REGULATION OF LAKE BIENNE UNDER CONSIDERATION OF THE INFLOW FORECASTS

IMPROVEMENTS DUE TO THE EXPERIENCES OF THE FLOOD EVENT IN AUGUST 2007

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INTRODUCTION

Most of the large lakes in Switzerland are regulated, and have thus a considerable flood retention potential. So far, at the most, seasonal aspects were considered in order to regulate the outflow resp. lake level. The consequences from the flood event of August 2007 in the Aar River and the lake system of Lake Bienne, Neuchâtel and Morat, were the starting point for the amendment of the regulation scheme of Lake Bienne by considering the forecasts for the inflow into the lake system. The analysis of the flood event showed that there is a potential to remarkably reduce high water levels of the lakes without aggravating the situation in the downstream stretch of the Aar River. The idea behind is the usage of the maximum retention capacity of lake system for reducing peak water levels. Hereby, all available meteorological and hydrological information should be optimally used, respecting all given boundary conditions such as ecological requirements, navigation, riparian slope stability, technical installations (specification of the weir), and especially the flood situation downstream.

THE SYSTEM OF THE JURA LAKES AND ITS PAST REGULATION

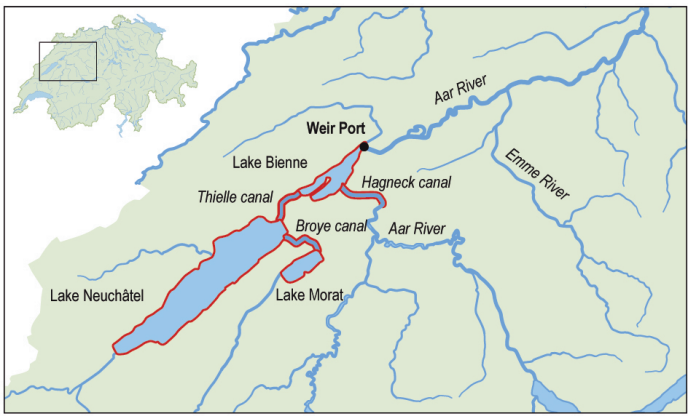

Fig. 1 System of the Jura Lakes in Switzerland

The Jura lakes system in Switzerland consists of three single lakes, which are nowadays connected by artificial canals allowing the water bodies of the three lakes to communicate. Hereby, the water can flow in either direction (Fig. 1). The Lake Neuchâtel with a surface of 218 km^2 has by far the highest retention capacity. The Aar River flowing into the Lake Bienne (surface 40 km^2) represents the main inflow into the system. The outflow of the lake system is regulated by the Weir Port immediately downstream of the Lake Bienne.

Besides the values prone to flood hazards on the lake shores, there is also a considerable damage potential along the Aar River downstream of the Lake Bienne. The Emme River is a fast responding tributary of the Aar downstream the lake system, and considerably determines the flood situation in the Aar. In August 2007, the peak discharge of the Aar River was 1260 m^3/s, to which the Emme River contributed by 660 m^3/s.

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Under normal conditions, the lake system is regulated by a seasonal regulation scheme indicating the set point of the outflow by the day of the year and the observed water level. This regulation respects different interests and boundary conditions, e.g. flood protection, ecology, fishery, agriculture, tourism and navigation. With respect to flood management, the regulation scheme represents a reactive procedure, as the outflow is increased only after the water level has already risen.

NEW CONCEPT OF LAKE REGULATION

In order to use the storage potential efficiently, the system should behave proactively. This means, the water level should be lowered already prior to the arrival of the flood in order to provide additional storage volume in the lake system. This requires information about the inflow into the system prior to the event. For this reason, a procedure was developed taking into account the available forecast for the runoff into the lakes five days in advance. This procedure uses the output of distinct weather models (two deterministic and one set of ensemble forecasts) as input for the already existing hydrological flood forecasting model. Based on the forecast inflow and the outflow proposed by the seasonal regulation scheme, the expected water level of Lake Bienne is calculated. If a certain threshold is reached, the outflow is increased and thus the lake level lowered prior to the forthcoming event (see Fig. 2.)

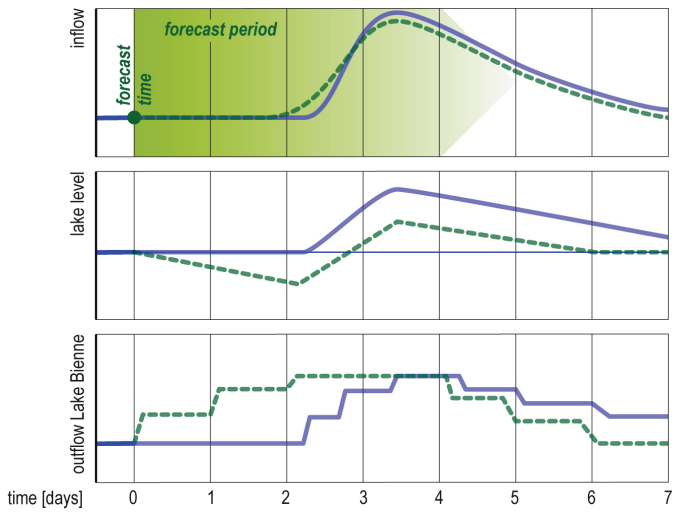

Fig. 2 Jura lakes system: seasonal regulation scheme, the outflow is increased according to the lake level rise (solid lines) & forecast regulation, the outflow is increased and thus the lake level lowered prior to a flood event (dashed lines)

Even in the case of large deviations between forecast and actual inflow, the procedure leads to lower lake levels than applying the seasonal regulation scheme. The procedure is designed such as it goes back to the normal seasonal regulation after a flood event or as soon as smaller inflows are forecast.

As downstream of the lake system the Emme River can contribute remarkably to the runoff in the Aar River, short term forecasts are additionally used to early stop the procedure and to reduce the outflow from Lake Bienne. This ensures that the risk of flooding downstream will not increase.

CONCLUSION

The procedure of the lake regulation presented here is robust. It allows clear decisions for the regulation even under uncertainties. It can be easily implemented in other watersheds, where the forecast time for the inflow runoff into the lake(s) is larger than the response time of the lake system (i.e. the time, in which the water level in the lake can considerably be changed), and where lake regulation is part of the flood management. It could therefore be also an example for improvements in other lake regulation systems.

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Keywords: lake regulation, flood protection management, runoff forecast