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Review article

Can stormwater control measures restore altered urban flow regimes at the catchment scale?

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ABSTRACT

Over the last 20–30 years, there has been an evolution in urban stormwater management towards the use of stormwater control measures (SCMs) at or near the source of the runoff. These approaches aim to protect or restore natural elements of the flow regime. However, evidence of the success of such approaches is to date limited. We reviewed attempts to both model and monitor the catchment-scale hydrological consequences of SCMs. While many catchment-scale studies on the hydrologic effects of SCMs are based on computer simulation, these modeling approaches are limited by many uncertainties. The few existing monitoring studies provide early indications of the potential of SCMs to deliver more natural flow regimes, but many questions remain. There is an urgent need for properly monitored studies that aim to assess the hydrologic effects of SCMs at the catchment scale. In future monitoring studies, these hydrologic effects need to be characterized using appropriate flow metrics at a range of scales (from site scale to catchment scale), and changes to flow metrics by SCMs need to be assessed using robust statistical methods. Such studies will give confidence to stormwater and river managers of the feasibility and benefits of "low impact" approaches to stormwater management.

Contents

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1. Introduction

Urbanization dramatically changes the condition of urban streams, due primarily to stormwater runoff drained via hydraulically efficient pipes (Booth et al., 2004; Walsh et al., 2005). The impacts of urban stormwater runoff on streams have been thoroughly described: alteration of the stream flow regime, erosion and scouring of instream habitat, pollution of water bodies caused by mobilization of pollutants from the catchment; and thus decreases in the biodiversity and ecological functions of waterways, along with losses of amenity (Booth and Jackson, 1997; Paul and Meyer, 2001; Bunn and Arthington, 2002; Walsh et al., 2005; Fletcher et al., 2013). Hydrology has been identified as a master driver of aquatic ecosystem health (Poff et al., 1997; Booth et al., 2002; Wenger et al., 2009). Modifications to the stream flow regime by traditional urban stormwater systems include increasing storm flow volume and flow variability, and reducing base flow volume (Konrad and Booth, 2005; Burns et al., 2012; Walsh et al., 2012; Fletcher et al., 2013). These are due to changes in catchment hydrologic processes such as increases in surface runoff volume and frequency (mainly from stormwater drainage pipes), and reductions in stormwater infiltration, evapotranspiration, catchment storage and time of concentration. Therefore, the question of "how to return the catchment-scale hydrology and stream flow regime in urban catchments as close as possible to the natural (pre-development) state?" has been recognized as a prerequisite to improving stream health, even though the feasibility and suitability of the natural flow regime for a modified stream may also remain poorly tested (Poff et al., 1997; Richter et al., 1997; Burns et al., 2012; Fletcher et al., 2014b).

To address this question, increasing efforts have focused on approaches to stormwater management that mimic natural hydrologic processes, while also delivering other benefits (e.g. recreation, aesthetics, using stormwater as a resource, and microclimate improvement; Marsalek and Chocat, 2002; Fletcher et al., 2014a). These approaches attempt to reduce excess surface runoff and return any lost baseflow, while providing treatment of polluted stormwater. They do so largely by promoting on-site stormwater control (i.e. infiltration, evaporation, transpiration, storage, detention, harvesting and purification). Such approaches have been denoted by various terms, such as ecohydrological approaches (Wagner and Breil, 2013), Source Control (SC), Best Management Practices (BMPs), Low Impact Development (LID), Green Infrastructure (GI), Sustainable Urban Drainage Systems (SUDS), Water Sensitive Urban Design (WSUD), and Stormwater Control Measures (SCMs) (see a thorough review on these terms in Fletcher et al., 2014a).

In this review, we focus on the hydrologic aspects of such approaches, and use the term 'SCMs' to refer to both structural and non-structural stormwater control measures over a range of scales. Structural SCMs include both technologies that aim to increase infiltration (e.g. infiltration trenches, swales, raingardens, porous pavements) and those that depend more on detention and retention (e.g. wetlands, green roofs, rainwater

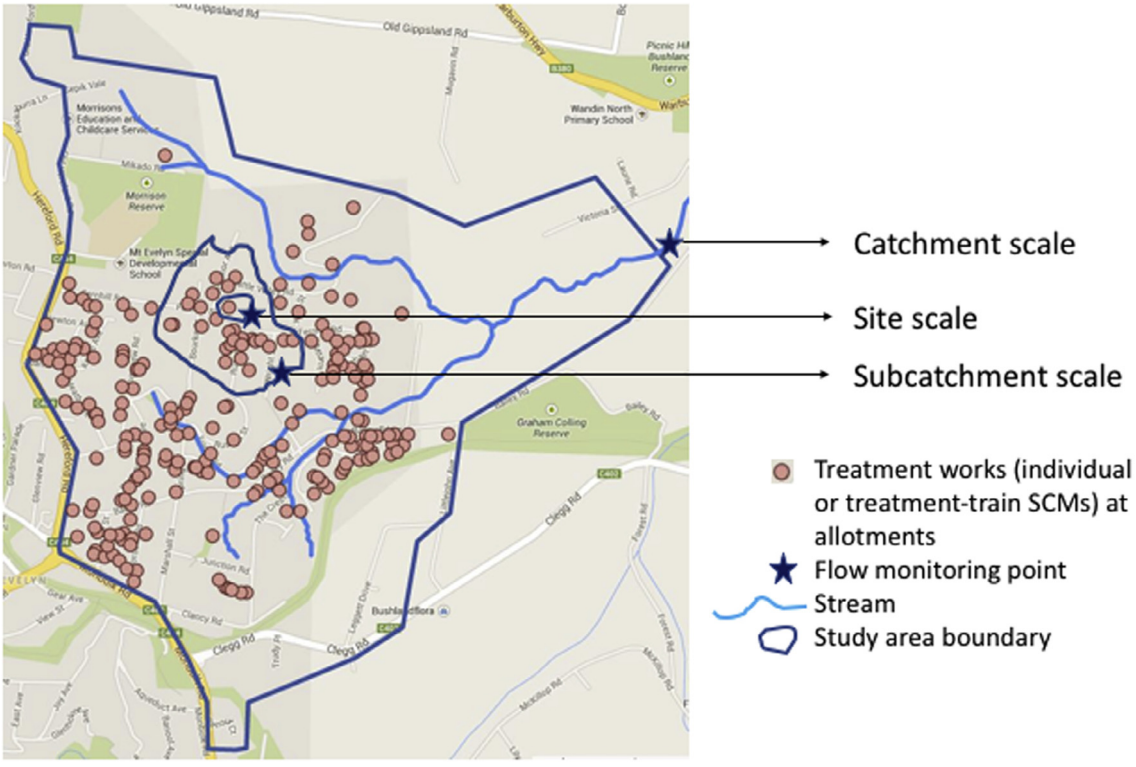

Fig. 1. A conceptual map of site scale, subcatchment scale and catchment scale.