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Numerical modelling of selective withdrawal for the mitigation of salt intrusion

Salt intrusion causes an additional strain on fresh water resources on top of the increased frequency and severity of droughts. The operation of sea locks causes a loss of fresh water towards the saltwater side and a flow of saltwater towards the fresh water side. A salt screen is a hydraulic structure that can be used to increase the efficiency of flushing salt water back to sea after a lock exchange flow, by selectively withdrawing only the intruded salt water.

The application of numerical and empirical models to the quantification of flushing effectiveness were investigated. Two numerical models, using STAR-CCM+ and Delft3D, were validated using the scale model experiments of the Noordland sluice (Delft Hydraulic Laboratory, 1973), and an additional STAR-CCM+ model was made to validate the empirical outflow concentration prediction model by Fan (2008).

Both numerical models showed good agreement to the scale model experiments. The accuracy of the RANS based STAR-CCM+ model goes down with the Reynolds number. The turbulent Schmidt number has a significant influence on the evolution of the density interface in low Reynolds numbers flows, but its effect cannot be generalized and it therefore should not be used as a tuning parameter to acquire the desired results. Overall, Delft3D is only slightly less accurate than STAR-CCM+, but the downside to Delft3D is that some modifications needed to be made to the geometry to reach the presented accuracy.

The empirical model has limited applicability in practical situations due to biases for withdrawal from a specific layer, which can cause an underestimation of the loss of fresh water. Calibration of the empirical parameters based on field measurements or experiments could improve the results. Some additional improvements are suggested based on assumptions made, altering said assumptions and introducing new model parameters. The presence of a mixing layer as opposed to a sharp density interface decreases the effectiveness of a salt screen, but this decrease in effectiveness could not be detected by the empirical model.

Sources:

Delft Hydraulics Laboratory (1973). "Stroomsluis Noordland in de Oosterschelde dam, selectief afzuigen twee-dimensionaal onderzoek". In: Verslag modelonderzoek (M1204).

Fan, J. (2008). "Stratified flow through outlets". In: *Journal of Hydro-environment Research* 2, pp. 3–18.

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