USE OF A 3D RANS MODEL TO PREDICT STRATIFICATION EFFECTS RELATED TO FISH PASSAGE AT HYDROPOWER DAMS

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This paper discusses the application of a 3D RANS model as a prediction tool to simulate flow and temperature distributions within the McNary Dam and its forebay (Fig. 1) situated on the Columbia River. The model contains all the relevant geometrical details of the hydraulic structures and forebay bathymetry (Fig. 2a) over a length of 13,000ft upstream of the dam, the 14 powerhouse units (Fig. 2b), 22 spillway bays and the navigation lock. Close to 6 million cells were needed to mesh the computational domain and properly resolve the thermal boundary layer at the free surface. The Boussinesq flow module in FLUENT is utilized to obtain the flow hydrodynamics and temperature distributions. The model is first validated using temperature field data supplied by the US Army Corps of Engineers (USACE). It is found that the model is able to accurately predict the salient features of the thermally stratified flow in the forebay for a test case corresponding to strongly stratified conditions. Next, two types of structural changes are considered to alleviate problems related to the presence of high temperatures at the gatewells of the powerunits, especially at those situated near the southern shore (units 1 to 4). The first consists of modification of the intake roof geometry in the intake units (two new designs denoted roof_1 and roof_2, see Figs. 2c, 2d and 2e) and the second consists of introduction of a floating barrier curtain in the forebay (two different positions of the curtain relative to the dam were considered, curtain_1 and curtain_2). The use of a modified intake roof geometry corresponding to roof_2 geometry (1:4 slope) was found to mildly decrease the gatewell temperatures at most of the intake units, however the effect at some of the units close to the southern shore was to slightly increase the temperature in the gatewells. Overall the use of the proposed new roof designs does not appear to be able to

address the observed problems near the southern shore. While curtain_2 results were also mixed and showed large temperature increases for the gatewell temperature in unit 1, it was found that curtain_1 configuration (Fig. 2f) induced more mixing in the critical region near the southern shore with the effect of decreasing the temperatures in that region and in the gatewells of the corresponding units. The results of these simulations will be used in combination with field collected water quality and biological information to support decisions to alleviate the occurrence of adverse thermal conditions at McNary Dam.

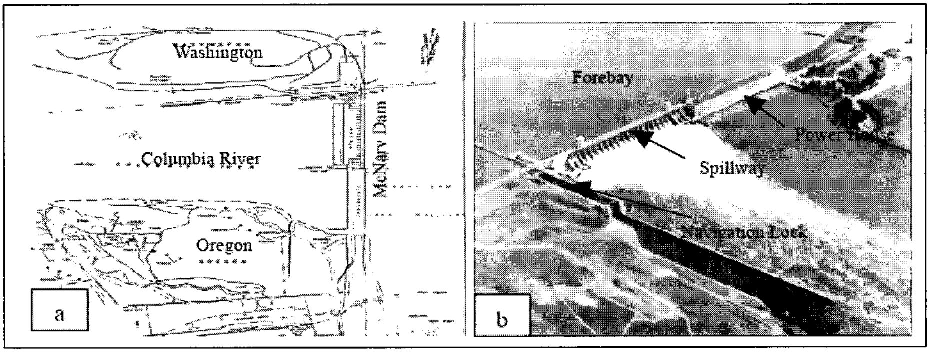
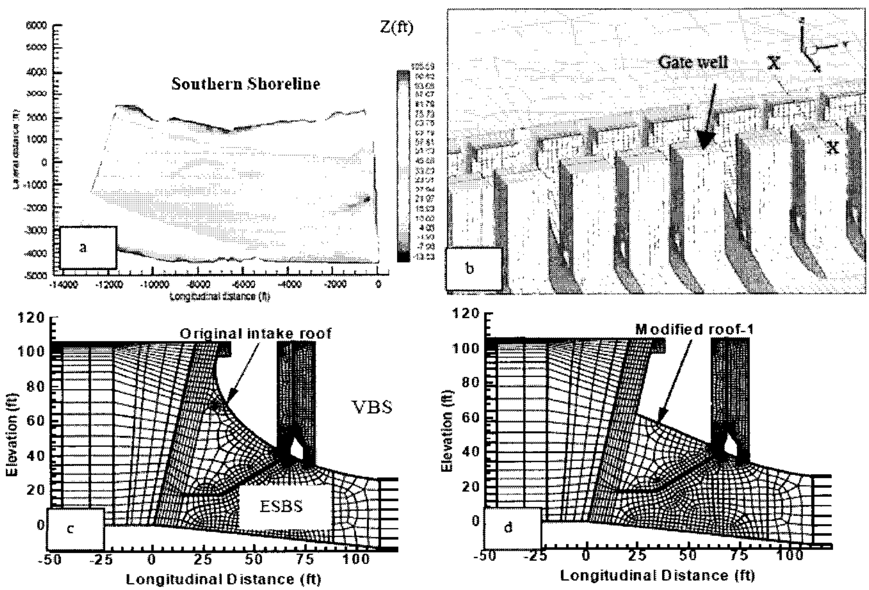


Fig. 1 Aerial view of the McNary Dam and its forebay. a) Location and orientation of the dam; b) Detail view of the dam and its appurtenances.



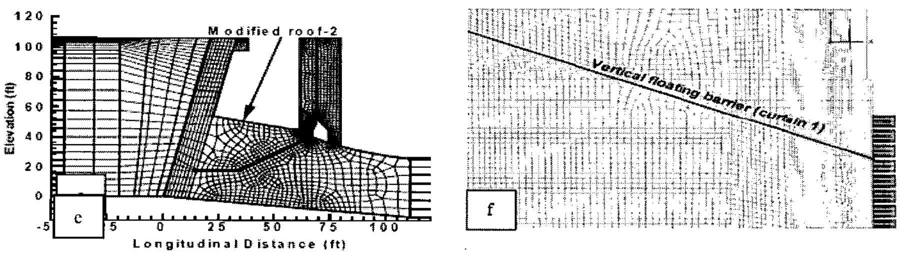


Fig. 2 Views of computational domain. a) Bathymetry contours; b) 3D mesh in the powerhouse area; c) Longitudinal section showing original intake roof in the intake; d) Section showing intake roof_1 geometry; e) Section showing intake roof_2 geometry; g) 2D mesh at the free surface showing the location of the floating vertical barrier (curtain_1).