From challenges to solutions: Implementing nature-based solutions for water quality and quantity management

Presented by Dr Mark Wilkinson

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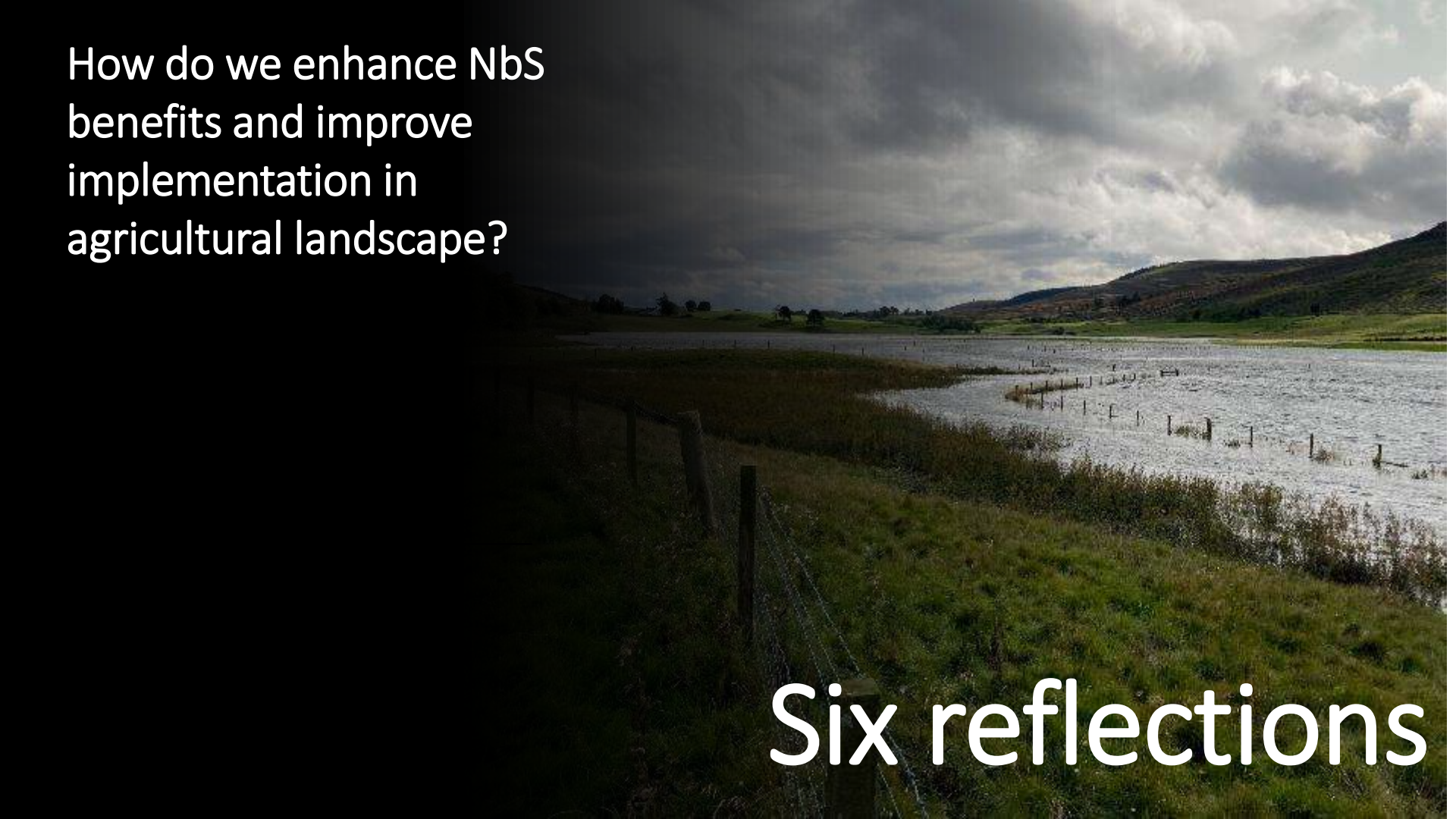
Our catchments are facing many water related challenges…

Nature-Based Solutions

- Nature-Based Solutions (NbS): working with nature to address societal challenges, providing benefits to both humans and biodiversity (IUCN)
- One potential solution to current and future water-related environmental pressures
- **NBS rollout is slow**
- **In some cases, existing measures are not working to their full potential**

How do we enhance NbS benefits and improve implementation in agricultural landscape?



Six reflections

1. Understand the issues* and that different issues can occur in the same place at different times

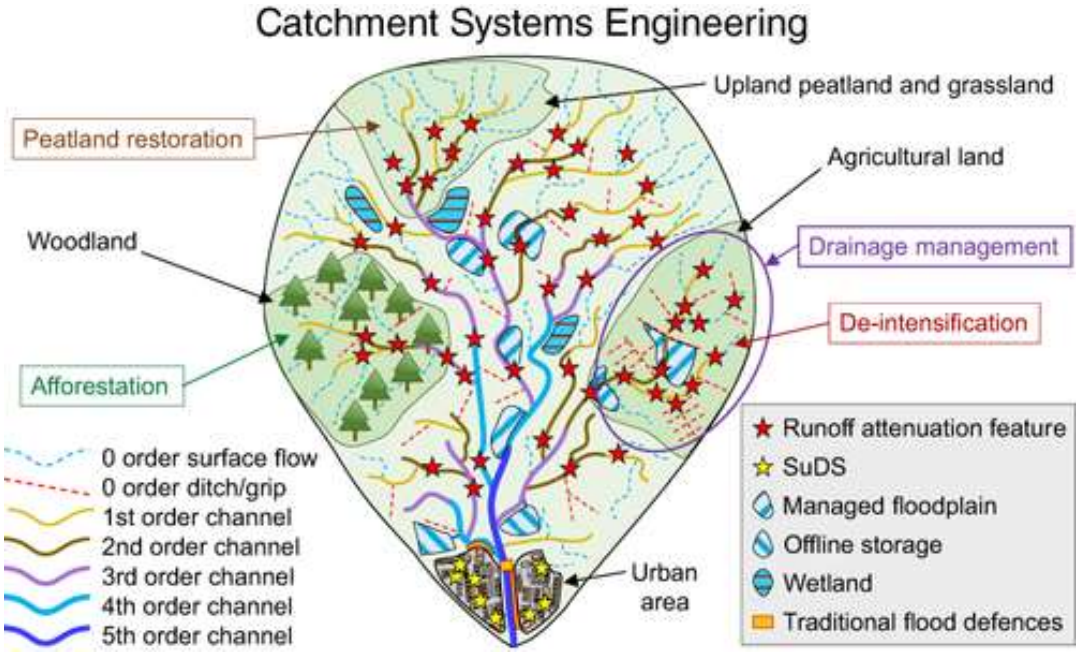
**inc. those in the future*

Catchment science and management

Requires a whole catchment perspective looking at multiple issues – quality and quantity

Increasing hydrological extremes → Fast erosive flow pathways → Soil loss, floods, droughts, water quality issues

Catchment Systems Engineering approach



- Recognizes the need to better understand how the catchment hydrological water balance has changed and the impact of those changes
- How we can act to **engineer** catchment systems to sustainable levels.
- Suggest proactive interventions that provide and enhance multiple ecosystem services

See Hewett, C.J., Wilkinson, M.E., Jonczyk, J. and Quinn, P.F., 2020. ***Catchment systems engineering: An holistic approach to catchment management****. Wiley Interdisciplinary Reviews: Water, 7(3), p.e1417.*





2. Design and implement measures* that follow *“the slow, store and filter”* for multiple purposes

**use the plural as a treatment train is needed*

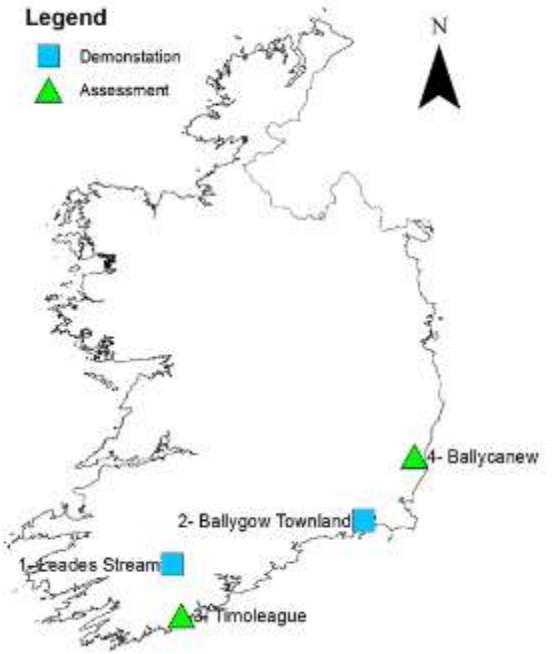
Case 1:

SloWaterS: a Strategic LOok at natural WAter reTention mEasuReS

Aim: Reviewing, demonstrating, mapping and modelling Natural Water Retention Measures potential in Ireland

2019-2024

www.slowaters.eu



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Newcastle University

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epaResearch
Climate - Water - Sustainability

OPW

This project is funded by the EPA Research Programme 2014-2020. The EPA Research Programme is a Government of Ireland initiative funded by the Department of Communications, Climate Action and Environment.

Demonstration sites: Treatment train

Ballygow (Co. Wexford) -
Wednesday's field trip

Leades (Co. Cork) – see D. Murphy's poster

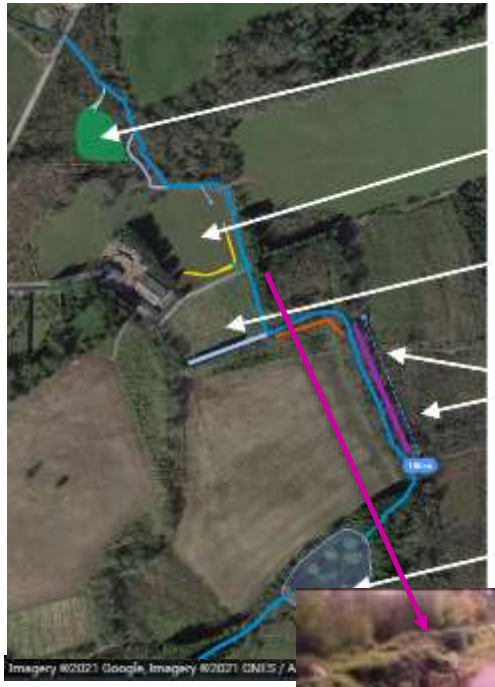


Photo credit: Mary Bourk, Darragh Murphy and Pia Laue

3. Re-think of existing approaches to deliver for wider catchment issues

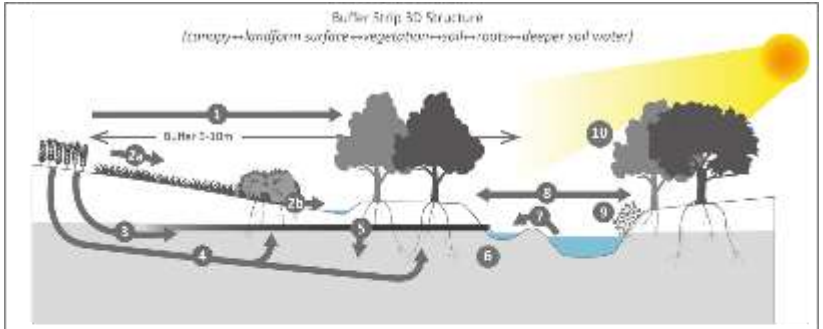
Lowland farmland: Grass riparian Buffers

- One of the most popular agri-environment measure in UK
- Min. width (2m), many not fully compliant and short lifespan
- Limited benefit for flood risk management
- Failing on multiple objectives despite areas given over to them

Stutter, Wilkinson et al., (2020) *3D buffer strips: Designed to deliver more for the environment. Environment Agency for England and Wales Scientific evidence report.*

https://www.fas.scot/article/3d-buffer-zones

The 3D buffer concept



1	Interception of spray drift by tree canopy	6	Interception of soil artificial drainage waters to encourage nitrate processing
2	Surface runoff control: (a) deposition and infiltration amongst vegetation, (b) for extreme erosion and fine particles against raised ground features	7	Altered bank profiles to increase connection with the floodplain, diversify soil wetness, trap sediments and nutrients
3	Within-soil processing by soil chemistry microbiology and soil fauna	8	Enhancing interactions between terrestrial biodiversity and aquatic ecosystems promotes in-stream nutrient processing
4	Nutrient uptake into biomass from shallow and deeper soil water via roots	9	Bank stabilisation via tree roots and bank-side planting
5	Increasing soil organic matter by plant litter and carbon via plant roots	10	Riparian shading to mitigate elevated river water temperatures

- Improve the effectiveness of buffer zones.
- Assessed the effectiveness of traditional grass buffer strips and suggests ways that buffers can deliver more for the environment.

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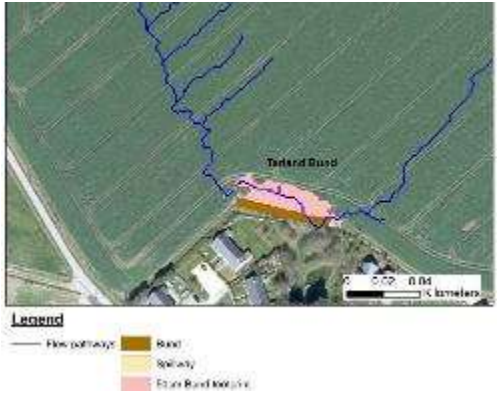
Case 2: Managing convergent pathways: raised field margins

N.E. Scotland – Balruddery Farm

N.E. Scotland – Tarland



https://tinyurl.com/AIMNBS

See Quinn et al., 2022. ***The Role of Runoff Attenuation Features (RAFs) in Natural Flood Management****. Water.*

There plenty of ‘design’ options and ways to enhance the benefits.

But putting the right measure in the right place is key with tools/advive to help practitioners

4. *Targeting and strategic placement are required: Right measure, Right place

www.smarterbufferz.ie

*Targeting is vital if funding is limited…

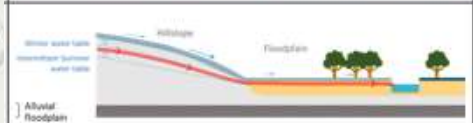
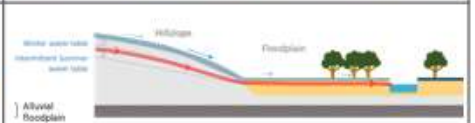
Task: To develop a framework for implementing riparian measures considering land take and attitudes to measures

A hierarchy system for measure placement: The three-tier system

Level 1 – Fixed linear 2m width, basic measure	• A default 2 m wide buffer (where appropriate fenced cattle exclusion) following a watercourse or ditch. • Entire length of all field margins with ditch/stream	
Level 2 – variable width at flow delivery points with enhanced wooded features	• Additional measures to level 1 including; (i) increases in width where smaller flow delivery points requires it; (ii) enhancement of wooded features if justified	
Level 3 – bespoke measures considering many aspects and upstream areas	• Additional measures to level 1 often instead of level 2 option. • Includes a wide range of measures bespoke to the field situation (16 measure database). Also, considers the wider functioning of the catchment. • 'Right Measure, Right Place' philosophy.	 

1. Diffuse to convergent management
2. Increasing engineering required
3. Increasing effectiveness

Case 3: Ballycanew, S.E. Ireland: 10km^2 (focus: 20% catchment)

2. Intensive grassland (subsurface soil drainage)	3. Arable (high erosion)
e.g. Ballycanew North	e.g. Ballycanew South
	
	
Main water quality issues: Phosphorus in overland flow and drain flow	*Main water quality issues:* Sediment and phosphorus erosion

1.5 0.75 0 1.5 3 4.5 6 Kilometers

From 16 measures database

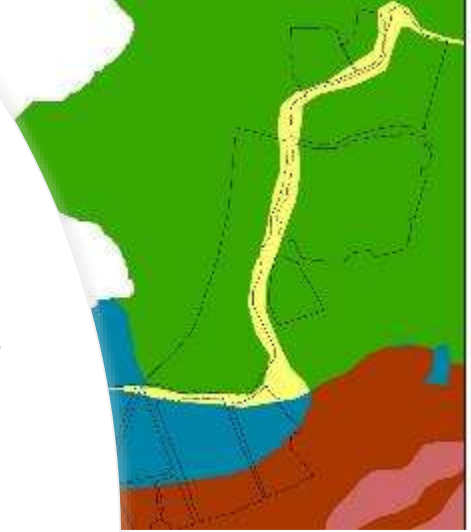
Steps in process

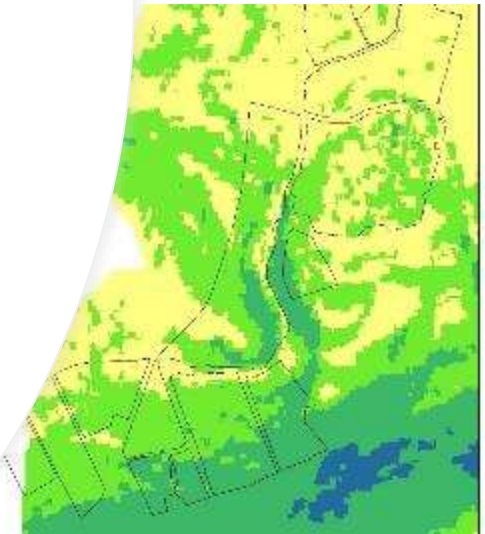
- Step 1: Use desk-based approach to explore level 1 to 3 options
- Step 2: Validate approach with field walk over
- Step 3: Correct maps and produce interactive outputs
- Step 4: Discuss outputs in Workshop
- *Step 5: Farmer engagement / implement*

Assess measure placement: desk-based approach

Available datasets inc.

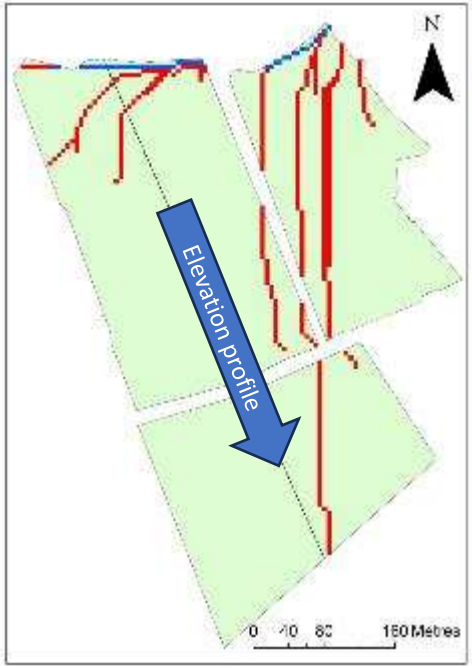
1) **Digital elevation model: from 0.25cm to 5m resolution**
   - **Slopes, terrain and overland flow maps.**
2) P-maps outputs
3) Soils maps
4) Field boundary and ditch/watercourse network datasets
5) Aerial imagery (inc. historic)
6) Google Street view data



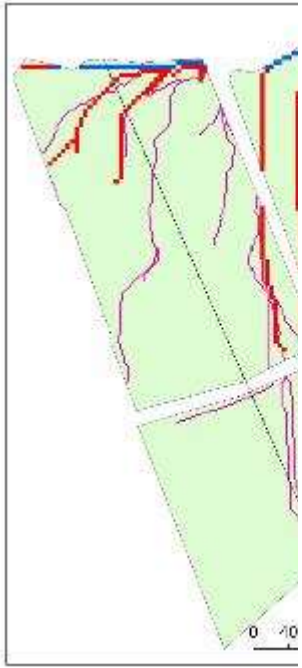


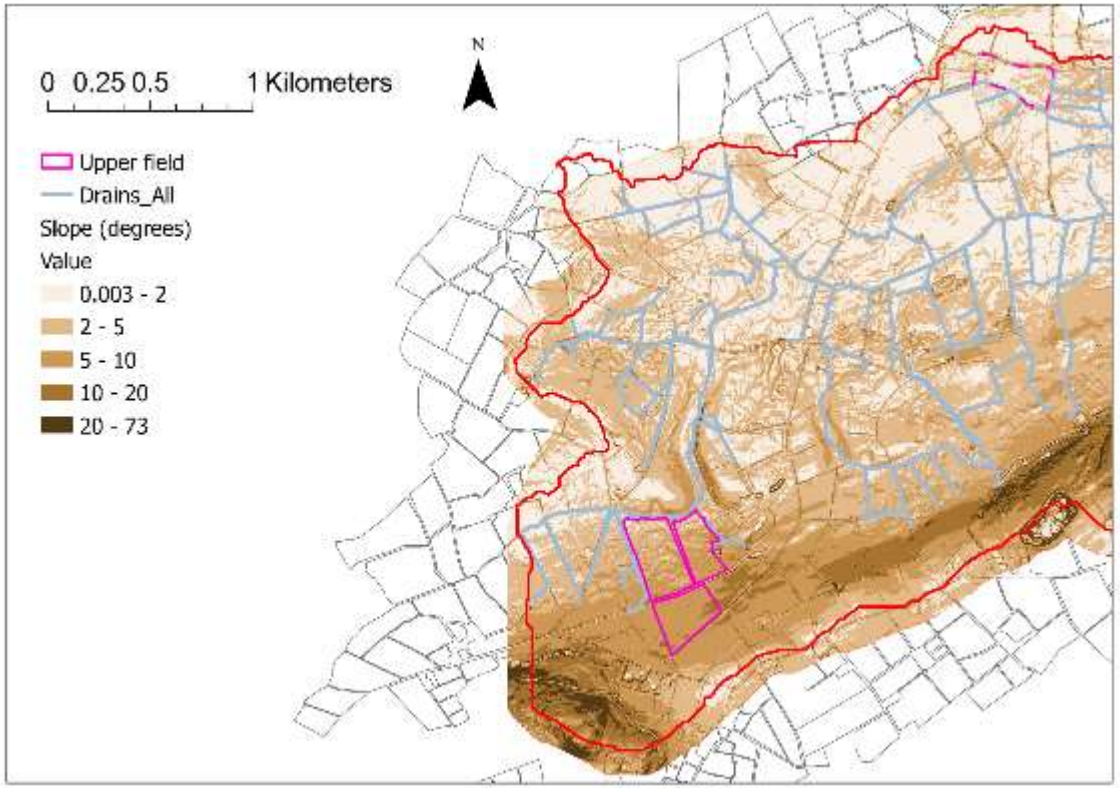
S.W. Ballycanew

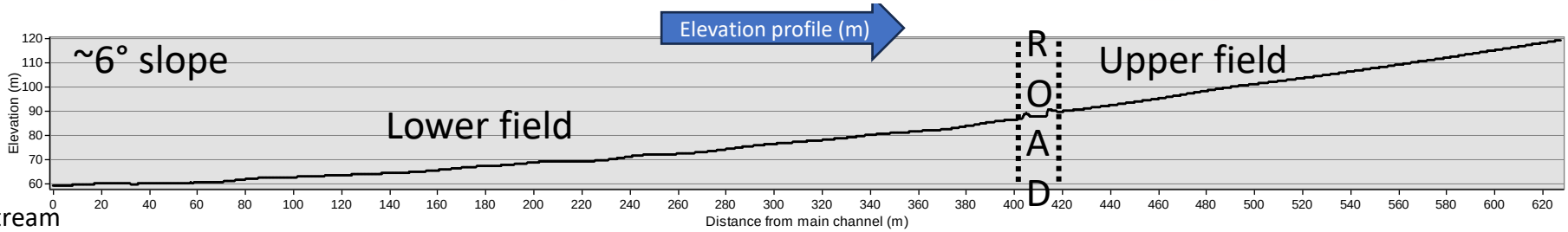
5m DEM



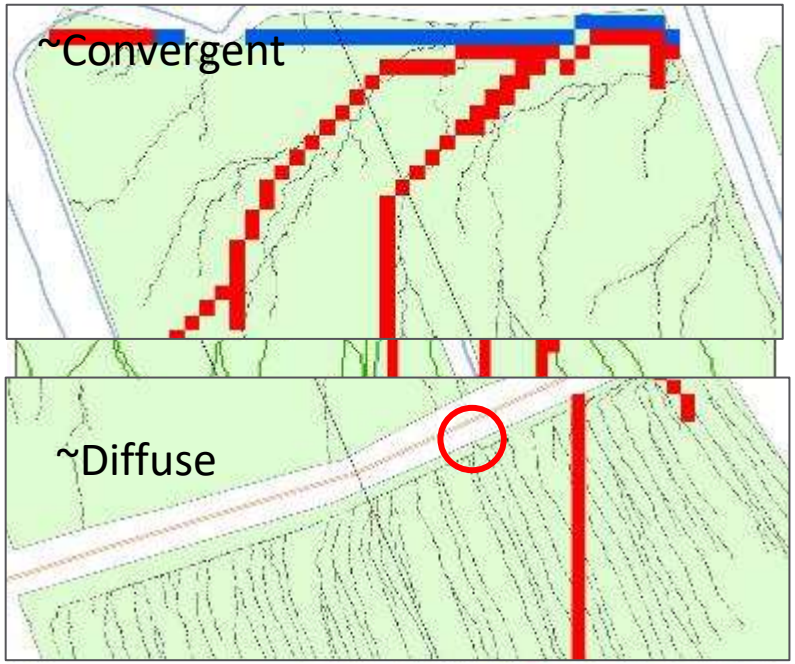
2, 5m DEM



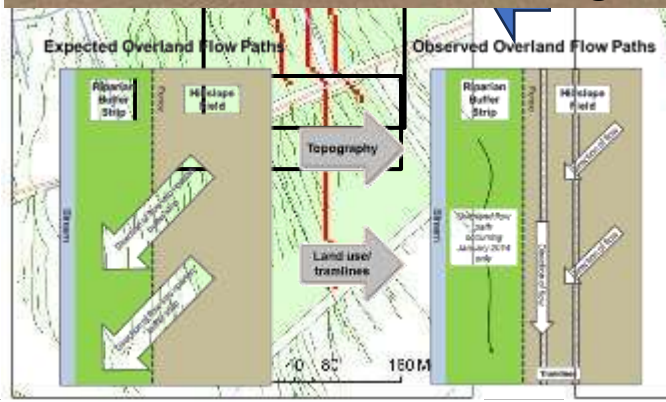


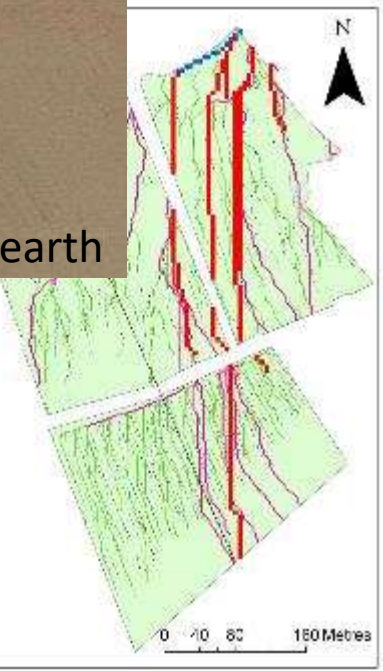


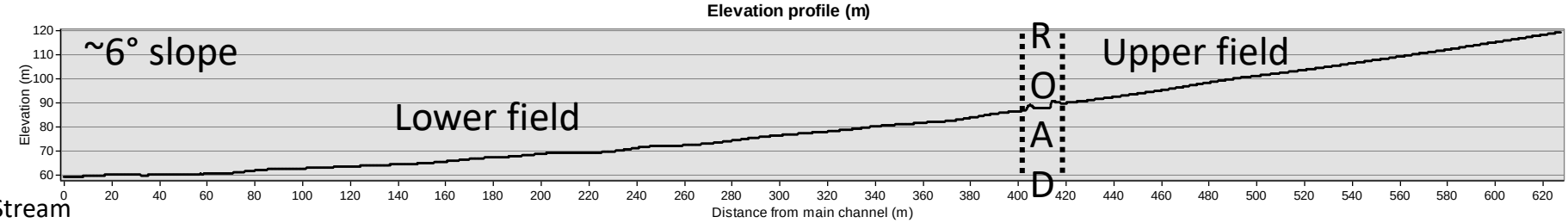
S.W. Ballycanew



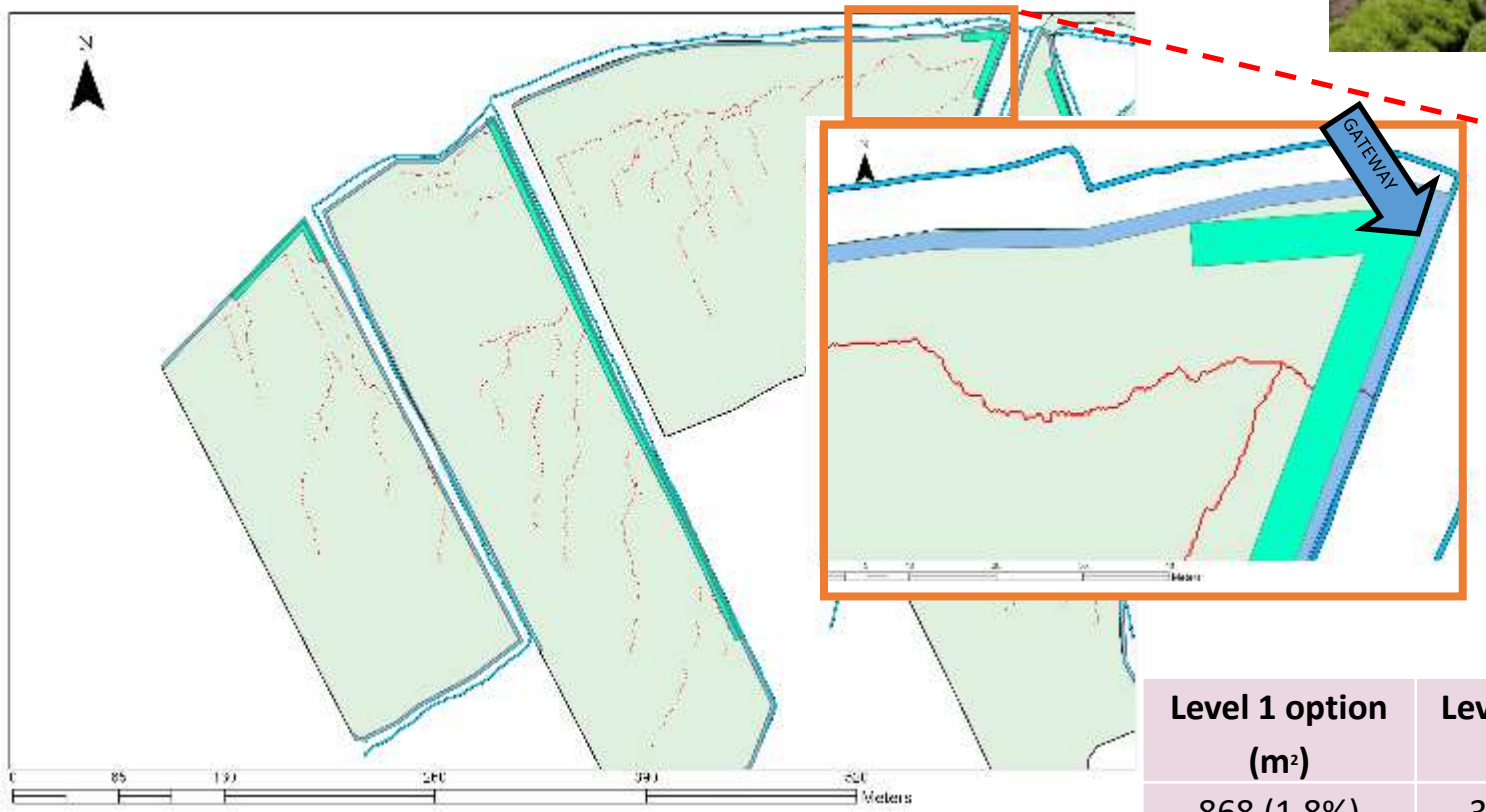
5m DEM





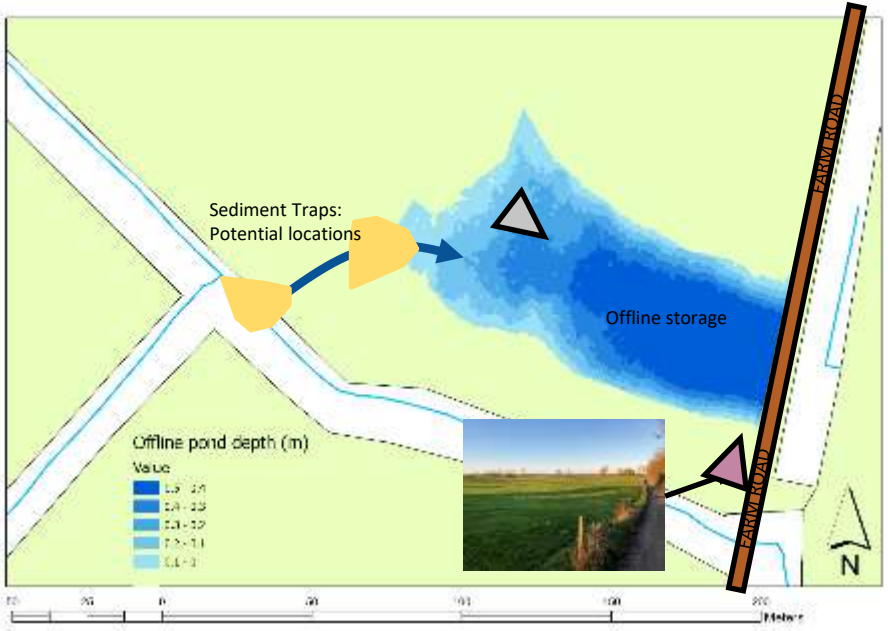


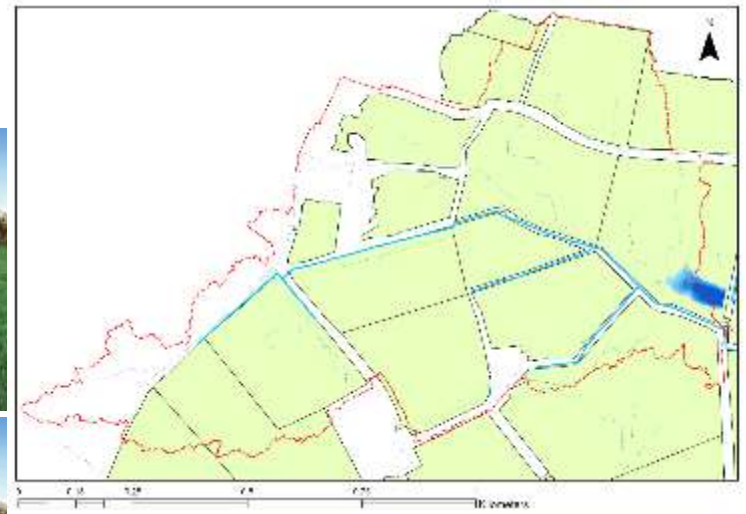
Scenario 1: example of Level 1 and 2

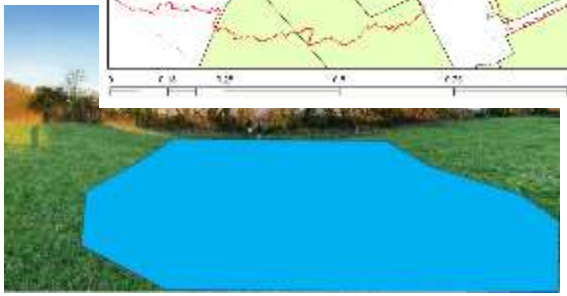


Level 1 option (m^2)	Level 2 option (m^2)
868 (1.8%)	327 (0.7%)

Scenario 2: Level 3 Overbank bund with infield sediment trap



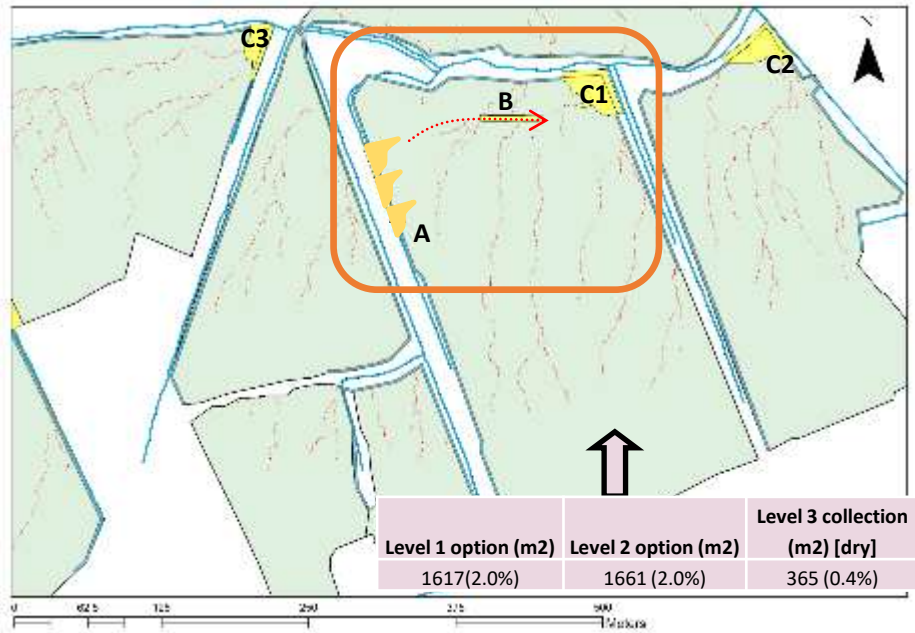




Bund (track) Height (m)	Bund length (m)	Approx. bund area (m2)	Temporary storage area (m2)	Temporary storage volume (m3)
0.5m	35	160	2465	1013

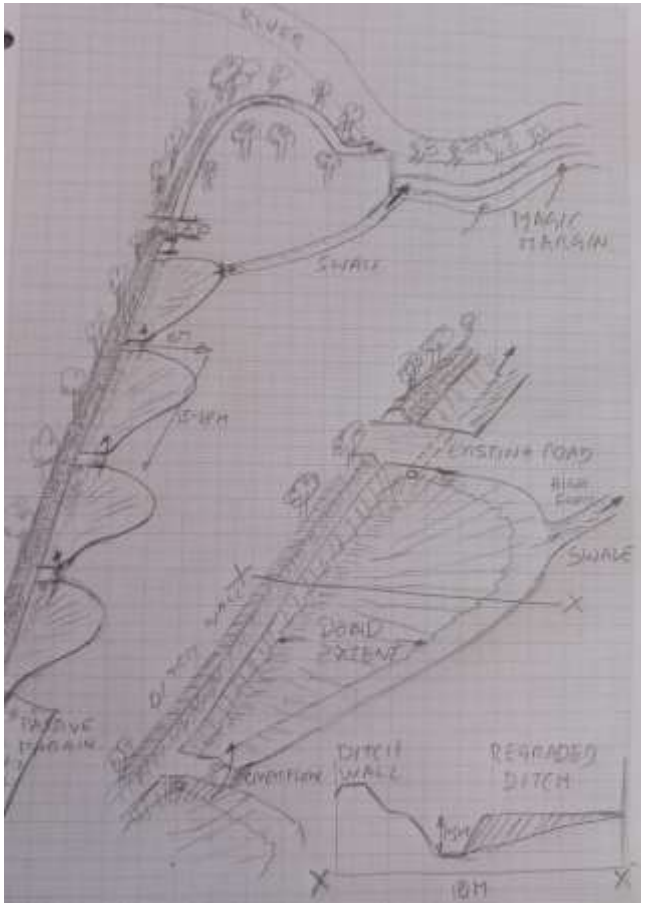
Level 1 option (m2)	Level 2 option (m2)	This option (m2) [dry]
2953 (2.3%)	630 (0.5%)	0 (0%)

Scenario 3: Level 3 In-ditch sediment traps, swales and raised bund treatment train



Level 1 option (m2)	Level 2 option (m2)	Level 3 collection (m2) [dry]
1617(2.0%)	1661 (2.0%)	365 (0.4%)

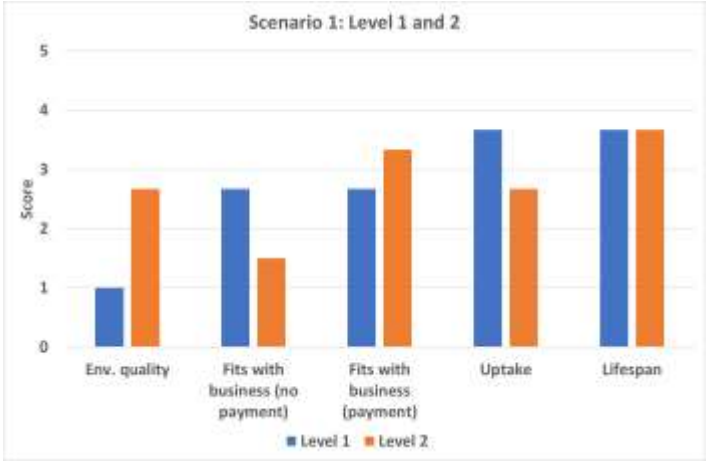
Location	Bund Height (m)	Bund length (m)	Approx. bund area (m2)	Temporary storage area (m2)	Temporary storage volume (m3)	Catchment area est. to bund (ha)
C1	1m	70 (L shape)	365	875	595	20
C2	1m	80 (L shape)	374	689	473	12
C3	1m	60 (L shape)	250	844	307	6

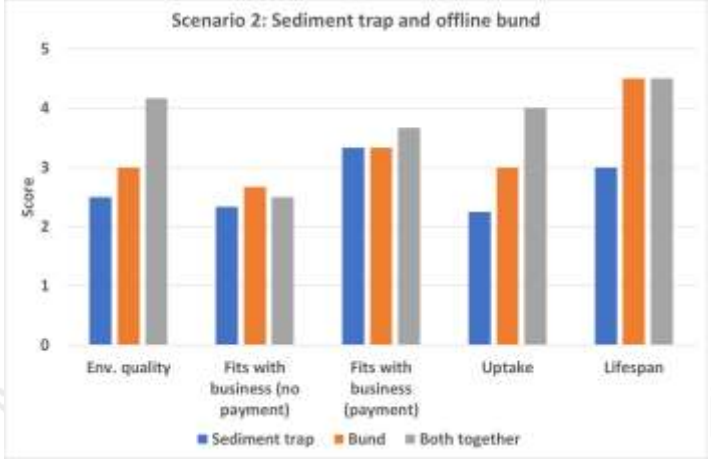


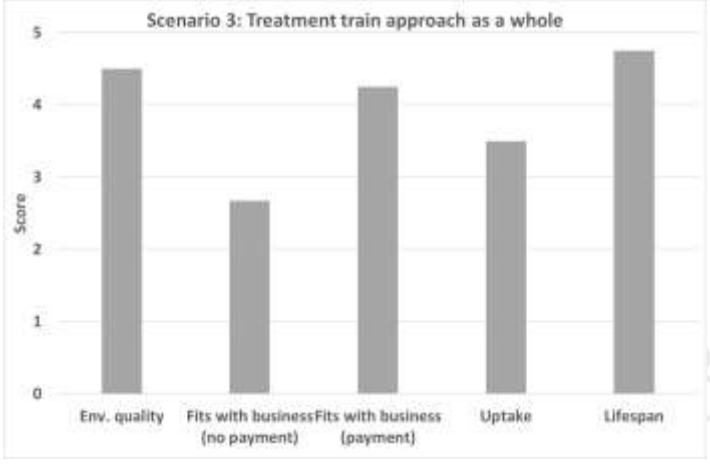
Workshop – Nov 2022, Wexford

- Attended by ~15 advisors & catchment scientists
- Three approaches presented
- Scoring 1 to 5 on:
  - **Environmental quality improvement potential**
  - **Fits with farm business and goals (no payment)**
  - **Fits with farm business and goals (part of a scheme)**
  - **Likeihood of uptake**
  - **Lifespan relative to management efforts**

Workshop feedback on approach



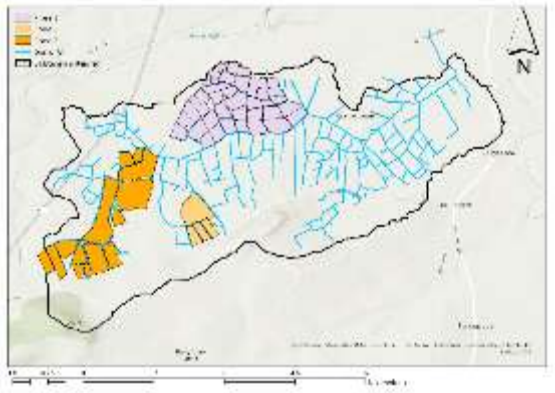




Land take for each level

Area (ha)	Total field area	Level 1 (%)	Level 2 (%)	Level 3 dry(%)	Level 3 field area wet (%)	Volume of ponds (m^3)
Total phase 1	**93.8**	2.2%	1.2%	0.05	0.4%	**1451**
Total phase 2	**97.4**	2.3%	1.1%	0.2%	0.6%	**3456**
TOTAL	**191.2**	**2.2%**	**1.2%**	**0.1%**	**0.5%**	**4907**

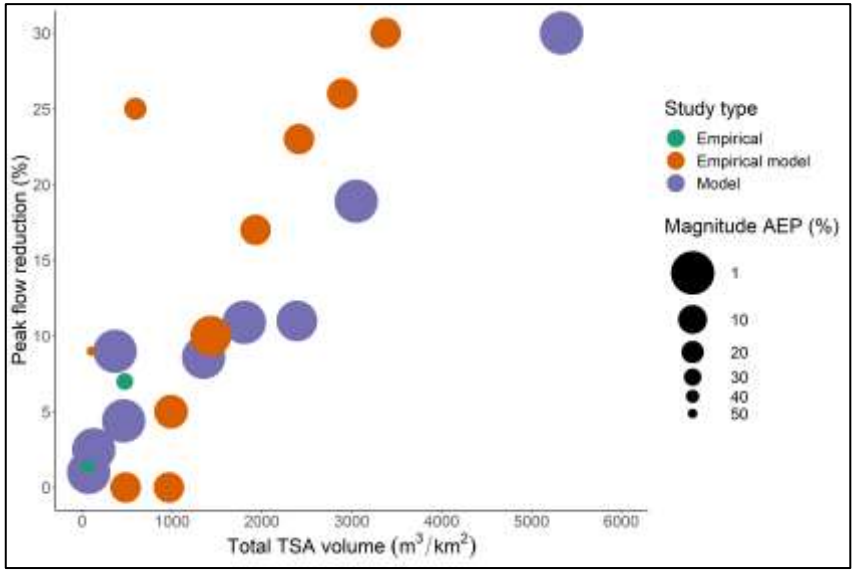
~2500m^3/km^2

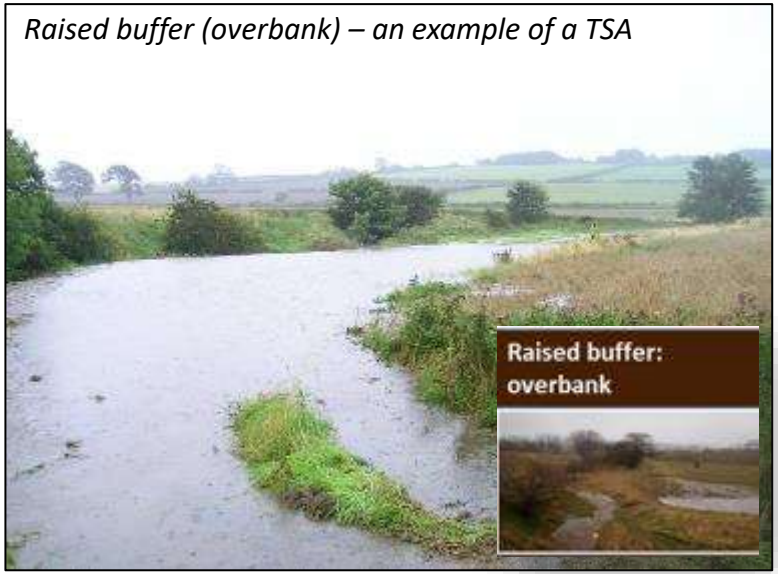


5. Communication with simple and robust metrics

e.g., m^3/km^2

- Vital for investment (public AND private financing) and improved uptake
- Example: Temporary Storage Areas (TSA) – summary of 7 UK studies





Raised buffer (overbank) – an example of a TSA

See Roberts, M.T., Geris, J., Hallett, P.D. and Wilkinson, M.E., 2023. **Mitigating floods and attenuating surface runoff with temporary storage areas in headwaters.** Wiley Interdisciplinary Reviews: Water, 10(3), p.e1634.

Developing Water Metrics and Standards

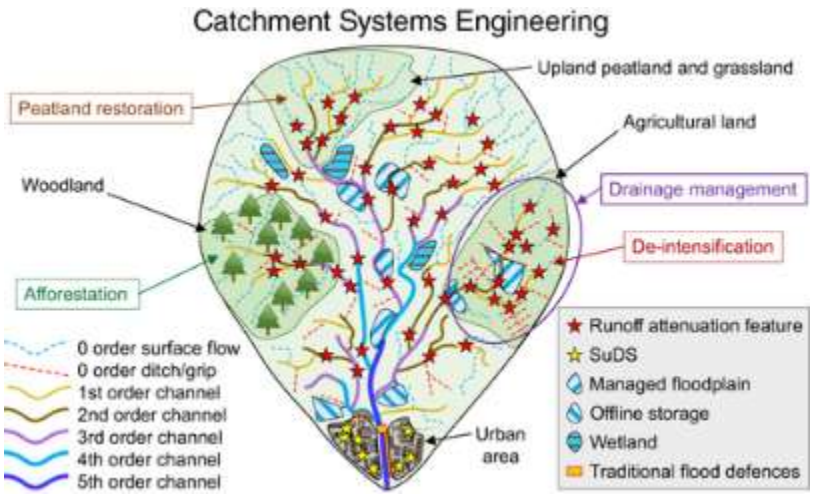
- E.g., Scottish working group on Water Metrics.
- **Aim - develop metrics and standards which:**
  - Recognise and value multifunctional benefits of nature-based and land management solutions
  - Encourage and support private ‘green finance’ investment (including as part of hybrid finance approaches)
  - Allow public finance to be more effectively and efficiently targeted (including as part of hybrid finance approaches)

https://www.hydronationchair.scot/projectoutputs


6. Integrated catchment management approaches are critical

How do we manage future flooding, drought, water quality issues etc.?

Large amounts of storage requires large amounts of land



Headwaters

Floodplains

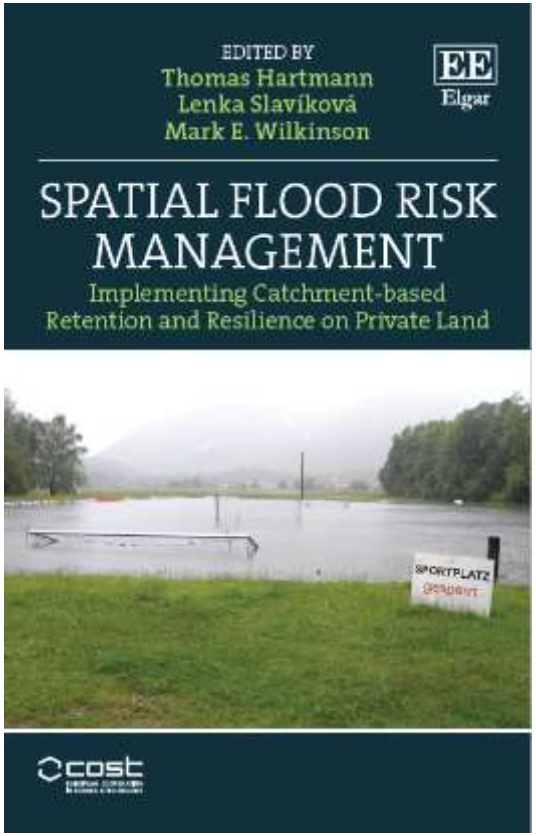
Built up areas

Hydrology

Socio-political

Stakeholders

'Natural' approach — Traditional engineering



- 23 authors from many countries across Europe
- Open access

- Spatial flood-risk management entails two aspects:
  - catchment-based approach to flood risks (orange arrows: i.e. headwaters, floodplains, built up areas)
  - it embodies the relevance of addressing land comprehensively in flood-risk management (blue arrows), i.e., with all its different **notions of land**

Concluding thoughts

- Next four years – a continuing need to mitigate issues
- Multifunctional design, location and scale matter for effectiveness
- It's not *'one size/approach fits all'*: Range of measure > treatment train
- Right measure, Right place approach can have less land take
- **Seeing is believing**

Acknowledgements

- CASE 1: SloWaters demonstration and assessment sites
- Contributing authors: **Mary Bourke (TCD), Darragh Murphy (UCC), Paul Quinn, Caspar Hewett (NCL), Caroline Bourke (TCD)**, Simon Harrison and John Wetherall.
- Funded by EPA Research and OPW
- **www.slowaters.eu**

- CASE 2: AiM NBS – N.E. Scotland
- Contributing authors: **Paul Quinn, Marc Stutter** and Martyn Roberts
- Supported by the Rural and Environment Science and Analytical Services Division of the Scottish Government
- **https://tinyurl.com/AIMNBS**

- CASE 3: Ballycanew, Ireland
- Contributing authors: **Daire Ó hUallacháin, Marc Stutter, Per-Erik Mellander,** Nikki Baggaley and Allan Lilly
- Funded by EPA Research Ireland
- **www.smarterbufferz.ie**

Questions?

- Tuesday: Sediment and total phosphorus effectiveness of riparian mitigation (versus costs) accounting for concentrated runoff flowpaths**, Marc Stutter**
- Wednesday: Simulation of the Impact of Nature-Based Solutions on Diffuse Pollution in Ballycanew Co. Wexford, **Paul Quinn** (Colin O'Flynn)
- Wednesday: Ballygow field trip *(i.e., seeing is believing)*

Previous days

Talks today

Posters

- The effects of an offline flood storage area (OSA) on peak stream flows, water quality and pasture health, **Darragh Murphy**
- A decision support tool for selecting between sixteen riparian mitigation measures based on farmed landscape factors**, Marc Stutter**

- Suite Sixteen: Expert evaluation of environmental effectiveness of riparian mitigation measures, **Daire Ó hUallacháin**

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