Analysis of flow process at the downstream side of various river measures using 1D- and 2D flow models

Master Thesis Michiel Clements

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After implementation of river measures in sub-critical flow, the water level upstream of the measure decreases. However, at the downstream boundary of these measures the water level tends to increase. This is observed as a local peak. Figure 1 displays an example of such a peak that after constructing a side channel (which flows into the main channel exactly at the location where the peak is at its maximum. In this research the existence of this peak is investigated.

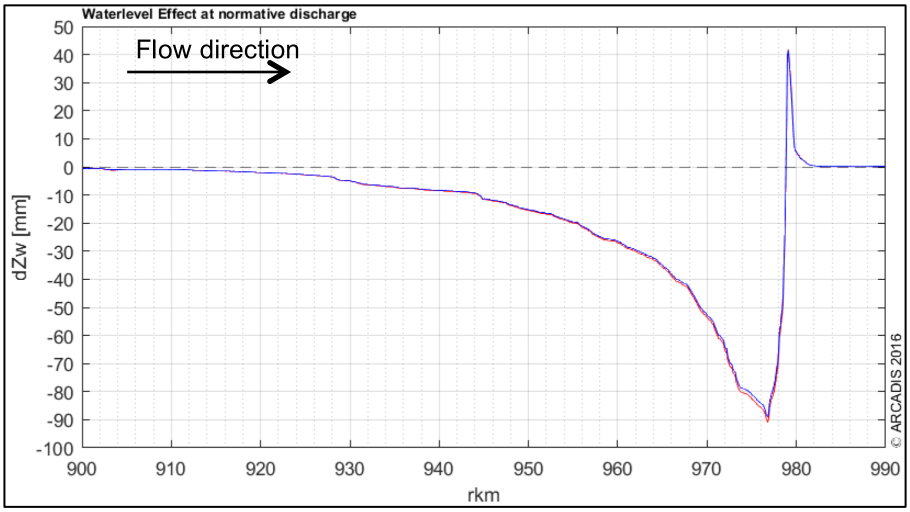

Figure 1; downstream peak at the downstream boundary of a side channel

This is undertaken by introducing two schematized river measures: a widening measure and a deepening measure. The focus was mainly on the downstream side of these measures.

It is shown that the flow processes that cause the peak at the downstream boundary of the both measures can be explained by the Bernoulli equation. Bernoulli states that when the flow decelerates, the water level increases. In sub-critical flow, the effects of the river measures are only experienced upstream. Implementing the deepening measure, no changes thus occur far downstream of this measure (see Figure 2). When going from that point in upstream direction, the flow decelerates since the river profile expands.

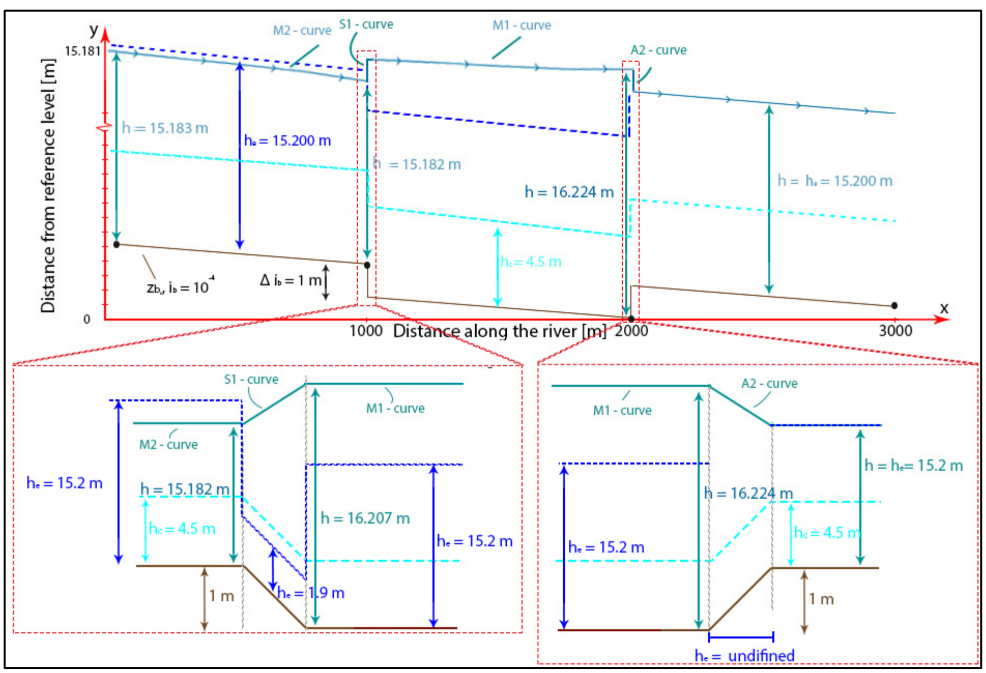

Figure 2; analysis of flow processes at deepening measure

Bernoulli explains that due to this deceleration the water level increases in upstream direction. It was also investigated what the effect of turbulence and non-hydrostatic effects were. It was shown that these effects can be neglected. A similar process occurs at the downstream side of the schematized widening measure. However, at the downstream boundary of the measure, the lateral change of the river profile causes lateral flow velocities towards the axis of the river. Figure 3 shows the result of the 2DH analysis of the widening measure compared to the reference situation (no implementation of a measure). It is shown that the water level increases in upstream direction at the downstream boundary of the measure in case of no use of a turbulence model ($\nu_t^H = 0\, m^2/s$). Furthermore, the case with use of the HLES turbulence model is displayed. There are significant changes observed whereby it is assumed that turbulence does have a significant effect on the shape of the peak.

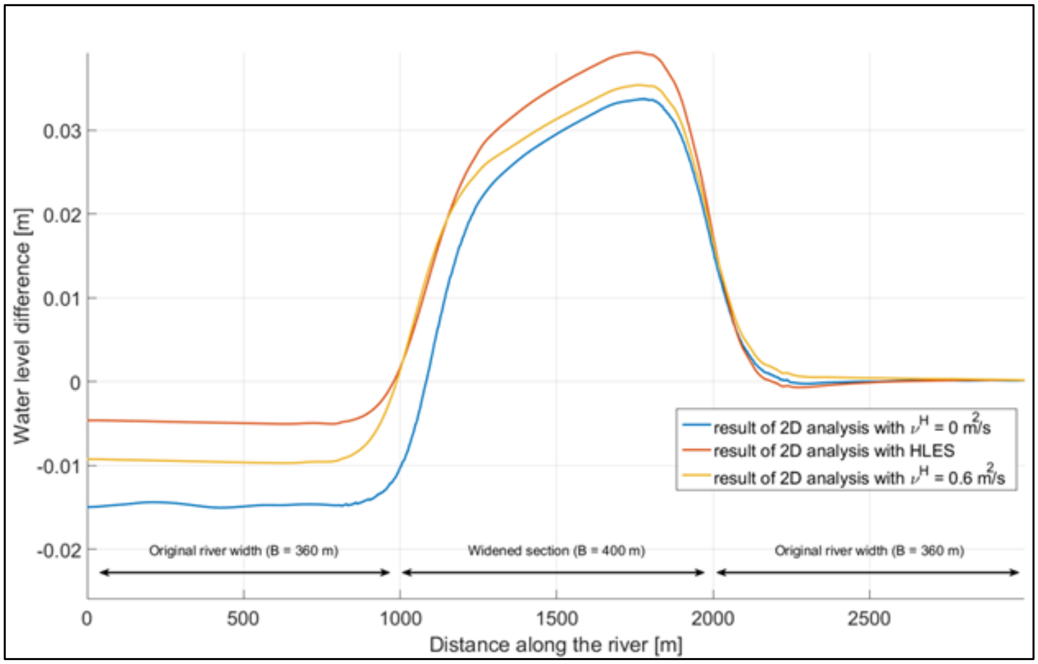

Figure 3; analysis of flow processes at the downstream side of a widening measure

There is also an analysis undertaken on the used grid size in flow models. Regarding the deepening measure, using a smaller grid size then length of the step in the bed, no significant changes occur. However, using a larger grid than this length results in a smaller peak and should therefore not be used. Regarding the lateral flow constriction, when a grid size is used that is smaller than 1 * db/dx, no significant change occurs. When using a larger grid size the peak is overestimated.

Besides the schematized flow constrictions, the real world case 'Scheller- and Oldeneler Buitenwaarden' near Zwolle is used. This project concerns the construction of a side-channel. Using the analysis of the schematized flow constrictions, it is attempted to reduce the peak downstream of the side channel. It is shown that adapting the mouth of the side channel such that the lateral flow velocities are reduced also reduces the size of the peak. It is furthermore shown that increasing the roughness that causes a local decrease of the water (the Bernoulli effect in opposite direction) only has an enlarging effect on the peak.