Floods are highly damaging natural disasters and their impact is often increased by the presence of sediments. In such cases, the strong morphological changes following an important flood completely redefine the riverbed and the landscape of the surrounding area. To minimize the material damage and human life loss, it is necessary to predict these floods in a reliable way.

The present thesis aims at modeling fast transient free-surface flows and the morphological changes consequent to a dam or dike failure. Here, one-dimensional models have been preferred to two- or three-dimensional models as they are much faster, time being a key factor during a crisis, and need much less data. Moreover, some two-dimensional phenomena are accounted for in the one-dimensional model such as the presence of islands, the non-uniform erosion distribution in a cross-section and bank failures. The thesis work is divided in two parts. First, the sediments are neglected and only the hydrodynamic flow is considered. Then, the sediments are included in the model.

In the hydrodynamic part, three important aspects of flow modeling (numerical and experimental) are studied. First, the computation of the source terms and the conservation of the discharge are investigated by comparing the results of three different approaches. Secondly, flows around islands are considered. To include this 2D phenomenon where the river is divided in two sub-channels on either side of the island, the river reach is separated into four different parts: (1) the channel before the island, (2-3) the sub-channels around the island and (4) the channel after the island. Then, inner boundary conditions connect these parts together. These conditions are written considering the characteristic paths and the conservation of water head. Finally, a new experimental method to measure the water level in the laboratory is presented. This method is based on the photogrammetry technique and allows the capture of the water level on a wide area, which greatly reduces the number of experimental runs needed to collect data.

In the second part of the thesis where sediment transport and morphological changes are considered, three important aspects are also investigated. First, four different modeling approaches for morphological changes in a one-dimensional framework are presented and compared. These models predict the evolution of the bathymetry without considering the sediment concentration in the flow and are thus better suited for modeling bed load transport. They differ in the computation of the fluxes and the level of coupling between the equations related to the sediment and the water. Secondly, experiments of dike breaching are presented and compared to predictions obtained using one- and two-dimensional models. Even though the breaching presents some 2D features such as the widening of the breach, the one-dimensional model was able to give surprisingly good results. Thirdly, new experiments of scouring at the interface between fixed and mobile bed in steep slope channels have been conducted. During the experiments, different phases of scouring have been observed and the relations between the velocity fields and the scouring have been highlighted.

Finally, possible improvements and future works are presented, focusing on three main topics: (1) the morphological changes around islands, (2) assessing the impact of restrictive assumptions of the current model, i.e. assuming capacity transport and neglecting the effect of sediment concentration when modelling morphological changes and (3) improving the photogrammetry technique to make it usable for fast transient flows.