

# Understanding Complexity and Uncertainty in Water Resources Management: An Introduction

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When developing strategies for the most effective and equitable use of water resources, a simple fact that every scientist, engineer and economist has to account for is that the behavior of these systems is highly unpredictable. This unpredictability can manifest itself in almost every aspect of water resources planning and management. The planning, design, management, and operation of flood control systems require the use of stochastic, rather than deterministic, descriptions of the behavior of both the water resource systems where flooding can occur and the human systems impacted by flooding. Developing long term water supply management plans not only requires an understanding of the intra- and inter-annual variability of natural water supplies, but, as has been realized within the last several decades, an understanding of how changes in climate will impact the variability of these supplies. This knowledge is required so that robust plans can be developed that ensure water supplies will be available to sustain our communities and societies in both the near and long term.

While it is clearly understood that our water resources systems can behave in a highly unpredictable fashion, our social, political, and economic systems require that the planning, design, and operation of these systems be undertaken in a concrete, and for the most part non-transitory, fashion. This presents a paradox for professionals engaged in water resources planning and management. That is, the description of water resource systems is inherently stochastic, but the plans that are used to design, manage, and operate these systems must be described with little or no uncertainty as to the actions and activities that will be undertaken. The reconciliation of this paradox has resulted in a great

deal of work over the last half century that focuses on better approaches to describing the uncertainty of the behavior of water resources systems and the constant improvement of methodologies on how to incorporate this uncertainty into risk-based decision-making processes.

This issue of the *Journal of Contemporary Water Research and Education* presents a series of articles that provide some of the latest approaches to describing the uncertainty of water resource systems and methodologies for how this uncertainty is used in risk-based decision making for a variety of water resource systems. These articles include case studies on uncertainty analysis and risk based decision making for flood control projects being developed by the U.S. Army Corps of Engineers. Not only are the methodologies used in these studies described, but a reflective analysis is also provided that describes the difficulties that are experienced when attempting to implement the use of advanced uncertainty and risk analysis methodologies in aiding the planning and design of flood control projects. Additional articles present case studies on how uncertainty and risk analysis can be conveyed to stakeholders in consensus-based water supply planning and management processes. In addition, an article addressing how uncertainty and risk can be incorporated into water quality planning and management through the TMDL process is presented. Finally, the difficulty of implementing advanced uncertainty and risk analysis procedures is discussed with the question posed “why isn’t risk analysis used more often in practice?” The author presents a hypothesis that for many water resource planning and management projects it may be a rationale decision not to use the most rigorous descriptions of uncertainty and

risk. This is followed by a reflective discussion on reasons why this may be a valid hypothesis; the discussion includes a qualitative analysis of the trade-offs that exist between the use of advanced analytical risk analysis tools and the budgetary and time constraints that exist in any water resources planning effort.

We hope that this issue will stimulate discussion not just on the technical aspects of implementing uncertainty and risk analysis methodologies, but also on the practical aspects of when these methodologies can be effectively used and how this information can be better utilized in decision making processes that involve the planning, management, design, and operations of water resource systems.

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