Monitoring NFM in the Evenlode Catchment: Evidence on the delivery of multiple benefits

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The Littlestock Brook Natural Flood Management trial:

The Littlestock Brook Natural Flood Management (NFM) trial ran from 2016 to 2022 (Figure 1). Key objectives were to reduce flood risk to the village of Milton-under-Wychwood in the Evenlode catchment (Oxfordshire) and improve water quality. UKCEH has led work on a detailed monitoring campaign to assess the effectiveness of the NFM interventions on reducing flood flows and improving water quality.

Figure 2: (right) Overbank flows during a flood event, a sediment trap full of accumulated silt, taking manual flow gauging measurements using an electromagnetic current meter; sampling sediment cores. (above) An instream leaky barrier; an online pond, and an offline flood storage area.

Table 1: NFM interventions and cumulative storage volume (m^3) added in the North & South sub-catchments.

Implementation Date	South sub-catchment		North sub-catchment	
	NFM Interventions	Cumulative storage (m^3)	NFM Interventions	Cumulative storage (m^3)
March 2017	None	0	Woody dams (for bedload transport control)	0
February 2018	Leaky woody dams; field corner bunds and offline storage areas; woodland planting; on-line ponds	11500	Woodland planting, offline storage area	140
February 2019	Field corner bunds and offline storage areas; on-line ponds	14700	Field corner bund and offline storage area; leaky woody dam and swale; on-line pond	2020
Sept/Oct 2020	None	14700	Field corner bunds and offline storage areas	8420
Winter 2020/21	Sediment/nutrient traps	14700	Sediment/nutrient traps and ponds	8420

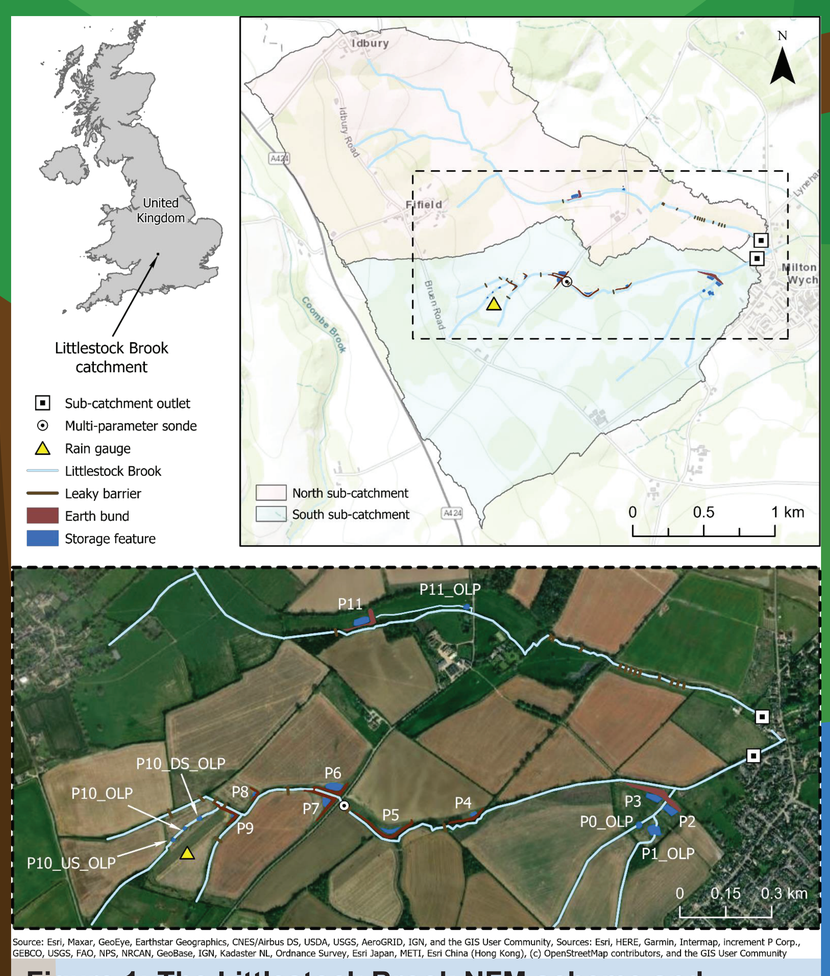


Figure 1: The Littlestock Brook NFM scheme and monitoring in the North and South sub-catchment (each draining 3.4 km^2).

Catchment monitoring:

A detailed water quantity and quality monitoring network was established, including:

- Sub-catchment outlet stream monitoring stations, recording water level (converted to flow) and turbidity (converted to Suspended Sediment Concentration) at 5-minute intervals.
- Water quality sampling (manual samples and automatic samplers) included suspended sediment and nutrient concentrations.
- Two tipping bucket rain gauges and a storage gauge.

Intervention monitoring:

NFM interventions were monitored to determine their effectiveness at storing water, sediment and nutrients:

- 13 water level sensors in Flood Storage Areas (FSAs) and online ponds (5-minute resolution water depth/volume).
- Sediment core sampling (physical/chemical properties) & sediment depth surveying within FSAs and online ponds.
- Water chemistry sampling of online pond inflow/outflows.
- Sediment trapping devices in online ponds (accumulation rates and physical/chemical properties).

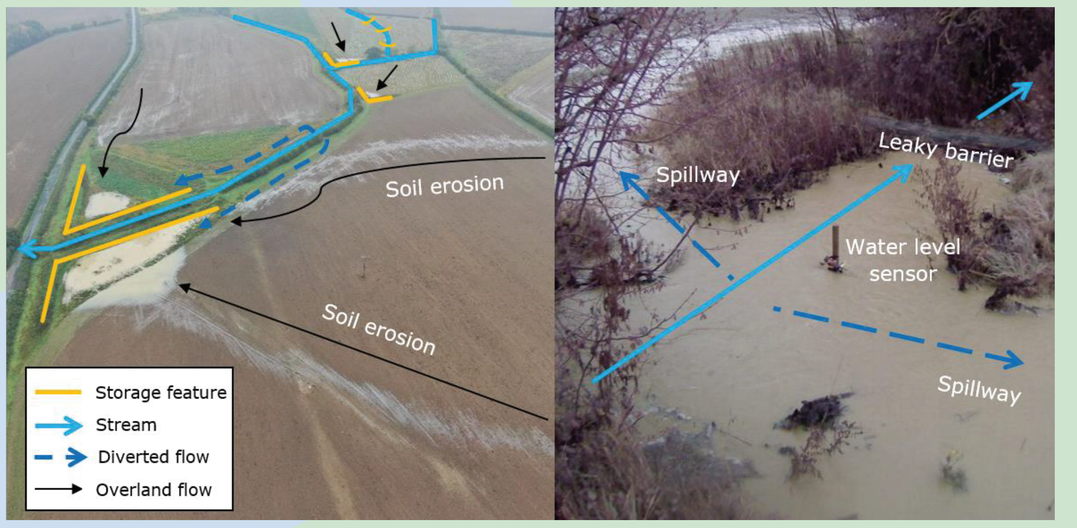


Figure 3: (above) Drone imagery demonstrating the capture of water & eroded sediment from run-off pathways. (Right) Leaky barrier pushing stormflow overbank into spillways connected to FSA.

Flood Attenuation:

The flood attenuation effect of the NFM was assessed through estimating pre-intervention hydrographs based on estimated FSA water volumes during events, and travel time calculated using estimated mean channel velocity and distance from FSA outlets to the discharge monitoring site at the sub-catchment outlet.

- Analysis showed reductions in flood peaks across events, ranging from 14.2 % to 55.2 %.
- The proportion of water stored by FSAs was highest during the larger and more intense events. We hypothesise that higher stream water levels resulted in greater overbank flow into the FSAs (as seen in Figure 3).
- Hydrographs demonstrate reduced discharge on the rising limb due to flood water storage at the start, peak, and first part of the falling limb, after which FSA drainage increased discharge on the falling limb (Figure 4).

Key Findings:

Online ponds

- Baseflow removal of dissolved nutrients
- Net trapping of sediment/total phosphorus
- Risk of remobilisation/flushing sediments during high magnitude events

Offline ponds/Flood Storage Areas

- Combined effect of FSAs reduced flood peaks by 14–55 %.
- 40 % storage remaining throughout, providing potential flow attenuation for larger events.
- Provide sediment, phosphorus & organic carbon storage, but accumulations do not compromise flood storage potential

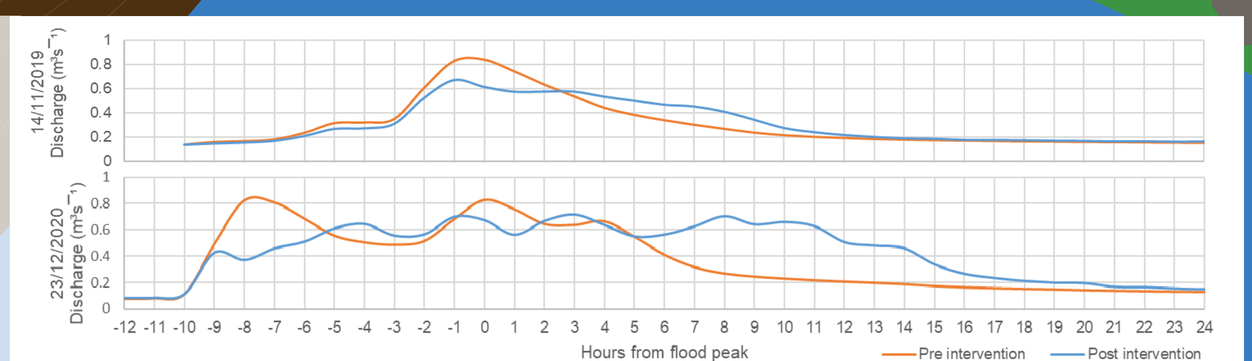
Leaky barriers

- Enhanced flood storage of bunded features during highest flows
- Encourage overbank flows and floodplain sediment deposition

Water Quality Benefits:

- Three small online ponds reduced soluble reactive phosphorus (biologically-available P) concentrations by an average of 29 %, and nitrate concentrations by 5 %.
- FSAs and ponds intercepted diffuse pollutants and in total accumulated 83 tonnes sediment, 122 kg phosphorus, and 4.3 tonnes organic carbon over 2-3 years since construction.
- Trapped sediment within FSAs and ponds is estimated to account for ~15 % of the South sub-catchment sediment yield.

Figure 4: Pre and post NFM intervention hydrographs for the South sub-catchment in two storm events. Pre-intervention discharge is estimated based on estimated FSA water volume timeseries and estimated travel times.



Research Outputs:

- Robotham *et al.* (2021) "Sediment and Nutrient Retention in Ponds on an Agricultural Stream: Evaluating Effectiveness for Diffuse Pollution Mitigation" https://doi.org/10.3390/w13121640
- Robotham *et al.* (2022) "Nature-based solutions enhance sediment and nutrient storage in an agricultural lowland catchment" (*in review*)
- Robotham *et al.* (2022). **High-resolution time series of turbidity, suspended sediment concentration, total phosphorus concentration, and discharge in the Littlestock Brook, England, 2017-2021.** NERC EDS Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/9f80e349-0594-4ae1-bff3-b055638569f8
- Trill *et al.* (2022) **High-resolution time-series of flood storage area water levels and estimated stored volumes in the Littlestock Brook, Thames Basin, England (2018-2022)** NERC EDS Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/cf70f798-442a-4775-963c-b6600023830f
- Trill *et al.* (2022) Littlestock Brook Natural Flood Management Pilot: Hydrological and water quality monitoring and analysis report (*open access report available soon on NERC Open Research Archive*)

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