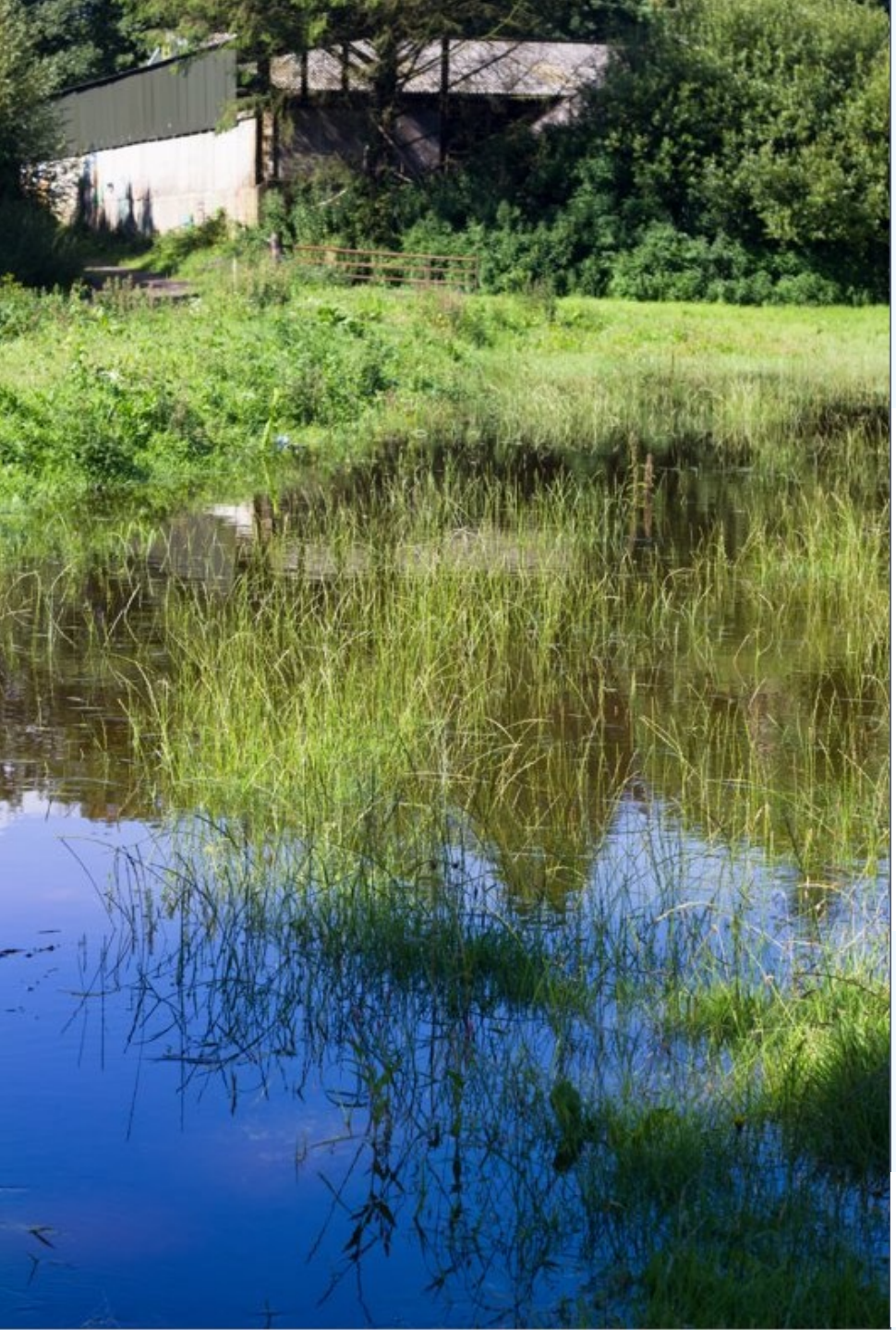


Studies in flood peak attenuation and water quality using Nature-based Solutions

Investigations into the functioning of four natural water retention measures on a farm in Co. Cork

Darragh Murphy – PhD Student
Simon Harrison – PhD Supervisor
John Weatherill – Co-supervisor

SlowWaterS

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

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

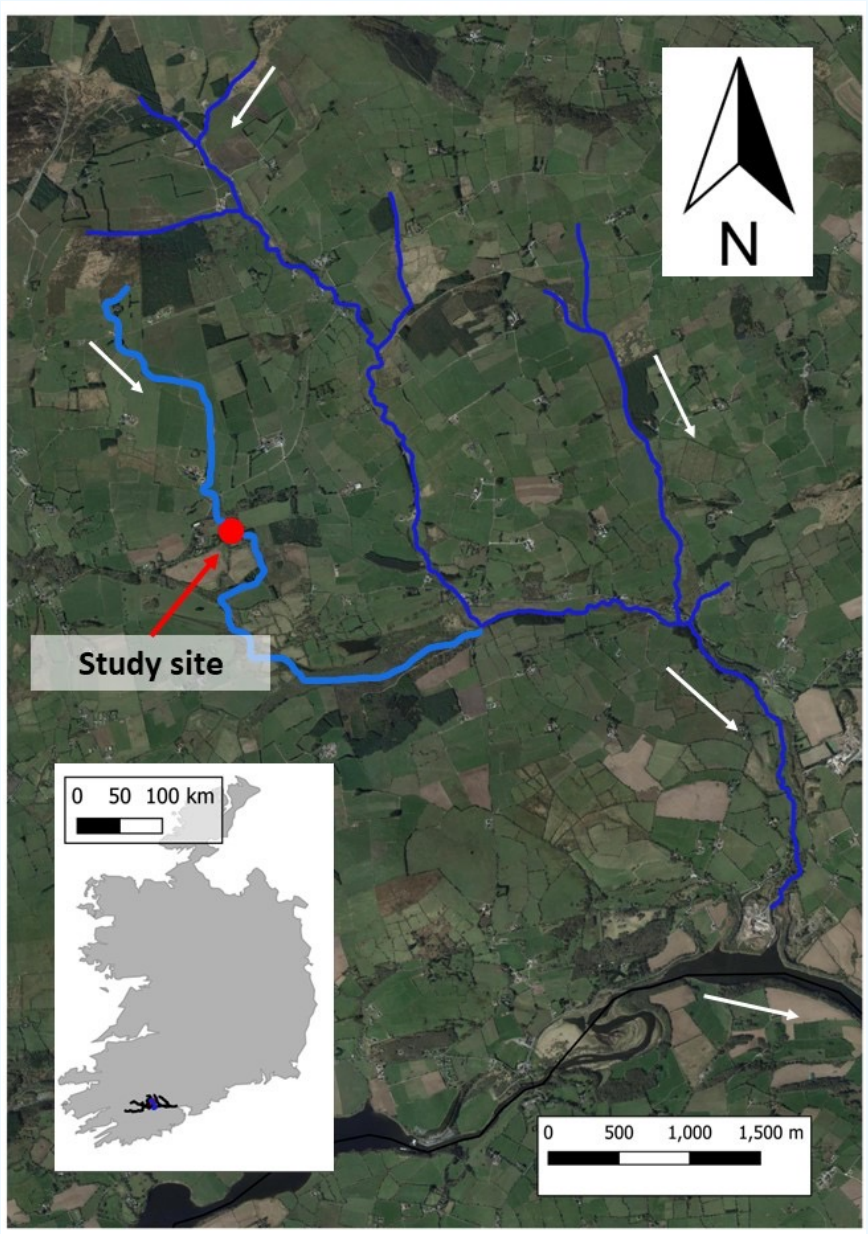
epa Environmental Protection Agency

OPW

teagasc Agriculture and Food Development Authority

Leades Farm study site

- First order stream in the Glashagarriff catchment in the upper Lee, Co. Cork
- 1km^2 catchment dominated by peat and fine loamy soil
- Land-use: forestry and agriculture



Outline

- Empirical study in a mixed-use farm (2021 – 2023)
- Installed four Nature-based Solutions (NbS) measures, selected from review of international literature
- Investigated impacts on flood peaks and water quality
  - Process led, comprehensive

1. Flood detention basin

2. Low-head boulder weirs

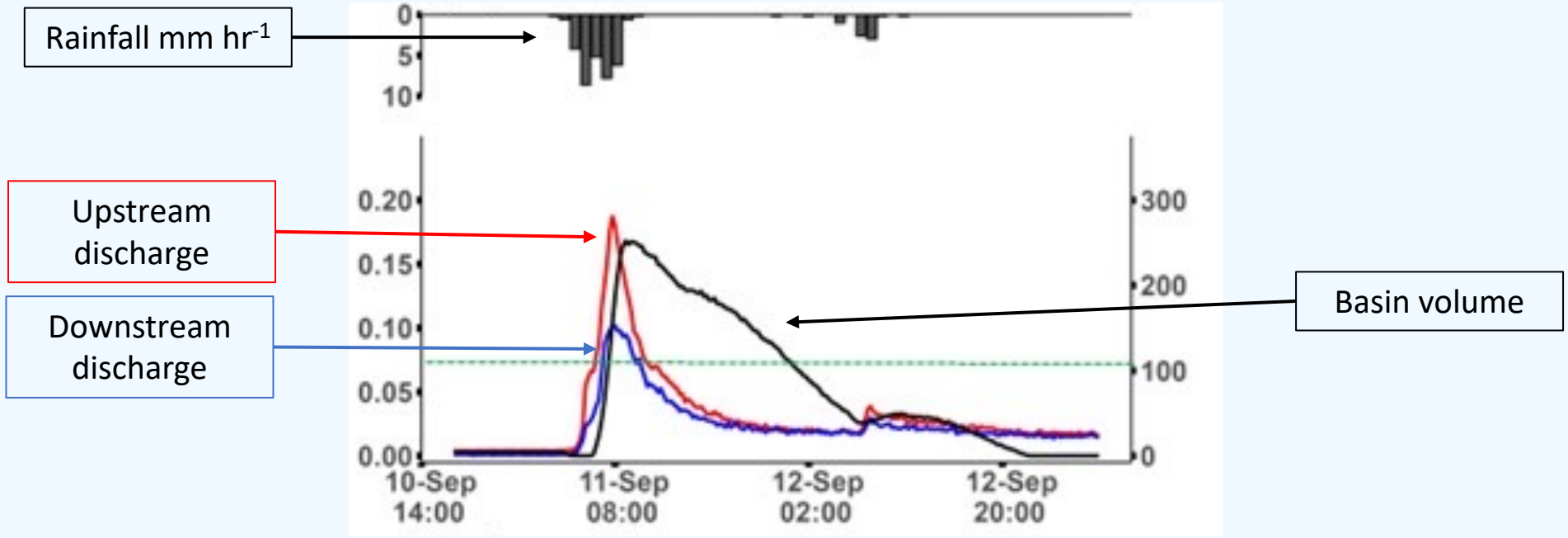
3. Leaky dams

4. Runoff treatment swale

1. Flood detention basin

- Hydrological impact
  - Reduce and extend flood peaks
- Water quality
  - Physical, geochemical and biological effects of storage
- Sward health & productivity
- Soil quality
  - Impact of flood mitigation measure on pasture

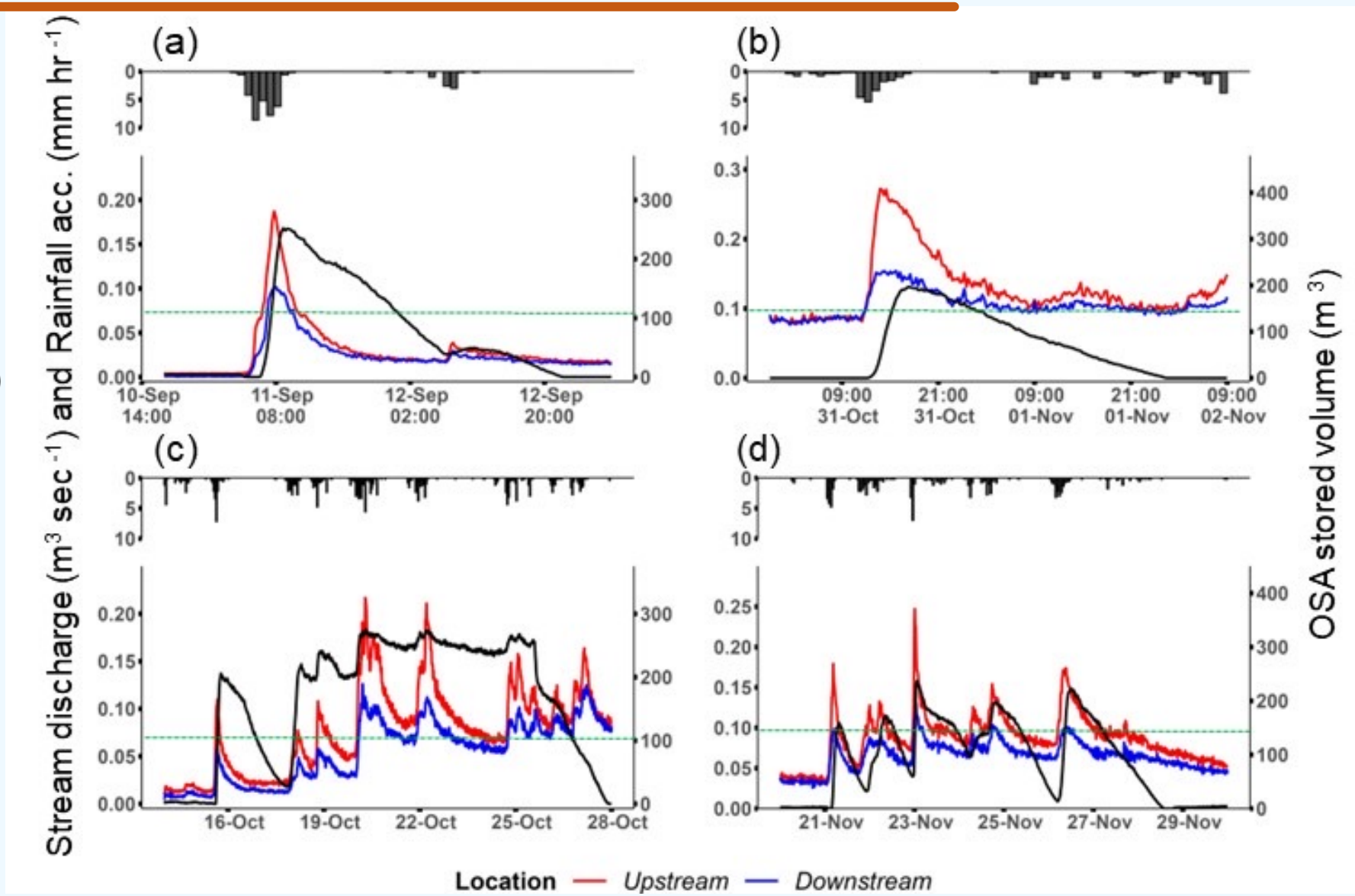
Flood peak attenuation



Flood peak attenuation

Results

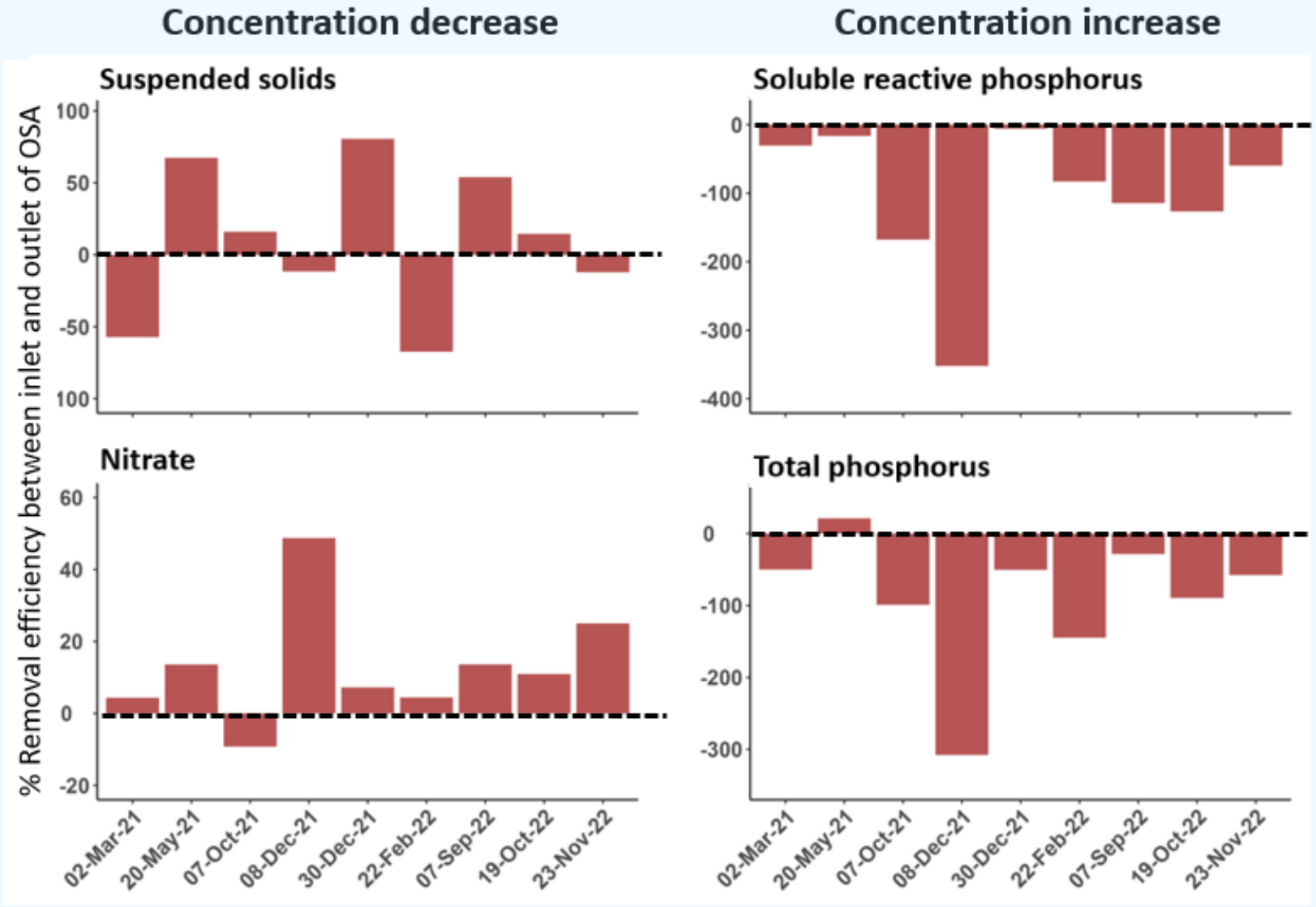
- OSA stored flood water during 15 inundation events (Mar 2021 – Jan 2023)
- Effectively attenuated flood peak discharge (mean = 0.063 $m^3 sec^{-1}$; 38%)
- Mean of 820m^3 (38%) flood peak attenuation by the OSA
- Elongated peak flow hydrographs (2.5 times duration of mean peak; 3 hours 35 mins)



Water quality impacts

Results

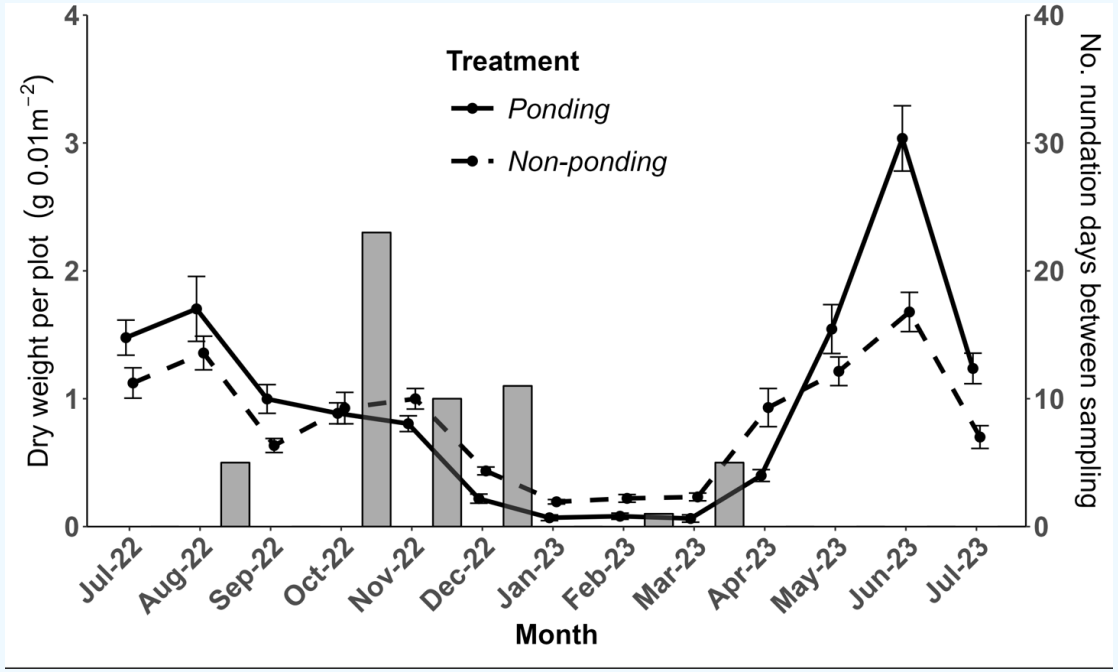
- Statistically significant attenuation of **suspended solids** and **nitrate** across eleven flood events
- Significant increase in concentrations of **soluble reactive phosphorus** and **total phosphorus**
- Water quality changes varied between flood events, within flood events, and at different locations with the OSA

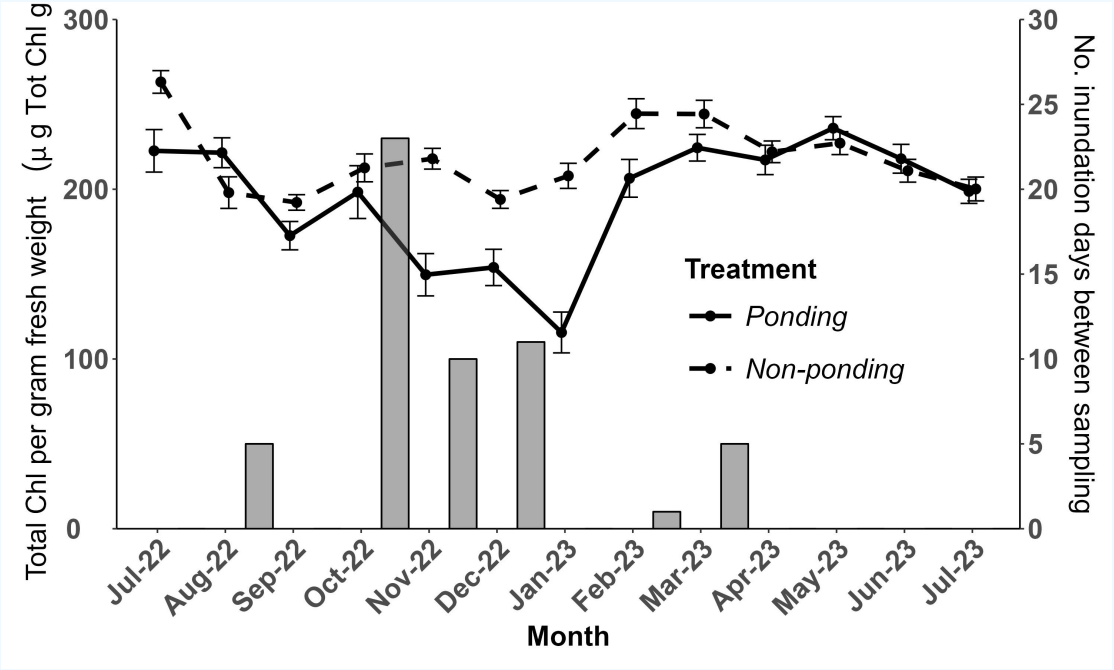


Sward health & productivity

Results

- Productivity of the ponding zone sward was reduced in winter, slightly higher during the growing season
- No significant impact of flooding on biomass production
- Total Chlorophyll reduced in flood zone
  - Chl *b* affected more than Chl *a*
- Sward diversity and abundance of grassland species was not affected by inundations

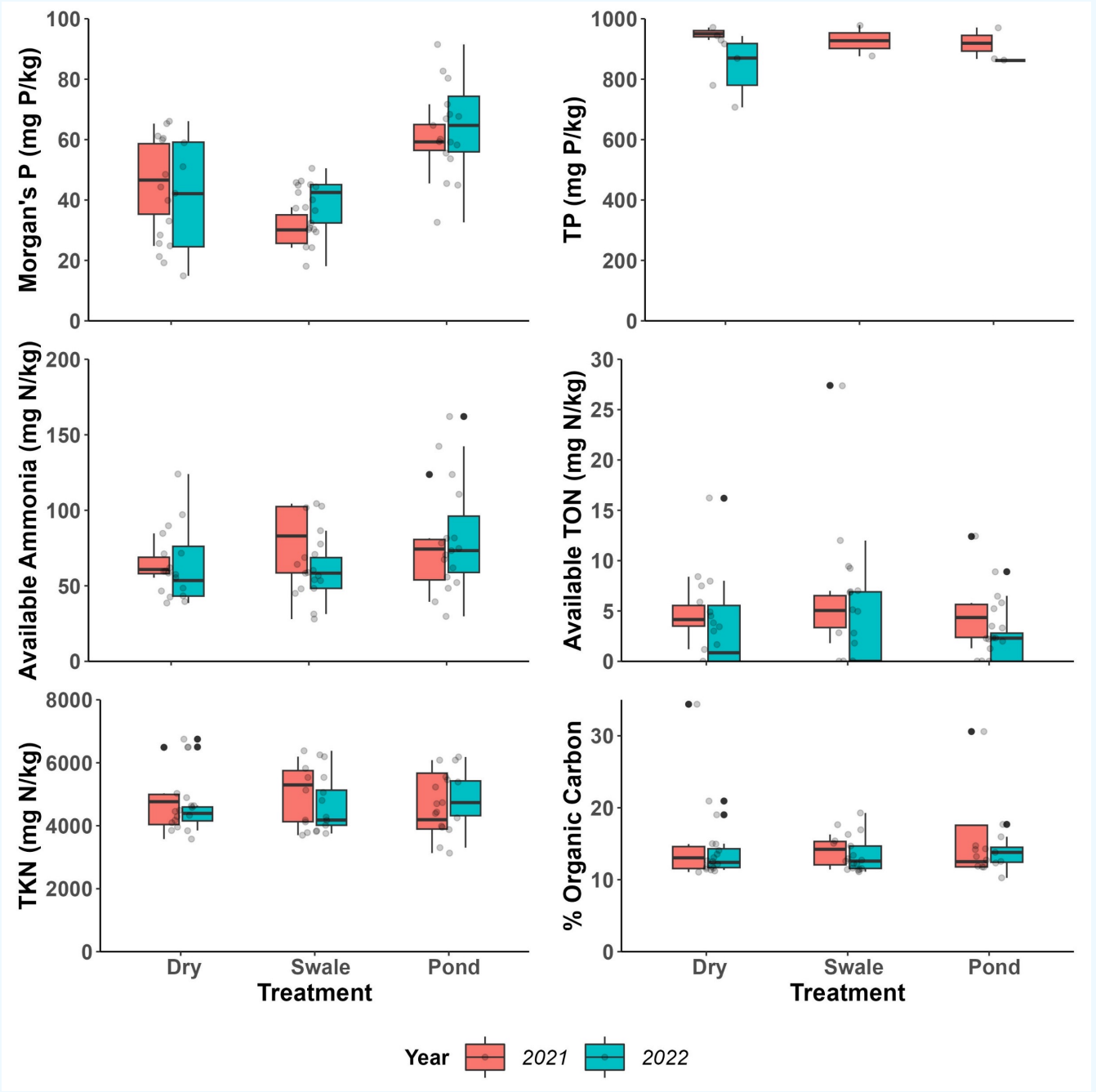




Soil analysis

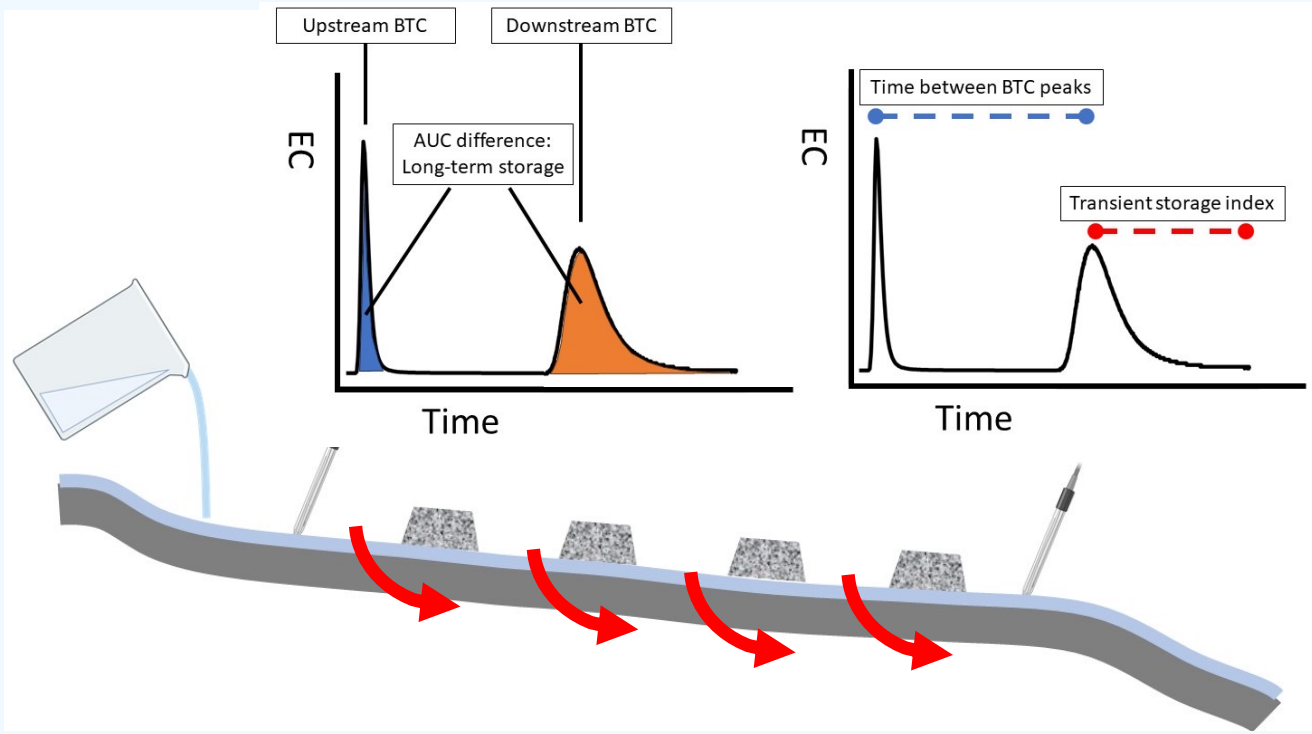
Results

- No indication that inundation during flood peaks affected soil chemistry
- No indication that a given flood event has immediate effects
- Morgan's P significantly elevated in flood zone: no difference between pre-flooding (2021) and post-flooding (2022)



2. Low-head boulder weirs

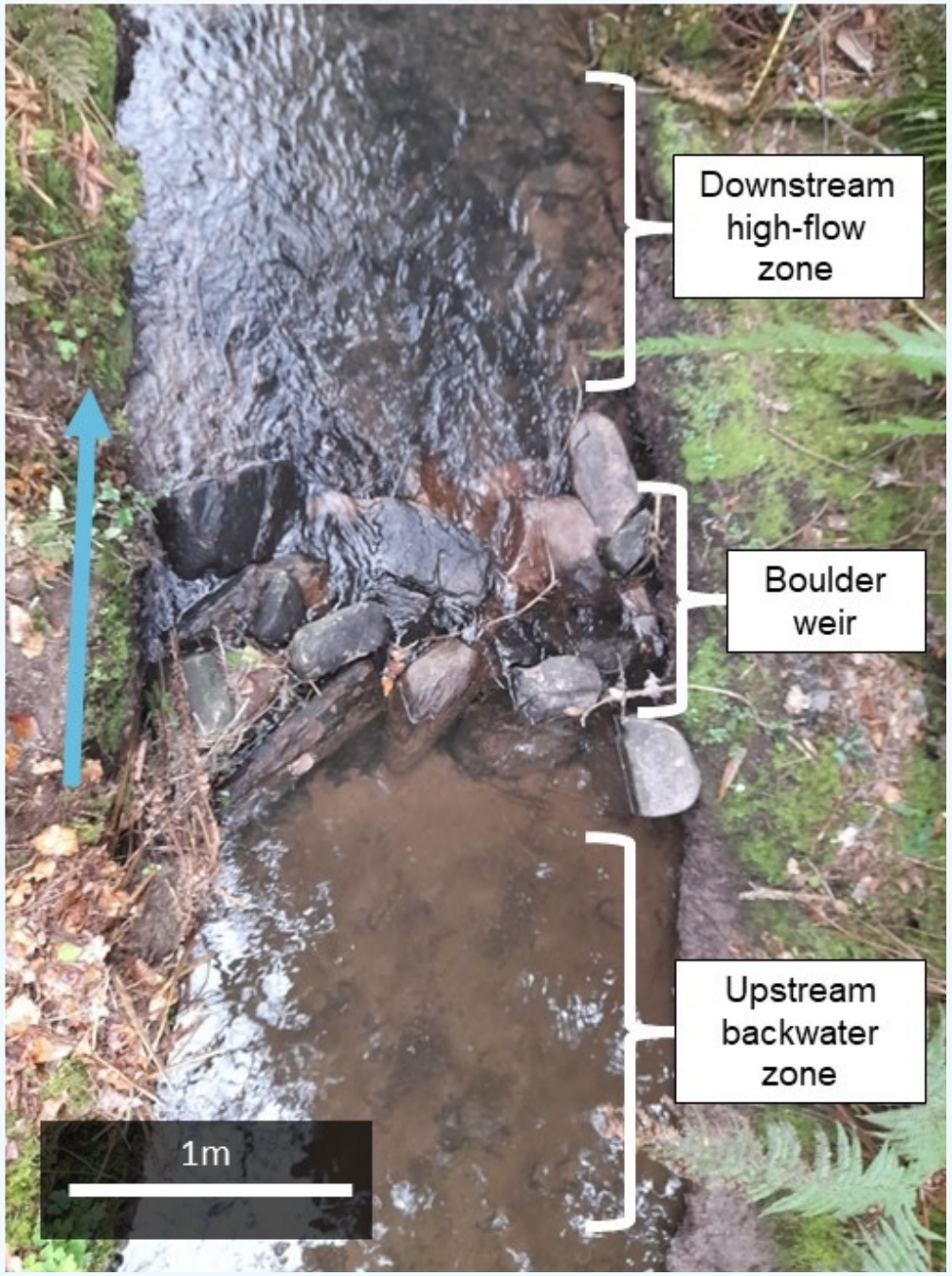
- Channels in agricultural catchments are often denuded of gravel beds & morphological complexity (meanders, pools, riffles, boulders)
- Impaired flow of nutrient-rich water over microbial biofilms in streambed gravels (the hyporheic zone)
- Low-head boulder weirs may promote hyporheic exchange and nutrient uptake



Low-head boulder weirs

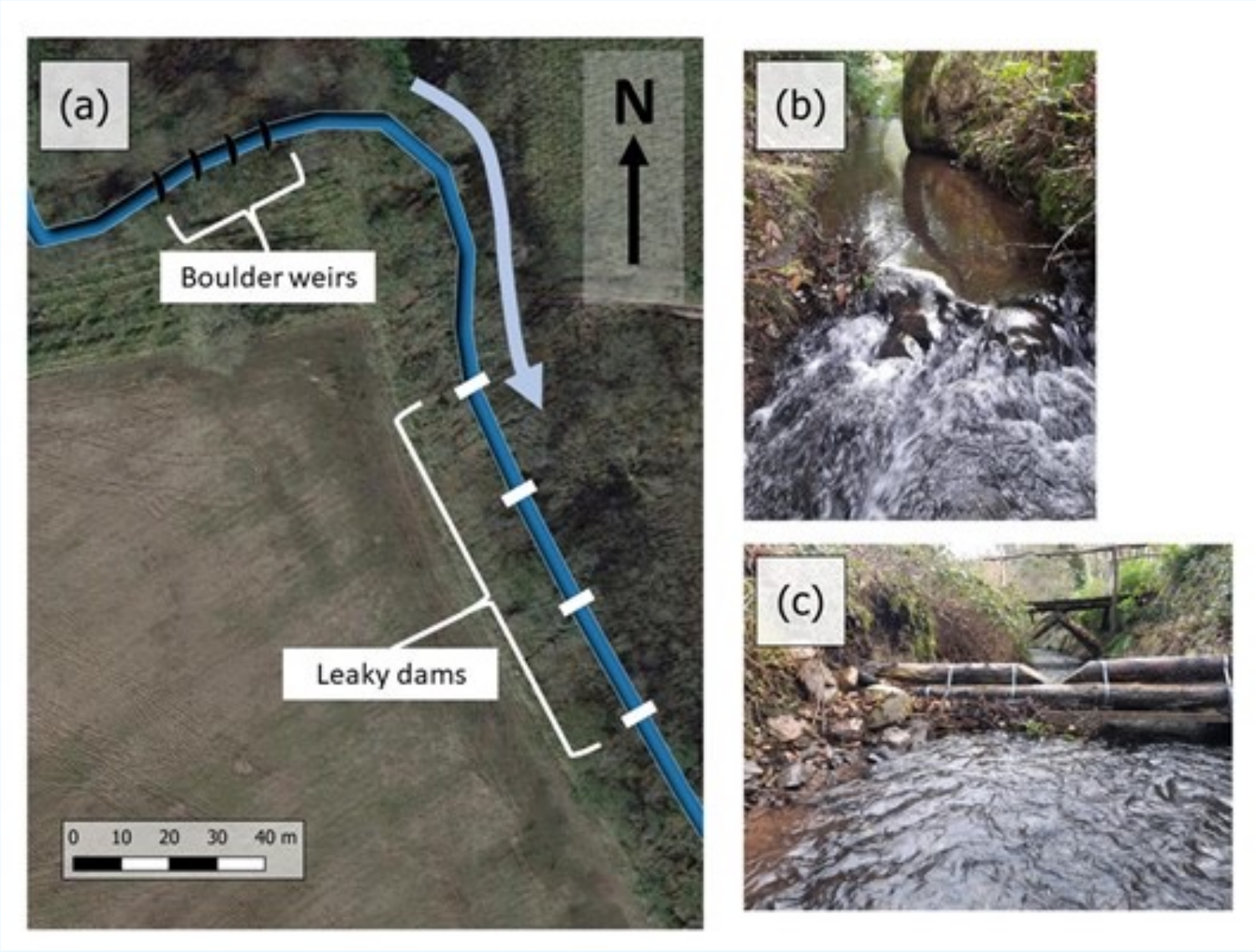
Results

- Weirs led to reduction in solute storage and nutrient uptake by the streambed at low flows
- At higher flows, weirs helped to reduce flow velocities
- Substantial upstream deposition of sediment, downstream scour



3. Leaky Dams

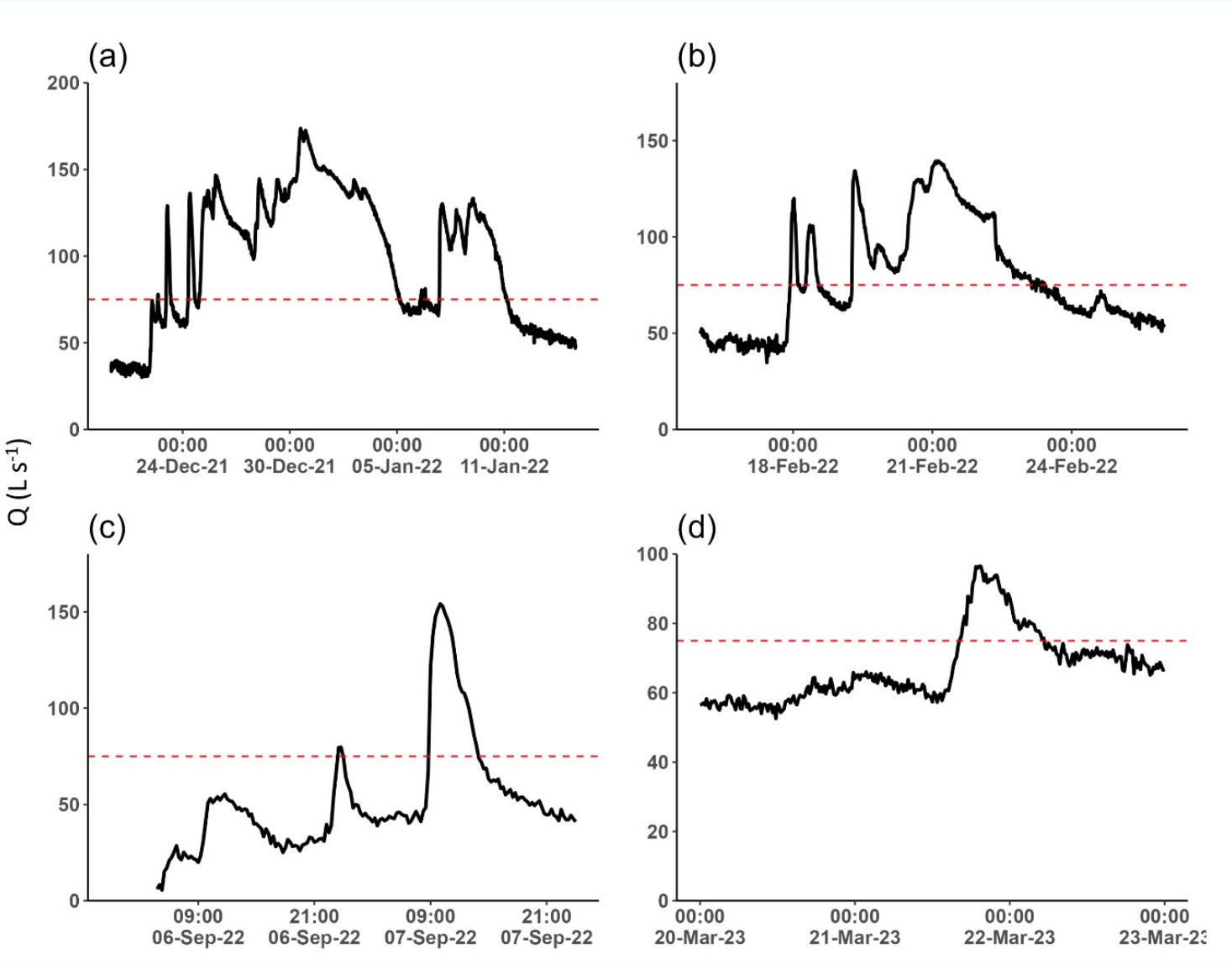
- Large woody debris has been removed from channels to reduce over-bank flooding, channel deformation and collision with built structures (e.g. bridges, culverts)
- Leaky dams to reduce and slow peak flows
- Hydrographs of high-flow events were examined for comparable flows before (Oct 2021 – Apr 2022, n = 6) and after the leaky dams were installed (June 2022 – Apr 2023, n = 8)



Leaky Dams

Results

- Leaky dams did not appear to affect onset of downstream flood peaks
- Significant reduction in downstream peak discharge (p = 0.04)
- No evidence that leaky dams changed shape of peak

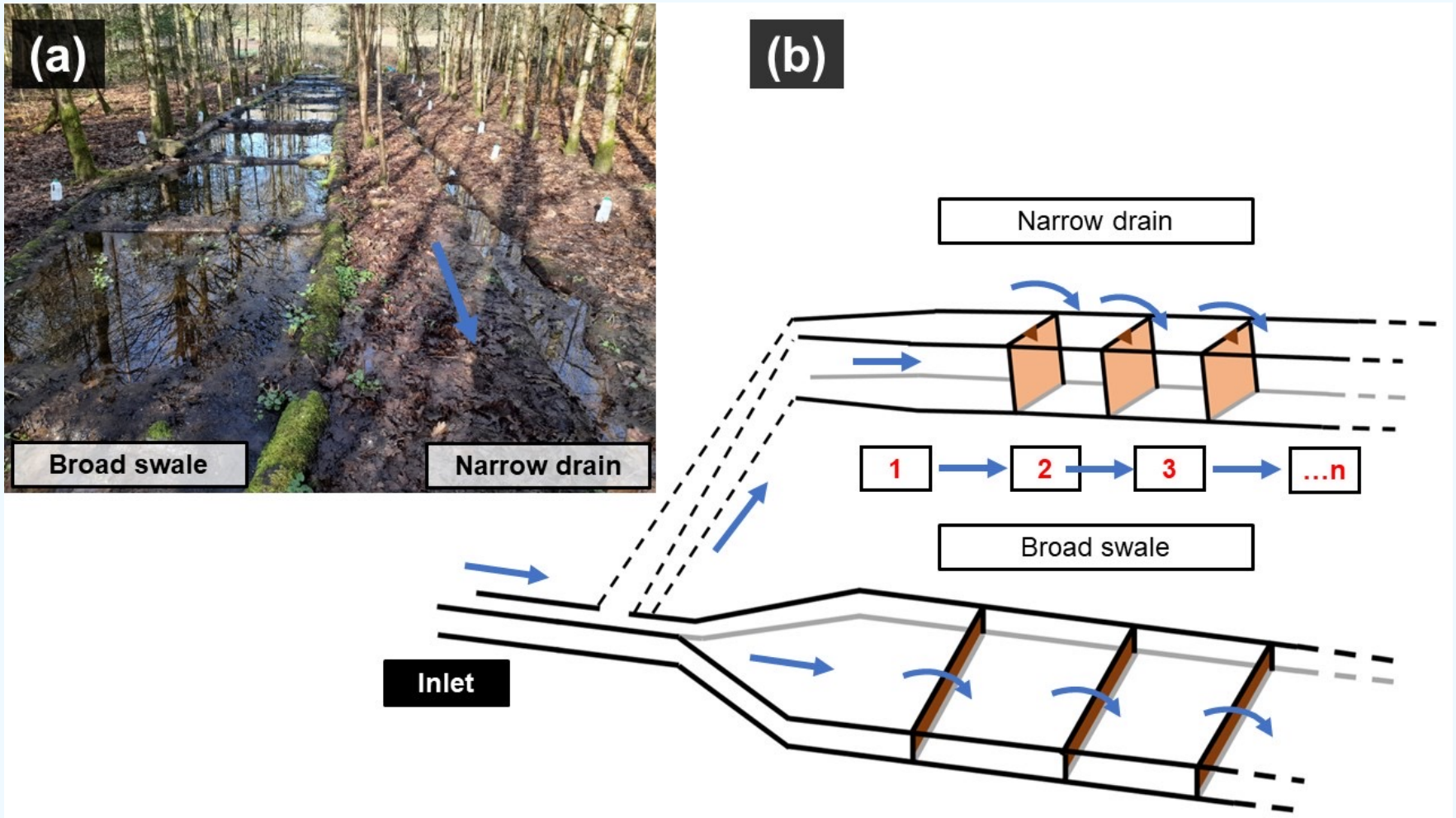


Leaky Dams

- Woody debris and leaf-litter build-up at leaky dams induced localised erosion to stream bank and stream bed
- Scour of stream bed during any high flow (Q > 80 L s^{-1})
- Storm Babet in October 2023

4. Woodland runoff swale

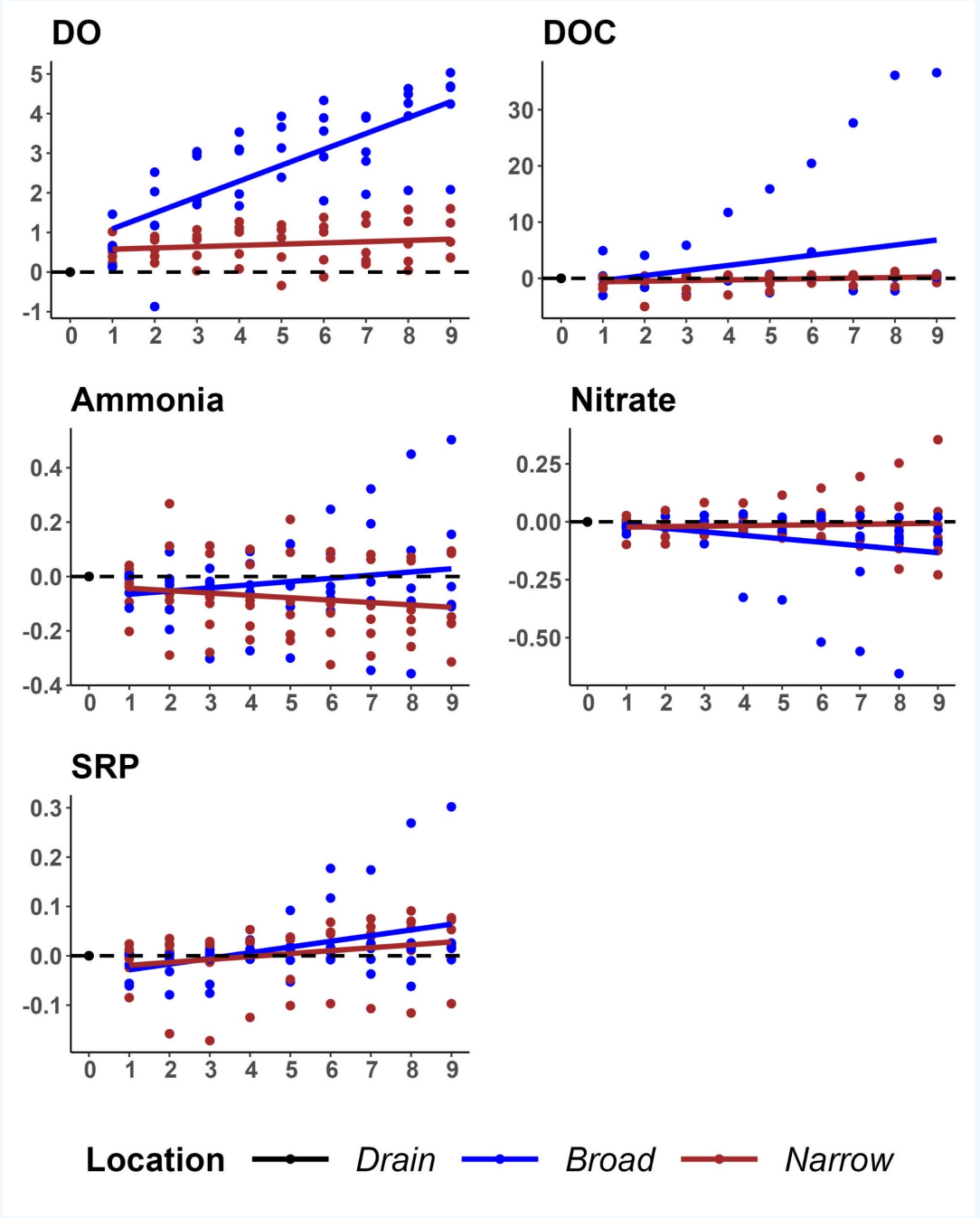
- Organic runoff in agricultural streams induces high BOD and consequent low oxygen conditions which are harmful to aquatic life
- Agricultural drains are typically linear, deep: low degree of contact between soil microbes and water
- Broad swale to facilitate aerobic processing, U.V. effects, biomat development



Swale

Results

- DO recovery and nitrate conc. reduction greater in broad swale than narrow drain
- Variable changes in other parameters
- Narrow and broad cells appear to affect WQ differently
- Differences in structure of biomat in broad vs. narrow cells

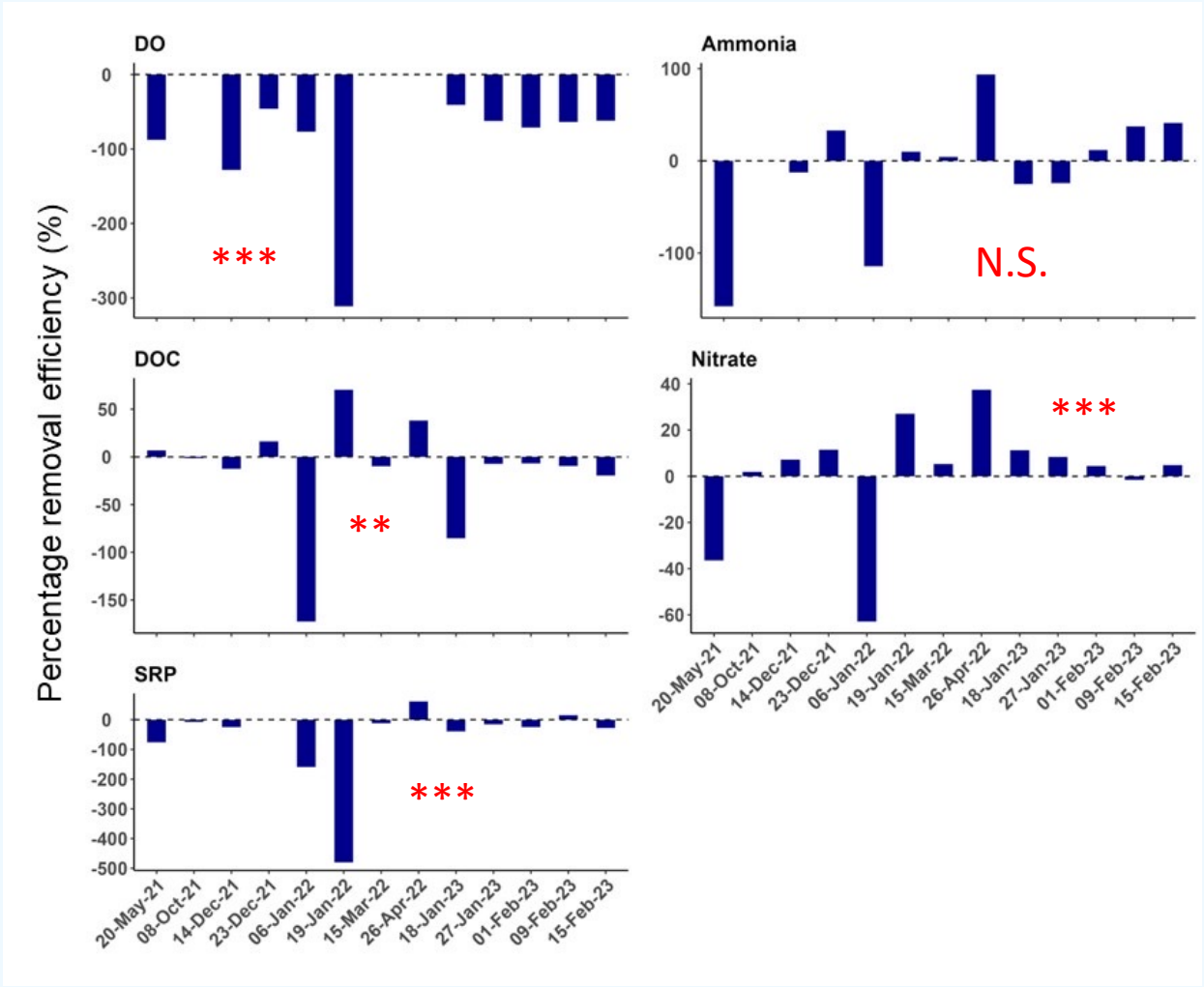


Swale

Results

- Significant recovery of dissolved oxygen (DO) and reduction in nitrate concentrations
- Increase in DOC and SRP along cells
- Discharge and initial concentrations in top drain: affected changes in wetland

	Parameter	Estimate	F	df	R^2	p-value
% RE : Q	DO	-4.99	0.129	8	-0.107	0.729
	Ammonium	-68.11	12.71	9	0.539	0.006*
	Nitrate	-26.84	17.11	9	0.617	0.003*
	SRP	-46.82	7.628	9	0.399	0.022*
	DOC	-26.78	1.434	9	0.042	0.262
% RE : Inlet concentration	DO	23.14	5.011	9	0.286	0.052.
	Ammonium	-25.41	1.062	11	0.005	0.325
	Nitrate	-0.92	0.014	11	-0.09	0.909
	SRP	-32.51	0.029	11	-0.088	0.869
	DOC	-2.75	11.48	11	0.466	0.006*



Swale

Conclusions

- Volume of narrow and broad cells equal but effects on oxygen recovery markedly different
- Simple enhancements to drain morphology can improve water quality
- Increase in hydraulic residence time may promote breakdown of organic matter and soil infiltration
- Reduce risk of run-off reaching waterbodies

Overall Conclusions

- Natural water retention measures can be built at low cost and have pronounced effects on hydrology and water quality
- Farming practices were unaltered over the 2020 – 2023 study period while five investigations occurred
- The effects of the studied measures were variable: forces which mediate effectiveness are complex
- Investigations were approached with two guiding principles:
    - Measures should target specific issues, guided by scientific principles
    - Measures must be simple, safe and unintrusive to farming practices