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CHAM Case Study – Pumping Station Water Extraction

CFD Simulation of a Water Extraction Pumping Station

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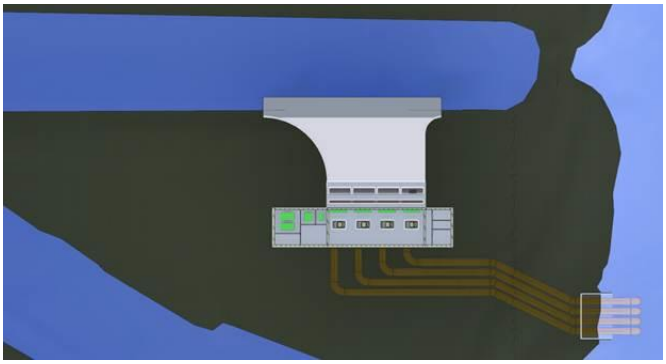
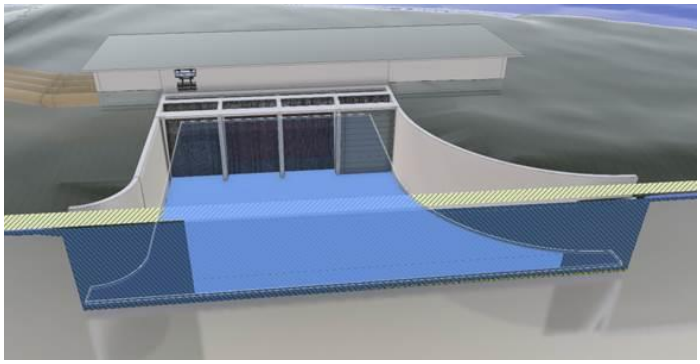
October 2018

Haskoning DHV UK Limited, a division of the Royal Haskoning DHV Group, approached CHAM for assistance in predicting the operation of a new pumping station being designed for a planned development in the Middle East. The objective was to model water entering a pumping station from the approach channel/forebay, through an intake and past dividing walls that separate four pumps. Two orientations of the pumping station were considered; the first angled at 90^{o} to the channel, and the second angled at 30^{o}.

The purpose of the exercise was to compare the two proposed designs by reviewing the 3D velocity field approaching the pumping station, through the intake bend and fine eel screens and finally through separation walls to the pumps.

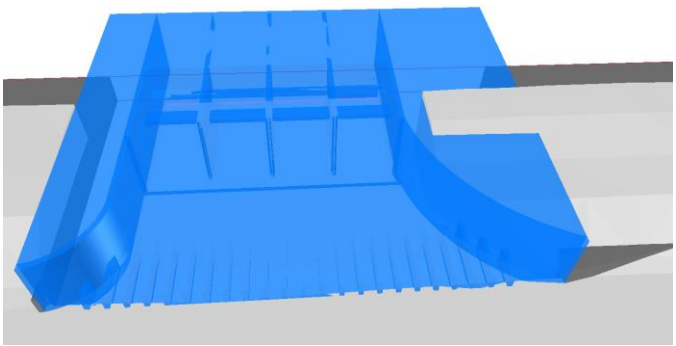


Pumping Station schematic Plan View

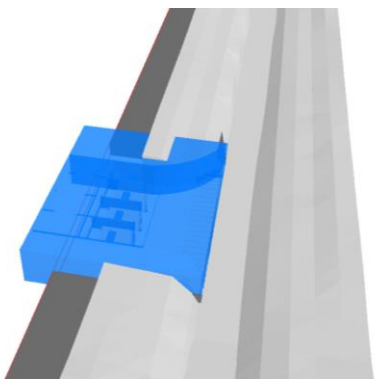


Pumping Station schematic with intake bend & eel screens

The CFD model was created using terrain data for the approach channel and CAD input for each pumping station orientation. The cases were run as single-phase, steady-state models, with the upstream water level and downstream pump capacity both fixed (and taken from other modelling data). The CFD model ended downstream of the pump intakes at four abstraction points before the pipes.



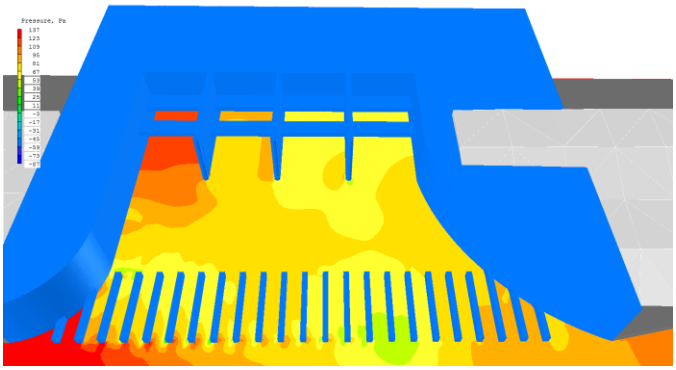
Pumping Station CAD import



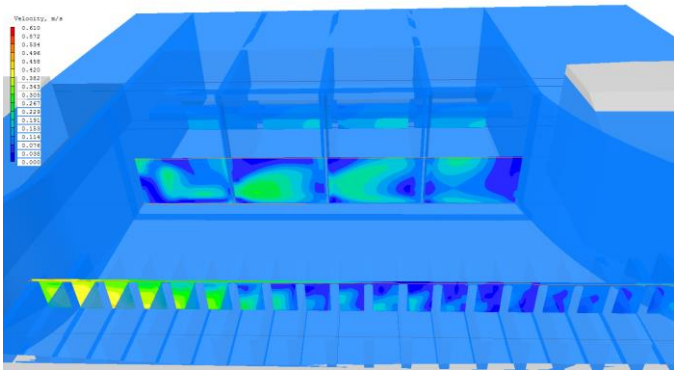
Pumping Station CAD import with approach channel

The initial case studied the water flow without the eel screens in situ. The case used a grid of 800,000 cells and took less than 2.5 hours to run to convergence on a 3.4GHz quad-core PC with 16GB RAM.

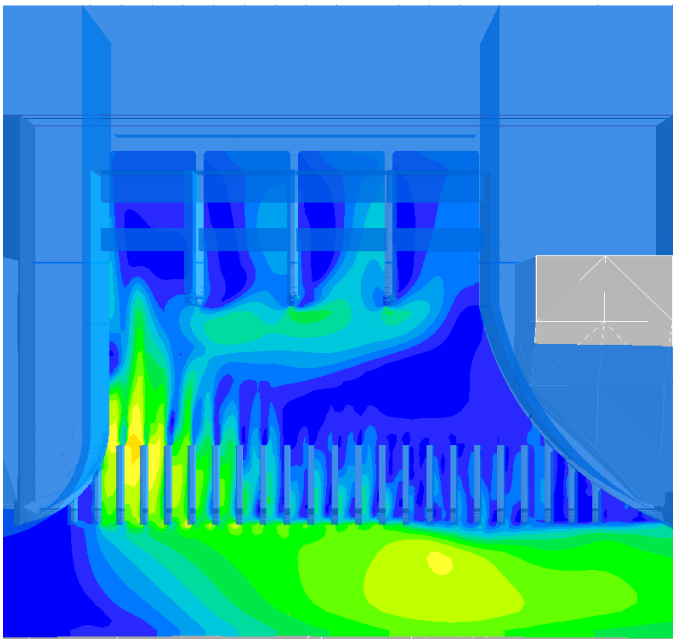
The result for the 90° angle shows the not-unexpected imbalance in water pressure and velocity has been tempered only slightly by the preceding guide channels. The momentum of the water in the approach channel carries it past a large section of the pump station intake, resulting in the bulk of the water entering the station through the downstream baffles. The pumps, all operating at the same extraction rates, force the water to redistribute itself in the area between the baffles and the separation walls to the pumps, resulting in an uneven and circulating flow field.



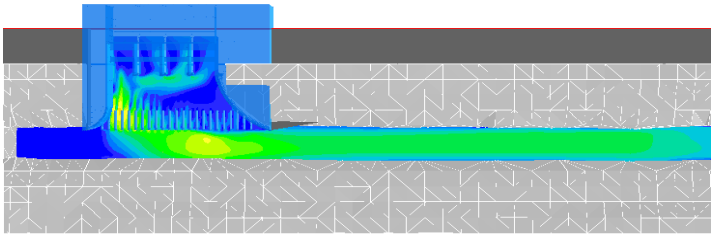
Pressure 0.9m depth



Velocity Y slices

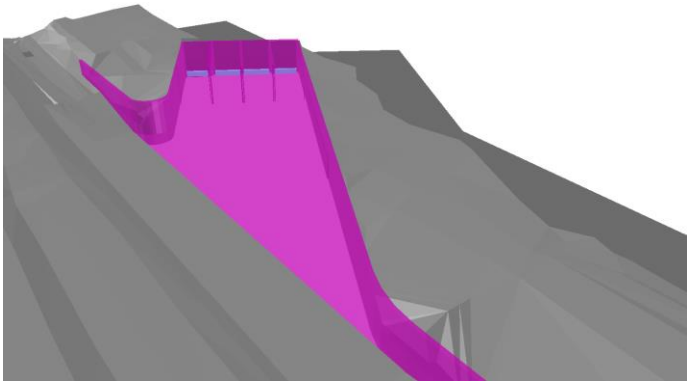


Velocity 0.9m water depth Plan View

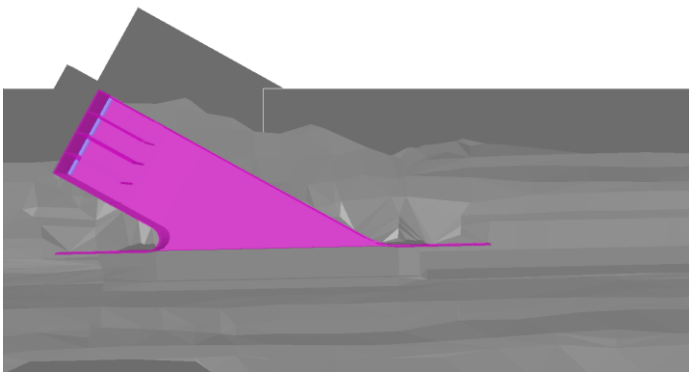


Velocity 0.9m water depth including approach channel

An alternative orientation for the pumping station to the channel was investigated; this involves a shallower, 30° angle of the pump station to the channel, as shown below:

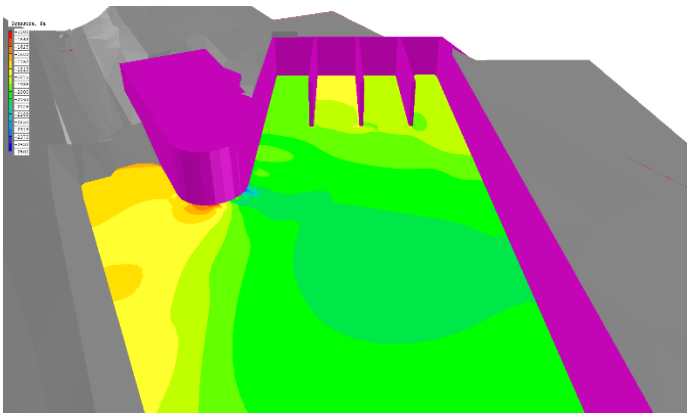


Pump Station re-positioned at a 30° angle

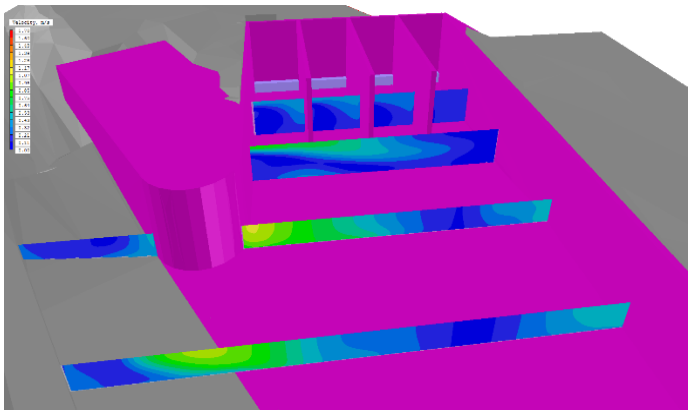


Pump Station with approach channel

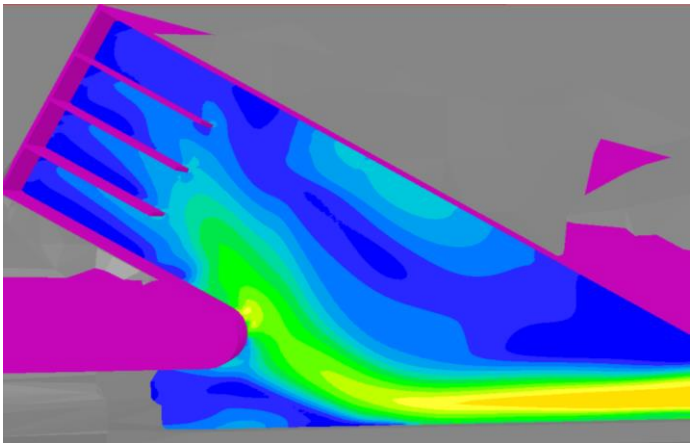
The expectation being to spread the incoming water flow more evenly across the forebay and four pump intakes.



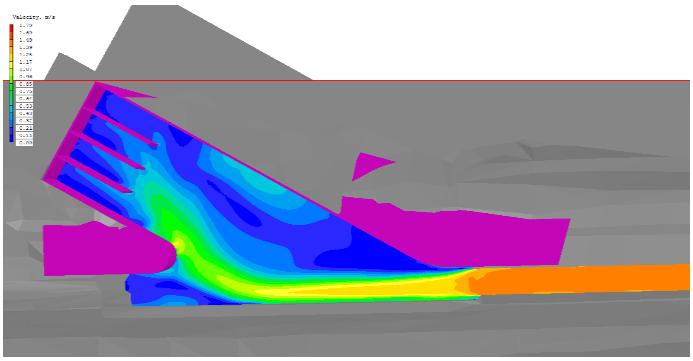
Pressure at water depth of 0.9m



Velocity Y slices



Velocity at depth 0.9m, Plan View



Velocity at 0.9m depth with approach channel

The preliminary 30^{o} rotated design shown proved to be only partially successful. The high-momentum water from the channel continues to travel along the same direction as the channel, and eventually turns into the pump station due to the pumps and a pressure build up in the overflow channel. This results in a large rotating region of water covering most of the pump station forebay.

This particular design did not employ guide vanes, as were installed in the previous CFD model. These were subsequently re-instated by the client and their curvature adjusted for optimum performance during their next stage of design investigations – once again demonstrating the cost- and speed- benefits of using trial-and-error CFD simulation ahead of physical modelling or full-scale construction.

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