HYDRODYNAMIC SIMULATION OF FLOODING SCENARIOS FOR CRISIS MANAGEMENT IN PRAGUE

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Abstract

Important part of flood protection measures in city Prague are mobile flood barriers along banks of river Vltava. Eventual failure of mobile flood barriers could cause flooding of vulnerable urban areas. It was decided that contingency planning and crisis management for such situations will be prepared on the basis of numerical simulation of flood protection failure scenarios. Critical places of flood protection hypothetical failures were assessed and unfavourable discharge and water level scenarios were prepared. Flooding of most vulnerable urban areas was simulated by detail 2D hydrodynamic unsteady flow modelling. On selected localities were defined also scenarios of flooding through sewer system man holes. Results of simulations were presented in form of maps showing flooding extent, flooding depth, water surface elevations, flow velocity magnitudes and directions, as well as by text description of flooding situation, all in selected time steps. Video animations showing flooding evolution in space and time were created. All results were elaborated to form of interactive graphical application which helps planners and crisis managers on city level.

Keywords

Flood mapping, flood protection mobile barriers, flood protection failure, 2D hydrodynamic modelling

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1 INTRODUCTION

Important part of flood protection measures in city Prague are mobile flood barriers along banks of river Vltava. Eventual failure of mobile flood barriers could cause flooding of vulnerable urban areas. It was decided that contingency planning and crisis management for such situations will be prepared on the basis of numerical simulation of flood protection failure scenarios.

2 DEFINITION OF CRITICAL LOCALITIES AND FLOODING SCENARIOS

Critical localities of possible failures of flood protection structures were defined. Selected were places with highest elevation of flood protection structure crest above terrain and localities where failure could lead to most unfavourable scenarios. Dimensions of failure opening in protection line were defined based on technical assumptions and type of structure (mobile barriers, earth dike).

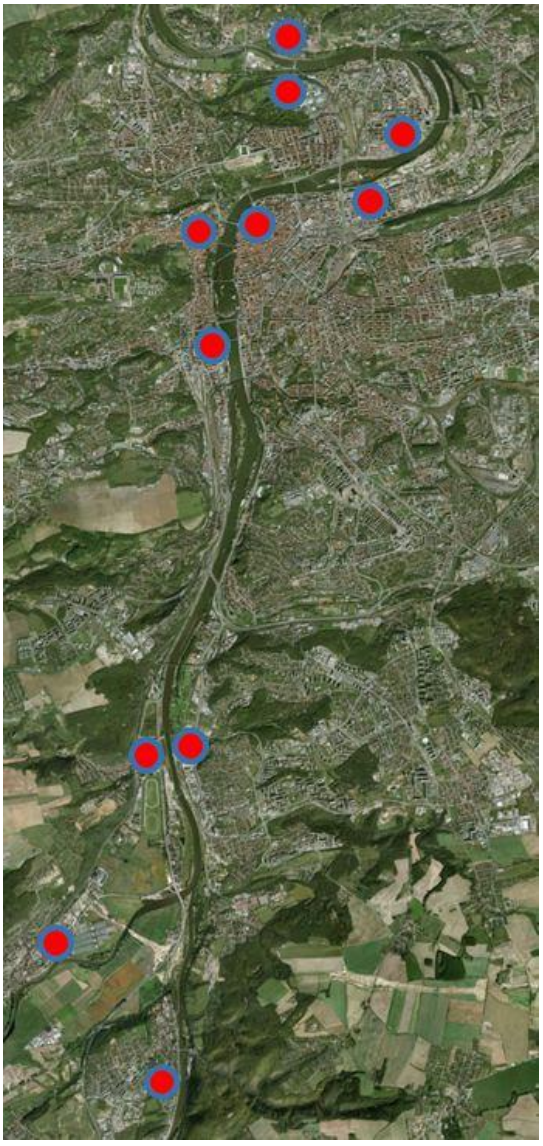

Fig. 1 Critical places of flood protection hypothetical failures in Prague

Fig. 2 One of the selected critical places with high mobile barriers – Na Kampě

3 NUMERICAL SIMULATIONS

Flooding of most vulnerable urban areas was simulated by detail 2D hydrodynamic unsteady flow modelling. Modelling tool MIKE 21 FM was applied. Detail 2D computational mesh of models combined triangular and quadrangular elements, followed directions of streets and roads and covered areas of interest in detail. Planar positions of buildings were excluded from models. Topography of the areas in models was defined on the basis of actual high resolution Digital Elevation Model.

Inflow discharge through simulated openings in flood protection lines was defined by model on the basis of water level boundary conditions in Vltava River. On selected localities were defined also scenarios of flooding through sewer system man holes. Discharge of water through man holes was defined as point source time series inflow defined on the basis of sewer system hydraulic calculations.

To achieve the required results, it was necessary to prepare and run together 33 simulations of flooding scenarios within 11 individual areas. Handling of needed computational effort in reasonable time was supported by parallel computing.

4 APPLICATION OF RESULTS AND CRISIS MANAGEMENT TOOL

Results of numerical simulation of flooding scenarios were processed. For each of the simulated scenarios were in selected time steps prepared following outputs:

- Maps of water surface elevation, water depth and flow velocities in form of ESRI grids with 2 x 2 m resolution
- Extend of flooding in form of ESRI polygon SHP file
- Vector arrows of flow velocities in form of ESRI point SHP file
- Video animations of flooding evolution in time and space
- Text descriptions of flood protection failures and flooding processes

The above mentioned model results and GIS layers will be elaborated into an interactive crisis management viewer, from which user will be able to open various maps, video animations, text descriptions and relevant technical drawings.

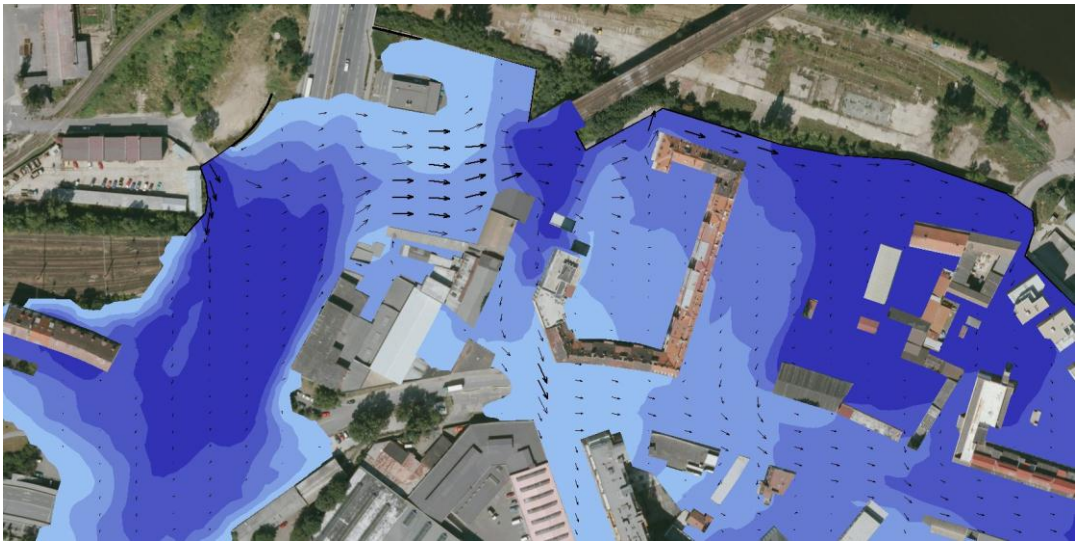

Fig. 3 Simulated depths of flooding and flow directions in one of the model areas

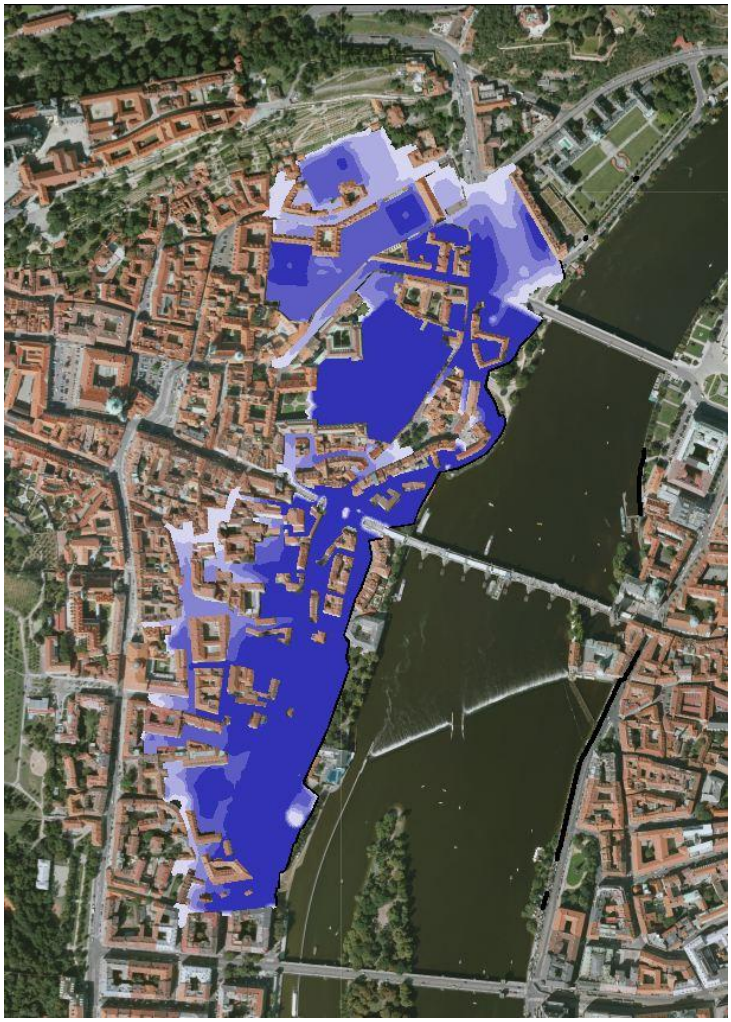

Fig. 4 Simulated flooding of part of historical centre

5 CONCLUSION

Flood protection measures and structures should not be regarded as 100 % reliable. They can fail in consequence of various reasons. It can be overload of structure design parameters, technical failure or other destruction. Potential damages in such situations can be significantly reduced by adequate preparedness and preventive measures. For such purpose can be adequately used results of numerical simulations of crisis scenarios.

References

[1] Severa, T.: Nejpravděpodobnější scenáře poruch a destrukce prvků protipovodňových opatření realizovaných na území hl. M. Prahy, final report, Vodní Díla TBD, Prague 2013.

[2] Sklenář, P. et al.: Aktualizace nejpravděpodobnějších scénářů při dílčím selhání protipovodňových opatření na území hl. m. Prahy. Final report, DHI a.s., Prague 2013.

[3] MIKE by DHI: MIKE 21 FLOW MODEL FM, Hydrodynamic Module, User Guide, 2012