Smithland Lock and Dam Modeling

Background

The development of a hydroelectric power plant at the existing Smithland Lock and Dam is proposed by American Municipal Power-Ohio. The dam is located on the Ohio River near Smithland Kentucky, and the proposed power house would be located on the east side of the river. The proposed turbines have a capacity of about 50,000 cfs and operate at Ohio River flows of less than 300,000 cfs. MWH Americas is the Owner's Engineer and hydraulic model studies are being managed by Franklin G. DeFazio, Inc.

Construction of the plant will result in a change in the discharge patterns downstream of the locks and dam. Under the existing condition, flow passes through 11 radial gates on the west side of the river for all flows less than 300,000 cfs. Under the proposed condition approximately the first 50,000 cfs will pass through the turbines.

The change in flow distribution and the need to construct a tailrace through an existing island will change the flow patterns and sedimentation patterns downstream of the dam. Numeric and physical model studies were undertaken to quantify the changes. The numeric model study was used to evaluate the changes in erosion and sedimentation downstream of the powerhouse.

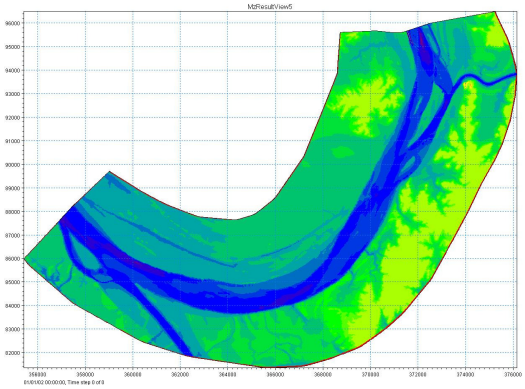

Figure 2: Model domain colored by elevation.

Modeling Description

The numeric model MIKE21-C was used to simulate a range of steady state flow conditions ranging from 18,000 cfs to 929,000 cfs. In addition, the model was used to simulate 3 month flood hydrographs. The hydrodynamic model and sediment transport model in MIKE21-C are coupled, thus the flow patterns are recomputed as the bed geometry changes. Hydrodynamic time steps are 4 seconds or less and bed geometry is updated every 2 minutes. The relatively short time steps make it possible to simulate rapid changes in flow and stage and capture sediment deposition due to falling hydrographs.

Model results showed that changes in sedimentation patterns are generally local and confined to a few channel widths downstream of the dam. The model was able to capture transient sediment movement during periods of high flow, showing where sediment is deposited and then scoured at lower flows.

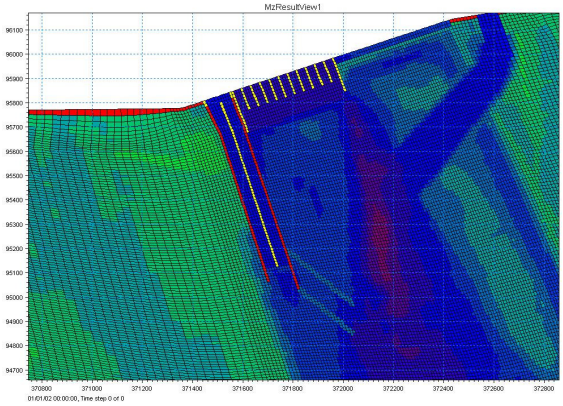

Figure 1 Upstream end of model showing computational mesh, colored by elevation.

MIKE21-C is a comercially available software package well suited to modeling sand bed ricers where water stratification can be neglected. The model solves the shallow water equations on a curvilinear grid giving a two dimensional depth averaged flow field. A variety of forcing functions are incorporated in the model including bottom shear stress, wind shear, barometric pressure, Coriolis acceleration, momentum dispersion, sources and sinks, evaporation, flooding and drying and wave radiation stresses. Seven sediment transport functions are incorporated in the model to accommodate various river bed types. The numeric scheme used in MIKE21-C is able to simulate areas with periodic wetting and drying without numeric stability problems.

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