

Opportunity Mapping of Natural Flood Resilience Measures

A case study from the headwaters of the Warwickshire-Avon



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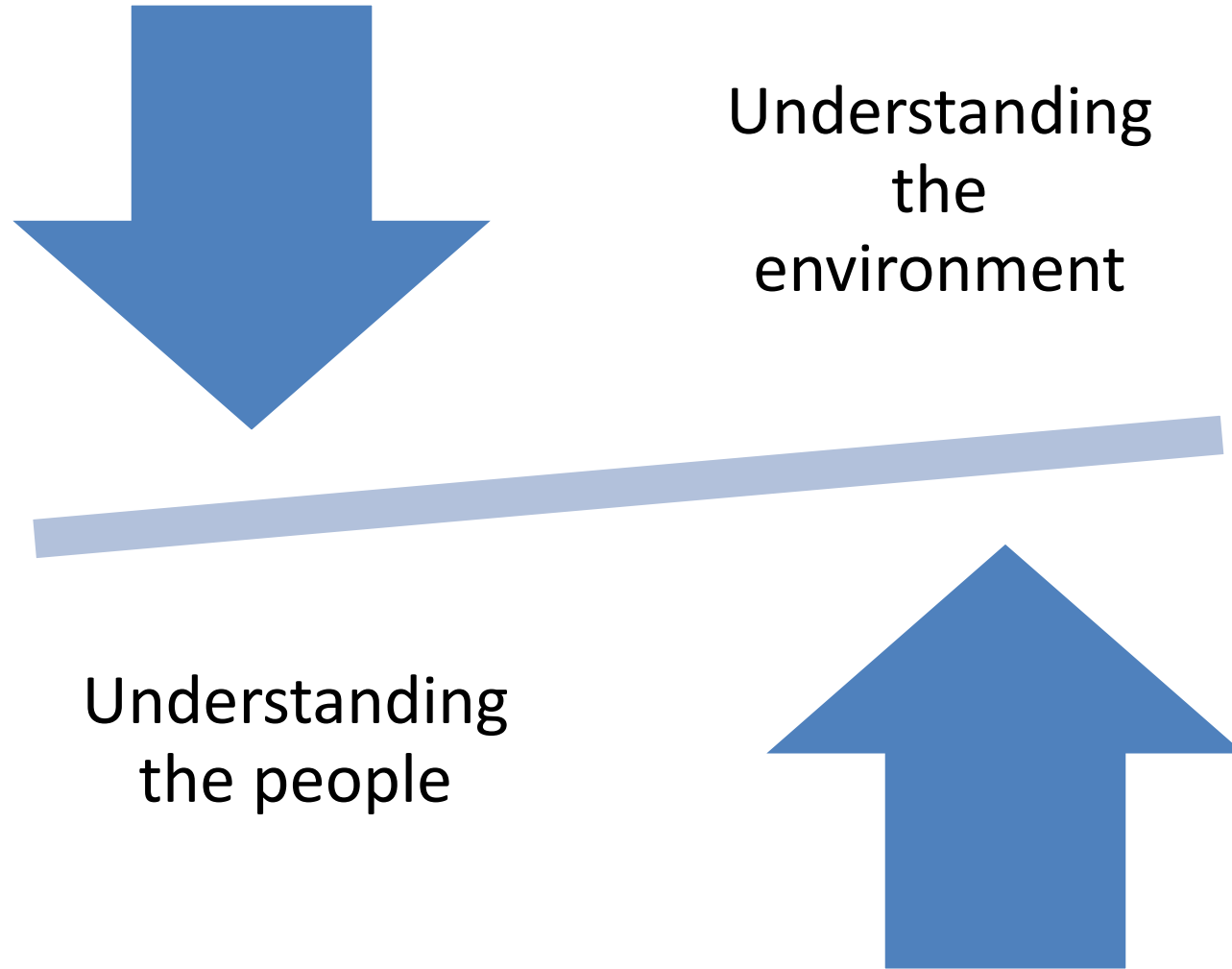
The Centre for Agroecology, Water and Resilience

Coventry University

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Natural Flood Resilience (NFR)





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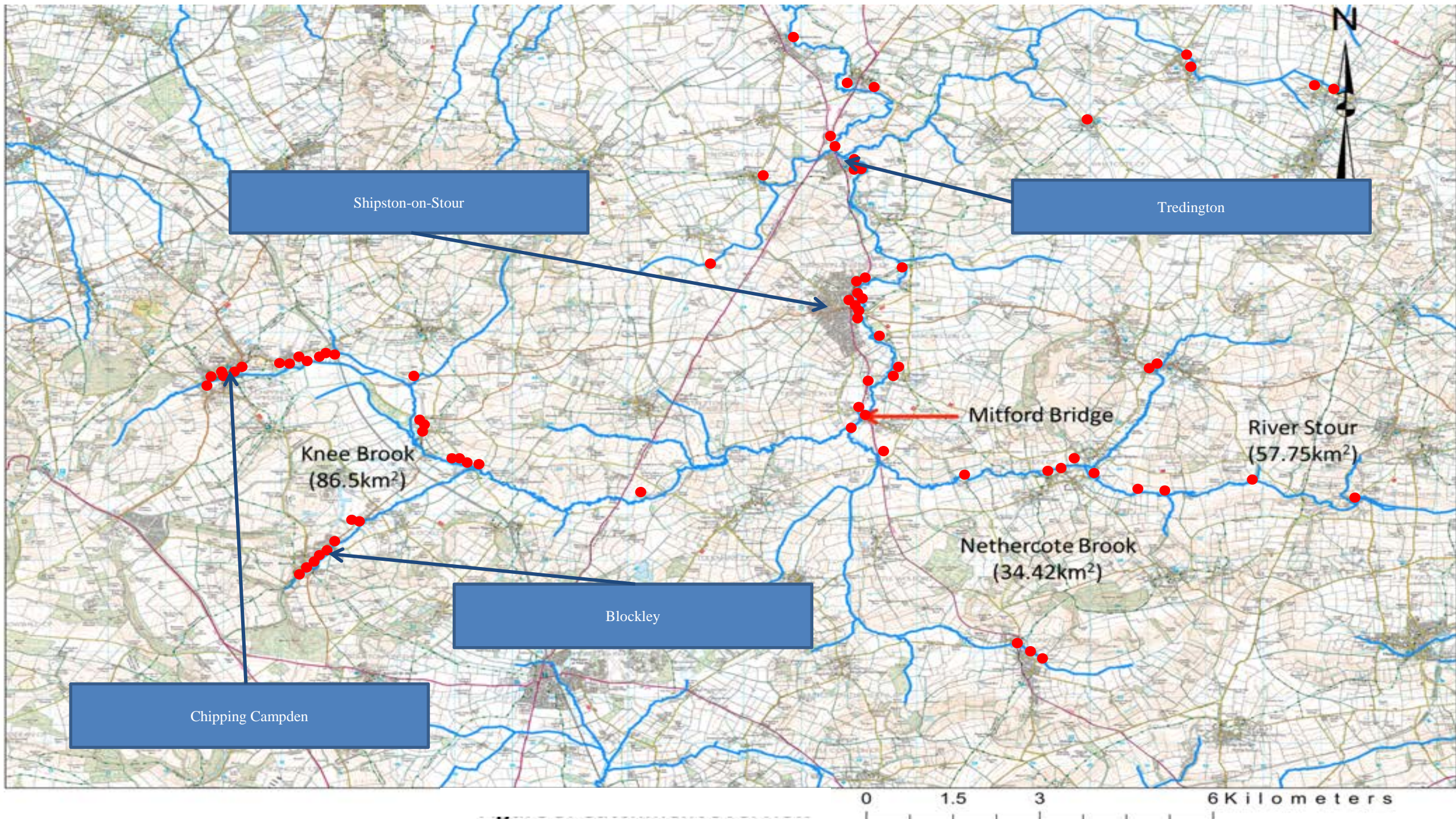
EVA and
FRANK

(winter flood
2015-16)

EAC (2016)

Defra Multi-
Objective
Pilot Projects
(2000)





Shipston-on-Stour

Tredington

Knee Brook
(86.5km²)

Mitford Bridge

River Stour
(57.75km²)

Nethercote Brook
(34.42km²)

Blockley

Chipping Campden

0 1.5 3 6 Kilometers

“...the journey of a thousand miles begins with one step”

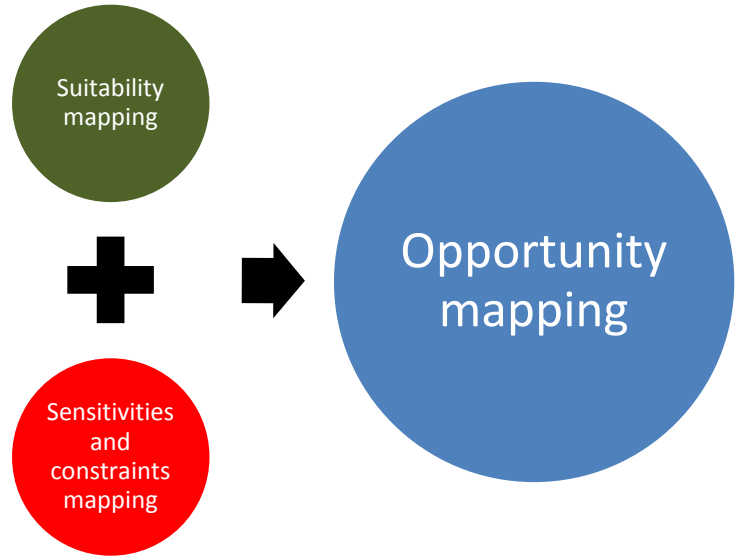
HOWEVER, THE ONE STEP CAN BE BACKWARDS...

**“...the value of local knowledge”
(Holstead *et al.* 2012)**

Table 1. Data and input used for NFR Opportunity Mapping



Suitability mapping elements	Sensitives and constraints
Hydrology of Soil Types (HOST) (CEH 2009)	Grade 1 Agricultural Land
Updated Flood Maps for Surface Water (UFMfSW)	Urban/settlement buffer area (500m) and road networks (300m)
Fluvial Flood Maps (FFM)	National Flood Risk Assessment data (EA)
Digital Terrain Model (DTM)	Environment Agency washlands
LiDAR (1m and 2m resolution)	Ministry of Defence (MoD) land.
Potential new woodland (Broadmeadow, Thomas and Nisbet 2013)	Scheduled Ancient Monuments
Land Cover Map (LCM) 2007 (CEH 2014)	RAMSAR/ Sites of Special Scientific Interest (SSSIs)
Countryside Stewardship Targeting areas (Natural England)	Land Cover Map (LCM) 2007 (CEH 2014)
<u>Community and Landowner/Farmer Engagement</u>	



Mapping phases

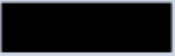


DTM – Delineation – Hydrological/LiDAR

Mosaic LiDAR coverage
(LiDAR_1m_res.)

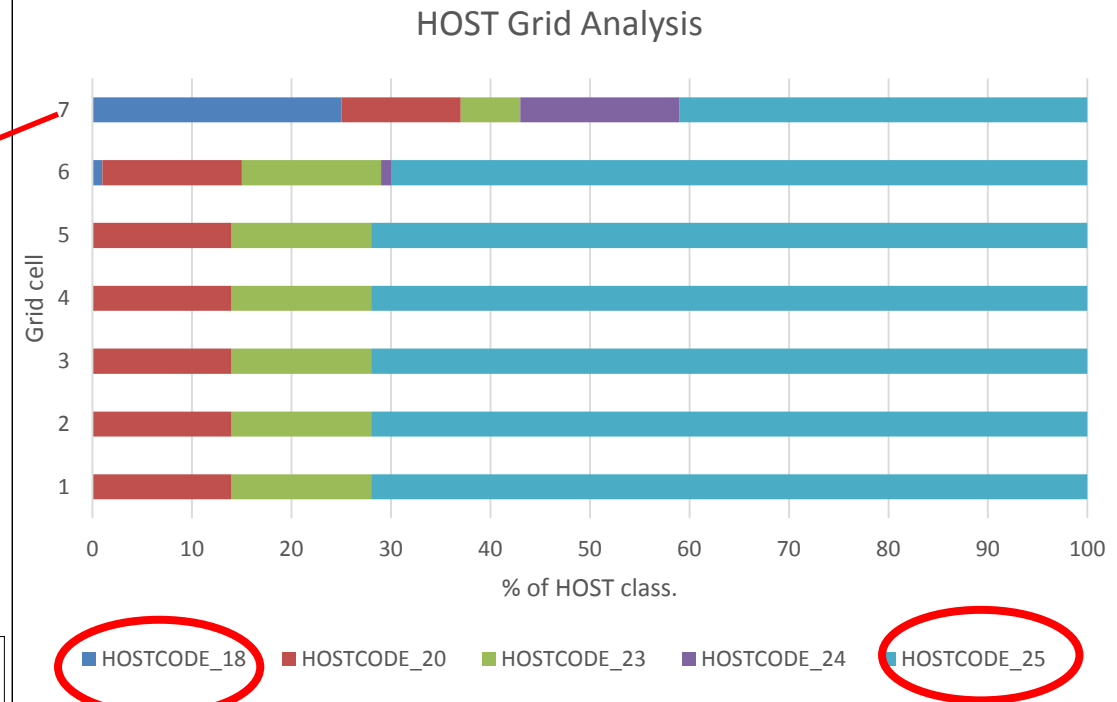
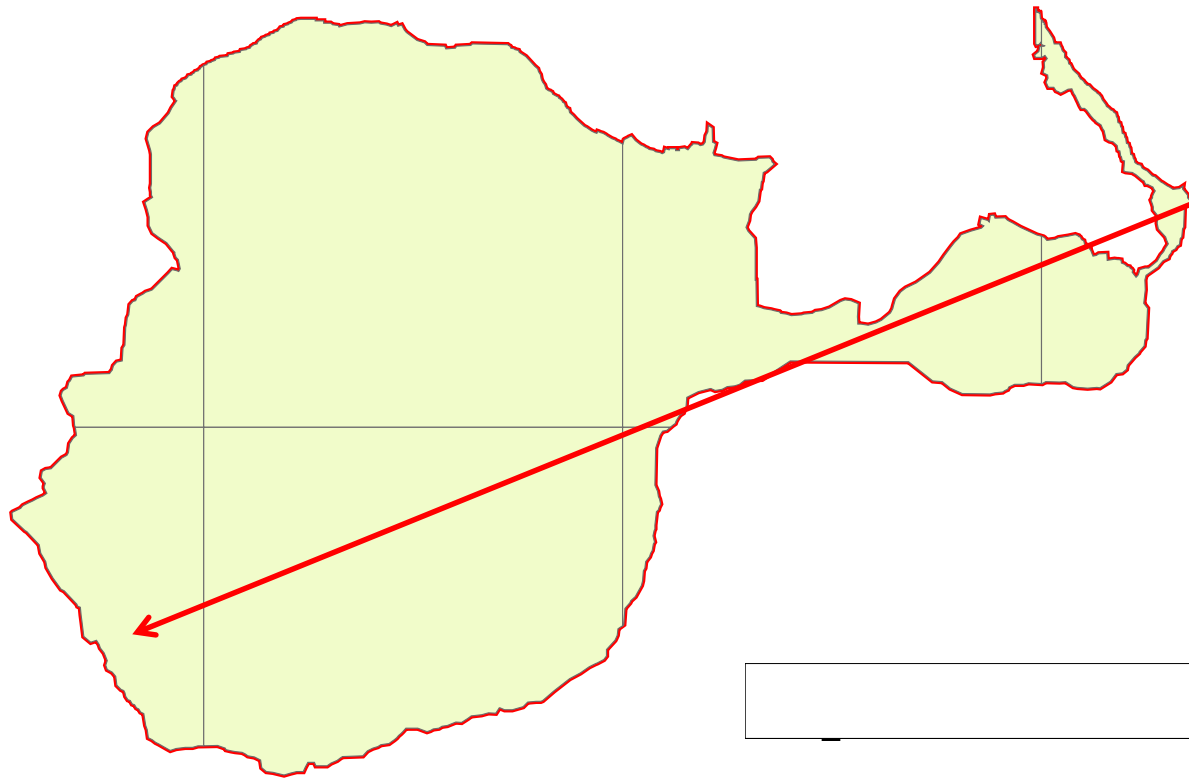
Use Arc Hydrology tools
Delineate sub-catchment



Verify flow pathways
and discharge routes

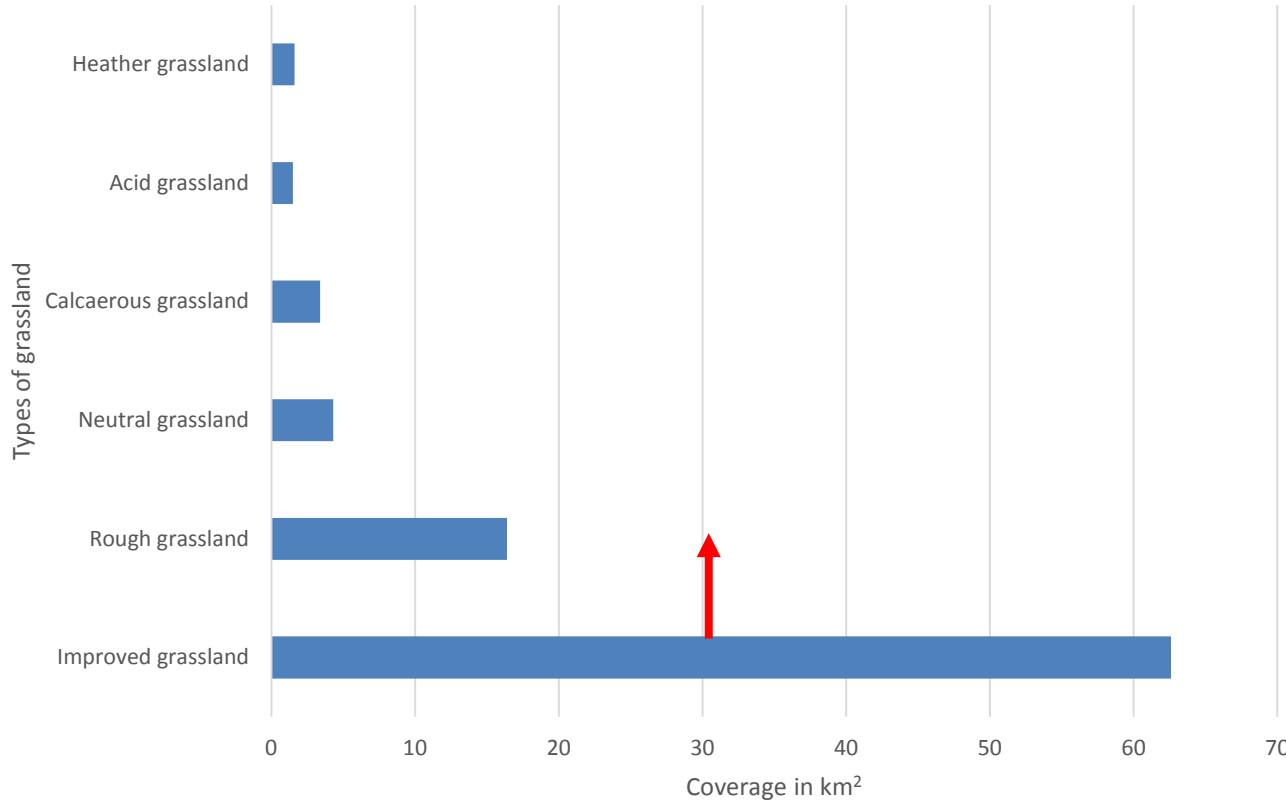
Drainage network	Key
Overland flow routes	
Field/farm drainage	
Pig Brook formation	

Pedology and Geology

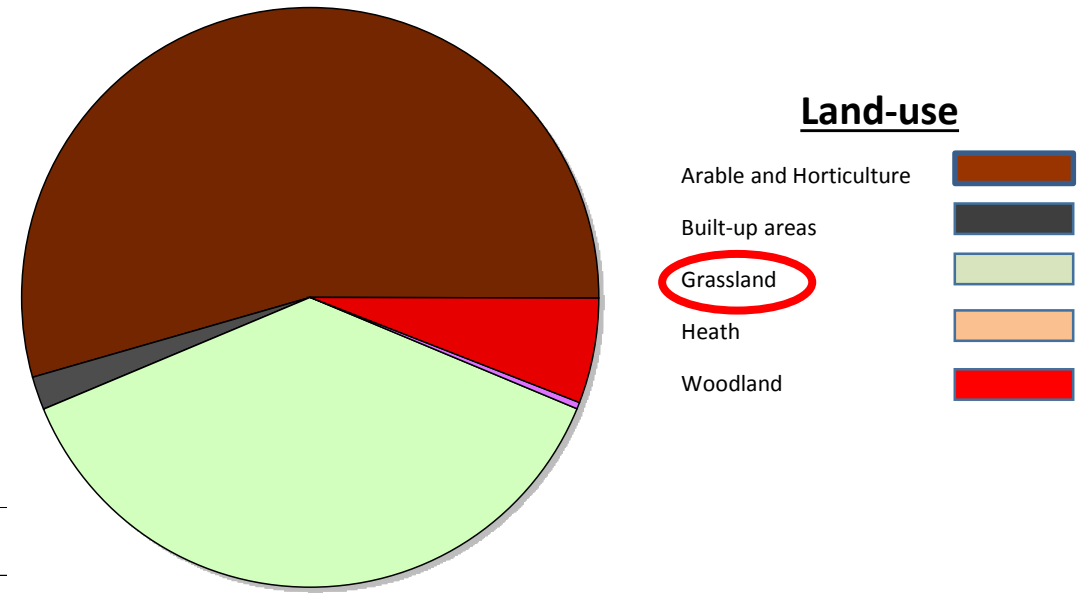


LCM2007 land-use

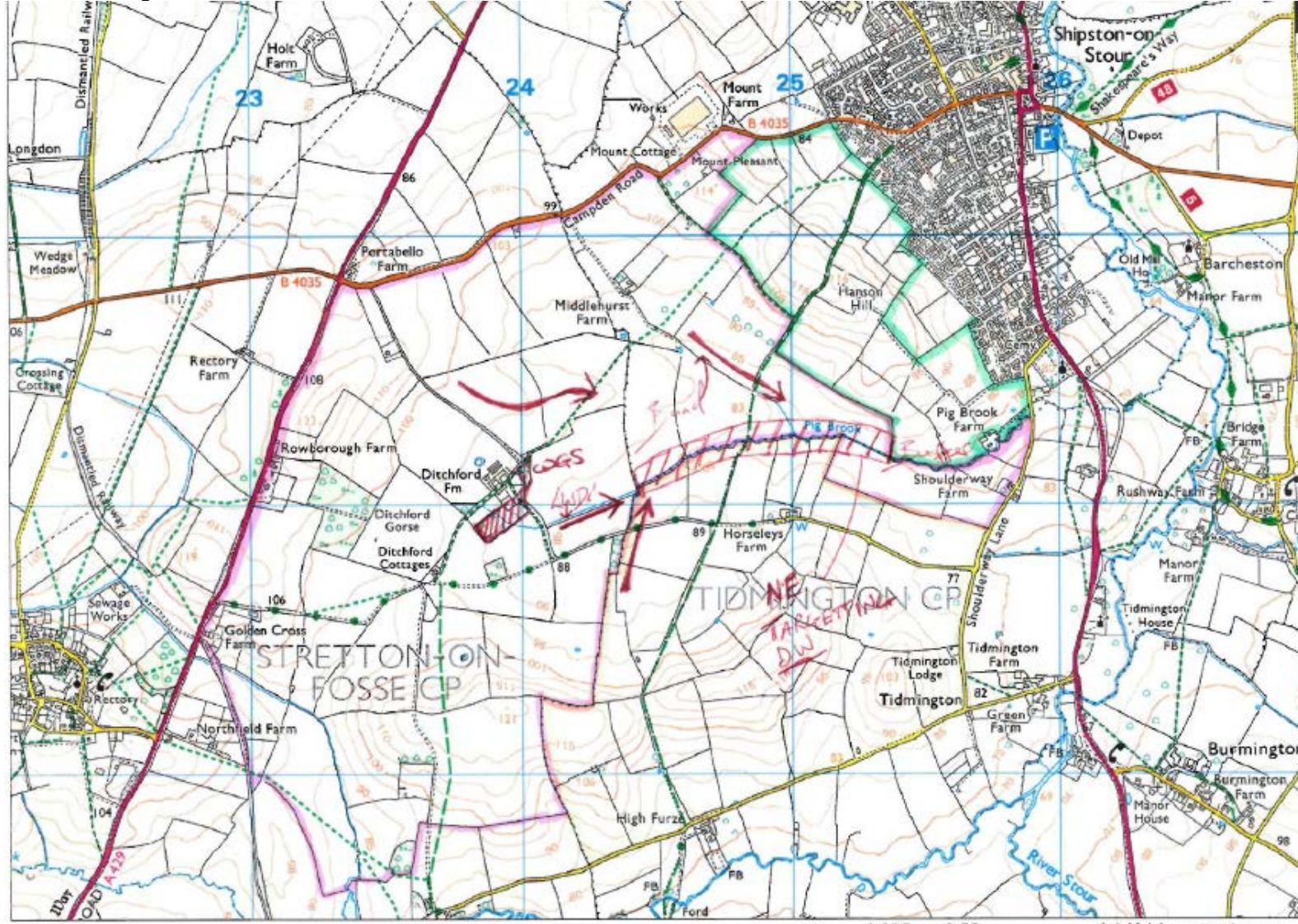
Catchment coverage of grassland types



LCM2007 Warwickshire-Avon headwaters



Engagement process








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ecology.
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NFR measures mapping shp. files



NFR Measure	Code
Potential new floodplain woodland (supported by FC 2013)	
Large Woody Debris Dams (LWDs)	
Hedgerow reinstatement	
Clay bunding	
Offline pond	

Opportunities across the catchment



NFR measures	Knee Brook	Nethercote Brook	River Stour
Forested Water Retention Areas	50800m ²	4800m ²	8400m ²
Wider catchment afforestation	6700m ²	2400m ²	4900m ²
Hedgerows	400m	200m	280m
Soil aeration	84400m ²	21000m ²	31200m ²
Large/Coarse Woody Debris Dams	96	49	38
Riparian buffer	570m	230m	120m
Floodplain and riparian afforestation	32700m ²	2800m ²	21300m ²
Clay bunding	15	5	6
Offline pond	16	8	7
Offline retention pond	4	1	2

Conclusions

- Great opportunity to WwNP across the catchment to slow, store and filter flow (to a lesser degree). With the potential to attenuate the storm peak by de-synchronising peaks.
- Environmental Audit data indicates these measures can have wider remunerations through ecosystem services, supported by engagement.
- Engaging with landowners and farmers has given an unrivalled insight into local hydrological and land-based influences to fluvial/pluvial activity.
- NFR has allowed farmers to consider how to use water more **efficiently** across their farm holdings.

Further works

Modelling the effectiveness of the NFR scheme and determine costs to benefit

- What are the most contributing sub-catchments? Why?
- What are the most effective measures? Why?
- NFR cost-benefit analysis.

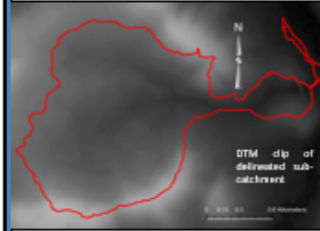
Undertake workshops with community, farmers and landowners regarding attitudes towards NFR modelled results and possible challenges faced

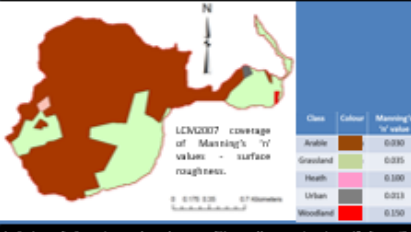
- Give a further practical insight, future research needs.

3.0 Introduction
Working with Natural Processes (WwNP) has become widely recognised as a means of managing catchments holistically, whilst providing multiple-benefits through ecosystem services. This allows flood risk management to assess the consequences of significant storm events, whilst simultaneously enhancing stakeholder resilience to climate change and the wider challenges it brings to hydrological management (e.g. water scarcity and pollution).
This research aims to:
- Develop the evidence base from the opportunity mapping (Charlesworth and Lavers 2016).
- Determine the flood attenuation potential of Natural Flood Management (NFM) and apply to a Cost Benefit Analysis.
- Understand catchment processes by detailed hydraulic modelling using openwet3D.

2.0 Catchment processes and flood risk decision-making
*Do spatially heterogeneous changes in runoff patterns in the rural environment affect flooding at the meso-scale?
If so, to what extent?*
This has been a key question for many stakeholders in flood risk, that presents key challenges to understanding catchment processes for modelling and prediction. In recent years, availability of high resolution data regarding the rural environment and the hydraulic influences (e.g. LIDAR at 25cm resolution) has enabled a much more informed understanding of how our catchments are affected by the two principle elements of flood generation, rainfall and runoff. Therefore, this research aims to utilise the concurrent data to assess the effectiveness of an NFM scheme across a headwaters catchment extent.


3.0 1D/2D Integrated model build methodology
Commencing with 2D domain then constructing 2D layer

2D domain (in-channel)
Based on visual surveys, determine cross-sectional areas of channel, collating and checking the digital terrain model (DTM) data.

From visual surveys and mapping, including any in-channel structures that would impede and alter flow (e.g. weirs, bridges and culverts). Assign channel roughness values of channels Manning's 'n' (more varied in 2D environment).
Generate input hydrograph for headwater catchment extent node, based on gauged data and rainfall records.
Generate initial model conditions, including water depths and antecedent conditions. Verify model stability through running in both steady and unsteady states, allowing a reliable model to be integrated with 2D domain.

2D domain (floodplain)
Verifying outputs from hydrology mapping tool in ArcMap 10.6. Define the 1D and 2D extents of the model domain, assigning DTM and 2D Grid vector function on openwet3D.
Connect the 1D and 2D domain, enforcing the bank crest levels identified from DTM. The crest extents are then merged with the floodplain roughness values determined from LCM2007 data and assigned Manning's 'n' values.


Class	Colour	Manning's 'n' value
Arable	Light Green	0.030
Grassland	Dark Green	0.035
Heath	Light Blue	0.100
Urban	Yellow	0.013
Woodland	Red	0.150

Inclusion of downstream boundary conditions allows water to spill from the floodplain, the gradient of which is calculated from DTM.
Inclusion of nodes on the floodplain to record pluvial flow in pre-determined locations, such as outflows. Base floodplain characteristics are also enforced, such as hedgerows and buffers.

4.0 Desired outcomes
The method above broadly follows the recommendations from Ddori (2014) and Wilkinson et al. (2014) in how to model complex, large scale catchment processes (>50km²). In terms of making an economic case for NFM, this method can be related to current standards of protection and the current thresholds the dwellings and businesses (under the National Flood Risk Assessment (NaFRA) scores) are exposed to:

Another key consideration includes the points of synchronisation across the sub-catchment delineations. Through multiple flood hydrograph analysis a determination of flood impacting potential sub-catchments delivers further evidence for PCERM decision makers to assess the value of a catchment NFM scheme and possible NFM priorities within it.

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Any questions?



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