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Flood risk assessment for a heavily modified urban stream

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INTRODUCTION

One of the main effects of uncontrolled urbanization is the ecological degradation of urban streams (Ehrenfeld 2000), and more specifically of the flow pattern, channel morphology, water quality, and biotic communities alterations (Wang *et al.* 2001). Changes to flow patterns, which are characterized by a tendency for more frequent and larger flow events with faster ascending and descending limbs of the stream hydrograph, are perhaps the most obvious and consistent impacts of urban land use on hydrological ecosystems (Walsh *et al.* 2005) that threat human security.

In Greece, urban flooding is probably the most frequent type of flood hazard, while some of the most catastrophic events have occurred in the Athens metropolitan area (Koutsoyiannis *et al.* 2012). The streams of Attica, despite the fact that almost 90% of them have been covered (Hadjibiros 2014) and most are also suffering from environmental degradation due to anthropogenic activities (Argyraki *et al.* 2013) through rapid and violent urbanization, are also often responsible for flash flood events, endangering the residences in the riparian zone and often causing severe damage and human casualties. The gentle slope morphology, the special climatological conditions, the uncontrolled urbanization without the necessary concurrent infrastructural work and the lack of adequate green spaces that would allow sufficient infiltration of precipitation, are the main causes of the increased flood risk of the area (Dimitriou *et al.* 2012, Lasda *et al.* 2010).

In order to achieve a better understanding of the hydrological processes occurring in the heavily modified urban stream named Pikrodafni at Athens, and to retrieve the high flood risk areas, hydrological and hydrodynamic models were used. This particular stream is one of the last natural systems in Attica and, despite the many pressures it is subject to, its restoration is still possible with respect to the locally-generated ecosystem services (climate regulation, and recreation and cultural values; Bolund and Hunhammar 1999). Although Pikrodafni stream is not historically connected to flood events, in February 2013, after heavy rainfall the stream overflowed. Pikrodafni stream originates on Imittos Mountain and discharges into the Saronikos Gulf. Of the total 9300 m length of the stream, only the last 6000 m still retain its natural banks, while the rest is embedded as a canal. The drainage system is considered to be inadequate, while buildings are illegally constructed over or very close to the stream bed.

METHODOLOGY – RESULTS

The hydrodynamic modelling tool used in the present effort for the simulation of Pikrodafni stream is MIKE 11 by DHI, a one dimensional, fully dynamic model. Due to the lack of discharge data during the flood event in February 2013, simulating the entire Pikrodafni watershed during a flood event was necessary to derive the flood hydrograph for the hydrodynamic simulation. The hydrological modelling of Pikrodafni watershed was accomplished using MIKE SHE by DHI, an integrated catchment modelling system able to simulate the entire hydrologic cycle.

During the simulation of the hydrological model, only the overland flow was taken into consideration, based on the assumption that the rainfall intensity exceeds soil infiltration capacity (Horton 1933). The hydrological model of Pikrodafni watershed was first set-up for the flood event during 7–8 November 2012 (correlation factor R = 0.85) and then validated for the flood events during 19–20 and 20–22 November 2012 (R = 0.77). Finally, the flood hydrograph of 22 February 2013 was retrieved. The maximum discharge was observed at the stream mouth (83 m^3/s), while a time lag of about 30 min for the flood peak to arrive close to the stream mouth was observed.

The detailed hydrodynamic model of Pikrodafni stream was set-up for the downstream area of interest and was also first set-up for the flood event during 7–8 November 2012 (R = 0.93) and then validated for the flood events of 19–20 and 20–22 November 2012 (R = 0.89). Based on the results of the model for the flood event on 22 February 2013, the maximum water depth of the flood wave in the inundated area was 2.4 m. The area with the highest flood risk is located at the outflow of Pikrodafni stream to the Saronikos Gulf and 800 m upstream of the stream mouth (Fig. 1).

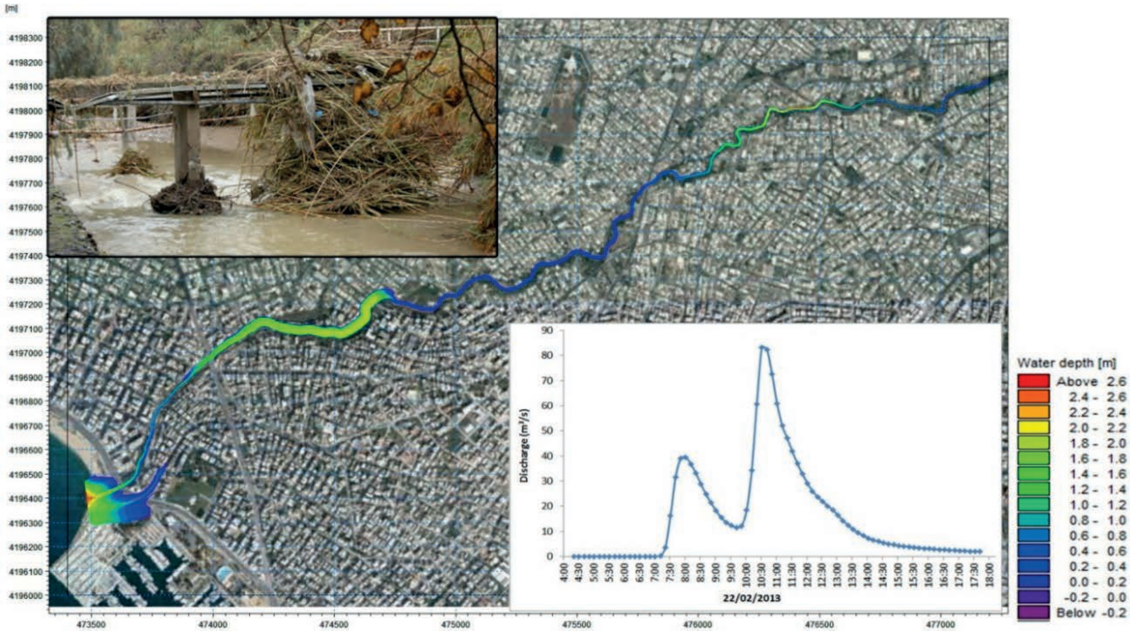

Fig. 1 Maximum water depth of the flood wave and flood hydrograph on 22 February 2013.

CONCLUSION – DISCUSSION

Hydrological and hydrodynamic models were used as tools for better understanding of the causes of the extreme flood events that took place on 22 February 2013 on the Pikrodafni stream, a heavily modified urban stream that is enduring many pressures in a rapidly changing human system and threatens water security in the metropolitan area of Athens. It was concluded that the capacity of Pikrodafni stream cross-sections to convey the flood event on 22 February 2013 was adequate. The overflow observed can be attributed to the debris accumulation (tree branches, reeds and garbage) at footbridge piers that intercepted the water flow. In order to assure and improve the water security of Athens, increasing flood management and environmentally friendly protection provisions will be required.

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