Assessing the efficacy of offline water storage ponds for Natural Flood Management

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Introduction

- Natural Flood Management represents a range of catchment-based measures that enhance flood resilience through the restoration and augmentation of hydrological and morphological catchment features.
- Offline storage ponds are designed to emulate naturally occurring floodplain ponds, increasing floodplain surface water storage.
- Despite research highlighting their potential benefits, there is a limited quantity of robust and science-based empirical evidence on how these structures function in the landscape and their efficacy in reducing flood hazards.

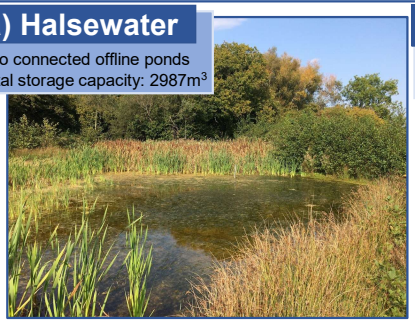
Research Questions:

1. What are the lower and upper limits at which offline ponds function?
2. What is the efficacy of offline ponds to attenuate flow, based on their ability to fill, store and spill storm water?

Study sites

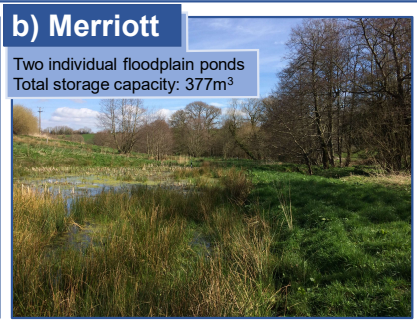
a) Halsewater

Two connected offline ponds
Total storage capacity: 2987m³

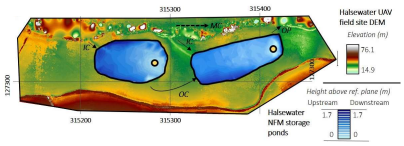


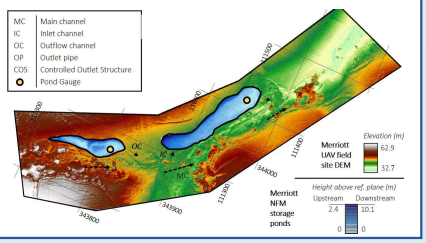
b) Merriott

Two individual floodplain ponds
Total storage capacity: 377m³

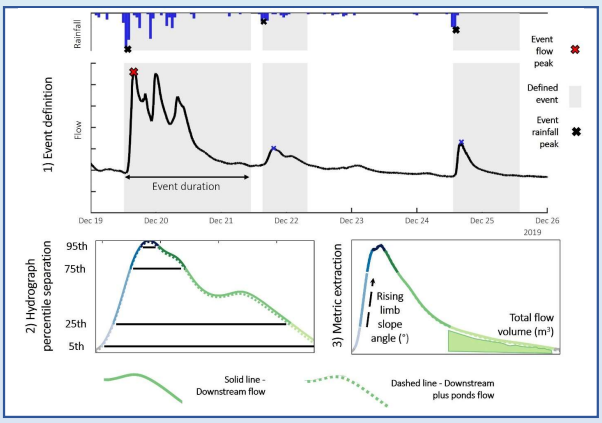


From April 2018-December 2020, 2 contrasting offline storage pond sites were monitored for rainfall, flow and volume in the Tone and Parrett catchments, SW-England.





Methodology



1) Event definition

Rainfall and flow data were processed using a rules-based event definition workflow, using a minimum interval time.

2) Hydrograph percentile separation

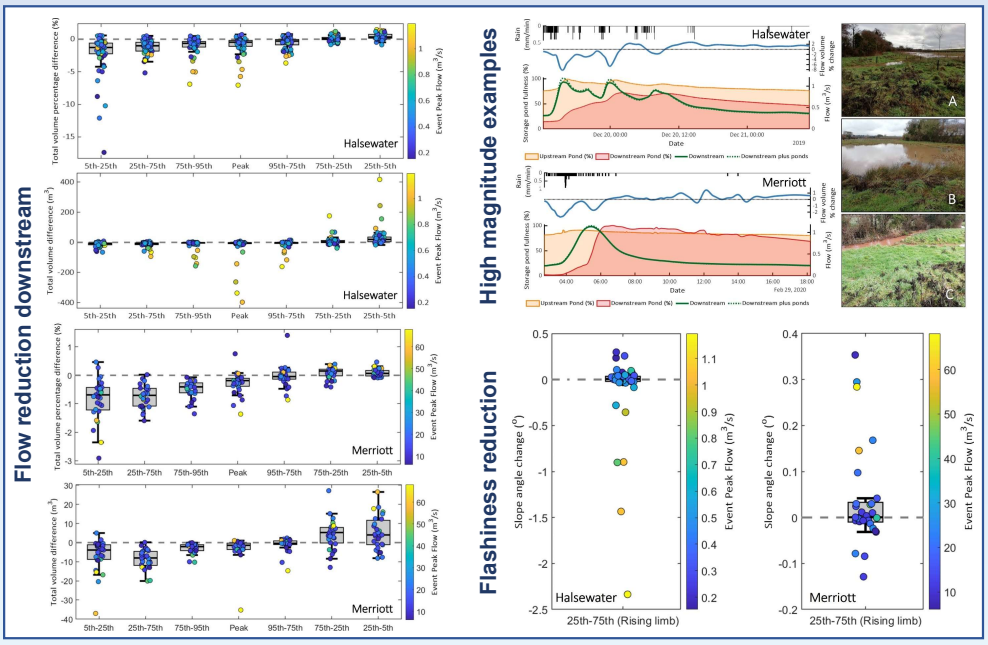
Hydrographs were split into percentile groups, based on the range of flow values in each event. These were used to analyse the impact of ponds across a full range of events.

3) Metric extraction

The efficacy of ponds to attenuate was analysed by comparing two scenarios: 1st where ponds are included (downstream flow) and 2nd where ponds are omitted (downstream flow summed with all pond volume change). The impact of ponds on total flow volume and rising limb slope angle were assessed.

Results

1) Offline storage ponds can generate flow reductions downstream, notably in the largest magnitude events
2) Halsewater ponds generated reductions in peak flow of up to 7% and rising limb slope angle by up to 2.3° downstream. This corresponds with peak volume storage of up to 408m³
3) Merriott produced lower levels of attenuation (max 1.4%), with few cases of floodplain connection due to high inlet heights.
4) Pond spilling is generally slow (up to 7 days to reach pre-event volumes during the highest recorded events).
5) The majority of captured events do not produce flows high enough to generate inlet filling. Pond filling occurs from rainfall and surface/ subsurface flows.



Conclusions and wider implications

- Individually, offline storage ponds are unlikely to produce marked peak flow reductions for flood mitigation, even immediately downstream (as monitored here) due to their size, floodplain location and natural design.
- However they can contribute to small peak flow storage, utilising unused farmland.
- Pond structure must enable occasional filling (low enough inlet heights) and sufficient spilling (low enough outlet heights) following events. Pond design must be flexible and allow for these improvements following construction.
- These results may be applicable for use as observational data in future modelling applications, to understand the impact of floodplain-based features for flood risk at the catchment scale.