Water Friendly Farming Phase 2

Funded by RFCC Anglian North and EA

19th July 2024

Prof. Jeremy Biggs (Freshwater Habitats Trust)

Water Friendly Farming (WFF)

Catchment-scale demonstration project on effectiveness of nature-based solutions for:

- Protecting against downstream flooding
- Reducing sediment and diffuse nutrient pollution
- Enhancing aquatic biodiversity

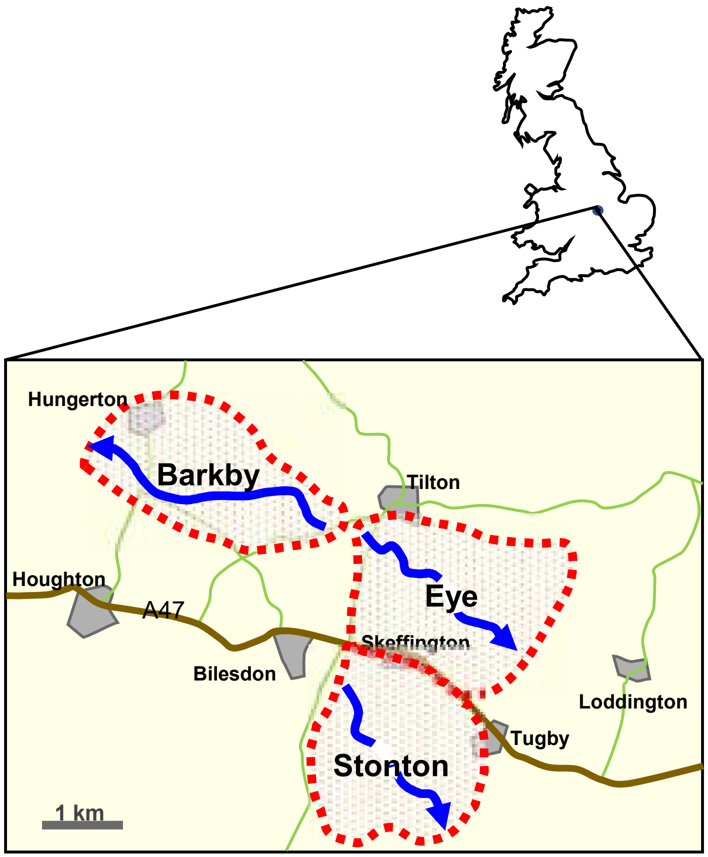
Working with 30 landowners in upper Welland

- **Phase 1: 2010-2020**

2010-12	3-year baseline
2014	Nature-based measures installed sequentially from 2014
2014-20	Monitoring and evaluating effects
2020	First major results published

- **Phase 2: 2021-2027**

2021-27	Phase 2 focused on NFM benefits
2020-26	Spinoff projects: Pitsford Water Friendly Farming (Anglian Water + EA); in 2021 WFF becomes demonstration site in EU Horizon 2020 PONDERFUL project



Natural flood management

- Project focusing especially on natural flood management
- **Key concept**: what really works? Water Friendly Farming is evaluating the effectiveness of a range of NFM measures through rigorous modelling and field observations
- Approaches include detention ponds, offline storage, bunded ditches, afforested buffers, leaky barriers
- Landowner engagement drives focus on in-bank storage (avoids productive land loss), especially **leaky barriers**

New style leaky dam on the Eye Brook

Overall aims of Phase 2

1. Extent to which NFM interventions can be scaled up, especially evaluating the risk of synchronisation

2. Improving the evidence base for NFM methods: maintenance, longevity, benefits

3. Evaluating effects of soil management and other land use changes on soil carbon content, sediment loss and water infiltration rates (i.e. benefits as NFM solutions) [will only touch on this briefly today]

4. Groundbreaking freshwater biodiversity results in Phase 1: are they maintained in medium to long term? Do nature-based solutions lead to biodiversity benefits?

Measures installed - Phase 1

'Nature-based solutions' including……

- **Leaky dams**
- Bunded ditches
- Interception ponds
- Clean water ponds
- Flood storage basins

Leaky dam on the Eye Brook

Measures installed - Phase 1

Include……

- **Leaky dams**
- Bunded ditches
- Interception ponds
- Clean water ponds
- Flood storage basins

Location of leaky dams on the Eye Brook

Measures installed - Phase 1

- Leaky dams
- **Bunded ditches**
- Interception ponds
- Clean water ponds
- Flood storage basins

Bunded ditch on Eye Brook tributary

Measures installed - Phase 1

- Leaky dams
- Bunded ditches
- **Interception ponds**
- Clean water ponds
- Flood storage ponds

Field drain interception pond

Measures installed - Phase 1

- Leaky dams
- Bunded ditches
- Interception ponds
- **Clean water ponds**
- Flood storage basins

Clean water pond, Stonton Brook catchment

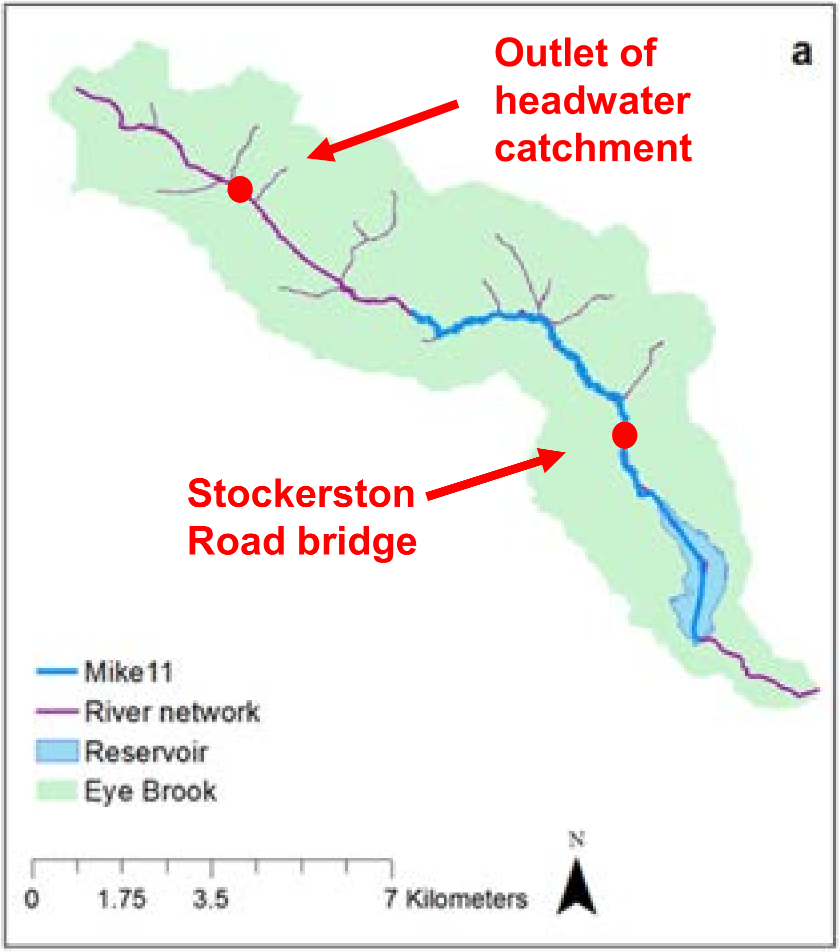
Measures installed - Phase 1

- Leaky dams
- Bunded ditches
- Interception ponds
- Clean water ponds
- **Flood storage basins**

Flood storage basin on the Eye Brook

Phase 1: Assessed effectiveness of leaky dams

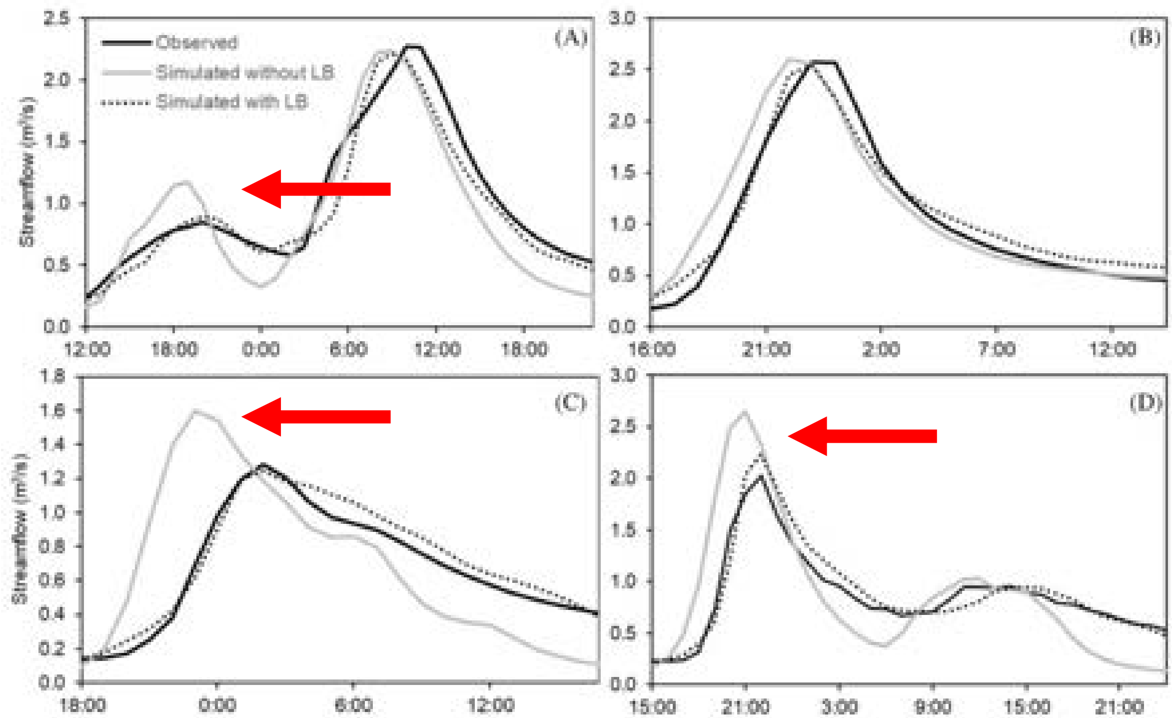
- Existing Agency hydraulic model (MIKE 11) for lower Eye Brook catchment
- NAM upstream input replaced with full hydrological modelling (SWAT)
- Bespoke model to simulate effect of leaky barriers in headwater streams
- Assessment points at outlet of the headwater catchment and at Stockerston Road Bridge



Phase 1: results

- **Phase 1 work showed strong benefits of headwater flow interception:**
  - 17,700 m^3 of water storage provided by the 27 leaky barriers
  - Reduced peak flows at the catchment outlet by 22% ± 6%
  - Delayed the peak in flow by up to 5 hr for (11 storm events)

Comparison of observed and simulated peak flow events before and after leaky barriers installed



- **RFCC questions on Phase 1 focused on issues of:**
  - Maintenance
  - Longevity
  - Scaleability etc

Phase 2: potential for scaling-up NFM interventions

WATER FRIENDLY FARMING

From Phase 1……

- Not clear whether leaky dam benefits would be maintained as scheme scaled up
- Little information about resilience of leaky dams (maintenance, longevity) and other NFM measures

Became Phase 2 focus of the project

Scaling-up NFM interventions:

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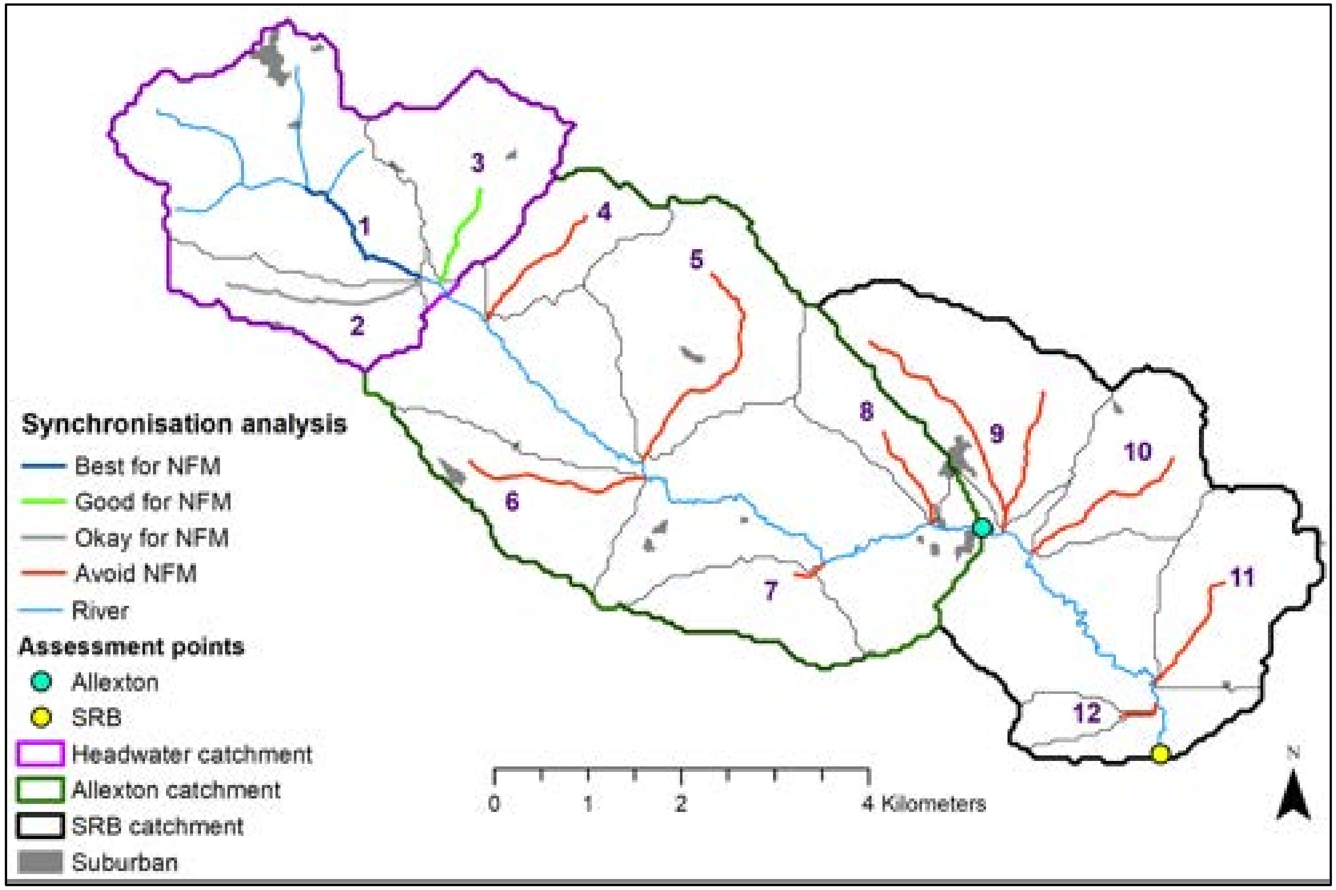
Synchronisation

- Assessed using Environment Agency's NFM storage calculator
- All 12 major tributaries of Eye Brook included in the assessment



Results

- 1-3 are experimental catchments
- Sub-catchments 4-12 **all increased synchronisation**

Scaling-up NFM interventions:

Conclusion

- We were already working in the most favourable areas for NFM
- Eye Brook was **not** suitable for further addition of leaky dams
- **For the project**: outcome has led us to focus on improving and understanding NFM measures in existing areas
- **More generally:** Critical to have local evaluation before NFM measures implemented catchment-wide

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Aim 2: Increase evidence base for NFM measures including relative hydrological performance, stability, longevity, cost-effectiveness and biological impacts/value

Focusing particularly on design and performance of leaky barriers

Leaky barriers

Longevity and fate

- Very little information on the longevity and fate of leaky barriers (impacts for cost effectiveness)
- Theoretically expected to last only 5-10 years (CIRIA 2022)
- WFF 30 original-style dams: put in place 2017-19
- Of these:
  - 40% lost in first 7 years (27% in first 3 years)
  - 20% have now partially collapsed
  - 40% still in reasonable condition
- All significant collapses occurred in floods / storms (e.g. Babet and Henk)
- Most damage to barriers in larger streams (1.5 - 2 m wide)

Old style leaky dam as built

Old style leaky dam still functioning after seven years

Leaky barriers

<u>Reasons for loss</u>

- All dams lost through bank erosion effects out-flanking the logs.
- Local bank erosion typically significant: double-triple the width of the channel
- So, replacement dams need to be located in new sites
- No dams lost through the logs rotting away: in some dams up to 25% of the logs are showing significant rotting creating holes (but these dams are just more ‘leaky’)

Dam which later failed catastrophically due to bank erosion

Seven year-old dam, still functioning but with some rotting timbers

Leaky barriers

Fate of collapsed dams

- Most we removed and replaced when they showed signs of significant collapse/inefficiency

Remainder very unpredictable:

- Two were catastrophic losses in flood (but both dams previously degraded)
- Five are gradually disintegrating and losing logs downstream
- Four are collapsing into debris dams and raising bed levels upstream by 20-30 cm

Dam gradually disintegrating and losing logs

Dam silted up at the base: now acting like a debris dam

Leaky barriers

Fate of logs

- Often concern about the fate of logs from failed dams
- We generally removed logs from collapsing dams
- Some logs got away – generally caught by lower dams or trees. No evidence of other issues e.g. damage to bridge footings
- Are now leaving some dams to collapse naturally and track logs (number tags)

Dam collapsed catastrophically. All logs trapped trees and a narrow channel

Number tags to track the logs of a degrading dam

Leaky barriers

New style dams

Designed to address weaknesses of original dams

- Stronger: Single span logs
- Embedded: logs long enough to be embedded up to 2 m into the bank (stable even with bank erosion)
- Drain quickly: logs spaced apart so flood water does not remain trapped behind the barrier encouraging erosion
- Safer? Long logs so shouldn't move far downstream if dam collapses.

New style leaky dam on the Eye Brook

Significant bank erosion around a new style dam following 2023/24 flood events

Result:

- 2020: 10 dams (8 replacements, 2 new)
- All still stable and in good condition after 4 years (including major floods)
- Much better design: more stable but...
- (i) more expensive and (ii) still significant bank erosion (up to double stream width), so may eventually collapse.

Alternative leaky barrier designs: use of live wood

Issues with current leaky barriers:

- **Short life span: 3-7+ years (collapse, rotting)**
- **Issues in terms of bank erosion, fate and replacement**

Question: Are they really cost effective?

Water Friendly Farming alternatives?

- **Trial use of different types of live wood barriers**
- **Hinging bankside willow (i) into the water (ii) over streams (iii) onto the bank to create barriers**
- **Also other species (hawthorn, blackthorn, hazel, alder)**
- **First trials 2022/23 – seemed to have worked well, significant ability to increase roughness and back-up water in flood.**
- **2023/24 – extended to seven more sites using different techniques.**

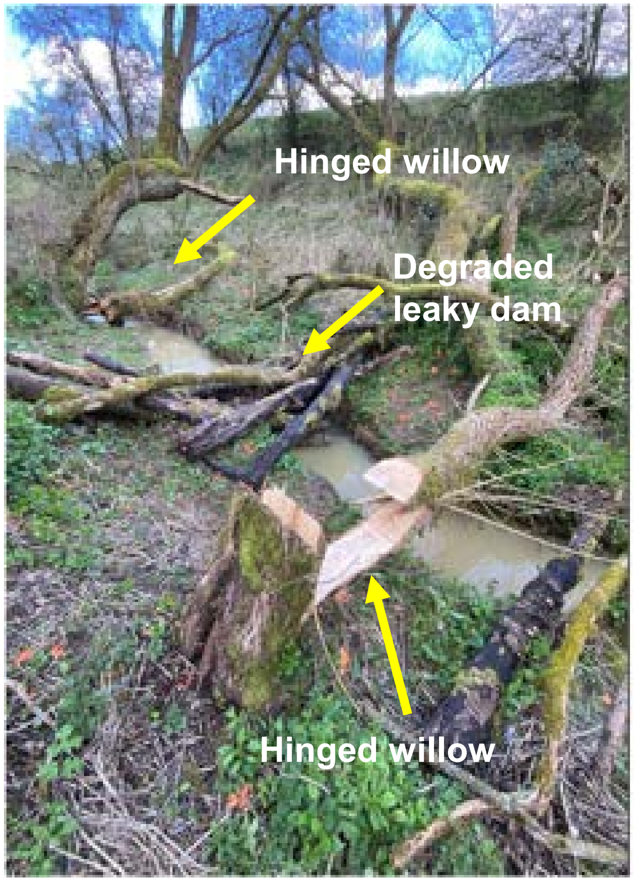
Tree hinging on the Eye Brook

Tree hinging likely benefits

Cheaper (chainsaw, winch), long lasting (live wood), no risk of downstream damage from timbers, easily modifiable, bank protection around barrier from tree roots

Willow hinged *into* stream

Hinged willow: stable and apparently effective after 2023/24 flooding that caused catastrophic loss of an adjacent traditional dam



Willow hinged *over* stream. Degraded traditional dam in mid picture

Use of live wood

Growth of willow also offers additional opportunities – e.g. laid or woven barriers to adjust the height or permeability

Two hinged willow trunks, with their vertical 1 year old regrowth 'laid' to increase the height of the barrier

Conventional leaky barrier

Demonstration of different barrier types

Vertical willow shoots on a hinged log prior to laying / weaving

Use of live wood

Disadvantages

- Outcomes at individual sites likely to be difficult to predict in advance for modelling
- Very new – so little data on effectiveness for flood amelioration

  So…..WFF in 2024 adding gauge boards and cameras to measure effect

Also:

- Needs appropriate trees to be present on the bankside

  So......WFF in 2024 now adding cut sallow stakes to banksides: no cost – but what timescale to be effective for hinging? (3 - 5 years?)

Likely outcome of live wood use?

- (we think...) Probably not viable in all areas – but *exciting potential* to be a useful, and more sustainable, stable and long-lived option compared to standard dead leaky dams.
- Next few years will tell us about their effect on hydrology

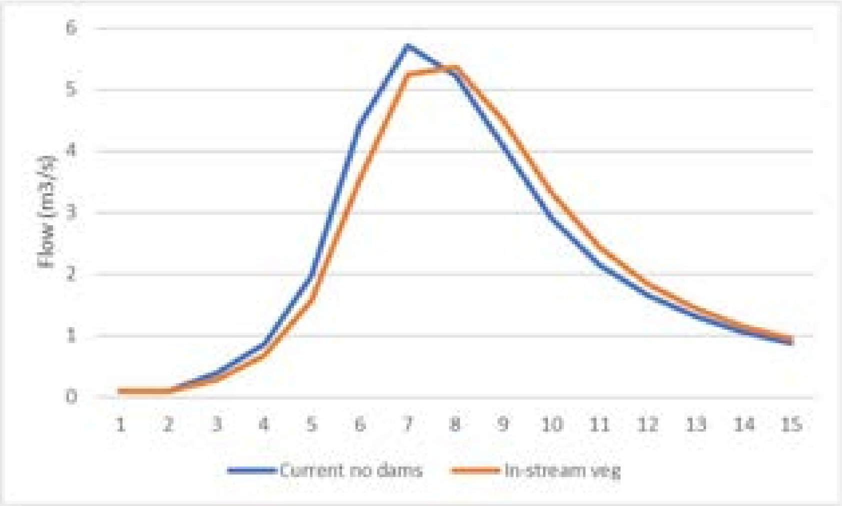
Other methods for enhancing channel roughness

Promoting in-channel vegetation

- Another potential way to slow flood flows is to increase the amount of vegetation in channel
- WFF streams are very heavily overshaded by trees – with little channel vegetation.
- What would happen if we opened up sections to allow more aquatic plants to grow, and increase roughness?
- To look at this we modelled the effect
- **Result**: 6% reduction in flood peak

10% AEP ('1 in 10')

5.9% Peak flow reduction
1-hour peak flow delay



In practice

- Were planning experiments to look at this
- But observations from a tree-cleared area in Stonton catchment showed flood events in these small fast-flowing upper catchments uproot and wash channel plants away
- For UPPER catchments, not a viable option.

Overbank roughness

- Been considering increasing overbank roughness to slow flood flows
- Standard option, as widely applied in the real world, is riparian planting
- Our observations (in WFF and other catchments): riparian planting typically has very low Manning's roughness.
- Have significant reservations about its effectiveness for roughing up floodplains – so have *not* progressed this
- Our view: need alternative forms of *floodplain* landcover e.g. low scrub/bramble (*pers. obs*) to be effective
- But appears to be no standard roughness indices for this land cover type, and no evidence that others are trialling in practice.
- So progressing this is very new...

Typical woodland planting on Eye Brook floodplain (10+ years): very low roughness

Other flood storage

Bunded ditches (available in Countryside Stewardship)

- Total of 30 bunded ditches created in the Eye and Stonton catchments (2013/14).
- Function: mainly to store sediment, with some flood storage capacity.

Design:

- Earth bunds with channel excavation,
- Area: varied from $10m^2$ to $150m^2$

Small bund

Large bund

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Bunded ditches (2013-2024): lessons learnt

- **Sediment fill**: most filled with sediment within 4-10 years (mainly during floods)
- **Significant rate of damage**: **56% of dams had significant structural issues after 10 years**: either holes through the dam or erosion of the dam top.
- **Damage most likely when bunds are full of sediment:** blocked outlet pipes and bund erosion
- **Construction**: wide, well-compacted, dams may help reduce breaches through the dam
- **BUT essential to have a regular commitment to dredging-out** to prevent rapid degradation when dams are full (possible catastrophic loss)
- **This appears to be the first assessment. Our view**: a liability if not regularly dredged and maintained. Useful info for AES.

A bunded ditch full of sediment. Over-bund erosion has already eroded away 80% of the bund width and it is now close to (catastrophic?) collapse

Aim 3. Soil management and runoff

Background

- Management of soils, including carbon content, important for runoff management as a result of soil compaction and (lack of) infiltration
- Many small-scale studies suggest there could be benefits, BUT catchment and landscape scale data to evaluate this policy remain scarce
- The extent to which soil management actually reduces flows and sediment loss at large scale remains uncertain

Aim 3. Soil management and runoff

- In Water Friendly Farming evaluating soil management by re-running our SWAT model of catchments with more realistic soil infiltration
- This is perhaps most difficult part of the project as practical measurement of infiltration is challenging
- **Main steps**:
    - Estimate carbon content of different soil types/agri-scheme soil management measures (e.g. no-till areas, flower-rich margins)
    - Measure ‘in the field’ infiltration rates in different soil types/agri-scheme measures
    - Measure in the lab soil moisture capacity of different soil types (with Cranfield Uni) – sand table at Cranfield University
    - Re-run whole catchment model with new ‘real-world’ infiltration and soil carbon data evaluating effect of soil management on runoff and flows

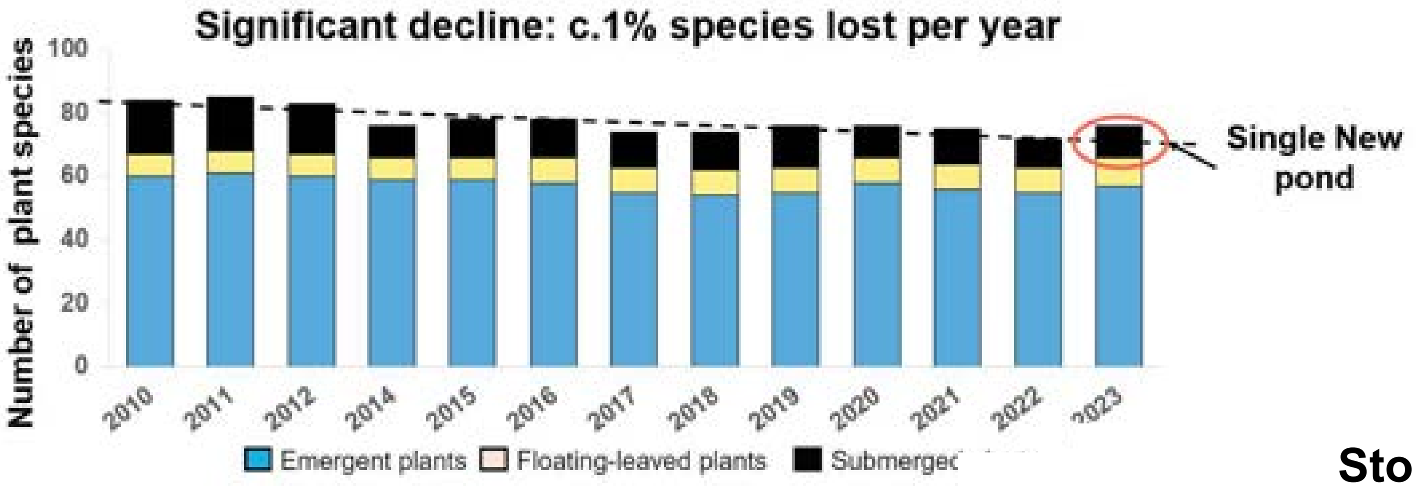
Aim 3. Soil management and runoff

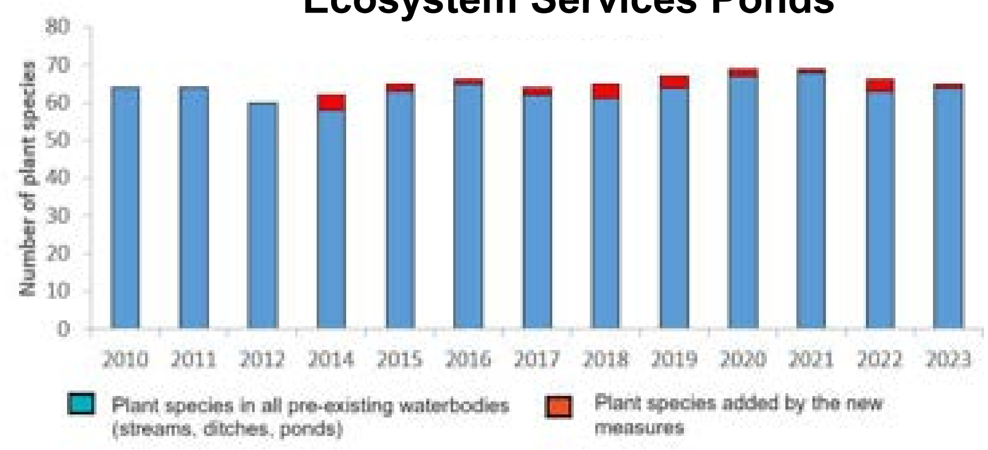
How we do it

Purpose built rainfall simulator on loan from Cranfield University

Aim 4. Freshwater biodiversity

- Annual wetland plant surveys of all waterbodies have shown internationally-significant results
- Slow background loss of freshwater biodiversity (c.1% of species/year)
- Nature-based measures halted the decline for common species, but not for rare wetland plants





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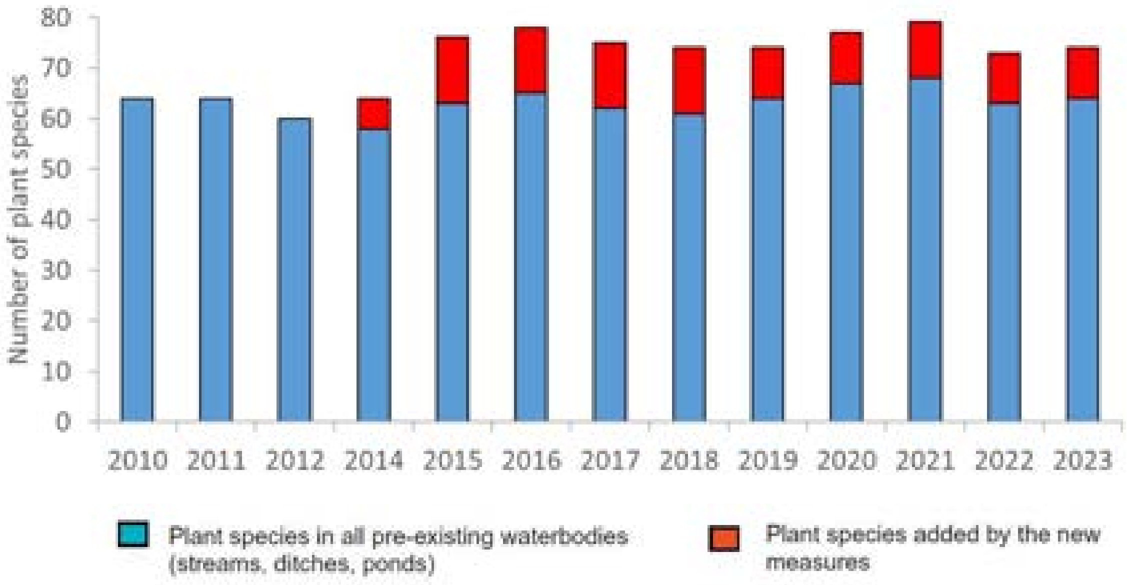
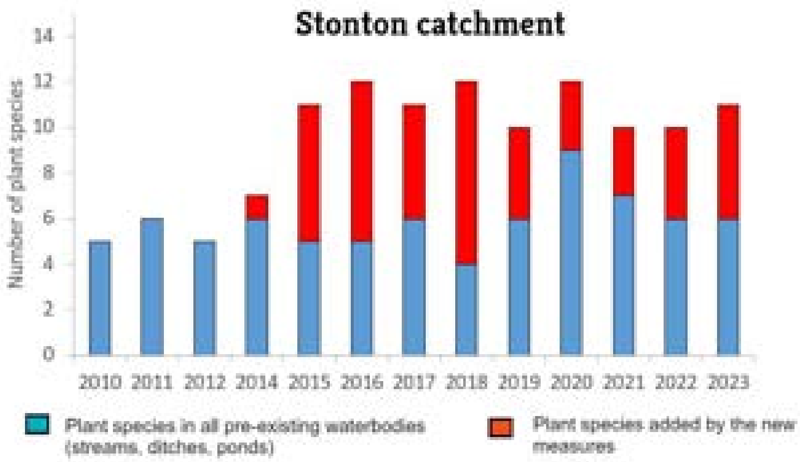
Aim 4. Freshwater biodiversity

- Creating clean ponds reversed the decline, delivering a 16% increase in biodiversity across the catchment; c80% increase in uncommon species 2023

Stonton catchment: wetland plant species added by new ponds compared to all other habitats



Uncommon wetland plant species found in new ponds compared to all other habitats

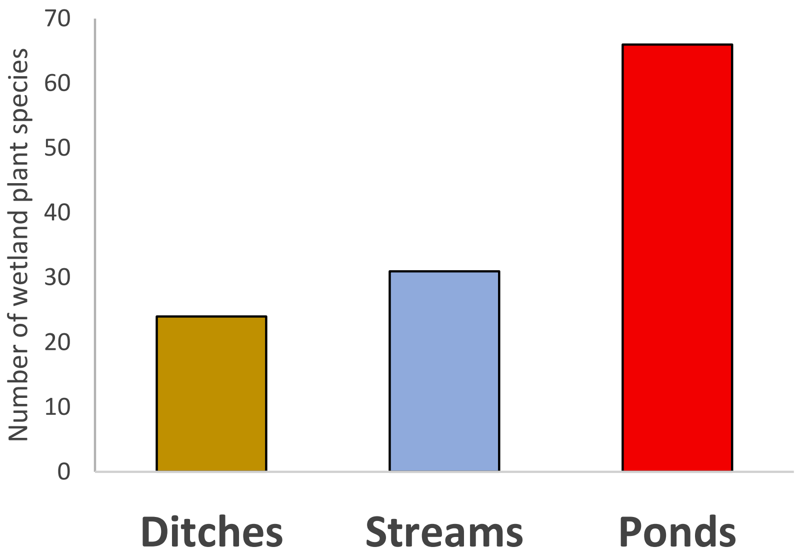


Pitsford Water Friendly Farming

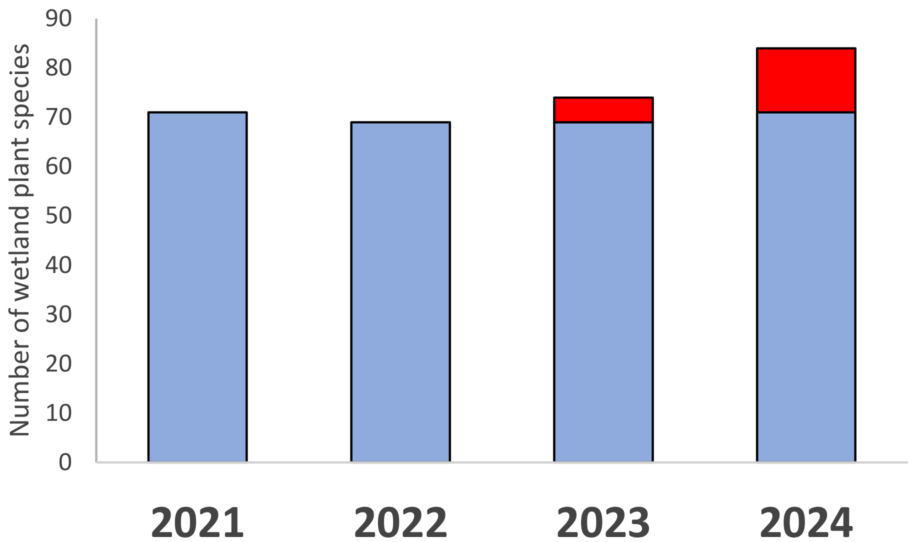
WFF biodiversity results inspired Pitsford Water Friendly Farming (2021-2024)

Results of main WFF study so far fully replicated

- Ponds crucial component of freshwater landscape
- Creating and managing ponds increased wetland plant species richness in the landscape by 19% and enabled many regionally uncommon species to return



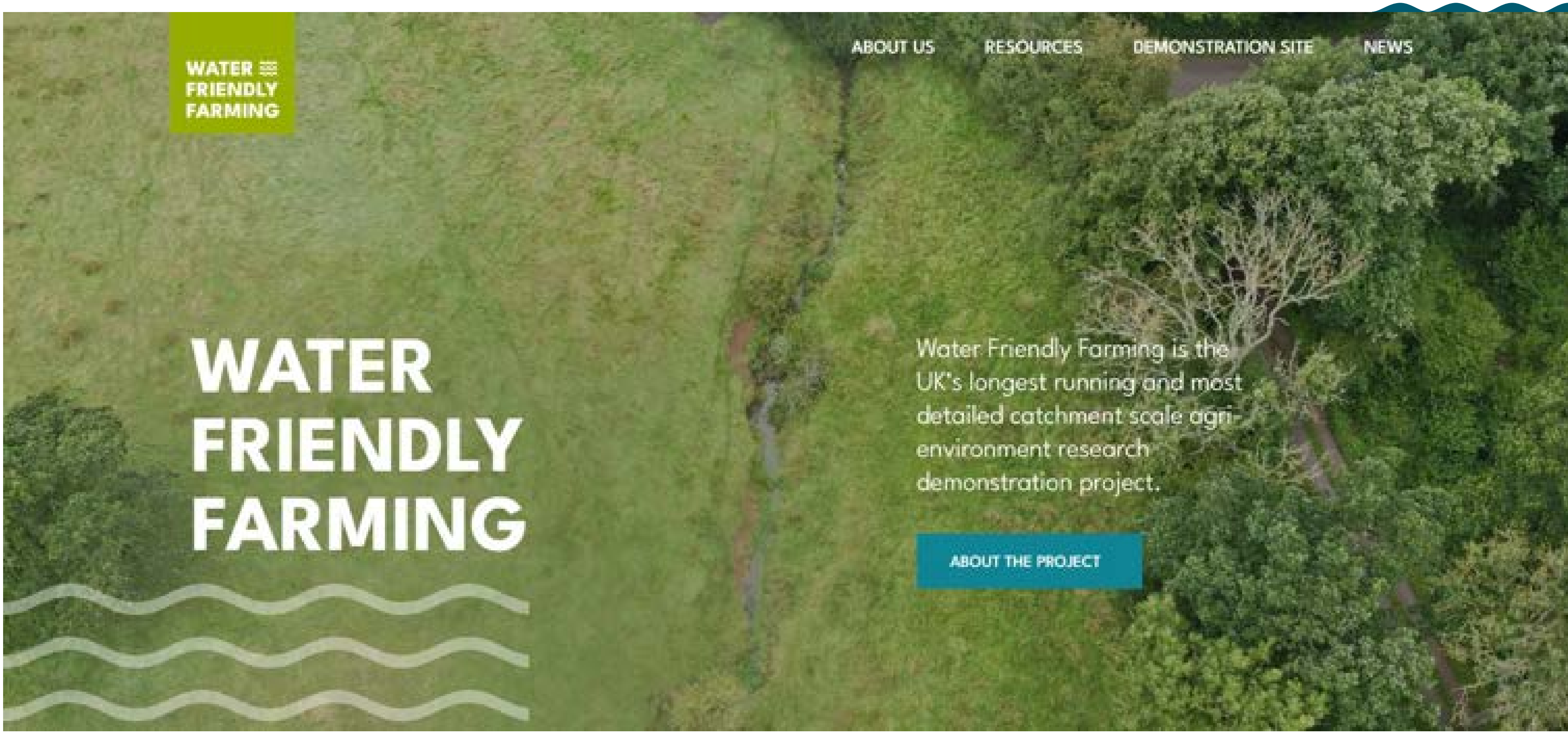
Number of plant species in different waterbody types



Number of plant species added by creating and managing ponds

Disseminating results: new website

WATER FRIENDLY FARMING



THE ALLERTON PROJECT

UNIVERSITY of York

Environment Agency

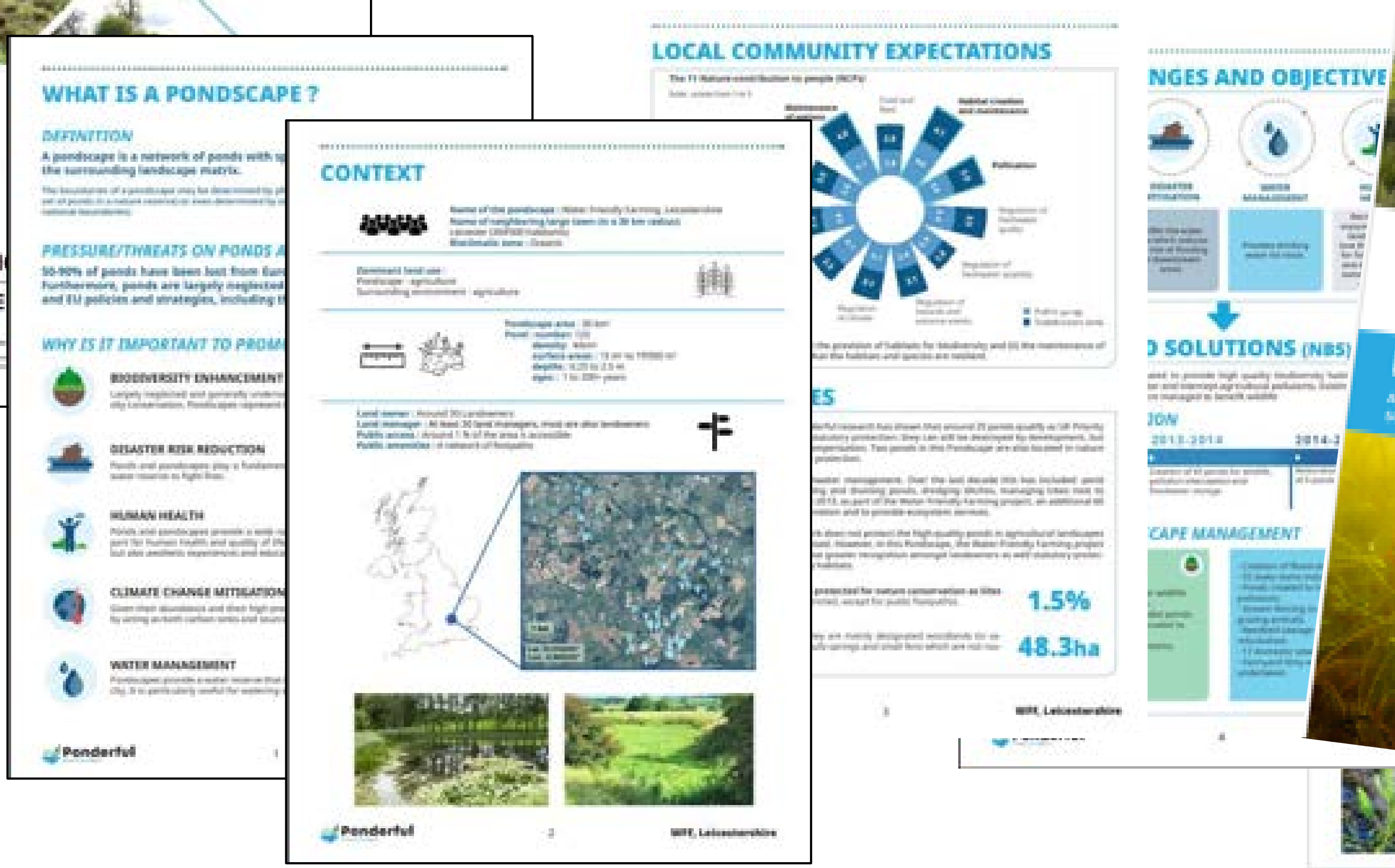
Freshwater Habitats Trust

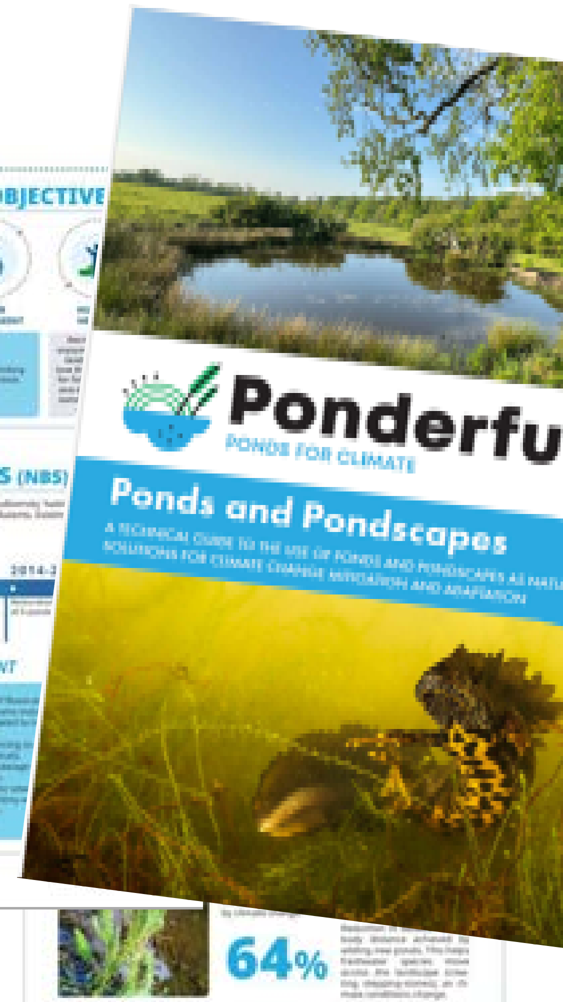
Application of Water Friendly Farming results

- **Evidence from project is being widely shared and applied**
  - **e.g. in scientific papers from project**
  - **in national media coverage**
- **Development of practical guidance on leaky dams (CIRIA NFM guide - 2022)**
- **Applying results practically in Anglian region and beyond**
- **Preparing project videos now**

Application of results

- **Project selected as EU Demonstration Site with results being disseminated throughout Europe in PONDERFUL Technical Handbook Case Studies**

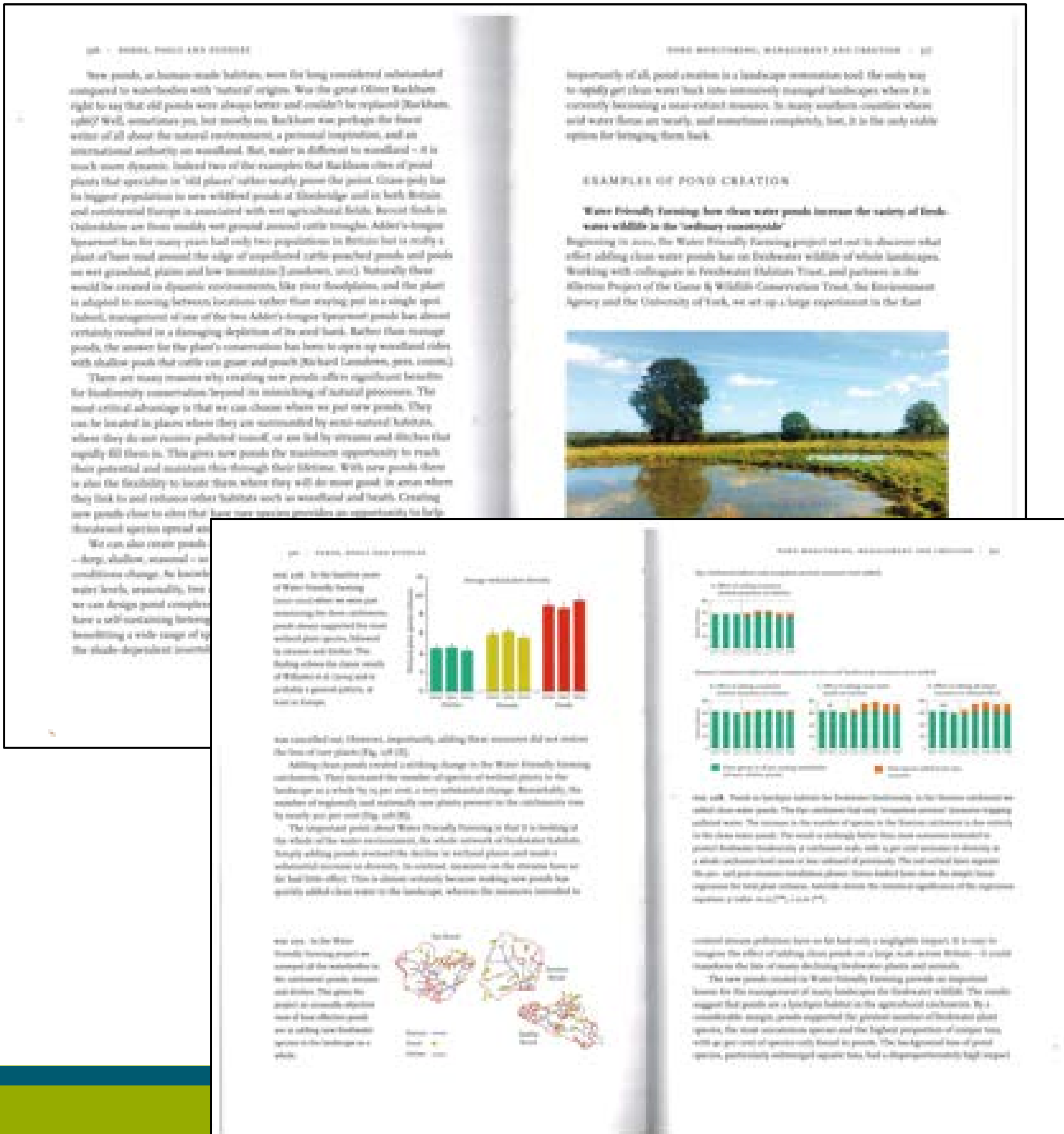




Application of results

- **HarperCollins: Ponds, Pools & Puddles: April 2024**
- **Long-running national series (since 1946)**

WATER FRIENDLY FARMING


EXAMPLES OF POND CREATION

Water Friendly Farming: how clean water ponds increase the variety of fresh-water wildlife in the 'ordinary countryside'

Conclusions

- Evidence for the effectiveness of leaky barriers
  - **Quantified for range of design flood events**
  - **At local and downstream locations (c. 10 km below leaky dams)**
- Important conclusions on synchronisation of flows: can't just do NFM measures everywhere
- Refining designs of leaky barriers in terms of longevity, effectiveness, maintenance
- Better understanding of effectiveness / limitation of ELM scheme NFM measures (e.g. RP33: Large leaky woody dams; RP32: Small leaky woody dams) and bunded ditches (Countryside Stewardship measure RP10)
- Benefits to water quality better quantified showing degree of landscape change needed (it's substantial)
- Important gains for aquatic biodiversity from the full range of catchment interventions but especially ponds with the project's unique data on small waters
- Results are being applied both within the Anglian Northern RFCC area and elsewhere (including internationally)

Next steps

- Phase 2 ends March 2027
- Over next 3 years and beyond:
  - provide practical advice for application of NFM methods
  - apply results widely e.g. through CaSTCo project, catchment plans, Landscape Recovery projects
  - advice on maximizing biodiversity co-benefits of NFM
  - support whole landscape improvements needed on agricultural diffuse pollution to complement changes required to sewage works
- Complete and publish modelling results showing effectiveness of different NFM measures
- Disseminate and publicise results widely with national conference 2026-27