Fishfriendly Innovative Technologies for hydropower (FIThydro) Swiss case studies HPP Bannwil & HPP Schiffmühle

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Introduction

Two case studies at run-of-river hydropower plants (HPPs) in Switzerland are conducted within the scope of the interdisciplinary "Fishfriendly Innovative Technologies for Hydropower (FIThydro)" project which is funded by the Horizon 2020 framework program (grant agreement No 727830) of the European Union for research and innovation. The investigations focus on the velocity field (ADCP measurements and numerical modeling), the monitoring of fish downstream migration, and the sediment connectivity.

Run-of-river hydropower plant Bannwil

The run-of-river HPP Bannwil is a block-unit power plant at the River Aare in Switzerland (Fig. 1) with a design discharge of 450 m^3/s. The gross head amounts to 5.5 – 8.5 m depending on up- and downstream water levels. The three 4.35 m diameter bulb turbines have an installed capacity of 28.5 MW, resulting in an average annual production of 150 GWh. The downstream Aare reach features nine run-of-river HPPs and two nuclear power plants with water abstractions for cooling.

Fig. 1: Head water of block-unit HPP Bannwil with the turbine intakes in the background (Photo: VAW)

Restoration targets

The target fish species in that Aare reach are salmon and barbel. For upstream migration, a fish pass is installed which has to be renewed until 2020. Downstream migrating fish are routed through the turbines or over the weir in case of flood events. Fish protection and bypass systems have to be installed until 2025.

Field measurements within FIThydro

Within the FIThydro project, 250 fish will be equipped with radio-telemetric tags. Their migration routes in the vicinity of the HPP will be observed for 2 years. The fish behaviour will be further observed with DIDSON sonar systems at specific locations (e.g. in front of the intake rack).

VAW will conduct ADCP measurements of the velocity field (Fig. 2) and will set up a 3D numerical model. Hydraulics and fish data will be evaluated to assess the current situation and the effectiveness of operational measures (e.g. spill flow). Furthermore, the installation of a fish guidance structure with vertical bars and an adjacent bypass system will be considered in the numerical study.

Fig. 2: ADCP measurements downstream of HPP Bannwil (Photo: VAW)

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Residual flow hydropower plant Schiffmühle

The HPP Schiffmühle is located at the River Limmat some 30 km downstream of Zurich. The 400 m long Schiffmühle side weir divides the river into the headrace channel of the main HPP and the residual flow reach. The residual flow HPP is located at the upstream end of the side weir and is equipped with a 1.45 m diameter bulb turbine to use the residual flow for electricity production. With a gross head of 2.97 m and a design discharge of 14 m^3/s the installed capacity is 285 kW. The annual electricity production is 1.9 GWh corresponding to the electricity consumption of approx. 430 households. Aiming at a natural sediment continuum, a vortex tube was installed on the headrace channel invert at about half the channel length to divert bed load material into the residual flow reach (Fig. 3a). The residual flow HPP Schiffmühle is equipped with a natural fishway and a vertical slot fish pass for upstream migration. In 2013 it was equipped with a horizontal bar rack bypass system for fish downstream passage (Fig. 3b). Resulting from the lateral HPP intake, the horizontal bar rack is arranged parallel to the main flow. The bars with rectangular profiles have a clear spacing of 20 mm. The approach flow velocity at design discharge is 0.5 m/s. At the downstream rack end 3 bypass openings are located at different water depths (near-bottom, mid-depth, and near-surface) leading into a vertical shaft. The subsequent downstream passage into the residual flow reach is provided via a 0.25 m diameter bypass pipe.

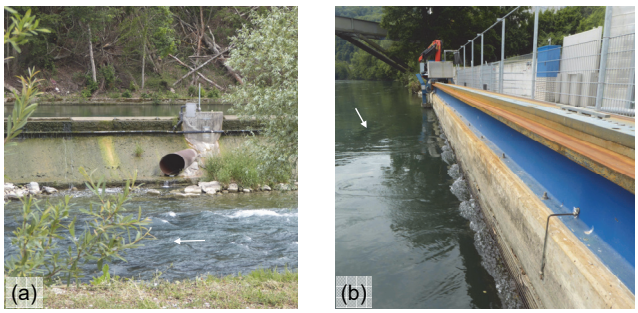

Fig. 3: (a) Vortex tube connecting the headrace channel with the residual flow reach (Photo: VAW)
(b) Horizontal bar rack for fish protection (Photo: VAW)

Field measurements and numerical modeling

The velocity field around the residual flow HPP Schiffmühle will be measured with an ADCP. More than 1000 individual fish will be marked with PIT-tags to monitor their migration. To track their swimming paths, all upstream and downstream migration corridors are equipped with RFID antennas. To quantify the sediment balance, the bed load transport in the vortex tube and sediment deposition and erosion will be monitored. For the residual flow reach the investigations include sediment sampling, habitat and shelter mapping and the quantification and numerical modeling of flow conditions.

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