a mechanism would provide an incentive for collaborative, innovative work and reward teamwork.

- Provide science and technology to:
  - Analyze detection in real world water (source, treated, and distributed).
  - Sample preconcentration (pathogen, chemicals and toxins).
  - Develop better detection technologies:
    - More analysis.
    - Greater specificity.
    - Greater selectivity.
    - Lower false alarm rate.
  - Support creation of a water system / SCADA system that mimics the human immune response system — that can detect problems and self-heal.
  - Develop a water system that is resistant to cyber attack, power supply issues.

- Develop continuous inexpensive monitoring of basic water quality parameters (pH, conductance) to detect change. Such monitoring is used to disprove hoaxes and to establish the end of an event.

- Back up risk modeling with data collection. Validate the models.

- Create a common database. Information has to be in the public domain (IP access).

- Provide a multi-barrier approach (source, treated, and distributed water).

- Create a market for new technologies through policy.

- Provide consumer education for water safety, treatment, and monitoring.

SESSIONS ON WATER TECHNOLOGIES

Desalination and other water purification technologies

Desalination allows communities to utilize sea and brackish water sources to supplement fresh water reserves. There are significant regulatory, technological, political, and economic risks that need to be addressed to secure adequate financing to lead to more widespread implementation of new technologies to address the nation's and the world's growing water supply challenges.

Targeted Recommendations

- The Bureau of Reclamation should address the issue of brine discharge management through research to reduce the cost, environmental impact, and regulatory burdens, especially for inland communities. EPA should conduct science-based studies on the discharge of brine to assess the environmental impacts as well as the appropriate regulatory environment for brine.

- NGOs, universities, governments and professional water organizations should create a public health education campaign for cost/value and sources and needs for the next generations.

- More coordination among federal and state agencies for implementation and support of those working on research. The Department of the Interior would be an appropriate agency to take the lead and a program could be modeled after U.S. Global Change Research Program.

- The Bureau of Reclamation and DOE should jointly look at energy and water technologies as well as consider the interrelationship of energy and water policy.

- Fund more non-membrane research.

- EPA should exhibit greater leadership and develop

national guidance on new desalination and water treatment technologies to guide state regulatory agencies. More effort should be placed on integrating energy into water treatment to address cost feasibility and implementation. Energy and water supply issues are inextricably intertwined.

- Better definition and diminution of risk would help the private sector engage in the deployment of desalination and other water treatment solutions critical to developing countries.

SESSIONS ON WATER TECHNOLOGIES

Irrigation and agriculture

Irrigation accounts for 70 percent of water use in the United States. For this reason, irrigation must be a focus of any program for water sustainability. Participants in this session discussed how agricultural practices and irrigation techniques affect water availability and water quality.

Targeted Recommendations

- Research the sociological and economic impact of the adaptability and acceptance of current technology and best management practices by the irrigation industry.
- Assess watershed impacts of irrigated agriculture on water quantity, water quality, energy use, air quality, and other resources.
- Develop improved practices and systems that optimize timing, placement, and amount of irrigation water.
- Establish interdisciplinary coalitions to connect researchers and to integrate research conducted across the many disciplines invested in and affected by water use issues.
- Develop a spatial database of water resources used for agriculture/ irrigation and their respective watersheds for assessment of current use and for predicting areas of concern.
- Develop irrigation practices and technologies that reuse waste water without compromising the public's health or the environment.
- Conduct research to develop crops and varieties with improved water use efficiency and additionally respond to lower water quality while sustaining economic yield levels.
- Support research regarding ways for irrigated agriculture to use less water without degrading the water quality.
- Create a database identifying all current state, local, and national regulations governing agricultural water use.
- Establish and consolidate a national database of information on ecological water quality and use from each watershed that includes citizen science, case studies, and comparative analysis to enlighten policy makers.
- Support research to develop optimal irrigation management systems that incorporate timing, amount, and placement along with agronomic crop science.
- Identify the role and impact of irrigation technology in extending current agricultural water supplies.
- Identify the role and impact of irrigation technology in utilizing reclaimed or marginal water supplies in agriculture.

SESSIONS ON ESTUARIES AND COASTAL RESOURCES

Addressing coastal pollution at the watershed level

Coastal pollution problems such as nutrient over-enrichment, "dead-zones," and toxic contamination are increasingly attributed to diffuse sources far inland. Therefore, effective solutions to these issues must be holistic, recognizing social, economic, and environmental considerations as well as the strong coupling of watersheds to coastal receiving waters. This session discussed strategies for bringing insights from natural and social science to bear on coastal pollution at the watershed level.

Targeted Recommendations

- Encourage policy makers to set non-point source pollution goals based on scientific linkages between cause and effect and in partnership with social scientists and economists.
- Evaluate various governance structures for effectively developing and implementing regional strategies for addressing watershed and coastal pollution problems.
- Incorporate spatial and temporal aspects of non-point source pollution into watershed assessments and monitoring programs.
- Develop a better understanding of processes responsible for the lag time between the implementation of best management practices, and the achievement of a desired outcome.
- Develop a classification system of water bodies to allow more effective vulnerability assessments, improved BMPs, and transfer of information.
- Compare, contrast, and improve models that estimate non-point source pollution from watershed to coastal water bodies.
- Develop new assessment tools to allow condition determination in resources not yet assessed (e.g., wetlands, shoreline, and coastal waters).
- In addition to baseline, determinations, and land-use trends, have assessments include transects up-watershed to link downstream impairments.
- Establish a research initiative to develop cost effective, post-project monitoring.

SESSIONS ON ESTUARIES AND COASTAL RESOURCES

Protecting and restoring estuaries

Estuaries, areas where fresh water mixes with salt water from the ocean, serve as important habitats for fish and provide unique ecosystem services. Participants in this session discussed strategies for protecting and restoring estuaries that have been damaged by human activity.

Targeted Recommendations

- Conduct estuary research and education programs with an awareness that the dynamics and health of estuaries are intimately tied to the dynamics of the watersheds that feed them.
- Create an international panel on aquatic ecosystems that will:
  - Help compile national and international data.
  - Model and forecast the future health of aquatic ecosystems.
  - Undertake needs assessments.
  - Undertake research on the economic and social values of estuaries and watersheds.

- Encourage governments and scientists to work together to support and foster increased community involvement in estuary protection and restoration, including policy setting, science, prevention of water pollution, water conservation, invasive species efforts, and best management practices (BMPs). Create public service announcements to highlight issues.

- Encourage Congress to both encourage efforts and appropriate significant additional resources for successful estuarine programs, such as the National Estuarine Research Reserve System (NERRS), National Status and Trends Program (NS&T), and National Estuaries Program (NEP).

- Encourage Congress to increase funding for innovative research efforts such as those that are focused on developing new tools for understanding estuarine systems (i.e., environmental and economic modeling, GIS, LIDAR), long-term monitoring, analysis and synthesis across federal, local, state, and tribal governments and agencies.

- Encourage all stakeholders to work together to develop long-term financial mechanisms for protecting and restoring ecosystems, including increasing staff for restoration and protection activities. These efforts may include: establishment of non-profit organizations; local funding efforts, such as special license plates; and other innovative efforts.

- Encourage school systems, governments, non-governmental organizations, and universities to work together to ensure that all residents have the opportunities to engage in life-long estuarine/watershed system education. They should encourage and provide hands-on learning experiences for elementary, middle, high school, and college students and the general public.

SESSIONS ON ESTUARIES AND COASTAL RESOURCES

Coastal ecosystems and fisheries

Fisheries represent the largest extractive use of wildlife in the world. Worldwide, fish is the primary source of protein for some 950 million people, and the value of fishery production in 1999 was approximately $125 billion. About 200 million people depend directly upon ocean fishing for their livelihoods. World production of fish, crustaceans, mollusks, and marine plants reached 142 million tons in 2001. Marine and freshwater fish are also an increasingly important recreational resource for anglers, tourists, sports divers, and nature-lovers. Participants in this session explored the relationships between coastal ecosystems, fisheries, and aquaculture.

Targeted Recommendations

- Encourage scientists to lead an inclusive process to develop a vision of coastal ecosystems for the 21st century. Specific goals and objectives should follow from that vision.

- Encourage researchers and managers to take an ecosystem-level approach that includes:
  - Criteria to guide identification of areas for restoration and management.
  - Description of the historic and current states of the ecosystem and species.
  - Development of indicators of ecosystem criteria and species status.
  - Development of management options.
  - Process for evaluation, monitoring, follow-ups.

- Fully integrate local communities and their knowledge of their local ecosystem needs into ecosystem science and management (e.g., engage and listen to fishermen).

- Provide educational opportunities that emphasize the interdisciplinary nature of environmental studies and

the need for sustainability throughout the educational system, including K-12, undergraduate, graduate, and professional levels. (For example, field internships and research experiences could be used to help give students an interdisciplinary introduction to the connection between research, policy, and its application and perception by the industrial/ occupational side of fisheries.)

- Conduct research with the following characteristics:
  - Interdisciplinary (including socioeconomic aspects).
  - Anticipatory.
  - Long-term.
  - Involving community knowledge.
  - Predictive.
  - Relevant and scaled to the needs of decision-makers at various levels.

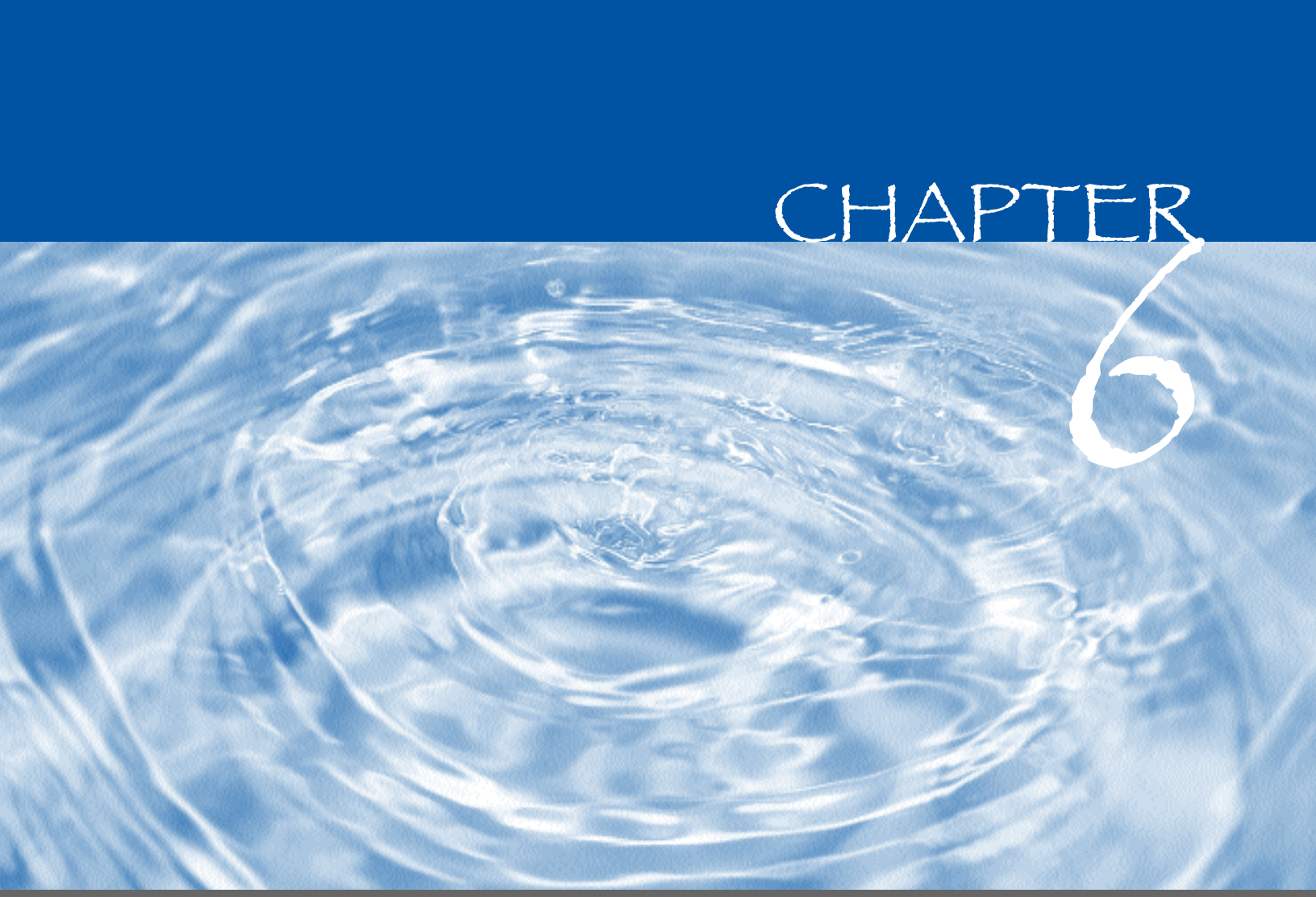
- Conduct the following specific research:
  - Costs and benefits of ecosystem approaches to management and restoration.
  - Development of ecological forecasting and scenario-building as a tool.
  - Likely impacts of specific practices such as removal of oil and gas platforms in the Gulf of Mexico.

- Precede whatever management or regulatory actions are proposed by predictive research and follow them with research to evaluate and monitor the impacts of the proposed actors.

- Encourage the agencies to increase the emphasis on their responsibilities for advice and consultation required through statutes such as the Fish and Wildlife Coordination Act.

- Encourage the scientific community to exercise its responsibility to communicate with the public and decisionmakers in a way that presents factual information in an ecological context and is easily understood.

- Establish a central coordinating body to maintain a unified long-term database of information on fisheries, including historical datasets.



CHAPTER 6

CONCLUSION: PRIMARY RECOMMENDATIONS

Several crosscutting themes emerged during the 4th National Conference on Science, Policy and the Environment: *Water for a Sustainable and Secure Future.* Many of the breakout sessions addressed the need for improving data and monitoring systems, advancing interdisciplinary research, integrating social science and natural science research, and improving education and outreach on sustainable water management. The general recommendations in this chapter have been drawn from a synthesis of the targeted recommendations in the previous chapter.

RECOMMENDATION 1

Develop A Robust Set of Indicators for Sustainable Water Management

As we pursue sustainable water management, we must be able to measure our progress. Carefully selected indicators of water sustainability can help us assess and improve our management of water resources.

- A coordinated and sustained effort is needed to develop and maintain a linked set of indicators at multiple spatial and temporal scales that encompasses the relevant ecological, economic, and social conditions and processes.
- Reporting of indicators should include measures of precision or uncertainty.
- The public should participate with scientists, resource managers, and other stakeholders in identifying the important issues, selecting the indicators, and developing the institutional capacity to produce and use them.

RECOMMENDATION 2

Improve Data and Monitoring Systems for Sustainable Water Management

There are major gaps in the data and monitoring systems needed for sustainable water management and for improving homeland security.

- Make better use of existing data by:
  - Building cyber-infrastructure systems that make data available across all institutions and sectors.
  - Encouraging consistent methodologies, data conventions, and data-collection initiatives, including geo-reference in all data collection.
  - Focusing on watersheds to unify data from disparate sources and scales.
- Expand data collection and monitoring projects by:
  - Collecting systematic watershed data to fill in recognized gaps, which include ecological forecasting, the relationship between hydrologic regimes and ecosystem consequences, baseline ecosystem requirements, and surface and ground water resources and consumption patterns.
  - Ensuring inclusion of data on human factors such as human health, demographic information, land use, and management practices.
  - Developing and deploying monitoring systems that provide timely data that are needed to improve sustainable water management and homeland security.
- Data systems should be designed to be useful for and available to decisionmakers and scientists.

RECOMMENDATION 3

Advance Interdisciplinary Scientific Research on Sustainable Water Management

Water is inherently a multidisciplinary media. The development of water policy draws on research from a variety of disciplines, including hydrology, biology, geology, soil science, environmental science, health science, behavioral science, and economics. The need for integration and synthesis is paramount.

- Provide more research and science by:
  - Connecting environmental conditions to human health research.
  - Spanning spatial scales that range from small watersheds to large watersheds of policy interest.
  - Making models flexible to incorporate emerging science and targeted to key management decisions.
- Provide synthesis and integration by:
  - Improving visualization of results that have meaning to non-specialists.
  - Providing summaries for policy makers and the public.
  - Including variable scales, from molecule to watershed, in approaching research and policy.
- Build a balanced R&D portfolio of long-term and short-term initiatives and large-scale and small-scale projects.

RECOMMENDATION 4

Integrate Social Science and Natural Science Research on Sustainable Water Management

The integration of social science and natural science research is essential for progress on many aspects of sustainable water management. The economics of sustainable water use — such as the valuation of ecosystem services associated with freshwater resources — is fundamentally based on the integration of natural and social sciences.

- Managing the demand for water requires advanced research at the interface between the social sciences and the natural sciences, such as:
  - Quantifying the full costs of providing water for various user classes.
  - Improving our understanding of the risks, costs, benefits, and behavioral barriers associated with water reuse.
  - Understanding impediments to adopting pricing schemes, such as progressive rate structures, that establish market incentives for water efficiency and conservation.
- Improved integration of the social and natural sciences would help:
  - Reduce outbreaks of water-borne diseases.
  - Meet future water infrastructure needs.
  - Reduce non-point source pollution.
  - Advance community-based watershed restoration.

RECOMMENDATION 5

Close the Gap Between Water Science and Water Policy

There are numerous opportunities to move toward sustainable water resources management by closing the gap between water science and water policy.

- Hydrological and ecological linkages, rather than political boundaries, should form the basis for water management.
  - Governance structures should be designed to facilitate a watershed, basin, or ecosystem approach to water management.
  - Effective solutions to these issues must be holistic, entering at the watershed level and connecting coastal pollution with inland sources.
- In many states, groundwater and surface water are two legally unrelated entities.
  - This gap may lead to practices of unsustainable groundwater withdrawal and ineffective water management policies.
  - Groundwater and surface water are inextricably linked through the hydrologic cycle, and we should reform governance to reflect this.
- We should create science-based model legal frameworks, regulations, and rules as recommendations for states and municipalities.

RECOMMENDATION 6

Develop a Broad Spectrum of Technologies to Advance Sustainable Water Management

The development of a broad spectrum of technologies is crucial to the success of a transition to water sustainability.

- The development of more efficient irrigation technologies is critically important because irrigation accounts for 70 percent of water use in the United States.
  - Develop improved practices and systems that optimize timing, placement, and amount of irrigation.
  - Develop irrigation practices and technologies that reuse waste water without compromising public health or environmental quality.
  - Develop crops and varieties with improved water use efficiency and that respond to lower water quality without sacrificing economic yield levels.
- Develop a broad spectrum of water purification technologies.

  - Develop new desalination technologies that allow communities to utilize sea water and brackish water to supplement freshwater resources.
  - Because energy and water supplies are inextricably intertwined, it is important to jointly address energy and water technologies and policies.
  - Develop affordable, culturally acceptable, point-of-use water purification technologies for developing countries.
- Secure water supplies are critical components of homeland security.
  - Develop better detection technologies that have more analytical capabilities, greater specificity, greater selectivity, and lower false alarm rates.
  - Develop continuous, inexpensive technologies to monitor water quality parameters to detect change.
  - Develop water systems that are resistant to attack.

RECOMMENDATION 7

Improve Education and Outreach on Sustainable Water Management

Improvements in education and outreach are essential to achieving sustainable water management.

- Schools, governments, and non-governmental organizations should work together to ensure that all residents gain an understanding of their local watersheds, estuaries, and coastal regions.
  - Residents of a community should learn where their water comes from, how much water they use, the resource limits, and opportunities for more efficient use of water resources.
  - People should be educated about the importance of source water protection to human health and ecosystem health.
- The scientific community needs to exercise its responsibility to communicate to the public and decisionmakers about sustainable management of water resources.
- Strengthen communications among decisionmakers, scientists, engineers, and citizens regarding sustainable management of water resources.

RECOMMENDATION 8

Promote International Capacity Building on Sustainable Water Management

The United States has numerous opportunities to build capacity that will improve access to safe drinking water and sanitation in developing countries.

- Partnerships between institutions in the United States and developing nations should be encouraged in order to build capacity and enhance collaborative research and development to improve water sustainability.
- R&D programs for developing low-cost, small scale, culturally acceptable water purification and hygiene technologies should be instituted and promoted.
- Investigate the most effective use of U.S. resources to build capacity that will improve water quality and sanitation in developing nations.

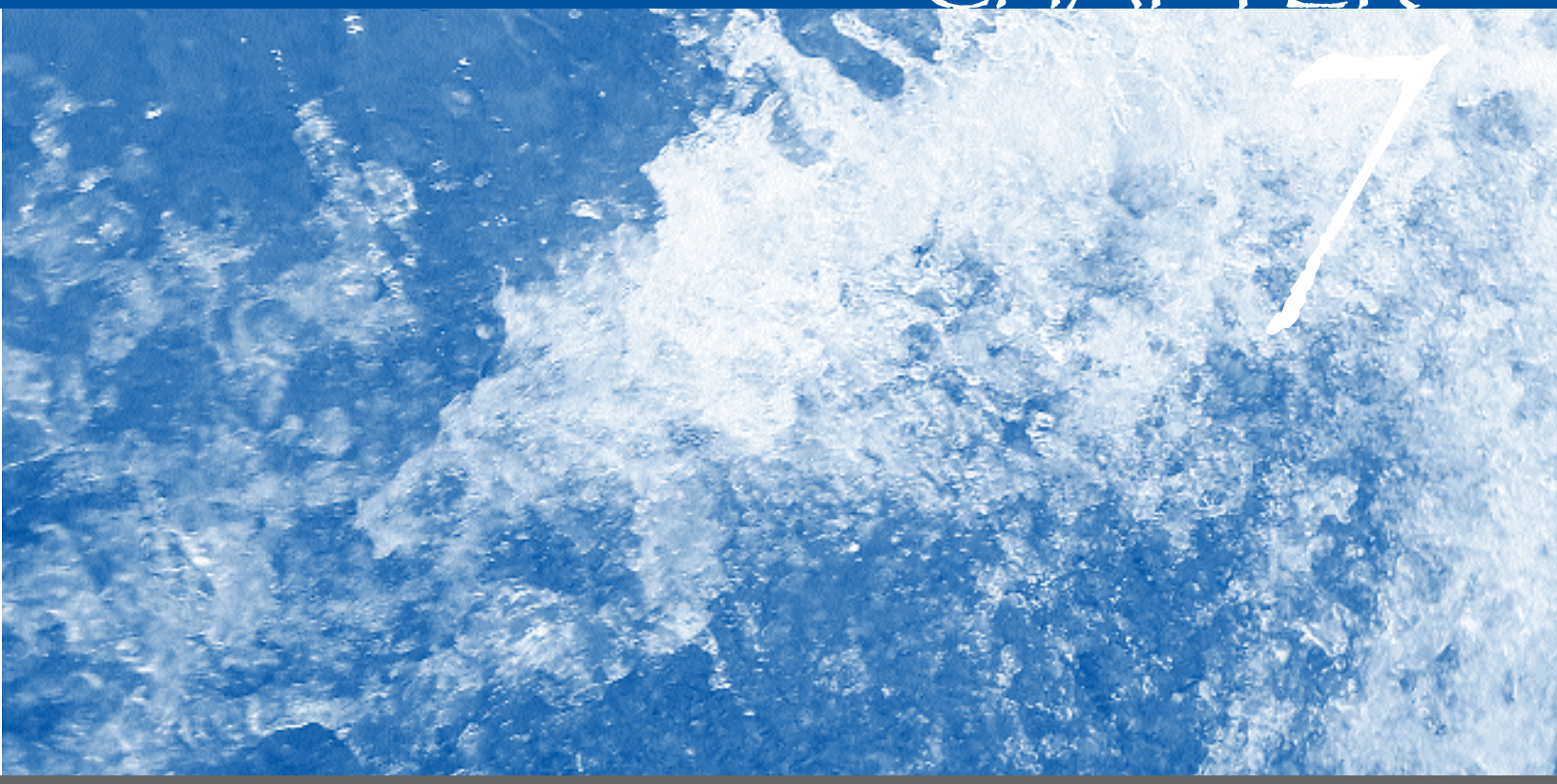
RECOMMENDATION 9

Establish a National Commission on Water Sustainability

Congress and the President should establish a National Commission on Water Sustainability. The Commission should be charged with addressing domestic water sustainability issues as well as the U.S. role in international water sustainability issues. It has been over 20 years since the United States has conducted a national assessment of water availability and use.

- Following the example of the U.S. Commission on Ocean Policy, the Water Commission should be a multi-stakeholder body of experts.
- The Commission should address many of the issues raised in this and other recent reports on water policy and recommend strategies for implementation.
- The Commission should solicit feedback on a draft from local, state, and regional decisionmakers.

CHAPTER 7



APPENDICES

Appendix A

Agenda

Water for a Sustainable and Secure Future

Fourth National Conference on Science, Policy and the Environment

January 29-30, 2004, Washington, DC

THURSDAY, JANUARY 29, 2004

8:00 am
REGISTRATION AND CONTINENTAL BREAKFAST

9:00 am
WELCOME

Craig Schiffries, Conference Chair, National Council for Science and the Environment

Amb. Richard Benedick, President, National Council for Science and the Environment

9:15 am
KEYNOTE ADDRESS

William K. Reilly, President and CEO, Aqua International Partners; Chairman, World Wildlife Fund; Former Administrator, U.S. Environmental Protection Agency

10:00 am
ROUNDTABLE—SUSTAINABLE WATER USE: OVERCOMING BARRIERS TO CHANGE

Amb. Richard Benedick (Moderator), President, National Council for Science and the Environment

Bruce Babbitt, Former Secretary of the Interior; Former Governor of Arizona

Mohamed El-Ashry, CEO and Chairman Emeritus, Global Environment Facility

Barbara Sheen Todd, Commissioner, Board of Commissioners, Pinellas County, Florida; Past President, National Association of Counties

10:45 am
ROUNDTABLE—MANAGING WATER IN THE 21ST CENTURY: TOWARDS A COMPREHENSIVE WATER VISION

Jerry Delli Priscoli (Moderator), Senior Policy Analyst, Army Corps of Engineers

Gen. Gerald Galloway, Vice President, Titan Corp.; Chair, National Water Policy Dialogue; Past President, Universities Council on Water Resources

Peter Gleick, President, Pacific Institute for Studies in Development, Environment and Security

William Graf, University Professor, University of South Carolina; Past President, Association of American Geographers

Robert Hirsch, Associate Director for Water, U.S. Geological Survey; Co-Chair, National Science and Technology Council Subcommittee on Water Availability and Quality

Harry Ott, Director for Environment and Water, The Coca-Cola Company; Co-Chair, Water Sustainability Working Group, Global Environmental Management Initiative

Jane Valentine, President, American Water Resources Association; Associate Professor, UCLA

12:15 pm
LUNCH

1:30 pm
BREAKOUT SESSIONS — 16 CONCURRENT SESSIONS (SEE APPENDIX B FOR CHAIRS AND SPEAKERS)

Sessions on Sustainable Water Management & Institutions

1. Allocating water between people and ecosystems
2. Integrating surface and ground water management
3. Water sustainability indicators
4. Managing demand for water: improving efficiency & conservation
5. Economics of sustainable water use

Sessions on Water Quality and Sanitation

6. Water, sanitation and human health
7. Water infrastructure needs for the 21st century
8. Control of non-point source pollution
9. Community-based watershed restoration
10. Research and data needs for better decisionmaking

Sessions on Water Technologies

11. Technologies for water monitoring and homeland security
12. Desalination and other water purification technologies
13. Irrigation and agriculture

Sessions on Estuaries and Coastal Resources

14. Addressing coastal pollution at the watershed level
15. Protecting and restoring estuaries
16. Coastal ecosystems and fisheries

5:30 pm
RECEPTION

7:00 pm
FOURTH JOHN H. CHAFEE LECTURE ON SCIENCE AND THE ENVIRONMENT

Introduction— Stephen P. Hubbell, Chairman, National Council for Science and the Environment; Professor, University of Georgia

Reflections— Hon. Lincoln D. Chafee, United States Senator

Lecture— *Lessons from Environmental Collapses of Past Societies*

Jared Diamond, Professor, University of California at Los Angelis; Pulitzer Prize-winning author of the national bestseller *Guns, Germs and Steel: The Fates of Human Societies*; recipient of the National Medal of Science

FRIDAY, JANUARY 31, 2004

8:00 am
CONTINENTAL BREAKFAST

Film Screening—*Journey to Planet Earth: Hot Zones,* a documentary that explores links among environmental change, water and human health

9:00 am
PLENARY ADDRESS

INTRODUCTION

Amb. Richard Benedick, President, National Council for Science and the Environment

PLENARY LECTURE

Klaus Toepfer, Executive Director, United Nations Environment Program

10:00 am
SYMPOSIA— 4 CONCURRENT SESSIONS

Sustainable Water Management and Institutions
How can we make watershed management work? How can we better align water policy with water science?
Peter Gleick, President, Pacific Institute for Studies in Development, Environment and Security, **William Graf,** Professor, University of South Carolina and Past President, Association of American Geographers; **Brian Richter,** Director, Freshwater Initiative, The Nature Conservancy; **Ethan T. Smith**, Coordinator, Sustainable Water Resources Roundtable

Water Quality and Sanitation
Have we turned the corner on water pollution? How safe is our water? How should priorities be set, and who should set them?
Marcia Brewster, Task Manager, United Nations Interagency Gender & Water Task Force; **G. Tracy Mehan**, former EPA Assistant Administrator for Water; **Eric Olson,** Senior Attorney, Natural Resources Defense Council; **Harry Ott**, Director for Environment and Water, The Coca-Cola Company; **Robbi Savage**, Executive Director, Association of State and Interstate Water Pollution Control Administrators

Water Technologies
How can technology help meet U.S. and international water supply and sanitation needs? How can we bring new water technologies to the marketplace?
Shannon Cunniff, Director of Research and Development, U.S. Bureau of Reclamation; **A. Judson Hill**, Aqua International Partners; **Allan Hoffman**, Winrock International; **E. Timothy Oppelt,** Director, U.S. EPA Homeland Security Research Center; **David Zoldoske,** Director, CSU Fresno Center for Irrigation Technology

Estuaries and Coastal Resources
How can we manage estuaries and coastal resources more comprehensively?
Darrell Brown, U.S. EPA Coastal Management Branch; **Mark Castro**, University of Maryland Center for Environmental Science; **Barry Costa-Pierce**, University of Rhode Island; **Chris Dionigi**, Assistant Director, Interagency Invasive Species Council; **Mark Van Putten,** ConservationStrategies; Past President, National Wildlife Federation

12:00 pm
BUFFET LUNCH

1:30 pm
AWARDS CEREMONY

Lifetime Achievement Award
Presented to **Ruth Patrick**, Francis Boyer Chair of Limnology, Academy of Natural Sciences

Lifetime Achievement Award
Presented to **M. Gordon "Reds" Wolman**, B. Howell Griswold Jr. Professor of Geography and International Affairs, The Johns Hopkins University

2:00 pm
ROUNDTABLE— LEARNING FROM EXPERIENCE: DESIGNING WATER POLICY FOR THE FUTURE

Thomas E. Lovejoy (Moderator), President, The H. John Heinz III Center for Science, Economics and the Environment
Thomas F. Caver, Deputy Director of Civil Works, U.S. Army Corps of Engineers
Robert Glennon, Morris K. Udall Professor of Law and Public Policy, University of Arizona
Benjamin Grumbles, Acting Assistant Administrator for Water, U.S. EPA
Karin Krchnak, Senior Associate, World Resources Institute; Co-Chair, UN Commission on Sustainable Development Water Caucus
Jeremy Pelczer, President, American Water; Deputy CEO, RWE Thames Water

3:30 pm
ADJOURN

Appendix B

Breakout Sessions

Allocating water between people and ecosystems

SESSION CHAIRS
Robert Hirsch, U.S. Geological Survey
Brian Richter, The Nature Conservancy

Integrating surface and ground water management

SESSION CHAIR
Robert Glennon, University of Arizona, James E. Rogers College of Law

PANELIST
Glen Patterson, U.S. Geological Survey

FACILITATOR
Juge Gregg, International Network for Environmental Compliance and Enforcement

Water sustainability indicators

SESSION CHAIR
Ethan Smith, Sustainable Water Resources Roundtable

PANELISTS
Karl Fennessey, Dow Chemical Company
Ted Heintz, White House Council on Environmental Quality
Robin O'Malley, The H. John Heinz III Center for Science, Economics and the Environment
Daniel Tunstall, World Resources Institute

Managing demand for water

SESSION CHAIR
Bonnie Kranzer, Consultant; former Executive Director of the Florida Governor's Commission for a Sustainable South Florida

PANELIST
Susan Gilson, Interstate Council on Water Policy

Economics of sustainable water use

SESSION CHAIR
Jerry Delli Priscoli, U.S. Army Corps of Engineers

PANELISTS
Audrey Chapman, Science and Human Rights Program, American Association for the Advancement of Science
Sylvia Tognetti, Consultant

Water, sanitation and human health

SESSION CHAIRS
Eric Olson, Natural Resources Defense Council
Philip Oshida, U.S. Environmental Protection Agency

PANELISTS
Aiah Gbakima, Morgan State University
Leanne Nurse, U.S. Environmental Protection Agency

Water infrastructure needs for the 21st century

SESSION CHAIR
Gen. Gerald Galloway (ret.), Titan Corporation; National Water Policy Dialogue

PANELISTS
Linda Eichmiller, Association of State and Interstate Water Pollution Control Administrators
Stephen Gasteyer, Rural Community Assistance Program
Worth Hager, American Waterways Conference
Brian Pallasch, American Society of Civil Engineers

Control of non-point source pollution

SESSION CHAIR
Dov Weitman, U.S. EPA Non-point Source Control Branch

PANELISTS
Carl Lucero, U.S. Department of Agriculture
Tamim Younos, Virginia Polytechnic Institute

Community-based watershed restoration

SESSION CHAIR
Karen Prestegaard, University of Maryland

PANELISTS
Robert Boon, Anacostia Watershed Society
J. Charles Fox, Chesapeake Bay Foundation

Research and data needs for better decisionmaking

SESSION CHAIR
Stephen Parker, National Academies
PANELISTS
Michael Haire, U.S. Environmental Protection Agency
Will Logan, National Academies
Timothy Miller, U.S. Geological Survey
Leslie Shoemaker, Tetratech

Technologies for water monitoring and homeland security

SESSION CHAIRS
Janet Jensen, U.S. Army Soldier and Biological Chemical Command
Eugene Rice, U.S. Environmental Protection Agency

PANELIST
Lisa Olsen, U.S. Geological Survey

Desalination and other water purification technologies

SESSION CHAIRS
Shannon Cunniff, Bureau of Reclamation
A. Judson Hill, Aqua International Partners, LP

PANELISTS
Debra Coy, Charles Schwab
Chuck Martz, Dow Chemical Company

Irrigation and agriculture

SESSION CHAIR
David Zoldoske, CSU Fresno Center for Irrigation Technology

PANELIST
Adam Skolnik, Senninger Irrigation

Addressing coastal pollution at the watershed level

SESSION CHAIR
Mark Castro, University of Maryland Center for Environmental Science

PANELISTS
Barry Burgan, Office of Water, U.S. Environmental Protection Agency
Dan Walker, National Academies

Protecting and restoring estuaries

SESSION CHAIR
Chris Dionigi, Interagency Invasive Species Council

PANELISTS
Gregory Colianni, Office of Water, U.S. Environmental Protection Agency
Barbara Sheen Todd, Board of Commissioners, Pinellas County, Florida
James T. Willie, Earth Conservation Corps

FACILITATOR
Kim Lamphier, Consultant

Coastal ecosystems and fisheries

SESSION CHAIR
Barry Costa-Pierce, Rhode Island Sea Grant, University of Rhode Island

PANELISTS
Ronald Baird, Sea Grant College Program
Robert Brock, National Oceanic and Atmospheric Administration
Dieter Busch, National Oceanic and Atmospheric Administration
Kristen Fletcher, Roger Williams University School of Law
Elaine Hoagland, Council on Undergraduate Research
Alan Thornhill, Society for Conservation Biology

Appendix C
Poster Presentations

Albietz, Jessica, T.M. Cronin, G.L. Wingard and D.A. Willard. U.S. Geological Survey. **Salinity Changes in Biscayne Bay, Florida: Human and Natural Influences.**

Allender-Hagedorn, Susan and Charles Hagedorn. Virginia Polytechnic Institute and State University. **Bridging the Gap Between Water Quality Science and Policy: Environmental Detection News**.

Briggs, Chad. California State University. **Science and Administrative Capacity in Water Regulation: a Case Study of Hungary.**

Brown, Lesley and Liza Agudelo. University of Maryland. **Reducing Nutrient Pollution at the Watershed-level: Decentralized Wastewater Treatment and Composition of Detergents.**

Czarnecki, John B., Brian R. Clark, Gregory P. Stanton and Thomas B. Reed. U.S. Geological Survey. **Optimization Modeling of the Mississippi River Valley Alluvial Aquifer in Arkansas.**

Dennison, Bill, Adrian Jones, Francis Pantus and Jane Thomas. University of Maryland. **Developing a Chesapeake Bay Report Card.**

Deslauriers, Sarah, Masayuki Kanzaki, Akshay Kumar, Gregory Keoleian and Jonathan Bulkley. Center for Sustainable Systems, University of Michigan. **Life Cycle Assessment as a Decision Support Tool in the Water Industry.**

Gbakima, Aiah, Mitchel Graham and Aisha Turnbull. Morgan State University. **Detection of Excherichia coli and E. coli 0157:H7 in Water Sources in Baltimore and Ghana.**

Gruden, Cyndee,[1] P. Adriaens, [2] S.C. Chang[2] and A. Khijniak.[2] [1]University of Toledo; [2]University of Michigan. **Mico-Flow Cytometry Application for Microbial Assessment in Complex Matrices.**

Hagedorn, Charles,[1] Annie Chapman,[1] Sue Herbein[1] and Philip Mcclellan.[2] [1]Virginia Polytechnic Institute and State University; [2]MapTech, Inc. **Microbial Source Tracking as a Technology for Identifying Sources of Fecal Pollution in Water.**

Howari, Fares M. Southwest Earth and Environmental Services. **Hydrochemical Analyses and Management Options to Route Water from Elephant Butte Dam to El Paso del Norte region, U.S.-Mexico Border.**

Lang, Micah. Thomas J. Watson Foundation. **World Water Scarcity: The Feedback Among Water, Culture, and the Environment.**

Keshawarz, M. Saleh[1]and Sayed Sharif.[2] [1]University of Hartford; [2]FAO Afghanistan. **Water Security and Sustainability in Afghanistan.**

King, Stanley, Xinglong Xu and Isabel Escobar. University of Toledo. **Improving Desalination Through Membrane Modifications.**

Klaine, Stephen J.,[1] M. Schlautman,[1] R. English,[2] J. Hayes,[3] T. Karanfil,[4] S. Templeton,[5] J. Smink,[1] C. Post.[2] [1]Environmental Toxicology Program, Clemson University; [2]Department of Forestry and Natural Resources, Clemson University; [3]Public Service and Administration, Clemson University; [4]Department of Environmental Engineering and Science, Clemson University; [5]Department of Agricultural Economics, Clemson University. **A Watershed Approach to Characterize the Influence of Land Use Change on Aquatic Resources.**

Knowles, Graham. National Environmental Services Center, West Virginia University. **Ensuring Sustainable Water Resources and Managing Growth: Putting Onsite Wastewater Management in the Mix.**

Mcpherson, Wendy. U.S. Geological Survey. **Monitoring Water Levels from Drought to Recovery in Maryland and Delaware.**

Perveen, Shama. Centre for Development and Environment Policy, Indian Institute of Management Calcutta. **Sustainable Water Resource Management: A Case Study of River Interlinking Project in India.**

Pidlisnyuk, Valentyna[1] and Iryna Pidlisnyuk.[2] [1]University of Georgia; [2]Academy of Foreign Trade, **Sustainable Development and Ecological Education Center. Sustainable Use of Water Resources: Challenges for the Future.**

Schmandt, Jurgen. **Improving Water Management on the Border with Mexico. University of Texas.**

Sempier, Stephen H., Katy R. Lloyd, Roger J. Harris and Hillary S. Egna. Aquaculture Collaborative Research Support Program, Oregon State University. **Sustainable International Aquaculture Research: A Focus on Low Food Chain Species.**

Sugiura, Shozo H. and Ronaldo P. Ferraris. New Jersey Medical School. **Aquaculture, Water Pollution, and Policy-Making: Better Technology or More Regulation?**

Van Walsum, Peter and Erin Doyle. Balor University. **Improving the Economic Incentive for Effective Manure Treatment: Removal of Phosphate Through Mix-Alco Conversion of Dairy Cattle Manure to Value-Added Fuels and Chemicals.**

Wilderman, Candie. Dickinson College. **The Realization of a Pipe Dream: Effective Partnerships in Community-Based Urban Stream Restoration.**

Wilderman, Candie. Dickinson College. **Top Down or Bottom Up? Models for Community-Based Participatory Watershed Research, with a Discussion of Their Impacts on the Development of Sustainable Water Policy**

Appendix D
Exhibitors

The following organizations exhibited their educational programs and products at the conference.

Aldo Leopold Leadership Program

ASES/2005 Solar World Congress-Bringing Water to the World

Consortium of Universities for the Advancement of Hydrologic Science

Department of the Interior-Bureau of Reclamation

Ecological Society of America-*Frontiers in Ecology and the Environment*

Environmental Literacy Council

EPA Office of Research and Development

EPA Office of Water

Environmental Systems Research Institute

Island Press

The Morris K. Udall Foundation

National Academies Press

National Park Service

National Oceanic and Atmospheric Administration

Resources for the Future Press

Society for Conservation Biology

Unilever

USAID Population, Health & Nutrition Information Project

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