The expanding role of urban fluvial geomorphology: South Creek

Stephanie J. Kermode
University of Wollongong, skermode@uow.edu.au

Phillip Birtles
Sydney Water Corporation

Geoff Vietz
Streamology

Stephen Lynch
Blacktown City Council

Jonathon Dixon
Sydney Water Corporation

See next page for additional authors

Publication Details
The expanding role of urban fluvial geomorphology: South Creek

Abstract
As aspirations for waterways in urban areas increases, and we demand more social and environmental values from them, an increased role exists for applied geomorphology in urban streams of the future. Previously, there has been a strong focus on flood mitigation and water quality in stream management, and even where geomorphology has been used to drive legislation (e.g. stream order, offsets), desired outcomes have not always been achieved. Understanding how physical attributes of channels are altered by urbanisation, and how the physical template and waterways can assist in achieving aspirational goals, is now central to urban landscape managers and planners. South Creek in Western Sydney is in the largest urban growth catchment in Australia. An opportunity currently exists for Sydney Water, local councils, developers, state agencies and regulatory bodies to work together to create a significant 'green and blue' corridor. This opportunity, however, is reliant on understanding landscape-waterway interactions. The greenfield development provides scope to apply advancing understanding of urban geomorphology, but this requires numerous questions to be addressed, including: How feasible is it to maintain desired geomorphic processes in South Creek under urbanisation? What outcomes are we hoping to achieve for the waterway? What broad considerations must be addressed (stormwater runoff, riparian space) and can they be addressed to the extent required? If we are serious about healthy waterways and green spaces how do we prevent the impacts of upstream urbanisation creating enlarged, eroded channels that frequently jeopardise riparian spaces for the community? Assessment of 'alternative waterway states' provides one approach under which aspirations and requirements can feed into management strategies.

Disciplines
Medicine and Health Sciences | Social and Behavioral Sciences

Publication Details

Authors
Stephanie J. Kermode, Phillip Birtles, Geoff Vietz, Stephen Lynch, Jonathon Dixon, Carl Tippler, and Michael Dean

This conference paper is available at Research Online: http://ro.uow.edu.au/smhpapers/4607
The expanding role of urban fluvial geomorphology: South Creek

Kermode S1,2, Birtles P1, Vietz G5, Lynch S3, Dixon J1, Tippler C4 and Dean M4

1. Sydney Water, 1 Smith Street, Parramatta NSW 2150, stephanie.kermode@sydneywater.com.au
2. University of Wollongong, Northfields Avenue, Wollongong NSW 2522
3. Blacktown City Council, NSW
4. CT Environmental, Sydney, Australia
5. Streamology, Victoria, Australia

Key Points
• Geomorphology has an expanding role to play in urban streams
• By articulating desired outcomes, metrics can be developed to determine required flows and geomorphic features

Keywords
Geomorphology, urban streams, riparian spaces

Introduction
As aspirations for waterways in urban areas increases, and we demand more social and environmental values from them, an increased role exists for applied geomorphology in urban streams of the future. Previously, there has been a strong focus on flood mitigation and water quality in stream management, and even where geomorphology has been used to drive legislation (e.g. stream order, offsets), desired outcomes have not always been achieved. Understanding how physical attributes of channels are altered by urbanisation, and how the physical template and waterways can assist in achieving aspirational goals, is now central to urban landscape managers and planners.

South Creek in Western Sydney is in the largest urban growth catchment in Australia. An opportunity currently exists for Sydney Water, local councils, developers, state agencies and regulatory bodies to work together to create a significant ‘green and blue’ corridor. This opportunity, however, is reliant on understanding landscape-waterway interactions. The greenfield development provides scope to apply advancing understanding of urban geomorphology, but this requires numerous questions to be addressed, including: How feasible is it to maintain desired geomorphic processes in South Creek under urbanisation? What outcomes are we hoping to achieve for the waterway? What broad considerations must be addressed (stormwater runoff, riparian space) and can they be addressed to the extent required? If we are serious about healthy waterways and green spaces how do we prevent the impacts of upstream urbanisation creating enlarged, eroded channels that frequently jeopardise riparian spaces for the community? Assessment of ‘alternative waterway states’ provides one approach under which aspirations and requirements can feed into management strategies.

Study area and methods
South Creek catchment in Western Sydney has an 80 km long corridor, which is heavily degraded by previous agricultural and urban development (Figure 1). In the early 1800s the South Creek catchment was the focus for intensive farming and changes to waterways that have shaped the current fluvial landscape. Current urban growth in Western Sydney is focused almost wholly within the South Creek catchment, and South Creek is the primary landscape feature in the region for future and existing residents. The creek system
remains subject to urban and agricultural runoff with nutrients, sediments and heavy metal loads as well as impacts from industry and waste management facilities.

Figure 1. Western Sydney as defined by the Department of Planning & Environment, LGAs are outlined in white

South Creek and a major tributary Eastern Creek typically have some permanent flow, which increases after rainfall. Ephemeral streams are also evident in the South Creek catchment, particularly in the headwaters and smaller creeks. This includes the existence of fluvial form ‘chain-of-ponds’ that is extremely rare in an urban setting anywhere in Australia (Hoban et al. 2016).

The approach being taken by Sydney Water is to develop an understanding of community values for the stream ecosystem and then determining the ecological requirements of key species which uphold these visions (see Tippler et al., this issue). From this assessment, we then aim to develop flow and geomorphic metrics which can achieve these requirements. Ultimately, a geomorphic categorisation, ecological study and stream condition assessment, combined with hydrological, hydrodynamic and MUSIC modelling will be used to compare possible waterway states or ‘visions’ for the catchment. Since urban development poses complex and pervasive pressures on waterways the approach to understanding pressures and opportunities is also necessarily complex and ambitious, but a full understanding is required to demonstrate opportunities.

Results and discussion

Increasingly, there is an understanding that to achieve healthy urban waterways, inputs that influence streams, such as flows, pollutants and sediment budgets, should be kept as close to their natural condition as possible. This recognition is leading to incorporation of geomorphic attributes in management plans and activities. Incision, enlargement and homogenisation are typical responses of urban stream channels, which have implications for infrastructure, water quality and ecology (Simon and Rinaldi, 2006; Vietz et al., 2014a; Walsh et al., 2005). To minimise degradation of streams, it is critical to understand the mechanisms that cause detrimental impacts (Vietz et al., 2014b). Significant impacts are noted to occur at 3% effective imperviousness and just 10% EI in a watershed has been found to lead to demonstrable, probably irreversible loss of aquatic system function (Booth and Jackson, 1997). It is difficult to envisage what the landscape surrounding a truly healthy urban waterway actually looks like; whilst a forested catchment is continually
**8ASM Short Communication/Technical Note**

*Kermode et al. – The expanding role of urban fluvial geomorphology*

used as the reference condition, hydrological attributes of urban areas typically drastically depart from those characteristics fundamental to maintaining stream health. Nonetheless, that hydrological condition directly correlates with ecological condition (Poff et al., 1997) shows that a focus on flow regime will provide better outcomes for managed waterways. However, even amongst urban rivers, a large variety of fluvial forms have been noted which points to different capacity of rivers to adjust to changes and respond to rehabilitation strategies (Gurnell et al., 2007).

Opportunities exist to reduce flooding and improve stream condition and function by managing stormwater, alongside sediment supply, within the catchment (Vietz et al., 2016; Wohl et al., 2015). It is treatment of the source of the problems at the catchment scale which provides the best hope for improved outcomes in stream management, in addition to providing adequate buffer space. The amount of treatment required in the catchment to mimic pre-development flow conditions, however, is often substantial or requires significant upfront investment. For these reasons restoration is most challenging in significantly urbanised catchments (Bernhardt and Palmer, 2007; Hatt et al., 2004; Vietz et al., 2014b; Walsh et al., 2012). Catchment scale approaches require foresight with requirements for cooperation from management bodies, policy drivers which support this bigger picture, inclusion of amenity provisions and community understanding of the links between stormwater and catchment strategies and waterway outcomes (Ives et al., 2013). Greenfields developments, such as most of the Western Sydney Growth Area, provide particular opportunities for effective stormwater and subsequently flow regime management which will result in better outcomes for waterways and more liveable cities.

The ability to improve flow regime to a sustainable ecological level for the shale based streams in Western Sydney is largely untested. Hoban et al. (2015) undertook to specify the stormwater requirements for an industrial development in Marsden Park appropriate to protect a small intact chain-of-ponds system. By specifying multiple scaled WSUD the modelled flow regime approached predevelopment flow. This option required widespread use of green roofs, water harvesting, and large bioretention systems within every lot of the development. Despite these encouraging results, the cost was noted to be excessive partly due to the significant additional engineering required for warehouse buildings to feature greenroofs. An alternate option of re-directing flow to a sacrificial catchment was proposed.

Whilst such a proposal would vary considerably in a residential context (more permeable ground to roof surface ratio is likely) a real question arises regarding the willingness of the community to pay for preserving functional natural systems in this part of Sydney when technical solutions are possible.

The past characteristics and dynamics of the stream are particularly important to understand future trajectories. Firstly, was the natural regime ephemeral or perennial and how has this changed? What is the sediment composition of the bed and banks? How do these factors interrelate? Hydraulic modelling, alongside grain size analysis, is required to determine at what shear stress (flows) erosion will occur for different reaches of a given stream (Vietz and Hawley, 2016). Studies have shown that flows which initiate erosion occur often under natural conditions (Booth et al., 2004). Flows as little as 0.5 year ARI have been identified as initiating bedload transport (Booth et al., 2004), while dominant discharge (i.e. discharge which transports the most sediment) can range from mean daily flows to those exceeded 8-10 times per year (Wolman and Miller, 1960). Therefore, any increase in low flows may provide conditions for constant erosion, particularly in an urban catchment where (especially coarse) sediment inputs are limited.

Clear objectives for waterway management would ensure articulation of what the management strategy is trying to achieve (Figure 2). By understanding what the priorities are, this in turn allows for description of which waterway attributes need to be retained/restored and identification of the mechanisms that will facilitate those attributes (Figure 3). Finally, by identifying what waterway (geomorphic) features need protection, the inputs such as flow conditions required can be determined providing a basis for development of thresholds which the fully developed scenario must meet (Figure 4).
**Determining thresholds**

![Flow threshold diagram with scenarios](image)

**Figure 2. Conceptualisation of the approach of this study; linking catchment outcomes or ‘visions’ with required flow thresholds.**

**Catchment approach**

- Allows different thresholds to be applied
- Prioritisation of works
- Different values can be implemented at appropriate places within the catchment
- Servicing adapted for optimal outcomes

![Catchment breakdown diagram](image)

**Figure 3. Conceptual catchment breakdown based on geomorphic assessment for development and management planning**
For objectives to be achieved, stormwater managers need specific guidance, including:

- Explicit links between flow regime and values
- Selection of appropriate flow metrics
- Specified performance targets
- A tool box of effective stormwater treatments.

Conclusions
Through the assessment of waterway values and ecological requirements, it will be possible to identify inputs which would support the necessary geomorphic attributes. This will in turn inform the feasibility of attaining the desired ‘alternate waterway state’ – for example, is the required flow regime realistic? Explicit information about species requirements combined with geomorphic understanding can translate into metrics regarding riparian space, flow regime, sediment budget and maintenance requirements. Only with this detailed information can we attempt to address considerations such as stormwater runoff and adequacy of the riparian corridor to the extent required to achieve outcomes. Without specific targets, and guidance on how to deliver those targets, managers and engineers are unlikely to achieve community visions for river systems. For ephemeral streams such as South Creek to be protected, stormwater harvesting must be extensively applied, and applied at a range of scales through the catchment (Duncan et al., 2014).

If we are serious about healthy waterways and green spaces, the impacts of upstream urbanisation must be addressed at catchment scale to prevent the degradation which threatens community enjoyment of these natural features.

Acknowledgments
Thanks to Blacktown City Council for working collaboratively on aspects of this work. Thank you to Leigh Smith for useful and constructive comments which improved this manuscript.
References


