Determination of the Optimal Level of Water Releases from a Reservoir to Control Water Quality

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Abstract: The increase of pollution loads and of the diversity of pollutants threatening water resources calls for sophisticated management of water resources. This paper shows that the thermal stratification of water in reservoirs and the variation of its density with reservoir depth make it possible to manage sudden water-pollution events by controlling water release as a function of lake depth to minimize effects associated with the release of polluted water from reservoirs. The best outlet level of a reservoir to release polluted water is selected in this paper using the technique for order performance by similarity of ideal solution (TOPSIS). The latter is a multicriteria decision-making (MCDM) tool for managing water quality in reservoirs. The application of MCDM is illustrated with the management of reservoir releases to cope with the sudden spill of 30 m^3 of methyl tertiary butyl ether (MTBE) into the Amirkabir reservoir (Iran). The CE-QUAL-W2 calibrated model is used to simulate the spreading of MTBE in the reservoir. Pollutant spreading is predicted under four seasonal pollution scenarios and one scenario considering all seasons simultaneously. This allows for the consideration of the effects of climatic and water demand conditions on reservoir water quality. This paper's results show that the water should be released from the low-elevation gate in spring and winter and from the high-elevation gate in summer and autumn to optimally manage the sudden release of MTBE spills in the Amirkabir reservoir. **DOI: 10.1061/(ASCE)HZ.2153-5515.0000295.**

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Introduction

Recent publications dealing with optimization models have included several domains of water resources systems, such as reservoir operation (Ashofteh et al. 2013a, 2015a), levee layouts and design (Bozorg Haddad et al. 2015b), design operation of pumped-storage and hydropower systems (Bozorg Haddad et al. 2014), and algorithmic developments (Ashofteh et al. 2015b). However, in the analysis of some systems, it is not possible to develop an optimization algorithm for solving the problem. In such cases, simulation models [such as the Monte Carlo approach (Ashofteh et al. 2015c)] can be used as an appropriate tool. To derive operating policy (either through the use of optimization or simulation models), a few of these research studies have considered the transition probabilities (Ashofteh et al. 2013b). In addition, only a few of these works dealt with the qualitative management of water resources systems [such as Bozorg Haddad et al. (2015a)].

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The growing demand for safe water has spearheaded research on optimal ways to control water quality. One case in point is the modeling of water quality in reservoirs to respond to the sudden release of pollutants. Because of wide-ranging properties among pollutants in water one must choose a suitable model to simulate the behavior of contaminants in reservoirs. One of the strategies that is used at the time of the entry of pollutants into the reservoir is to determine the appropriate outlet level by simulation models. Nandalal and Bogardi (1995) used the dynamic reservoir simulation model (DYRESM) and a nonlinear programming (NLP) model to determine appropriate locations for reservoir outlets in order to affect the quality of water released from the reservoir. The quality of released water from the reservoir was a constraint. The model was used to obtain a suitable operation policy for water release in the Rais-Ali Delvari dam (Iran). Elçi (2008) examined the effect of thermal stratification on water quality in the Tahtali reservoir (Turkey) by using field observation and statistical analysis. Their results indicated that air temperature, wind speed, and humidity were important parameters in the thermal stratification in the reservoir and had an effect on its water quality.

To determination of the appropriate outlet for a pollutant requires a pollutant simulator capable of simulating thermal stratification in a reservoir. The two-dimensional model CE-QUAL-W2, as well as models such as DYRESM and SNTEMP, can simulate thermal stratification in reservoirs (Norton and Bradford 2009). The following review of pertinent publications demonstrates the viability of CE-QUAL-W2 to simulate water quality in stratified reservoirs.

Gelda et al. (1998) applied the U.S. Army Corps of Engineers' water quality modeling (2D) (CE-QUAL-W2) to the Cannonsville reservoir (located in Delaware County, New York). The model was calibrated with temperature data collected at six locations within the reservoir over the April–November period of 1995 (with a weekly time interval). Their study succeeded in simulating temperature regimes in different climatic periods with the CE-QUAL-W2 model.

Etemadi-Shahidi et al. (2009) investigated the total maximum daily load (TMDL) of total dissolved solids (TDS) from the