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On the strategy of hydrograph estimation in streams with non-stable stage-discharge relationships

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The hydrograph describes the temporal changes in discharge at a measuring station. The prevailing method for estimating the hydrograph is based on the use of a stage-discharge relation which provides satisfactory results as long as this relation is stable. However, several things such as sediment transport, aquatic weed, backwater from tides or choking of flow during floods can render this relationship unstable.

In small or moderately sized streams in lowland countries, such as Denmark, seasonal changes in aquatic weed impose significant temporal changes in the stage-discharge relation. Likewise for streams running in unconsolidated materials, the elevation of the streambed often show temporal changes associated with storm flow. Previously, such temporal variations were often avoided by building hydraulic structures such as weirs. However, firm ecology based restrictions and the implementation of the European Water Framework Directive in reality prevents the use of such solutions. As a consequence, the nonlinear drift in weed density and sediment transport add significant uncertainty to the hydrograph in many streams.

We present here a study of a monitoring strategy for hydrograph estimation, in a stream with significant non-stationary hydraulic conditions. As part of the study the uncertainty of the hydrograph during different hydraulic conditions is also investigated. The study is based on simultaneous recording of stage and stream velocity at several elevations above the streambed. Velocity is measured with an acoustic Doppler-velocity meter (AVM) and stage is recorded using a pressure transducer.

The gauging station which has been selected for the study is an upstream station in the central/western part of Denmark in the Skjern River Catchment, with a size of 2378 km2. The area of the sub-catchment is 117 km2, and the annual average discharge at the gauging station is close to 1 m3/s. The stream conveyance is significantly influenced by aquatic weed and the streambed is unstable due to sediment transport.

Three ADV sensors are mounted at different elevations above the stream bed and measure continuously the average water velocities in the central part of a cross sectional profile. Together with stage, velocity data have been collected since December 2010. Monthly measurements of discharge have been conducted with an Acoustic Doppler Current Profiler in the same cross-section as the ADV sensors are placed.

The initial analysis of the data shows that the continuous measurements of flow velocity give a detailed picture of the temporal hydraulic changes in the stream. Furthermore, temporal changes in the stage-velocity relation indicate changed flow conditions at the station which cannot be inferred using the stage data.