Effects of Inflow Uncertainty on the Performance of Multireservoir Systems

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Abstract: Reservoirs are infrastructures that play an important role in supplying water. Hydrological and meteorological parameters, as the most important elements in reservoir systems' simulations, are uncertain. Thus, such uncertainties must be considered in integrated water resource management. This paper includes (1) generation of artificial time series based on probabilistic statistical models; (2) operation policies of hydropower reservoir systems; (3) analysis of risk and uncertainty of a reservoir system; and (4) development of performance indices for evaluation of hydropower reservoir system efficiency. To evaluate the effects of inflow uncertainty on the performance of a hydropower multireservoir system, this paper uses Monte Carlo simulation (MCS). Periodic stochastic models are used to generate different inflow time series. The generated time series are then used to run simulation and optimization models considering five scenarios. Subsequently, probability distributions of performance indices (volumetric reliability, time-based reliability, vulnerability, and resiliency) are extracted for each scenario. Moreover, the uncertainty of each parameter is measured by the coefficient of variation. Results show that the use of an optimization method to increase hydropower multireservoir system performance that considers inflow uncertainty yields the best volumetric reliability and vulnerability of management scenarios considered. The best values of temporal reliability and resiliency are obtained in single hydropower reservoir simulation and hydropower multireservoir simulation, respectively. In contrast, inflow uncertainty has the least effect on volumetric reliability (about 2%) and the most effect on resiliency (about 18%). **DOI: 10.1061/(ASCE)IR.1943-4774.0000756.** © *2014 American Society of Civil Engineers.*

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Introduction

Recently, many techniques have been developed and applied in many aspects of water resources systems such as reservoir operation (Afshar et al. 2010; Bozorg Haddad et al. 2008b, c, 2009, 2011a; Fallah-Mehdipour et al. 2011b, 2012), cultivation rules (Moradi-Jalal et al. 2007; Noory et al. 2012), pumping scheduling (Bozorg Haddad and Mariño 2007; Bozorg Haddad et al. 2011b; Rasoulzadeh-Gharibdousti et al. 2011), water distribution networks (Bozorg Haddad et al. 2008a; Soltanjalili et al. 2011; Fallah-Mehdipour et al. 2011a; Seifollahi-Aghmiuni et al. 2011; Ghajarnia et al. 2011; Sabbaghpour et al. 2012), operation of aquifer systems (Bozorg Haddad and Mariño 2011), and site selection of infrastructures (Karimi-Hosseini et al. 2011). Only a few of these works dealt with the effects of inflow uncertainty on the performance of multireservoir systems.

Parameters affecting the volume of water stored in a reservoir, as a part of a water resource system, include precipitation, river inflow, evaporation, leakage, and the amount of water released to meet demand. To develop a comprehensive and optimal operation policy of a reservoir system, uncertainties in meteorological and hydrological parameters need to be considered. Among those parameters, reservoir inflow is of paramount importance.

The stochastic modeling procedure comprises (1) preliminary analysis and model identification; (2) estimation of parameters; (3) tests of goodness-of-fit of selected model; (4) optimal tests of the model; and (5) reliability of estimated parameters. Many studies have been conducted to model periodic time series. Jones and Brelsford (1967) considered problems arising from data predictions based on periodic autoregressive moving average (PARMA) models. Salas et al. (1988) used multiple models of PARMA to provide artificial statistics of river flow. Anderson and Meerschaert (2005) used PARMA models to simulate static time series. They computed the asymptotic distribution for these estimates, which had a finite fourth moment. Anderson et al. (2007) presented an algorithm to immobilize periodic time series of river flow, and then used the algorithm to estimate model parameters. They used discrete Fourier transforms to represent the set of periodic autoregressive and moving average model coefficients. Anderson et al. (2008) used a PARMA model to analyze time series of weekly river flows. They computed the asymptotic distribution for the underlying noise sequence, which had an infinite fourth moment but a finite second moment.

There are two major approaches to determine reservoir operation policies: simulation and optimization methods. Wardlaw and

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