Hydrological-hydraulic modelling for future flood protection in Zürich

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INTRODUCTION

Large parts of the city of Zürich are built upon the fan delta of the river Sihl. This is a densely built up area, with partly sensible infrastructure like the central railway station and shops, all with high damage potential. During the flood in 2005 no great damages occurred, but this event showed the vulnerability of the city Zürich. A subsequent assessment indicated that there is acute need for action regarding flood management in the catchment of the lake Zürich - river Sihl - river Limmat. Based on these findings the cantonal office of Waste, Water, Energy and Air initiated the planning of a long-term flood protection. Among other options, two concepts were finally identified: a „discharge tunnel“ (DT) in the lower section of the lake Sihl and a „combination solution energy“ (CSE), where the hydropower plant at the lake Sihl is upgraded and additional water can be released from the lake Sihl to the lake Zürich.

Aim: The aim of this study is the evaluation of the two concepts DT and CSE and its impact on the level of lake Zürich by forcing a hydrologic-hydraulic model chain with extreme precipitation scenarios. How much does the additional input from the Sihl affect the safety of the environs along the lake of Zürich and the cross-sections at the outlet of the lake?

METHODS

The hydrological model PREVAH simulated the discharge, which provided the input data for the hydraulic 1d-model FLORIS and the 2d-model BASEMENT. Dry, middle and wet antecedent soil moisture were evaluated as well as different initial levels of the Sihl lake (888.0, 888.7, 889.34 m a.s.l). The wetter the antecedent conditions and the higher the level of the Sihl lake, the higher are the discharges of the Sihl river. 24 precipitation scenarios were designed, whereupon the catchment was structured in four sub-basins (Figure 1). Scenarios of accumulated precipitation with return period of 300 years have been designed by laying the focus on one of these sub-basins and by assigning to the remaining areas a precipitation scenario with a 50 years return period. The length of the accumulated precipitation scenarios was 48 or 72 hours. Analyses demonstrated that the most critical events are the ones in which the rainfall focus lays on the sub-area of the river Sihl or on the plain of the river Linth. The hydraulic model FLORIS simulated the lake level and the discharge of the river Sihl and Limmat, both without and with the relief concepts DT and CSE. The outflow of the lake Zürich is regulated at the weir Platzspitz, which lies just above the confluence of the rivers Sihl and Limmat. The hydraulic 2d-model BASEMENT allowed exploring the sensitivity of the channel between the lake outlet and the weir Platzspitz. The discharge of the lake Zürich outflow has to be limited, when the combined discharge for the river Sihl and Limmat at the measurement station Unterhard exceeds 600 m^3/s. This prevents damages in the downstream areas.

RESULTS

Simulation experiments identified that DT and CSE have impact on the level of the lake of Zürich. Nevertheless, the diversion of water from the Sihl catchment into the lake Zürich has for a 300-year precipitation event a comparatively small influence on the level of lake Zürich. Under the actual configuration, the lake Zürich level could additionally rise about 5 cm in case of a diversion of water from the Sihl catchment. This lake level rise is smaller than one could have expected. Due to the diversion of water from the Sihl catchment, the discharge limit of 600 m^3/s at the measurement station Unterhard is not reached. This is very positive for the downstream areas and eases flood management by regulation of the weir. Since the

discharge at the Platzspitz weir is not reduced, also the backwater effect (rising the surface of the water upstream) is not occurring.

Discussion and outlook: This study proved that the diversion of the river Sihl, either with DT or CSE, would not affect drastically the residents along the lake Zürich. But the water level rise of about 5 cm might cause increased vulnerability to damages. Adequate solutions to compensate for these effects are needed. A first option in this respect is the preventive drawdown of the lake Zürich level before a possibly critical event. A timely decision in this respect based on flood forecasts can compensate for the additional flood volume stemming from the diversion of the river Sihl. Furthermore, the 2d hydraulic simulations demonstrated that several local construction measures in the river branch between the lake Zürich outlet and the weir Platzspitz could contribute to increase the outflow capacity of the lake and thus reduce the impacts of DT and CSE. Currently the focus of the investigations is put on the effects of reshaping cross-sections between the bridges „Münsterbrücke“ and „Rathausbrücke „ (see Figure 1). The outcome of this study helps the office of Waste, Water, Energy and Air of the canton of Zürich with its decisions towards an improved flood management.

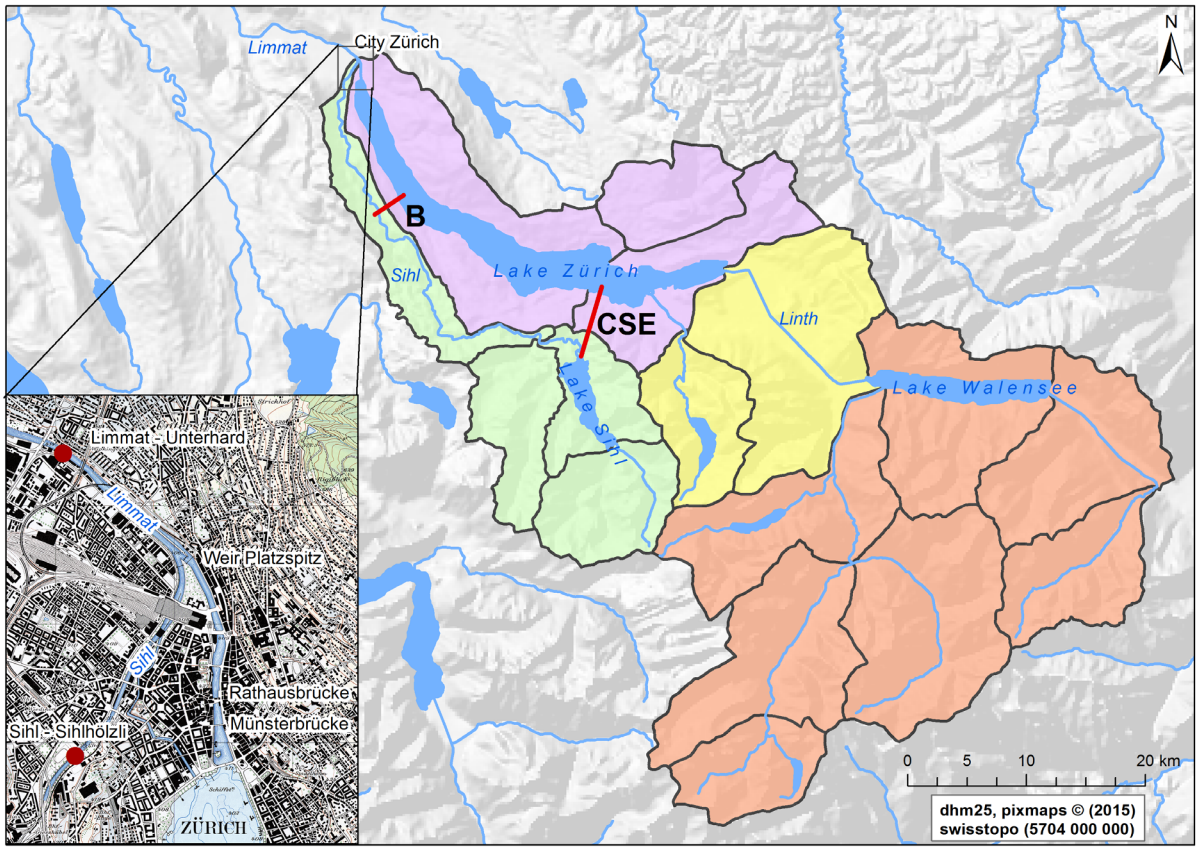

Figure 1. Catchment of river Sihl and Limmat with sub-basins “river Sihl” (green), “lake Walensee” (red), “plain of the river Linth” (yellow) and “basin of the lake Zürich” (violet); water deviation concepts: “discharge tunnel” (DT) and “combination solution energy” (CSE). Small map: confluence of river Sihl into Limmat with hydrological measurement stations at Sihlhölzli and Unterhard and with the weir Platzspitz which regulates lake Zürich.

KEYWORDS

Flood protection, flood management, hydrological modelling, hydraulic modelling, Zürich

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