Hydraulic modelling of a regulated river reach on different scales to evaluate its inherent environmental conditions

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Hydraulic modelling can be an important tool to assess ecological status of rivers and to evaluate where and how measures should be implemented to maximize their impact. This is becoming increasingly important in regulated rivers since hydropower's ability to balance intermittent electricity sources such as wind- and solar power is resulting in more frequent starts and stops of the power plants, which in turn is affecting the local environmental conditions. The resulting flow fields from the modelling can, for instance, be used to classify biologically important areas in rivers. A number of relevant flow parameters can be predicted and applied, e.g., depth and water velocities can be used to estimate habitat areas for specific fish species or the variation in water levels can be used to evaluate the risk of stranding for fish in different life stages.

This work specifically involves numerical modelling of a stretch of a heavily regulated river between the powerplants Akkats and Letsi in the Lule River in northern Sweden, which has been identified to have good potential to increase natural values through restoration. Models are created in 1D and 2D using HEC-RAS solving the Saint-Venant (shallow water) equations and a fully 3-dimensional model is simulated in Ansys CFX using a RANS approach to show strengths and weaknesses in the different modelling techniques. To ensure that the models capture reality, measurements of water levels and temperatures in the reach are performed over several months using pressure/temperature loggers. This data is then used to calibrate and validate the models and assess their suitability. River velocities are also measured with an Acoustic Doppler Current Profiler which are mainly used to validate the more advanced 2D and 3D models.

The results derived using the different modelling methods are all shown to be useful depending on relevant application. The dampening of flow changes along the river is most suitable to be investigated in 1D or 2D, habitat and stranding risk are most reasonable to evaluate with 2D models, and 3D models are required in instances when detailed knowledge of the flow field is needed. As an example, the results from the 2D simulations are used to find suitable habitat for European Grayling (Thymallus thymallus) in the reach and it is shown to be dependent on the flow rate of the river.

Future developments could include implementations of modelling tools with integrated modelling of fish populations and benthic fauna for a more direct assessment of the effectiveness of measures on e.g. habitat, seasonal migration and connectivity. However, such work must be carried out in close collaboration between hydraulic and biological competences.