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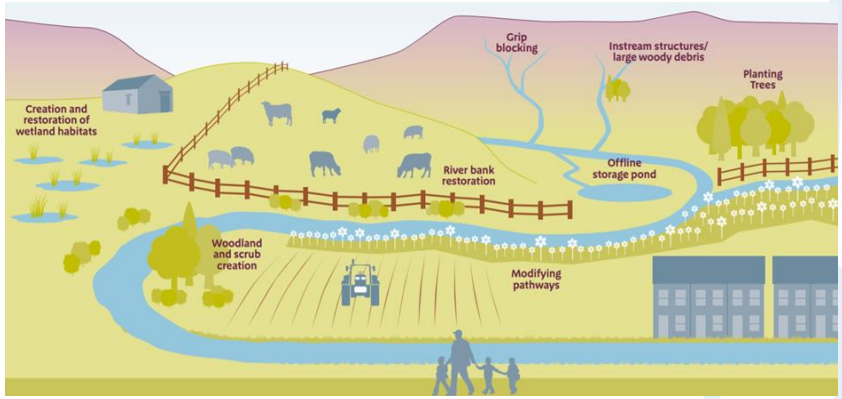
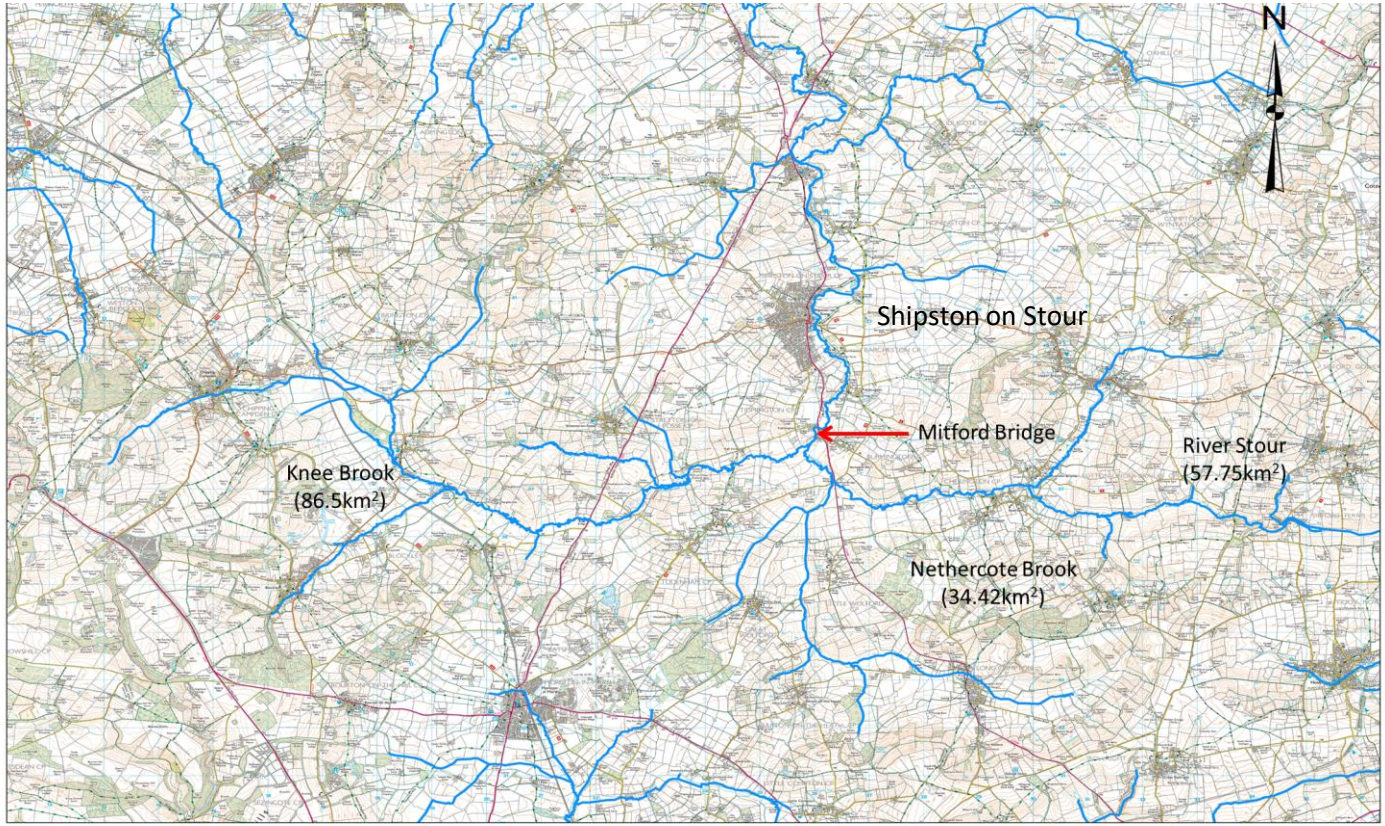
Co-designing Opportunities and Modelling Performance of Catchment Scale Natural Flood Risk Management: Stour Valley, Warwickshire-Avon, UK



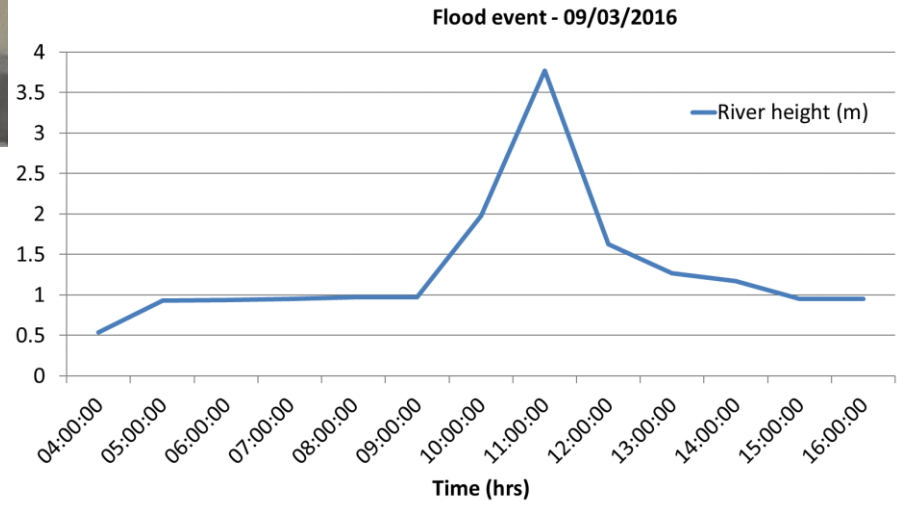
Acknowledge
Warwickshire County Council



Catchment overview

Large complex catchment. NFRM scheme required to reduce risk downstream whilst not enhancing risk to upstream communities via backwater effects or peak synchronisation. Climate change impacts.

Rapid response, time to peak < 1.5 hours.
Reflects steep, intense agricultural land use (70% arable)
Dominant clay soil



Site chosen as area inundated in 2007, and subsequently every other year.
Most recent internal flooding of properties occurring March 2016
14 flood warnings in last 5 years, more likely with CC

Physical information required

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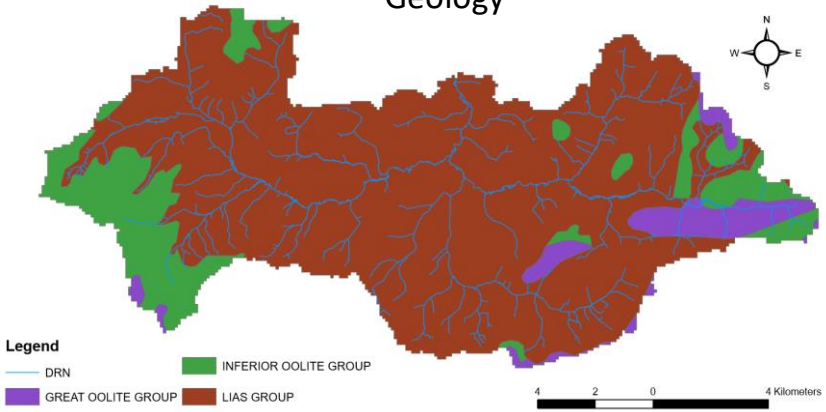
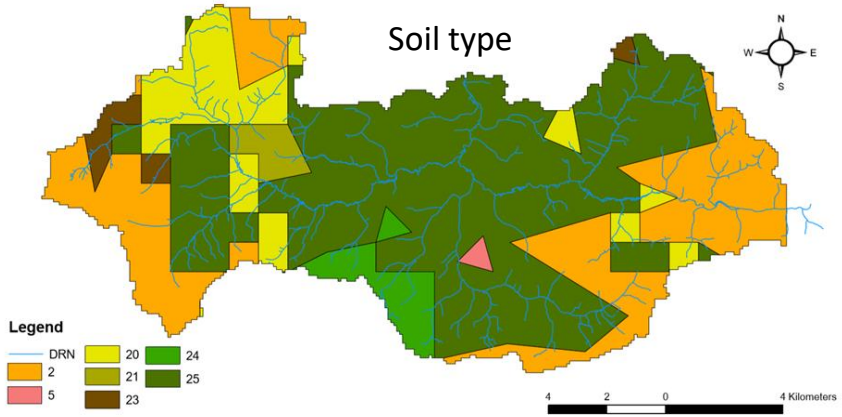
Geology



Soil type, geology, topography, landuse, rainfall, WFD status of catchment, SSSIs, likelihood of flooding etc

Soil type



Engaging with the community using opportunity mapping: Participatory GIS

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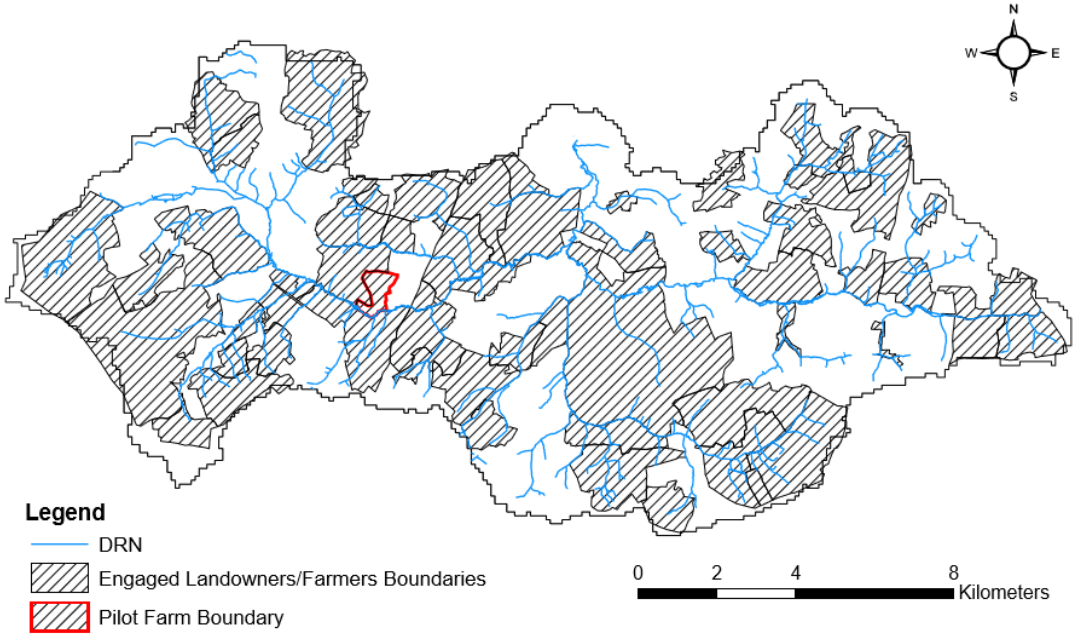
- Undertaken with individual farmers and landowners using active engagement
- Used Rural Payments Agency files to outline boundaries and details to make participatory engagement process more site sensitive, engaging individuals and obtaining local knowledge.
- People engaged across farms and estates on a one-to-one basis, took 14 months



129 participants recruited utilised local gatekeepers eg local flood action groups, Natural England (NE) and the National Farmers Union (NFU)
Enabled access to local farmers, landowners and tenant farmers (in consultation with landowner)

Extent of landowner and farmer engagement during the PGIS exercise.

Engagement process

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Step	Description
i. Introduction	Approaching landowners and farmers, following shared contact details and in some cases introductions by the gatekeepers.
ii. Project outline	Obtained consent from landowners and farmers, signed participant consent forms to participate in the PGIS exercise to allow farms/estates flood risk contributions analysed.
iii. Bespoke Farm Information Pack	Physical, hydrological and social characterisation maps per farm/estate.
iv. Conducting PGIS exercise	Identifying sources and pathways of flood flows per farm and estate, supported by referenced years in flood memories in order to inform co-designed NFRM opportunities.
v. NFRM confirmation	Confirming final co-designed NFRM opportunities, digitised in GIS outlining dimensions and capacities of each NFRM opportunity in precise locations.

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Preparatory

PGIS Exercise

Confirmation

1

Identify participants: farm and estate boundaries (Defra Magic Map and local gatekeepers)

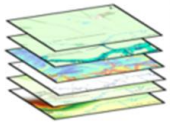
2

Introductions: Introduce researcher to farmer and aim of project, including willingness to participate via participant information sheet and signed consent form

3

Generic project brief: Send guidance document containing NFRM options and summaries to farmers before PGIS exercise. The document also outlines the format of the PGIS exercise.

4



Bespoke Farm Information Pack: Collate clipped maps of physical, hydrological and social characteristics per farm and estate, including base maps for PGIS exercise annotations

5

Flood memories: Recording the tactic flood memories of farmers, identifying 'problem' years they recall downstream flooding and how their land responded to heavy rainfall events.

6

Source(s) of flooding: During the PGIS exercise, the critical source areas of flood flows are annotated on the base maps per farm and estate.

7

Pathway(s) of flooding: During the PGIS exercise, the flow routes (in and out of channel) were annotated per farm/estate.

8

£

Farm business considerations: discuss and annotate key areas for the farm business that cannot be altered for NFRM purposes or if so, need to be considered sensitively, including stewardship areas and highly productive fields for crops

9

Opportunity areas: Sources and pathways in each farm and estate that can be utilised for NFRM purposes to slow, store, filter and disconnect flows

10

NFRM opportunities: Schemes that could be employed in opportunity areas that slow, store, filter and disconnect flood flows. - using project brief.

11

Digitised NFRM opportunities: The annotated maps containing co-designed schemes are digitised using ArcMap 10.4 and assigned attributes based on the co-designed area, dimensions and capacities. This is sent to the participants for confirmation.

Pilot Farm Investigation: location

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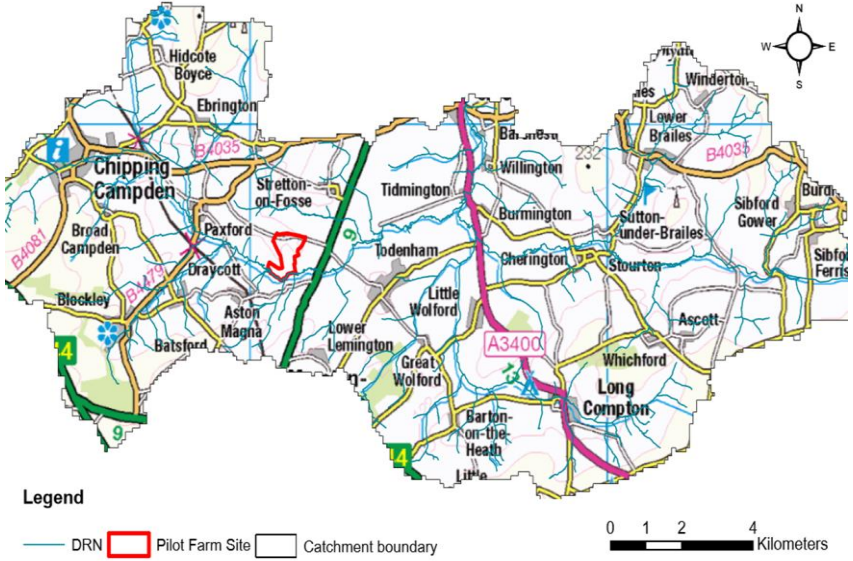
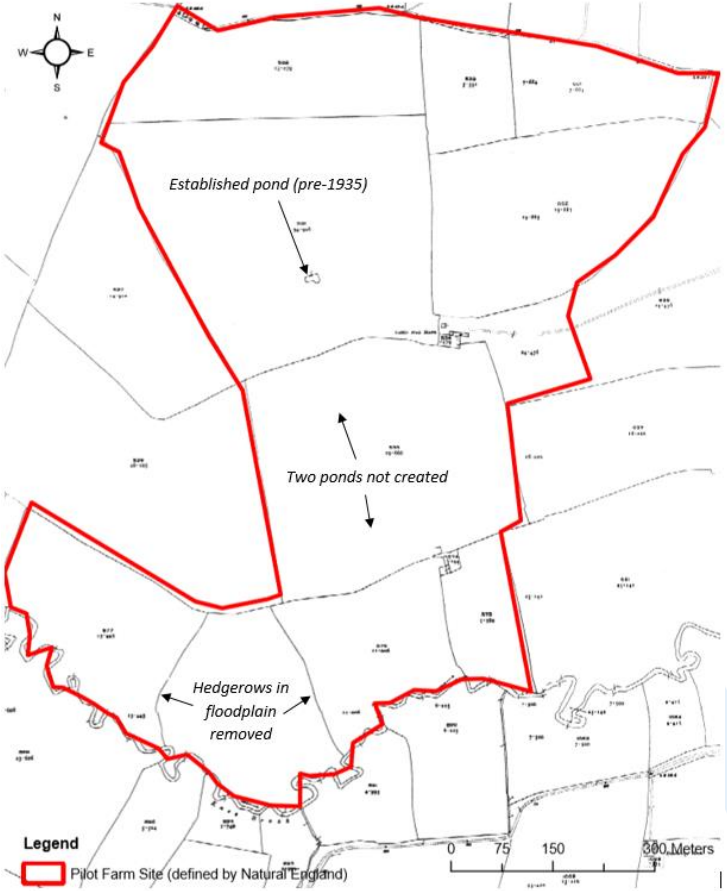
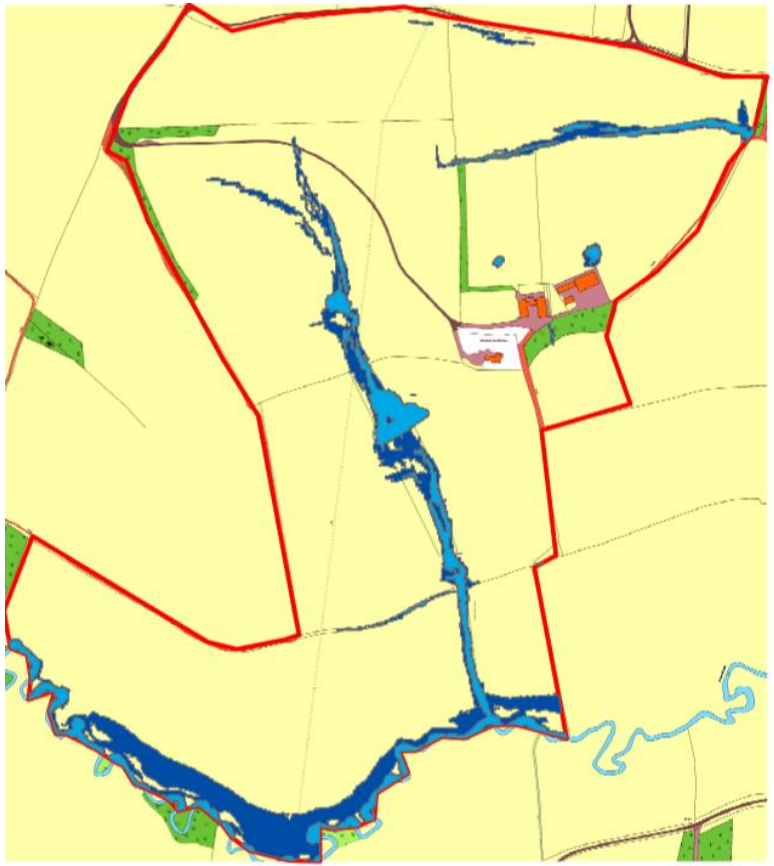




Key characteristics determined: soil type, geology, topography etc
Farm conveyed high levels of surface runoff into receiving watercourse from centre of the farm.
Overtopped existing ponds during larger events; frequent inundation of the floodplain.

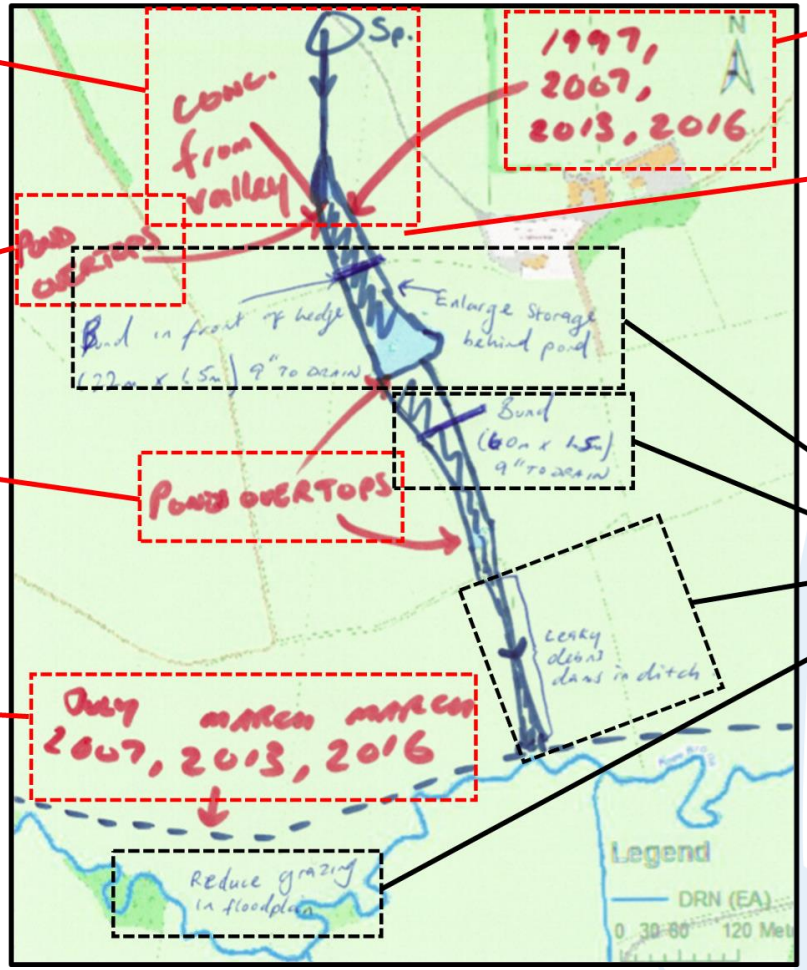

Legend
Pilot Farm Site (defined by Natural England)
Risk of Flooding from Surface Water 1%AEP
Risk of Flooding from Surface Water 0.1%AEP
0
75
150
300 Meters
N
S
W
E


Legend
Pilot Farm Site (defined by Natural England)
Risk of Flooding from Rivers and Sea
High
Medium
Low
0
75
150
300 Meters
N
S
W
E

***Sources and pathways**: gravel spring identified, concentrated flow pathway outlined as the steep valley feeding the receiving watercourse*

***Sources and pathways**: Existing ponds identified as a water features that overtop in flood events (all reference events). This shows there is a lack of headroom capacity and potential for additional surface water attenuation.*

***Flood memories**: Events when out of bank flows occurred. Floodplain depth was noted to be anywhere between 2ft (0.6m) for smaller events (e.g. March 2016) and 3 ft (0.9m) for larger events (e.g. July 2007).*



***Flood memories**: Events when overland flow occurred*

***Sources and pathways**: Overland flood route and extents identified (in relation to reference events). Note the overtopping of all existing water features and the concentration of flood flows down the valley to the receiving watercourse. This was noted to be at a depth of approximately 2ft (0.6m), and only last for a maximum of 24 hours before the flow route became inactive after the event.*

***NFRM Opportunities**:*

- *Bund: 9inch (22.86cm) pipe to drain, above pond*
- *Enlarged pond area, increasing storage behind pond*
- *Bund: 9inch (22.86cm) pipe to drain, beyond pond*
- *Leaky debris dams: 8 to intercept and slow flow*
- *Floodplain restoration: reduced grazing and rough grassland generation of floodplain to increase hydraulic roughness, evapotranspiration losses and infiltration losses. Any other attenuation scheme that required earthworks (e.g. offline ponds) were not feasible because the area is designated ancient ridge and furrow under existing stewardship and therefore has to be preserved. Any alteration to the ridge and furrow could generate PIFs under existing stewardship.*

Annotated base map by farmer: community mapping.
Included flood memory
Interventions must not interfere with farming business

Pilot Farm: Digitised PGIS NFRM

N
W
E
S

NFRM opportunities

Legend

- Leaky barriers
- Wetland
- Runoff Attenuation Bunds
- Floodplain set-aside as rough grassland

0 125 250 500 Meters

NFRM opportunity	Hydraulic function	Area (m^2)	Storage volume (m^3)
Bund 1	Interception and attenuation of overland flood flows	120	260
Wetland	Increasing hydraulic roughness Interception and attenuation of overland flood flows	1,010	790
Bund 2	Interception and attenuation of overland flood flows	230	390
Leaky barriers	Increasing roughness and slowing overland flood flows in ditch feeding watercourse	20	N/A
Rough grassland	Increasing floodplain roughness, slowing overland and fluvial flood flows	9,330	N/A
TOTAL		10,710	1,440

Total storage required for 1% Annual Exceedance Probability / 12 hour storm (Environment Agency) for a 0.59km^2 catchment = 3060m^3.
Co-designed NFRM attenuation features achieved 47.05% of this.
Additional measures would be required to protect the receiving watercourse

Upscaling

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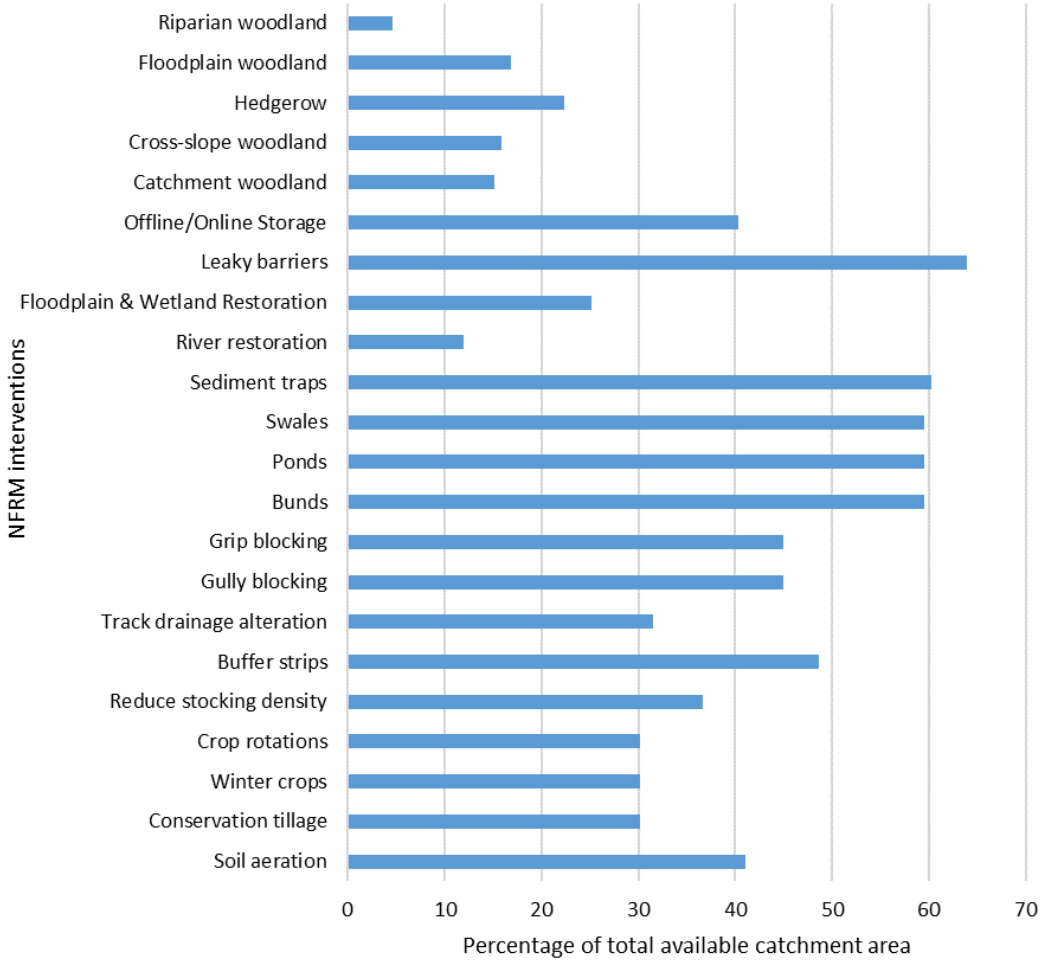
Across the total catchment area, 487 NFRM opportunities were individually co-designed with landowners and farmers using the PGIS framework using:

- **Runoff Management**: Features addressing the sources and pathways of overland flow routes, to slow, store, filter and disconnect runoff routes, eg bunds, ponds, sediment traps, swales, logjams and cross-drains. Soil and land management practices for rainwater harvesting and improved soil health for permeability also address runoff issues at the source.
- **River and Floodplain Management**: Features and changing land use to slow flood wave propagation, encourage natural stream and floodplain processes. Eg leaky barriers in-stream to slow the flood peak, earlier and greater connection to floodplain, enhance storage using eg offline ponds, re-meandering and bank lowering.
- **Woodland Management**: Afforestation in targeted areas to intercept flow routes and out of bank flows by increasing the hydraulic roughness, encourage permeability using deep rooting deciduous species and evapotranspiration losses with broadleaved canopies. Locations across slopes, in the floodplain, riparian areas, infilling or planting hedgerows, making field boundaries larger and more established. Management to encourage undergrowth, using woody material on the bare woodland floor to intercept flow pathways.



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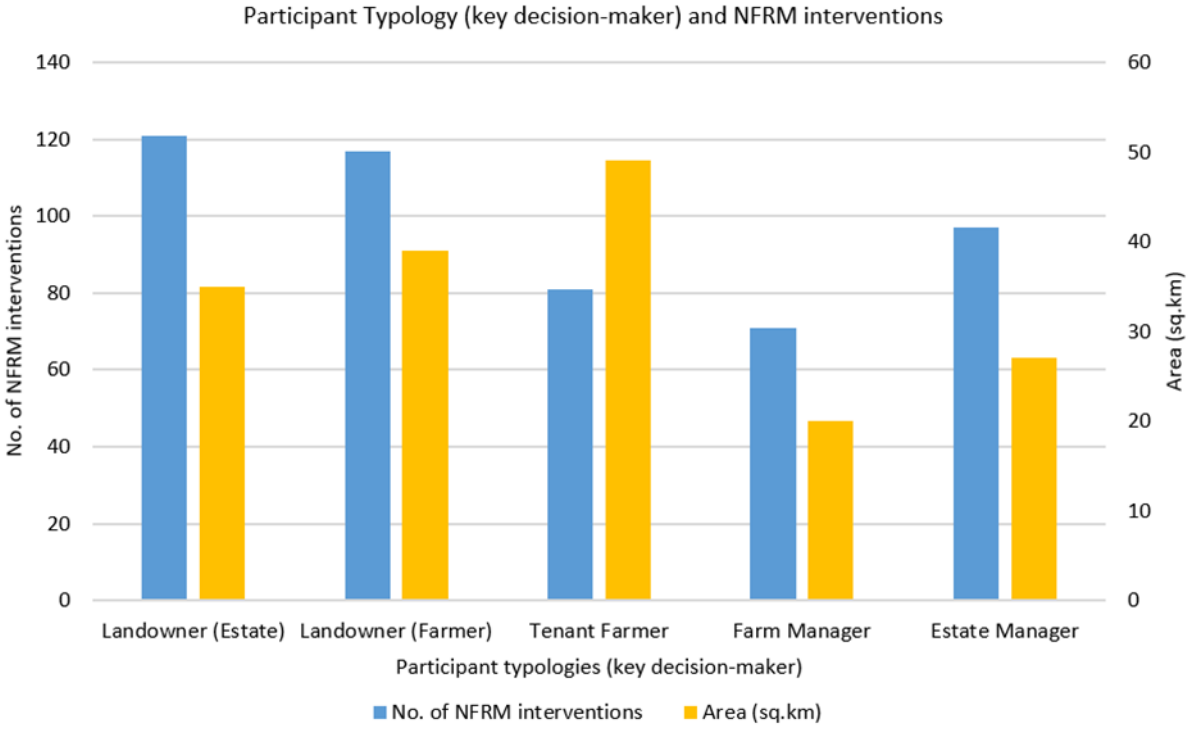
NFRM opportunities co-identified across useable catchment area and river channel network



Majority (83.36%) of NFRM opportunities were co-designed in areas with landowners (those who considered themselves estate owning landowners and farmers who own land)

Conclusions

- Engaging with farmers and landowners takes time and patience
- Flood memory can provide new information, correct currently held information, but can also be incorrect
- Modelling showed *theoretical* gains from catchment scale NFM, field monitored benefits required to be undertaken to validate modelled results.
- Farmers and landowners need to be interested
- Farm business must not be affected
- Flood peaks need to be desynchronised
- Funding needed eg Defra pilots, ELMS etc
- However, modelled results indicate that the larger the event, the less the impact:
- Extreme events with climate change

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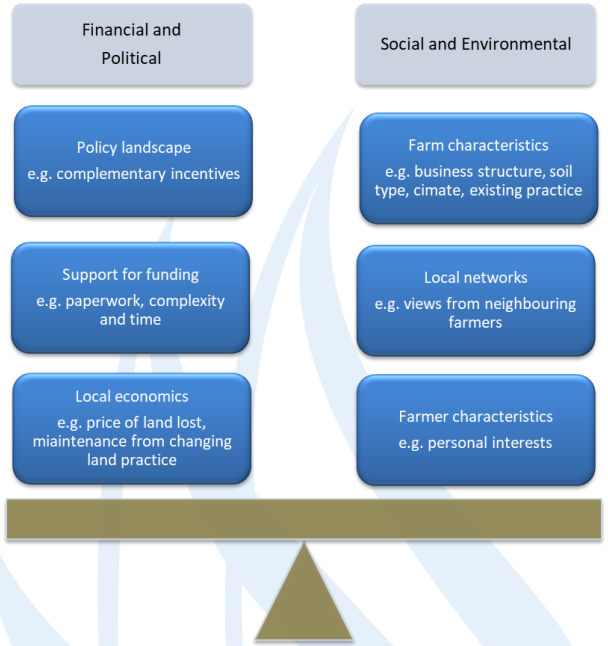

Factors influencing farmer's interest in implementing NFRM

- Lashford, C., T. Lavers, S. Reaney, S. Charlesworth, L. Burgess-Gamble and J. Dale. (2022) GI, NBS, NFM, SuDS and more – a review of the terminology and application of sustainable flood management techniques in the UK. *Water. 14, 1204.* *https://doi.org/10.3390/w14081204*
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