



# ACHIEVING REGIONAL SCALE SURFACE WATER MANAGEMENT USING SYNTHETIC STREAM NETWORKS

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## Introduction

Surface water flooding causes significant damage, disruption and loss of life, both in the UK and globally. Surface water flooding is predicted to worsen in response to the emerging pressures of climate change, urban growth and aging drainage infrastructure, and is consequently prioritised as an area for future research in national strategic planning, such as the Climate Change Risk Assessment [1], and academic research [2]. The hazard was recently described as “the biggest risk flood risk of all” by Sir James Bevan, Chief Executive of the UK Environment Agency [3].

Past flooding management has been achieved through application of conventional drainage interventions, typically developed using site based design standards. Consequently, the design and performance of solutions of this type and at this scale is well understood. However, recent government reviews indicate current implementation of novel strategies is insufficient, despite clear and established legislation available for almost a decade [4]. A significant challenge is developing the current site scale implementation of strategies through to integrated regional surface water management, accommodating a range of measures such as conventional strategies, natural flood management (NFM), sustainable drainage systems (SuDS) and flood resilience opportunities, to name a few [2].

This research responds to a need for regional scale surface water management through developing a novel surface water catchment database based on a new concept of ‘synthetic stream networks’. These are computationally derived flow patterns which map likely overland runoff to delimit the spatial relationships of surface water catchments. This abstract outlines the key methodological advances, applications and limitations of this approach.

## Methods and Materials

The concept of a synthetic stream network is taken from catchment delimitation and stream order algorithms applied in hydrology. A synthetic hydrological network is generated through predicting likely overland flow paths across a region through processing an open access digital elevation model (DEM) using geospatial software. The DEM is filled to remove depressions and develop a connected surface for flow routing, water movement is defined through processing flow directions between cells and flow accumulation is calculated based on a rolling ball method; generating a regional distribution of overland flow. A threshold value is then applied to the flow distribution to define the network of predominant flow paths across the terrain, hereafter referred to as the synthetic stream network. A Strahler classification [5] is applied to rank stream ordering from 1 (upstream) to 8 (downstream). Catchments are defined based on watersheds contributing to each junction in this network and classified using the same technique applied to the streams.

## Results and Discussion

Figure 1 shows the synthetic stream network applied to South West England. This analysis applied a 2 m resolution DEM (gaps patched with a resampled 50 m DEM) across Avon, Cornwall, Devon and Somerset. The regional scale maps clearly highlight catchment order classification. Understanding the catchment and stream network structure develops an integrated way to manage urban flooding across a region by creating an opportunity to implement flood management strategies tailored to a specific catchment order. For example, flooding in a first order catchment will likely require localised application of management strategies to mitigate runoff within that specific watershed; however, a higher order catchment will be more connected, and so management may be possible through integrated and distributed solutions dispersed across a wider area. This could be achieved using a variety of solutions suitable to the context, for example NFM in connected rural regions and SuDS in urban areas.

The level of catchment connection may be relatively straight forward when assessing natural flow channels, for example rivers and streams, however this is less clear when evaluating heavily modified catchments such as urban areas, where flow dynamics may not be immediately apparent. Open source regional scale mapping enhances insight through enabling planners to identify broad spatial relationships at a preliminary stage of catchment management, opening up opportunities for offsetting flooding which may not be apparent when measures are considered at the site level. The catchment scale map inset into Figure 1 highlights the resolution available across the region.

The methodology is subject to several limitations which highlight it as a preliminary screening tool which should be considered indicative of spatial dynamics of surface water catchments at a regional scale. This is an important distinction as this style of high level analysis only accounts for overland flow and does not include interactions with the

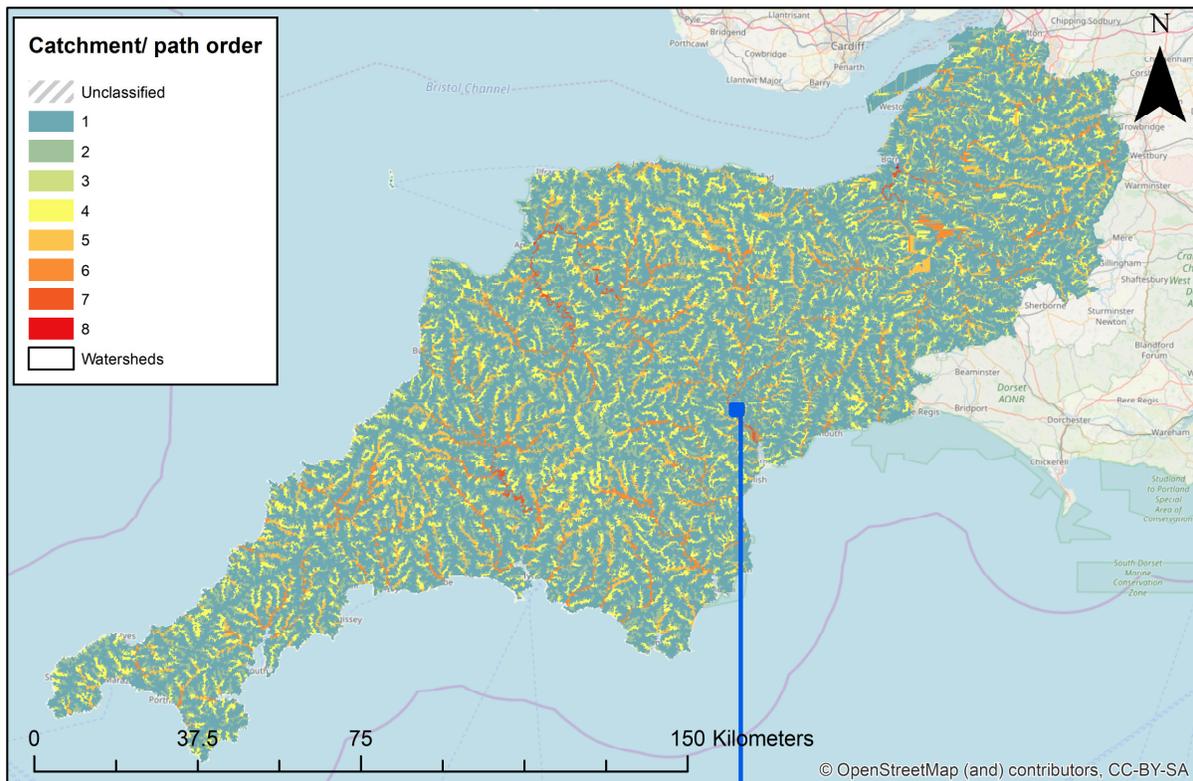
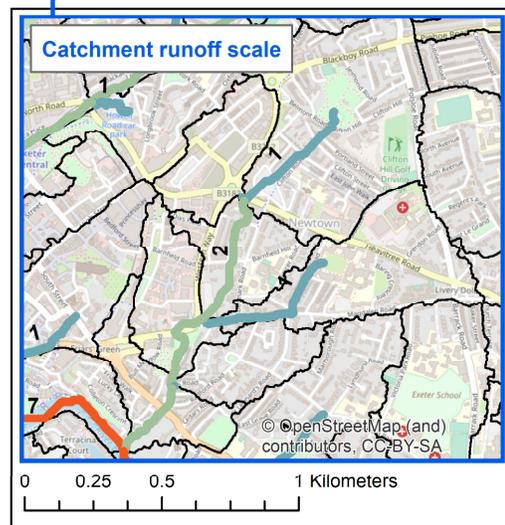


Figure 1. SW UK catchment order (above) and flow paths (right)

sub-surface sewer network, which may capture and route runoff between catchments or localised effects of urban micro topographical features, such as kerbs. However, the data set does represent likely overland flow routes when sewer capacity is full, a condition likely to be met during periods of surface water flooding.

### Conclusions

Developing a synthetic stream network enables researchers and practitioners to screen the spatial dynamics of regional surface water flooding at an early stage of management. The approach is currently in its early stages, however it is envisaged that this style of regional analysis can assist stakeholders in collaborating to design and implement integrated and novel surface water management strategies, which advance on the current paradigm of site based management. The next phase of development will validate and implement this approach across a range of case studies in South West England.



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