Migration of a dredging pit in the Rhone River (Valais, Switzerland) - 2005

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Disruptions of sediment transport in rivers caused by dredging pits modify the bed geometry and can endanger the stability of the banks and structures, e.g. bridges. Sediment transport is affected by a sudden change in the river bed geometry and consequently erosion is anticipated downstream of the pit. Therefore, geomorphic and also environmental effects of material extraction are one of the main concerns in river training (figure 1).

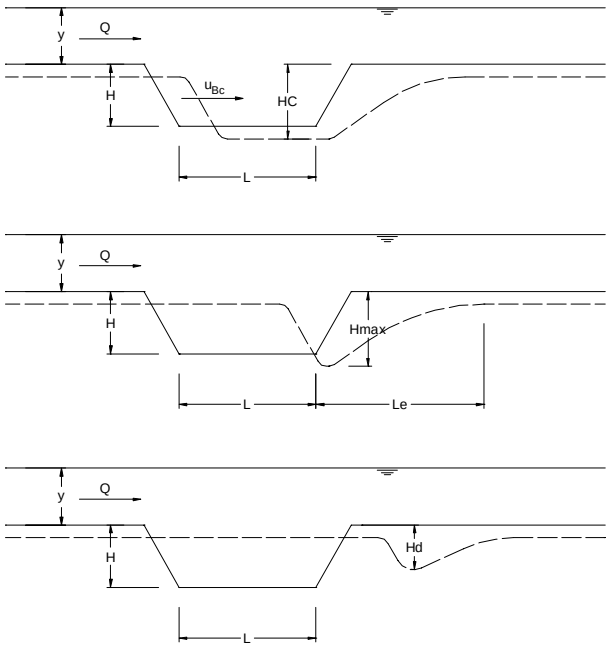

Figure 1 Physical Migration of a rectangular mining pit composed of uniform sediments (Lee & Song, 1993)

The 3rd correction enterprise of the Rhone River deals with all kind of hydraulic activities and structures in the Swiss part of the river, upstream of Lake Geneva. Sand and gravel extraction is carried out in particular locations along the river, among them in the Rarogne Region. The evolution of the bed geometry due to this mine pit was first examined on a physical model (figure 2). The experimental results have then been used for the calibration of a transient flow numerical model.

Figure 4 Physical model of the Rhone River with UVP transducers mounted on a measurement mobile frame.

A 1:45 scale physical model with mobile bed was submitted to experimental tests in order to investigate the pit migration and the downstream erosion resulting from the dredging activity. The main goal was to define the depth and extend of the erosion in the affected zone in order to establish criteria for the mine operator (Figure 3).

The temporal migration of the mining pit and the velocity field inside the excavation were measured for three steady state flow conditions corresponding to 10, respectively 50 and 100 return periods.

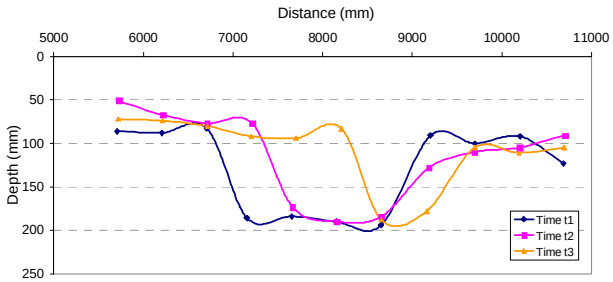

Figure 3 Migration of the dredging pit for a 50 years return period discharge"

For the purpose of the project, a new computational model has been developed inside the Excel programming environment. This numerical tool, called DuPiro performs the coupled hydrodynamic non steady simulation of 1D flow behavior and bed load transport. After calibration, different scenarios were simulated in the perspective of a sensitivity analysis referring to the following parameters:

Flow discharge

Grain size distribution

Depth of the pit

Width of the pit

Length of the pit (Figure 4)

Finally, the historical event of October 2000 was simulated in order to examine the behavior of the dredged pit during a high flood.

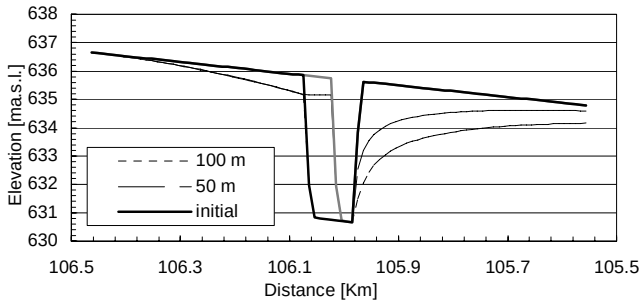

Figure 4. Envelope curves of the maximal erosion depth for two different lengths of the dredging pit.

The experimental and numerical results confirm that the erosion which develops upstream and mainly downstream of a dredged pit has a negative effect on the stability of the river banks and the civil works built in the river bed. This influence increases with the length and the depth of the pit. However, a pit of a reduced width diminishes the erosion depth downstream.

The results obtained in the case study of Rarogne help to quantify the impact of different configurations of the mining

pit on the river bed and to define its exploitation strategy according to the hydrological regime of the river.