Hydrological Functioning of an Evolving Urban Stormwater Network

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Abstract

As complex systems, urban stormwater networks (USNs) may reveal emergent features (e.g., scaling) and sudden changes in behavior, which can lead to unanticipated impacts. We explored this through the USN properties of connectivity, heterogeneity, and scaling, which were quantified using outputs from a hydrological model and network dispersion mechanisms. The network properties were determined retrospectively in space and time by reconstructing the contemporary history of urban development and stormwater infrastructure in an arid, urban catchment in the City of Scottsdale, Arizona, USA. We found that the relative importance to USN functioning of both network structure (geomorphology) and dynamics (spatial celerity pattern) changed with the spatial scale, with network geomorphology being more dominant at larger spatial scales. The importance of network geomorphology suggested that the structure of the USN itself could potentially serve as a stormwater control measure, for example, by enhancing flow dispersion. The temporal evolution of the USN revealed a sudden change in the hydrological functioning of the network, which seemed to be a consequence of the combined effects of patchy urban development and changes in network connectivity. The interactions between the urban spatial pattern, stormwater infrastructure, and surface runoff may result in threshold■like behavior. A spatial multiscale approach to stormwater management may be beneficial to ensure that hydrological benefits at one scale do not cause unintended consequences at another. Overall, the retrospective modeling and network analysis approach used in this study may be useful for understanding emergent urban stormwater impacts..