Hydraulic model for evaluation of peaking operation in Nidelva

Introduction

Energy transition is a fundamental step towards sustainability. In this frame, hydropower is expected to play a key role to balance the load of other renewable resources. **Hydropeaking** refers to releases of water retained in storage reservoirs to generate electricity in response to variations in market demand, for instance because of intermittent electricity generation from solar and wind energy.

The fluctuations caused by hydropeaking usually have a **high impact** on the downstream natural morphology and biological conditions, particularly related to stranding of fish and other species. Modelling and quantification of **ecological effect** of hydropeaking are a main issue in for optimization and decision making in order to select appropriate mitigation methods.

This research is part of the **H2020 project HydroFlex**. The HydroFlex project aims to develop new technology permitting highly flexible operation of hydropower stations. Flexibility of operation here means large ramping rates, frequent start-stops and possibilities to provide a large range of system services. All this while observing strict environmental and social regulations and being economically competitive compared to alternative solutions.

Objective

The present work develops a calibrated two-dimensional hydraulic model in Nidelva (Figure 1), Norway, for evaluation of hydropeaking operation downstream the lowermost hydroelectric powerplant outlets to the mouth of the river in the Trondheimsfjord.

Study site and data utilized

This river is part of the Nea-Nidelva catchment which includes a series of 17 hydropower production units producing an annual average of 2.550 GWh. The river topography was collected as a compilation of data from previous projects and original surveys. Most of the bathymetric data were collected using Acoustic Doppler Current Profilers (ADCP) from a variety of platforms including motor boat and kayak.

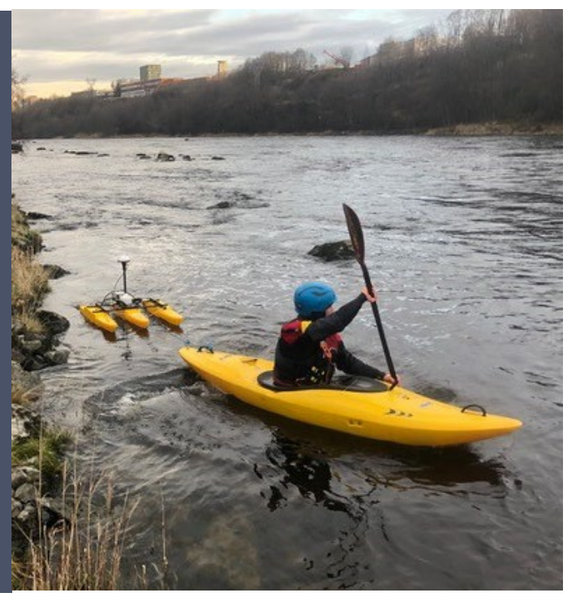

Figure 1: Picture of fieldwork in Nidelva measuring with ADCP sailed by a kayaker

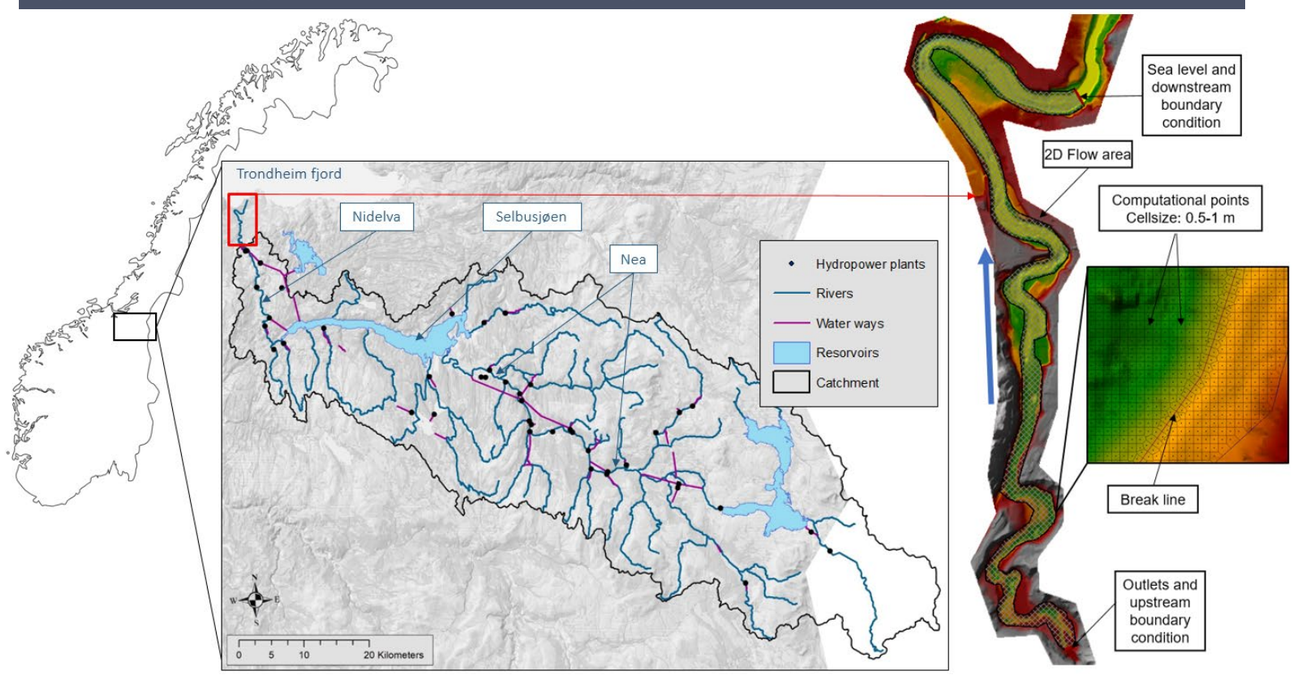

Figure 2: Map of the river Nidelva, flowing from Selbusjøen reservoir to Trondheimsfjord. The 9 kilometer long study reach of lower Nidelva from the outlets of the power plant to the mouth of Trondheimsfjord showing the computational area and cell distribution.

Methods

The program HEC-RAS 5.0.7 was used to create the 2D hydraulic model (Figure1). The model calibration was performed by altering the manning roughness coefficient.

Validation data: The results were compared against 42 RTK-GPS measurements (Figure 3) taken at 85 cms , aerial pictures at 97 cms additionally a 1D model was developed and temperature measurements were also compared.

Results

The results show that the simulation is dependent on the manning number calibration. The maning number was set to 0.045, 0.08 and 0.09 depending on the area. The error on water surface elevation modeled and measured was reduce to 6 cm after calibration.

Areal picture show similar patterns in the river channel (Figure 4)

The simulation shows that 80.000 m2 of dry areas appear from full production to minimum flow, some particular areas show drastical reduction in wetted area (Figure 5)

The 1D model for temperature modelling was also calibrated adjusting the manning numbers for every cross section giving a final error of 6 cm on WSE.

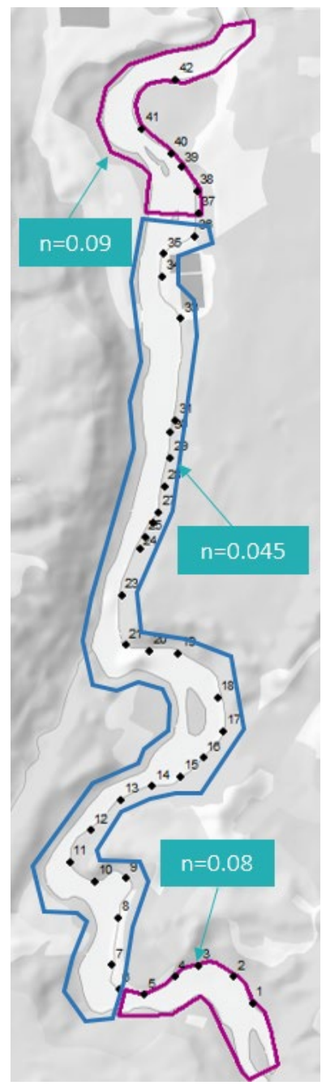

Figure 3. Calibrated manning number distribution and validation points

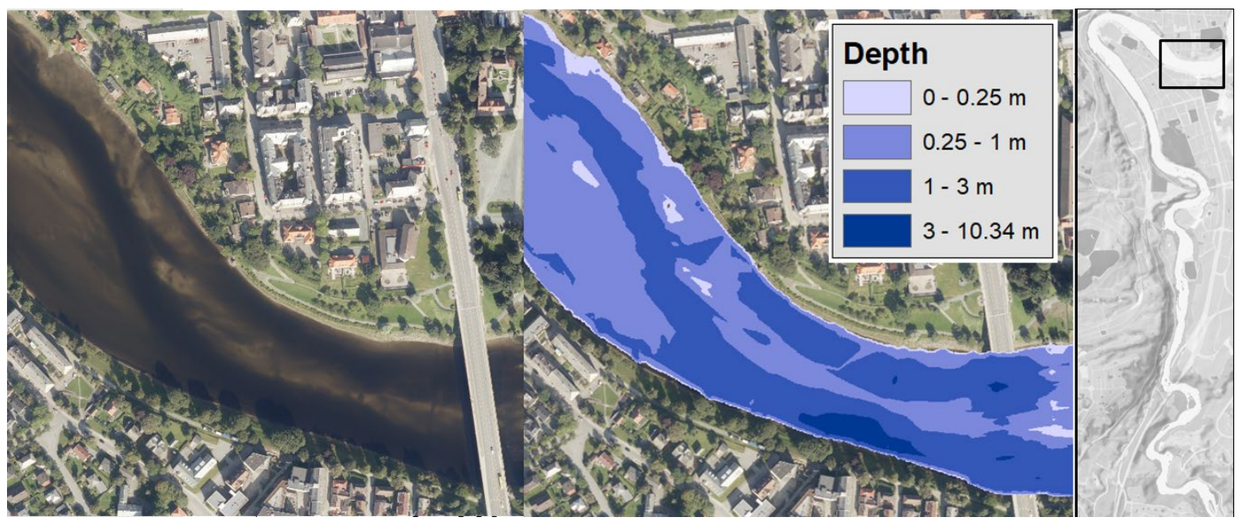

Figure 4. Visual comparison with areal picture of the river flow upstream of Elgeseter bridge

Figure 5. Visual comparison with areal picture of the river flow upstream of Elgeseter bridge

Discussion

We can conclude that this model is well calibrated and it will be a significant tool to evaluate the flow fluctuation and mitigation measures suggested for present and future scenarios. The results will help to evaluate drying areas at different flows and dewatering speed, which can identify critical areas on the river. These results will be related with previous studies on fish stranding and mortality, which have shown that the hydropeaking affects the trout population and suggest mitigation measures.

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