6-11-2002

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José Luis Minjares & Zohrab Samani, *Optimal Operation and Sustainability of the Multiple Reservoir System in the Yaqui Valley in Sonora, Mexico* [abstract], *in* ALLOCATING AND MANAGING WATER FOR A SUSTAINABLE FUTURE: LESSONS FROM AROUND THE WORLD (Natural Res. Law Ctr., Univ. of Colo. Sch. of Law 2002).

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José Luis Minjares, an interdisciplinary PhD student at New Mexico State University, has spent 23 years working in the operation of many irrigation districts in Mexico at the Comisión Nacional del Agua. As a PhD student, his research interest is focused in the optimal operation of water resources systems, specifically reservoir operation. He earned his bachelor's degree in Agricultural Engineering from the Universidad de Sonora in 1977, and his master's degree in Engineering and Administration of Water Resources from the Instituto Tecnologico de Sonora in 1986. Minjares has more than 14 years of experience teaching undergraduate and graduate level classes in several universities in Mexico.

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ABSTRACT

The increasing demand for fresh water in agriculture as well as municipal and industrial use calls for urgent measures to increase water management efficiency in irrigation areas around the world. Irrigation District No. 041, established in 1995 in the Yaqui valley, is one of the largest irrigation districts in Mexico. With an irrigated area of 227,224 hectares and 22,056 farmers, it is also one of the most productive. The infrastructure includes three dams with an effective storage capacity of 6712.5 million cubic meters; however, in the last six years this area has been faced with a severe drought, the worst in the history of the region. The economic and social impact of this event has been a disaster for agricultural users and for the

society in general. Water users and engineers of the irrigation district were not prepared to confront this long drought and have not been using stored water in the reservoirs in an optimal way. With the collapse of confidence in the security of available water from the reservoir's system, planning has become more difficult. Every agricultural year, farmers must wait until after the rainy season to know how much water will be allocated in the coming year; this uncertainty impairs farmers' planning and credit. Because the magnitude of the problem has been considered a regional emergency, Federal, State, and municipal government, as well as private water agencies, are trying to prevent or mitigate the negative effect of droughts.

Droughts are stochastic in nature, and thus perfectly accurate forecasting is nearly impossible. An alternative to minimize the negative effect of droughts in the Yaqui River watershed is to develop a reservoir operating policy (a formula for computing the optimal storage capacity for each reservoir) and to determine release commitments to be made at the beginning of each period. This operating policy must satisfy the users' objectives and maximize the total net benefits of the system. In this study a method based on seasonal water inflow to the reservoirs has been developed to determine the optimal operation for reservoirs, water allocation for irrigation of multiple crops, and municipal use. The proposed model uses genetic algorithms (GA), which are heuristic optimization techniques based on the concepts of natural selection. After the model was tested and validated, it was used to develop sustainable operational rules for the Yaqui River reservoir system. Seven hydrologic scenarios and different crops pattern were used to estimate the available volume of water to be used each agricultural year given some initial reservoir storage conditions. The model is easy to use, and the only input initial parameters are the storage volume at the beginning of the first month, and to choose the hydrologic scenario that will be used for the optimization.