PHOENICS News

Summer 2008

PHOENICS Applications by the Tennessee Valley Authority (TVA)

TVA's Boualem (Bo) Hadjerioua describes three TVA projects using PHOENICS. In the first two examples, several millions of dollars were saved.

The full report can be found at: http://www.cham.co.uk/casestudies/Summary_PHOENICS_Projects.pdf

1. TVA's Colbert Fossil Plant Skimmer Wall

The purpose of this study is to design an optimum skimmer wall at Colbert Fossil Plant (COF) to reduce de-rating due to thermal compliance and debris entrainment in the COF intake channel. The report presents the justification, potential benefits and the proposed design of a skimmer wall at COF.

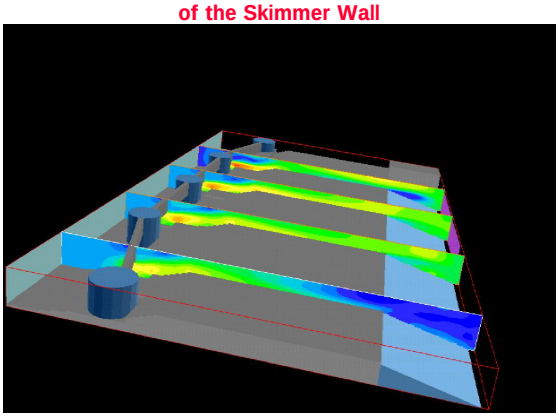
Barge Collecting Debris at COF, 2001

Water temperature monitoring at COF indicates that an improvement in water temperature could be made if water is withdrawn from bottom layers of the Tennessee River. Installing a skimmer wall at the appropriate location and depth would accomplish this goal.

The study determined the optimum location and depth of the skimmer wall to minimize de-rating at COF without any negative environmental impact. COF also experienced a big inflow of debris that affected the plant generation's efficiency. Therefore, by building a skimmer wall, two objectives would be targeted; lowering the intake water temperature during thermal stratification, and blocking the debris from getting in the intake channel. However, it was necessary to justify its implementation and the associated capital cost.

A detailed study of the water temperature profile has shown that if a skimmer wall is built at COF with a bottom elevation at 400 feet, the savings from thermal compliance would have been about $354,000 in 1999. The debris problem at COF cost 80,000 MWh of de-rating at the plant in 2000.

Computed Velocity Profile Contours at Several Locations of the Skimmer Wall

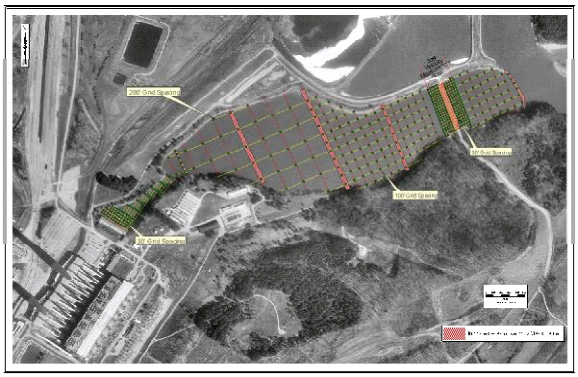


The estimated capital cost to built a skimmer wall at COF is about $1.4 million. Therefore, just the savings from 1999-2000 covered the cost of the skimmer wall, which is expected to last more than 50 years.
Numerical modelling of the intake channel, with skimmer wall bottom at elevation 400 feet, has shown that the maximum velocity below the skimmer wall is 1.5 fps compared to the existing conditions of 0.5 fps. The computed velocity profiles were used to evaluate the 316b issues (fish entrainment/ impingement by intake structures).

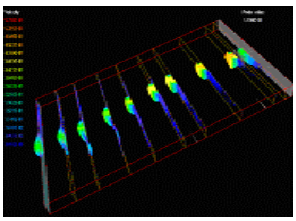
2. TVA's Kingston Fossil Plant Multi-Ports Diffusers

A reduction system for control of nitrogen oxides (NO_x) in the air emissions is being implemented at Kingston Fossil Plant (KIF). This new technique uses ammonia to reduce the emissions. The fly ash combustion by-product contains ammonia. The fly ash is sluiced to a series of ponds for settling, and the sluice-water is discharged from the ash pond into the intake channel.

Survey at KIF intake Channel



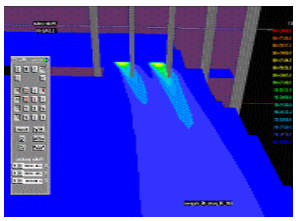
The maximum ammonia concentration entering the intake channel is predicted to be 2.85 mg/L. At such elevated levels, ammonia can be toxic to aquatic life. It potentially adds to the biological oxygen demand, lowering dissolved oxygen levels and encourages algal blooms. KIF is evaluating alternatives to avoid violating water quality standards for ammonia and prevent potential fish kills.



Velocity Vector taken at Several Intake Channel Sections

One proposed alternative is to route the ash pond discharge into the condenser cooling water discharge, where it would be fully mixed and diluted. The estimated cost for this option is about 8 million dollars. A less costly proposed alternative, costing about 500 thousand dollars, is to discharge from the ash pond through a diffuser system added onto the existing discharge pipes to enhance mixing and dilution in the intake channel.

Diffusers Angled at 45 degree, Instantaneous Mixing

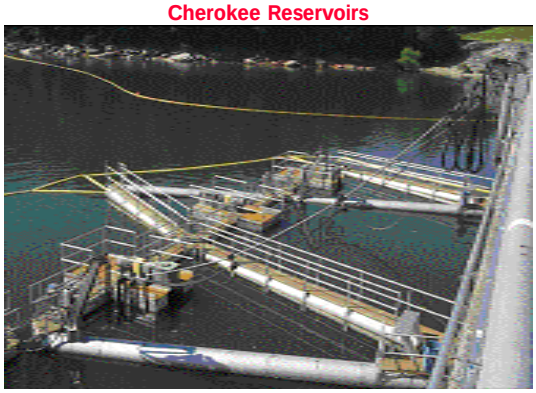


A detailed modeling study of the intake channel flow patterns was carried out to optimize the design of the diffuser system to facilitate instantaneous mixing in the intake channel, maximize dilution, and thus, bring the ammonia (NH_3) concentration to acceptable levels in the intake channel. The modeling results show an instantaneous mixing and reduction in NH_3 to about 0.23 Mg/L within 140 feet downstream the diffusers, concentration well below the Criteria Continuous Concentration (CCC) of 0.55 mg/L for KIF intake channel.

3. TVA's Tims Ford Reservoir Surface Water Pumps

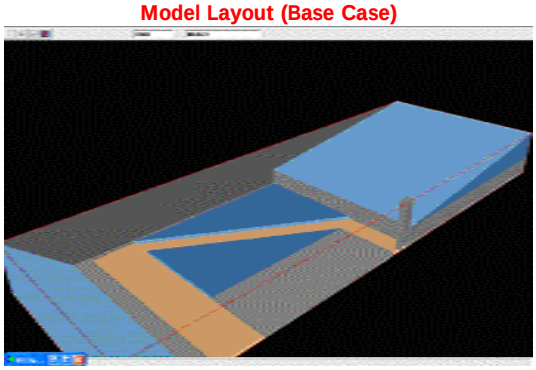
The report describes the numerical simulation of surface water pump performance at Tims Ford Dam. The modeling objective was to evaluate surface water pumps performance under several configurations, pump sizes, and initial propeller velocities.

Surface-water pumps being ssed at Douglas and Cherokee Reservoirs



The goal was to determine an optimum design to maximize the improvement of water temperature and dissolved oxygen (DO) content in hydropower plant releases without disturbing reservoir bottom sediment. The results for two alternatives are presented; a three 12-ft pump and a six 8-ft pump layout.

Model Layout (Base Case)



The modeling of the alternative layouts was evaluated under summer pool elevation with a relatively strong thermal stratification and a relatively high DO content only in the upper few feet of the reservoir. PHOENICS was used to evaluate the flow field, water temperature, and DO improvements. Turbulence was accounted for by using the K-E turbulence model, and the Boussinesq approximation was used to include the domain buoyancy effects. The report presents the modeling results of surface water pump designs, locations, and operating speeds under summer pool reservoir elevation for three and six pump layouts

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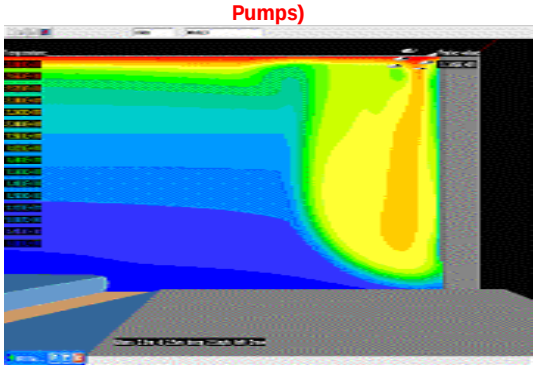
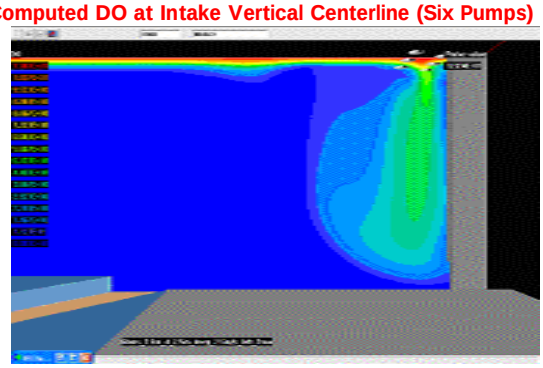
Computed Temperature at Intake Vertical Centerline (Six Pumps)



Computed DO at Intake Vertical Centerline (Six Pumps)



Based on the comparison of several surface pumps layout scenarios, the recommended option of surface water pumps for Tims Ford Forebay Reservoir is the six 8-ft pump layout. Under the June 26, 2003, forebay profile, this option improved the water temperature release by 10.3°F and the DO by 2.0 mg/L.

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