Interactions and Adaptations of Natural and Constructed Elements of Water Resources Systems

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Water resources management has faced many challenges, ranging from urbanization to population growth to climate change, all of which have altered water availability and demands. To build reliability into water resources systems and respond to growing societal and economic needs, the U.S. Army Corps of Engineers has provided the United States with water infrastructure projects to support navigation, flood risk management, water supply, hydropower and recreation needs. This increased reliability, however, has altered the natural characteristics of our freshwater ecosystems. As societal values shift towards protecting and restoring the environment, the negative effects of these ecosystem changes have become more apparent. Through this growing environmental awareness, the new field of ecohydrology has evolved, aiming to design and manage aquatic ecosystems and infrastructure to enhance compatibility with natural hydrologic variability. However, incorporating environmental constraints into water management removes some of the reliability at a cost to both society and the economy. Balancing environmental, societal, and economic needs is a challenge for today's engineers, scientists, and policy makers, especially with the added uncertainty of climate change.

The interactions between water management and the ecosystem management are unavoidable, and as these fields continue to develop they have begun to merge. Terms such as eco-engineering and hybrid engineering are now being used to incorporate a mix of ecosystem restoration and water management designed to benefit both the environment and society. Eco-engineering is the design, operation and management of ecosystems to provide societal and economic benefits while mitigating environmental impacts. Examples include ecosystem restoration to enhance fishery health, riparian restoration to support erosion control and navigation efforts, and tidal wetland restoration to mitigate coastal flooding. Further, while climate change has introduced uncertainty into the level of protection provided by structural water management designs, eco-engineering relies more on nonstructural and, therefore, less brittle approaches to water management that adds resilience into systems.

USACE and many water agencies at the state and local levels have begun to respond to these challenges and opportunities. USACE developed its ecosystem restoration business line to specifically restore freshwater ecosystems negatively affected by water management projects. In addition to restoration projects, traditional water management solutions are being adapted to a systems-approach, which combines structural and non-structural solutions. A systems approach attempts to build robustness into water management systems in order to protect against extreme events while maintaining a minimal impact on the environment. Efforts to estimate ecosystem goods and services—defined as socially-valued aspects or outputs of ecosystems that depend on either self-regulating or managed ecosystem structures and processes—are ongoing and incorporated into decision-making. Although these efforts are still in their early stages, considerable benefits for all sectors have become apparent.

As engineers and scientists, we must continue to explore solutions that meet societal, economic, and environmental demands by using ecosystem services to build reliability into our water management

systems. In this presentation, I will introduce the development of water resources management and ecohydrology, with a focus on the recent merging of these two fields into eco-engineering. It will highlight case studies from the U.S. Army Corps of Engineers, including the Sustainable Rivers Project, restoration work in the Everglades, and proposed approaches to the Hurricane Sandy recovery, as well as relevant work by other key agencies in these fields. The case studies will provide examples of key concepts in these fields, such as ecosystem goods and services and environmental flows. Finally, the presentation will highlight the challenges of decision-making under climate uncertainty and the role eco-engineering can play.