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Understanding and estimating the influence of urbanisation on the flood and low flow regimes of heavily urbanised catchments

Andrew Young (1,2), Andrew Black (2), Tracey Haxton (1), and Giuseppe Formetta (3)

(1) Wallingford HydroSolutions ltd, Maclean Building, Wallingford, United Kingdom (andy.young@hydrosolutions.co.uk), (2) School of Geography, University of Dundee, Dundee, United Kingdom (a.z.black@dundee.ac.uk), (3) Centre for Ecology and Hydrology, Wallingford, United Kingdom (giufor@ceh.ac.uk)

Urban hydrology research has historically been focused on understanding the influence of the positive drainage of impermeable paving and roof surfaces on extreme flood flows. The general body of evidence is that drainage of enhanced runoff from impermeable surfaces results in increased peak flows and a reduction in the time to peak of flood events and, furthermore, floods associated with summer convective storms may start to dominate. The coincidence or otherwise of the catchment area for drainage system and the natural contributing catchment area has a considerable influence on these impacts.

The body of literature on the influence of urbanisation on mean and low flows is sparse in comparison. The extrapolation of much of the literature is that the positive drainage of anthropogenic impermeable surfaces leads to the reduction of recharge and hence baseflows. However, the reality is more complex; the relationships between paved surfaces, reductions in infiltration and evaporation losses is poorly understood. Furthermore, there may be significant import of water into the urban environment through leakage associated with potable water supply. Similarly, sewer systems are not water tight and whether the exchange is exfiltration or infiltration will depend on the local water table which in turn may in influenced by historical extraction of water for purposes other than potable supply.
In this paper we explore the influence of urbanisation on both extreme flood flows and low flows considering the influence of both the positive drainage of impermeable surfaces and the import and export of water associated with water use.

We present results from a rare combination of monitoring studies in four heavily urbanised catchments and the broader scale generalised modelling of both flood and low flows across the United Kingdom. The latter considers the Flood Estimation Handbook Rainfall Runoff event model, the LowFlows model for estimating flow duration curves and a generalised version of the PDM rainfall runoff model incorporating a representation of urban processes. In the modelling studies we explore model residuals within urbanised catchments. This exploration is supported through the case study catchment analyses and scenario modelling of the potential magnitudes of the influence of the positive drainage of impermeable surfaces and the import of water through potable supply leakage.

The results support the consensus that positive drainage is the dominant impact of urbanisation on flood flows, if that drainage is retained in the catchment. However, catchment levels of urbanisation have to be very high before the influence can be detected in terms of either flood seasonality or increases in peak flow. In contrast, the impact of urbanisation on low flows is more complicated. The impact on natural recharge would appear to be relatively minor. However, the influence of net mains leakage can lead to a significant maintenance of low flows with the significance of this maintenance of flow being a function of both climate and catchment permeability. Export of water through the drainage system can have a very significant impact on both flood flows and the water balance of small catchments.