TWO-DIMENSIONAL HYDRAULIC MODEL FOR RESERVOIR SEDIMENT FLUSHING STUDIES

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This paper presents a two-dimensional hydraulic model using the finite volume method for reservoir sediment flushing studies. This model is based on an earlier work by Zhao et al. (1994). The sediment transport equation proposed by Ackers-White (1973) is used in the mathematical model. In this study, the reservoir sediments are treated as non-cohesive materials and also only one sediment size. The hydraulic equations used are the depth-integrated conservation equations of mass, momentum (longitudinal and transverse), suspended sediment, and total sediment. In the finite volume method, the mass, momentum, and suspended sediment fluxes of the conservation equations are calculated for each side of a finite volume based on an approximate Riemann problem solution. The Riemann problem solution involves approximating the fluxes by the characteristic solution of the governing equations. To solve the total sediment conservation equation, similar fluxes are calculated using the Ackers-White sediment transport equation. The reservoir sediment-flow model is applied to the Pulangi Reservoir in Bukidnon, Philippines for sediment flushing studies. Pulangi Reservoir is experiencing accelerated sedimentation and it is in danger of filling-up with sediments unless drastic engineering intervention measures are employed. In particular, the original storage capacity of Pulangi reservoir in 1985 has been reduced by as much as 30 percent based on 2002 field surveys. Prolonging the life of this reservoir would require proper sediment management and control. In the Pulangi Reservoir, sediment flushing operations is a more economical and long-term sediment control strategy, however, initially and perhaps occasionally in the future, dredging operations are needed. Two simulation scenarios have been performed. The first simulation scenario is the case with no sediment flushing operation in the reservoir for a total simulation period of 200 hours (8.3 days). The second simulation scenario is with sediment flushing operation started at the beginning of 121 hours for the next 48 hours. In this second scenario, the sediment flushing sluiceway gate was opened up to 1.0 meters and the gate opening and closing operations were accomplished in 1 hour. The simulation results indicate that sediment flushing operations over a 48 hour period can scour the reservoir bed to as deep as 2.5 meters in the vicinity of flushing sluiceway. Approximately 29,000 cubic meters of sediment is removed during this period (based on resulting bed elevations with and without sediment flushing). This is with 1.0 meter sluiceway gate opening and associated discharge of about 250 CMS. Reservoir elevation is about 281 meters at the damsite and reservoir inflow range from 85 to 100 CMS. This is a moderate hydraulic condition for flushing operations since reservoir inflows (historically) can be over 270 CMS and water elevations of 285 m. It is concluded that flushing operations is effective and especially when scheduled during periods of high flows and subsequently high reservoir elevations without compromising hydropower generation.

Keywords: Reservoir sedimentation, sediment flushing operations, two-dimensional model, finite volume method, simulation studies