GLOBAL CHANGE AND WATER RESOURCES MANAGEMENT

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SUMMARY AND COMMENTARY

We are pleased that UCOWR provided us with a forum to discuss the implications of global warming for water resources management. We should remind the readers that we view this forum as a debate about the respective viewpoints of scientists, policymakers, and water resources decisionmakers about key issues surrounding adaptation, rather than as a scientific appraisal of the facts about whether there is evidence for climate change. To that end, we assembled a group of experts to address the issues of adaptation to global warming and climate change within the water resources sector. This group of very knowledgeable individuals, who were asked to contribute their thoughts in this issue of *Water Resources Update*, have all been involved in various aspects of the evolving climate change debate at the highest national and international levels for at least the past decade.

Yet, we must remark on a glaring deficiency - the "rank and file" water managers and operators, i.e., the true water resources decisionmakers, are not represented in this forum even though we tried very hard to elicit their views. In fact, climate change issues seem only recently to have become of concern to the operating water management community, coincident with the greater attention devoted to El Niño in the press, and the salience of proposals to control greenhouse gas emissions and their economic consequences. This should not be interpreted to mean that water managers are oblivious to the potential serious consequences of global warming. Their apparent indifference may stem from their intuitive understanding that the coping strategies for dealing with contemporary climate variability and those suggested for potential climate change are virtually the same. We believe that the views of the water management community must be more actively sought after by the climate change impacts community, particularly on the subject of adaptation, because the success of whatever course of action selected depends on their receptivity to implementation measures that are being advocated largely by policymakers outside the water resources profession.

We are taking some liberties and editorial license to crystallize the key issues, as we see them. Our commentary is not intended to be even-handed. Rather, we feel that the voices of the water resources profession have not been heard clearly amidst the din of thousands of scientists proclaiming new findings about global warming and its consequences, along with an array of presumptuous initiatives. Also, we are somewhat alarmed about the tendency to formulate and evaluate adaptive management strategies without the active participation of water resources managers. The individual papers in this issue "speak for themselves," and every reader will be able to sort through the issues in their own terms. However, it is important to highlight the fact that water resources have finally moved to the forefront of thinking by the climate change impact community (Moss, Dresler *et al.*). The water resources sector is recognized by the climate scientists as the nexus for many of the other sectors (agriculture, ecosystems) that are considered to be critical for human survival. In that light, we think it is important that the climate policymakers recognize the essential role and contributions of the water resources managers in helping to achieve sustainable adaptive management strategies.

Climate variability, and all the attendant statistical methodologies that hydrologists and water resources engineers depend on as part of their work, has always been a core concern of the water resources management profession. Yet, the concern for climate change, i.e., a shift in the mean, and consequent implications for water managers has been addressed largely in the province of

academicians, government scientists, and policymakers in regulatory agencies and environmental ministries. Very few "real" water managers or natural resources managers (e.g., BLM, Forest Service, FWS), i.e., the actual decisionmakers, ever get involved or are asked to be involved in any aspect of the global warming debate or research, whether it be as part of the UN Intergovernmental Panel on Climate Change (IPCC), or in defining the U.S. Global Change Research Program, and certainly not as part of the countless National Research Council panels devoted to global change issues. So we view this issue of *Water Resources Update* as a forum for the imputed views of the water resources profession. While we cannot directly speak for those water managers, as we are involved with the more esoteric and abstract policy issues surrounding water management reforms, we at least work in a water management agency and have direct contact with public interest groups, operators, design engineers, and planners on many different issues that touch on the basic questions of climate variability and risk management.

Water resources managers are, first and foremost, technical and empirical pragmatists. The nature of their jobs forces them to be empiricists because they are directly accountable to the public for their decisions, both in operating projects and as part of the planning process. Virtually every major decision in the Corps is accomplished through a formal public participation process with extensive stakeholder involvement. The water resources profession incorporates a good deal of empirical science, along with a large dose of economics and social and environmental considerations that are tempered by politics and public values about the outputs, balance, and quality of services provided. It became evident in the two national conferences on "Climate Change and Water Resources Management" that the Corps helped organize in 1993 and 1997 that the subgroup of water managers (as distinct from academicians and researchers who attended) held the basic view regarding climate nonstationarity that was encapsulated by Matalas in his article (this issue). To whit: "claiming nonstationarity is not enough. It must be shown that the perceived nonstationarity is real enough and has a significant effect on the management of water systems." They also adhere to the corollary (also by Matalas) which posits that the current analytical practices, represented by stochastic hydrology, "can accommodate the uncertainties in water supplies induced by global warming with the operational assumption of stationarity as meaningfully as with the assumption of non-stationarity." In other words, until water resources managers see credible and more certain evidence of climate change, their existing methods, which inherently deal with risk and uncertainty, are sufficient to deal with any emerging near term trends. This is simply their understandable pragmatic response to the large uncertainties associated with climate scenario forecasts, as presented by Mulholland and Sales, in this issue.

However, based on our experience, we believe that water managers and operators are neither denying the hypothesis of global warming and its potentially adverse and beneficial hydrologic consequences, nor ignoring any interim information suggesting possibilities of trends or other climate signals. In fact, as is demonstrated by the information presented by Stakhiv and Schilling, Steiner, and Boland in their respective articles, there is a great deal of adaptive management and technological progress occurring at all levels of the water resources sector - continuously adjusting to both the signals of hydrologic variability, as well as shifts in the demand for services and geographic shifts in demand centers. This autonomous adaptive management strategy corresponds very closely to the core of a "no regrets" strategy advocated by the IPCC and other policy documents.

The basic argument of the scientists and policymakers in our discussion forum (e.g., Moss, Dresler *et al.,* Mulholland and Sales, and Gleick) is that the water managers should be doing more to prepare for the ultimate eventuality of CO_2 -induced warming, even though the predictions of the general circulation models for specific regions are highly uncertain (Mulholland and Sales, Gleick). The perfectly sensible (in our view) recipe for preparatory planning advocated by the various authors can be summarized as follows:

- Prepare for "potential surprises" resulting from the interaction of population growth, increasing per capita water use, land-use changes, pollution and loss of biodiversity by engaging in creative scenario-building, forecasting, and tradeoff analysis (Moss).

- "The water resources community must be engaged in the determination of possible adaptation and coping strategies that might be employed under a changing climate to improve society's resilience to the natural year-to-year fluctuations in the climate" (Dresler *et al.*).

- "Water agencies should reexamine basic engineering design assumptions, operating rules, system optimization, and contingency planning ... under a wider range of climatic conditions than traditionally used" (Gleick/AWWA).

- "Governments at all levels should re-evaluate legal, technical, and economic approaches for managing water resources in the light of possible climate changes" (Gleick/AWWA).

- "Cooperation of water agencies with leading scientific organizations can facilitate the exchange of information on the state-of-the-art-thinking about climatic change and impacts on water resources" (Gleick/AWWA).

- "Water agencies and providers should explore the vulnerability of both structural and non-structural water systems to plausible future climate changes, not just past climate variability" (Gleick/AWWA).

We heartily agree with all of the above recommendations enumerated by the American Water Works Association (AWWA) task committee, on which Dr. Gleick served. We have shown examples where each of the recommendations has been acted on by at least one water management agency (Stakhiv and Schilling), river basin commission (Steiner), or utility (Boland). There are many other examples where climate change and variability are significant factors in ongoing federal agency planning activities (e.g., Great Lakes, coastal erosion studies). Progress, however, is slower at the state and local levels, and the practices are not widespread because there is simply very little incentive for water managers in public utilities, irrigation districts and flood control districts to undertake the very broad and creative scenario-building and sensitivity analyses advocated by Moss and others. There are five very practical reasons for this: (i) no money for research; (ii) current methods are adequate; (iii) economic analysis discounts future uncertain conditions; (iv) cost-sharing partners in project planning are not interested in paying for or pursuing these issues; and (v) most adaptation at the local level is incremental capacity expansion rather than large-scale capital investments, so the time horizons are shorter. Nevertheless, despite the relatively slow pace of water policy reforms, there has been a quantifiable positive cumulative effect. Total fresh water withdrawals in the U.S. have declined during the past 15 years, as has per capita use, despite a 16% increase in population (Stakhiv and Schilling). Water quality in most rivers has improved markedly. Water managers must be doing something right, but they rarely get any credit for those achievements. And the irony is that they are being ignored by the climate change advocates.

While we agree with the overall strategy enunciated by the AWWA, we take exception to the Gleick/AWWA conclusion that "none of these recommendations requires expensive, difficult changes or actions." Consider that over $1 billion is spent annually on the U.S. Global Change Research Program, with most of the money staying in the academic research community and the "science agencies" (NOAA, USGS, NASA, EPA). The research program is clearly needed to better understand the geophysical dimensions of global warming and its consequences, but to undertake the types of analyses suggested for major projects, reservoir systems and systems of levees, including a systematic review of engineering design procedures and technical approaches for managing water resources, would require an equivalent budget for all the natural and water resource management agencies. Yet, we doubt that more than several million dollars per year is expended on this matter among all these agencies. Even so, the assessment (establishing the facts) would only comprise the beginning of a lengthy evaluation, negotiation, and conflict resolution process among all of the affected interest groups and parties that would be required to implement the changes. In the current era of collaborative planning and stakeholder participation, any changes in water allocation, operating rules or any structural changes for major rehabilitation, requires years of public consultation and Congressional approvals. This is simply because virtually every aspect of federal water management is embodied into laws and published regulations and procedures which cannot be arbitrarily altered. The Corps has been involved in several recent examples where changing conditions, public values, water demands, and new hydrologic information and improved models dictated changes in water allocation and operating rules. In each case, considerable sums were spent to quantify the changes, optimize allocation and operating rules under varying social, economic environmental forecasts and assumptions about the future, including a wider range of climatic conditions (more severe droughts, larger floods) and make the tradeoffs for the various uses. These analyses then became the basis for a new set of encoded operating rules and legal instruments governing the allocation and uses of water.

Simply acquiring better knowledge about a water system's vulnerability, robustness, resiliency, reliability, and flexibility though an examination of quantified

operating characteristics and performance criteria is an important, but merely preliminary, step in a lengthy process of policy formulation. New policies and institutions are the ultimate mechanisms for steering adaptation strategies. That is why we made the necessary distinction between policy formulation and technical implementation in our article. No water management agency or utility can unilaterally introduce policies, regulations or other procedures simply on the basis of a set of scientific experiments, as advocated by Moss and Gleick, in view of the huge uncertainties involved. The public would simply not accept those changes. The water management profession must become more actively engaged in the scientific assessments that will influence the policy formation process. They must be part of the basic vulnerability assessments and ensure that the economic performance of water management systems are conducted in a comprehensive and realistic manner. Most of the work that we have seen to date in the academic literature, reflecting the evaluation of adaptive management strategies within the water resources sector, has fallen far short of the level of analysis that is meaningful to water resources managers or the public.

Considering the pragmatic realities and clear demarcation between scientific assessments and policymaking versus decisionmaking, we do have some concerns about the U.S. National Assessment of Climate Change effort described by Dresler *et al.* It is certainly noteworthy and laudable that such a national assessment is being undertaken, which will "facilitate comparison, interpretation, and synthesis of each of the assessment components... using a common set of scenarios for climate change and changes in socio-economic conditions." If the primary purpose is to "link research by scientists to specific issues and needs of the stakeholders; and will provide planners, managers, organizations, and the public with the information needed to increase resilience to climate variability and cope with climate change," then that basic function of information synthesis and transfer is well worth the effort. Water managers clearly need to be more fully involved in that effort. However, based on our long experience in several national water resources assessments and national water policy initiatives, it is doubtful whether the National Climate Assessment, as it is structured, can "...provide the scientific foundation on which policy analyses could be based." The reason is that science and scientific underpinnings of climate change, hydrology, or reliability of structures are but the preliminary and relatively small part of the formulation and evaluation of adaptive management strategies. Economics, societal values and preferences, technological innovations, demographic changes, and basic ability-to-pay considerations by the cost-sharing partners on many of the proposed adaptive management strategies, whether they be structural or non-structural, will play a much larger role in the ultimate decisions about coping strategies than whatever added insights that the National Assessment or the next IPCC assessment can offer about the certainty of hydrologic effects or the vulnerability of managed water systems.

One of the major failings of most climate impact assessments and evaluations of adaptive management strategies is the neglect of basic economic analyses, whether it be cost-effectiveness or benefit-cost analysis. We and others (Frederick, Major, Boland) feel strongly that the formulation and evaluation of management options, as well as vulnerability analysis must be carried out in a manner that is consistent with sound multiobjective evaluation principles, which include benefit-cost analysis, that have been developed over the past 50 years of water resources planning. Our stance is consistent with the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptation (1994) as well as the recommendations of the IPCC Working Group III on "Economic and Social Dimensions of Climate Change," (1996). In addition, Frederick demonstrated that the Corps planning and evaluation protocols and procedures, embodied in the U.S. Water Resources Council's "Principles and Guidelines" are flexible enough to incorporate many issues that might arise from the prospect of climate change, and are very much compatible with the concepts promoted by the IPCC Working Group on Economic and Social Dimensions.

The "Galloway Commission" has provided more substantive and implementable policy recommendations in the aftermath of the 1993 Mississippi River flood than we can envision coming from the National Climate Assessment. In fact, we found no adaptation mechanisms cited in any of the literature of the past decade that were unique to ameliorating the water resources impacts of global warming. Realistically, every management alternative advocated in this series of papers, or in the IPCC reports, is based on the mechanisms and options developed by the water resources management community itself, beginning with the benchmark 1973 National Water Commission Report. We expect that, collectively, the policy initiatives of the Clean Water Action Plan, the National Drought Policy Act, the Western Water Policy Advisory Commission, the Florida

Everglades Restoration Program, and the CALFED Bay-Delta program will serve as the platform for a new generation of policy initiatives that will transform water management over the next several decades, and simultaneously form the nucleus of a successful coping strategy for whatever climate scenario that materializes over that period.

In summary, we feel that the cumulative consequences of a perpetual suite of policy changes that are being advocated and implemented throughout the U.S., in all facets of water management especially floodplain and drought management, has the salutary effect of overlapping many of the strategies and options that are being advocated by the various authors in this issue. Combine those ongoing policy changes with the routine use of risk analysis methods (Major, Stakhiv and Schilling) in all aspects of Corps planning, design and hydrologic analysis, along with improved modeling capabilities and technologies, and a reasonable person could conclude that the water managers are keeping pace with the expectations of the climate change scientists. That does not mean that the water management profession can sit idly by and wait for "marching orders." They must be actively engaged in the assessment and policy formulation process to ensure that the practical, cost-effective solutions are implemented. It is their existing water control systems that will form the core of any future management strategies. Water managers must become innovators and implementers of new technologies and policies. The pace and success of adaptive management rests with them, rather than the climate scientists.

BIOGRAPHY

Kyle E. Schilling is Director of the U.S. Army Corps of Engineers, Institute for Water Resources. In this role, he directs a diverse program of research and policy studies that supports the Director of Civil Works and the Assistant Secretary of the Army. His public service career of over 30 years includes a wide variety of water resources planning and policy experience in state, watershed, river basin, regional, and national settings with several agencies. He has led major national and regional water supply, drought, and infrastructure investment studies. He is an active member and office holder in several national professional societies. Kyle Schilling is a registered professional engineer and Certified Diplomate of the American Academy of Environmental Engineers.

Eugene Z. Stakhiv is Chief, Policy and Special Studies Division, at the Corps' Institute for Water Resources. In that role, he directs about 30 policy studies annually on various water management issues including ecosystem management, watershed planning principles, economic analyses, and risk management. The program also includes special studies devoted to decisionmaking models, simulation modeling, climate change impact analysis, and project planning and evaluation. He has been involved in the IPCC since its inception in 1988, as co-chair and lead author for water resources and coastal zone management. Eugene Stakhiv received his Ph.D. in water resources engineering from Johns Hopkins University, and has been with the Corps of Engineers for 30 years, beginning his career as a river basin planner.