# River Restoration Centre
# 21st Annual Network Conference

***River Restoration: scaling up our ambition***

*9th & 10th September 2020 – Online*

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# RIVER RESTORATION CENTRE 21ST ANNUAL NETWORK CONFERENCE

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## PROGRAMME OF EVENTS

**DAY 1:** **- - - WEDNESDAY 9TH SEPTEMBER - - -**

### Session 1

**CHAIR:** *Martin Janes (River Restoration Centre)*

| | | |
|---|---|---|
| 10:00 | **River Restoration Centre introduction & welcome**<br>Martin Janes *(the River Restoration Centre)* | 15 mins |
| 10:15 | **Water Environment Grant**<br>Jenny Wheeldon *(Natural England)* | 15 mins |
| 10:30 | **Getting delivery done: Funding streams, up-scaling and payment for outcomes**<br>David Brown *(Environment Agency)* | 15 mins |
| 10:45 | **Live Question & Answer with presenters** | 30 mins |
| 11:15 | **Integrating NFM as a measure to reduce flood risk**<br>Jon Hollis *(Environment Agency)* | 15 mins |
| 11:30 | **Breathing life into Scotland's urban rivers**<br>Charles Perfect *(Scottish Environment Protection Agency)* | 15 mins |
| 11:45 | **Biodiversity Net Gain – An Opportunity for River Restoration**<br>Sarah Scott *(Environment Agency)* | 15 mins |
| 12:00 | **Live Question & Answer with presenters** | 15 mins |
| 12:15 | LUNCH | 75 mins |

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## Session 2

| | | |
|---|---|---|
| 13:30 | CHOICE OF ONE WORKSHOP | 2 h 30 min |

### Workshop A

Restoring connectivity between the stream & its floodplain

Facilitator: Fiona Bowles *(RRC),* Stewart Clarke *(National Trust),* John Phillips & Jo Shanahan *(Environment Agency),* & Jenny Wheeldon *(Natural England)*

The workshop will be an opportunity to explore the theory and practice of taking a 'Stage 0' approach to river and floodplain restoration. 'Stage 0' restoration has the potential to deliver multiple environmental and flood risk benefits through reconnecting river and floodplains creating a more resilient channel network and functionally linked floodplain wetlands. This workshop will explore the risks, opportunities and constraints of taking a 'Stage 0' approach in the UK. As part of the workshop the Environment Agency will present for discussion draft findings from a project developing geomorphic mapping tools and guidance for those seeking to identify potential 'Stage 0' sites as well as worked 'case study' examples that explore the technical and practical issues likely to require consideration in developing a 'Stage 0' project.

**Working with natural processes - a National Trust perspective**
Stewart Clarke *(National Trust)*

### Workshop B

Understanding the role of beavers in river restoration

Facilitator: RRC

This workshop will be themed around understanding the role beavers can play for river restoration, how to prepare for the implementation of beavers, and managing river restoration delivery. The session will look to encourage the delegates to discuss challenges related to beavers including how to anticipate benefits of the presence of beavers, how to manage land effectively, and who needs to be included in decision making. Delegates will feedback their thoughts and suggestions to the group, with the aim of looking forward to how we can efficiently encourage establishment of beavers for river restoration.



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| 16:00 | Close |

## Session 2

| | | |
|---|---|---|
| 13:30 | CHOICE OF ONE WORKSHOP continued… | 2 h 30 min |

### Workshop C
NFM Implementation Guidance

Facilitator: Emma Wren *(Mott MacDonald)*

This workshop will focus on the current CIRIA-led work to produce practical implementation guidance for NFM measures. This workshop will discuss the aim, proposed structure and content and provide an opportunity to influence the approaches taken by the project team.

NFM measures will be implemented by a wide range of organisations and individuals. There needs and requirements in terms of understanding, level and practical experience may vary considerably. The guidance should be as wide ranging as possible, be based on science and best practice and be clear and practical.

We will discuss the priority measures that will form this round of guidance and also what other NFM measures should be looked next.

What examples and key learning experiences related to NFM implementation can you bring to this discussion on national guidance and what would you want to see included?

### Workshop D
Application of NFM modelling

Facilitator: RRC, Chris Spray *(University of Dundee)*

This workshop will include talks & demos on modelling Natural Flood Management measures.

**Integrating monitoring and modelling of NFM at the whole catchment scale – emerging results from the Eddleston Water**
Chris Spray *(University of Dundee)*

**Modelling benefits of NFM in lowland catchments - River Hull case study**
Jessica Fox *(Hull City Council)*

**Shared learning experience in developing appropriate modelling for Natural Flood Management in four catchments in Yorkshire**
Steve Rose & Rachelle Ngai *(JBA Consulting)* & Sophie Vanicat *(Environment Agency)*

**Natural Flood Management (NFM): Bigger is not always better, prioritisation is key**
Charlie Bleasdale (*Atkins, University of Southampton*), Emily Brown (*Atkins, University of Nottingham*) & Emma Lancaster *(Atkins, Durham University)*

**Prioritising natural flood management opportunities for the Thames Regional Flood and Costal Committee**
Gavin Haughton *(Environment Agency)*

**Natural Flood Management in practice: managing environmental risks to improve resilience**
Clare Rodgers (*Environment Agency*) & Ian Dennis *(Royal HaskoningDHV)*

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| 16:00 | Close |

## Session 2

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|---|---|---|
| 13:30 | CHOICE OF ONE WORKSHOP continued… | 2 h 30 min |

### Workshop E
Landowner engagement & communication

Facilitators: RRC & Simon Whitton *(APEM)*

In this workshop we will discuss approaches to engaging and communicating with landowners to help us achieve more in our catchments. We will discuss common challenges associated with landowner engagement, and how these can be overcome. Case studies, examples and lessons learned will be used alongside group discussions to draw out key messages and recommendations for river restoration practitioners looking to engage landowners.

**Far from the water's edge: a new focus for near natural rivers?**
Jo Old, Louise Weller & Glenn Maas *(Environment Agency)*

**Restoring the Upper Wensum: Kick Starting Natural Processes**
Jacob Dew *(Five Rivers Environmental Contracting Ltd)*

**Slowing the flow in Dorset streams; working together for Poole Harbour**
Alasdair Maxwell *(Environment Agency)*

### Workshop F
Achieving Urban Flood Resilience in an uncertain future

Facilitators: RRC & Jenny Mant *(Ricardo)*

Urban Flood Resilience refers to a city's capacity to maintain future flood risk at tolerable levels by preventing deaths and injuries, minimising damages and disruption during floods, and recovering quickly afterwards, while ensuring social equity, and economic and cultural vitality.

Achieving urban flood resilience nationally requires a transformative change in planning, design and implementation of existing and new urban water systems. Flood risk, wastewater and stormwater management should be re-envisaged and transformed to: ensure satisfactory service delivery under flood, normal and drought conditions, and; enhance and extend the useful lives of ageing grey assets by supplementing them with multifunctional Blue-Green infrastructure.

The multidisciplinary Urban Flood Resilience research project, which launched in 2016 and comprises academics from nine UK institutions, has been investigating how such transformative change may be possible through a whole systems approach to urban flood and water management. Research was conducted under five work streams: resilience under change, stormwater as a resource, interoperability, citizens' interactions and resilience in practice.

This workshop will present the outputs from the project and show the potential for integrating Blue-Green and grey systems and implementing new approaches that put flood risk management at the heart of urban planning.

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| 16:00 | Close |

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## Session 3

| | | |
|---|---|---|
| 16:00 | **Keynote Speaker**<br>**Mark Lloyd, CEO The Rivers Trust** | 25 mins |
| 16:25 | Questions and reflections | 20 mins |
| 16:45 | Close | |

## EVENING SESSION

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|---|---|---|
| 18:30 | UK River Prize<br>**UK RIVER PRIZE & RIVER CHAMPIONS 2020** | 60 mins |
| 19:30 | End of Day 1 | |

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# Day 2 – Thursday 10th September 2020

## Session 4

| | Restoring resilience | Geomorphology for river restoration | Community Engagement | |
|---|---|---|---|---|
| | **CHAIR:** *TBC* | **CHAIR:** *TBC* | **CHAIR:** *TBC* | |
| 09:30 | **Revitalising Chalk Rivers, to Affinity AMP7 and beyond**<br>Jane Everett *(Five Rivers)* & David Watts *(Affinity Water Limited)* | **Will the river do the work? A practical guide for assessing River Recovery Potential to assess when passive river restoration measures can be used to allow rivers to self-heal**<br>Helen Reid *(Scottish Environment Protection Agency)* | **Engage, Engage, Engage – The key to delivering successful habitat creation**<br>Kevin Skinner, David Gasca & Marc Huband *(Atkins)* | 15 mins |
| 09:45 | **Increasing infrastructure resilience to future change by restoring natural processes**<br>Tamsin Chisnall & Sian Leake *(Arup)* | **The benefits to salmonid habitat resulting from process-based river restoration**<br>Hamish Moir *(cbec eco-engineering UK Ltd)* | **Unlocking the Severn and reconnecting Worcester with its river**<br>Jason Leach & Alex Ball *(Canal & River Trust)* | 15 mins |

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## Session 4 – continued…

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|---|---|---|---|---|
| 10:00 | **Improving resilience to low flows with integrated, nature-based solutions**<br>Nicola Nineham & Joanne Barlow *(Mott MacDonald),* Thomas Barden & Andy Banham *(Severn Trent Water)* | **Trapping estuarine sediment to restore urban estuary margins: the Estuary Edges project**<br>Richard Charman *(Environment Agency)* | **Hurdling NFM barriers in rural catchments: research and practice**<br>Jenny Broomby & Steve Rose *(JBA Consulting)* | 15 mins |
| 10:15 | **Integrating river & wetland habitat restoration into flood and major infrastructure schemes**<br>Jo Cullis (*Jacobs*) | **Live discussion with presenters** | **Live discussion with presenters** | 15 mins |
| 10:30 | **Live discussion with presenters** | **Live discussion with presenters** | **Live discussion with presenters** | 15 mins |
| 10:45 | | Coffee break | | 15 mins |

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## Session 5

| | Mitigating effects of dams & reservoirs | Citizen Science programmes | Using data to inform progress | |
|---|---|---|---|---|
| | **CHAIR:** *TBC* | **CHAIR:** *TBC* | **CHAIR:** Judy England *(Environment Agency)* | |
| 11:00 | **It's Rock 'n' Roll: Reintroducing a coarse sediment supply to drive ecological improvement downstream of an impounding reservoir**<br>Chris Tattersall *(Wessex Water)* | **How to promote citizen involvement in peri-urban river management**<br>Pere Vall-Casas *(Universitat Internacional de Catalunya)* | **Making the most of open biodiversity data for river restoration planning**<br>Martin Wilkes *(Coventry University)* | 15 mins |
| 11:15 | **Hafodty Reservoir – Dam removal and channel restoration**<br>Kevin Skinner *(Atkins)* | **FreshWater Watch (Citizen Science project)**<br>Kesella Scott-Somme *(EarthWatch)* | **The River Condition Assessment: A key component of river assessment within the Biodiversity Net Gain calculations**<br>Angela Gurnell *(Queen Mary University of London)* | 15 mins |

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**Session 5 – continued…**

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|---|---|---|---|---|
| 11:30 | **Environmental Benefits of Reservoir Discontinuance – Hurst Reservoir Case Study**<br>Helen Beeden *(United Utilities)* | **Measuring the Impact of Citizen Science (MICS) Project**<br>Hannah Joyce & John Wheatland *(River Restoration Centre)* | **Floodplain grassland restoration – a 3-year study of floodplain meadow restoration attempts in the UK – restoring resilience in floodplain agriculture**<br>Emma Rothero *(Open University Floodplain Meadows Partnership)* | 15 mins |
| 11:45 | **Live discussion with presenters** | **Live discussion with presenters** | **Live discussion with presenters** | 15 mins |
| 12:00 | **Live discussion with presenters** | **Live discussion with presenters** | **Live discussion with presenters** | 15 mins |
| 12:15 | | Lunch | | 75 mins |

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## Session 6

| | Woody dams for NFM | Evaluating urban rivers | Monitoring, evaluation & evidence | |
|---|---|---|---|---|
| | **CHAIR:** *TBC* | **CHAIR:** *TBC* | **CHAIR:** *TBC* | |
| 13:30 | **Implementing Leaky Woody Structure Guidance at a Catchment Scale**<br>Paul Millard, Emily Hale & Megan Barnes *(Mott MacDonald)* | **Assessing the impacts of urbanisation on the low order streams of Belfast Lough**<br>Andrew Moore *(Queen's University Belfast)* | **Evaluation of Aquatic Macroinvertebrate Communities Post-Weir Removal on Rivers in Cumbria, UK**<br>Ana Martinez Crucis *(AECOM)* | 15 mins |
| 13:45 | **Do Leaky Debris Dams Work? Implications for Natural Flood Management Schemes**<br>John Phillips (*Environment Agency*), Angelique McBride & Sabine McEwan (*FWAG (SouthWest))* | **Living Water Cities: Making a difference in our cities and towns**<br>Galen Fulford *(Biomatrix Water Solutions)* | **Developing an evidence base for the implementation of phosphorus and sediment agri-environment measures at the farm-scale in the Evenlode catchment, a headwater tributary of the River Thames**<br>Bethany Hancock *(Atkins)* | 15 mins |

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## Session 6 – continued…

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|---|---|---|---|---|
| 14:00 | **Live discussion with presenters** | **Rewilding 'lost' urban rivers for health and wellbeing**<br>Adam Broadhead *(Arup)* | **Mastering the monitoring: fish community responses to a low-cost passage easement at a bridge culvert**<br>Thomas Myerscough *(Wyre Rivers Trust)* & Jonathan Grey *(Wild Trout Trust)* | 15 mins |
| 14:15 | **Live discussion with presenters** | **Live discussion with presenters** | **Live discussion with presenters** | 15 mins |
| 14:30 | **Live discussion with presenters** | **Live discussion with presenters** | **Live discussion with presenters** | 15 mins |
| 14:45 | | MOVE TO GRAND FINALE! | | 15 mins |

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## Session 7

**CHAIR:** *TBC*

| | | |
|---|---|---|
| 15:00 | **Panel discussion, questions and summary**<br>Guest Panel | 40 mins |
| 15:40 | **Thanks & parting words** | 5 mins |

15:45 END OF CONFERENCE

# Day1: Wednesday 9th September

# Session 1

## BREATHING LIFE INTO SCOTLAND'S URBAN RIVERS

C. PERFECT[1], F. HAYES[1], L. STEWART[1] & D. WALLACE[1]

*1 Scottish Environment Protection Agency*

Scottish Government's Water Environment Fund is managed by the Scottish Environment Protection Agency to deliver projects which enhance the river environment as well as provide wider benefits to local communities. A key focus for the fund is on improving the health of Scotland's degraded urban rivers in a way that will help us thrive within the resources of one planet. This includes promoting projects with the potential to enhance active travel, reduce flood risk and create amenity value for communities with the aim of improving health and wellbeing in deprived areas of our towns and cities.

The presentation will introduce the key policy influences including:

- Scottish Government's Programme for Scotland which includes commitments to improving sustainability, prosperity, wellbeing and equality for communities in Scotland
- Climate Change (Scotland) Bill which sets ambitious targets for reducing Scotland's contribution to climate change by reaching net zero carbon by 2045
- Water Framework Directive which has clear objectives for improving the ecological condition of our burns and rivers
- Our regulatory strategy, reflecting the challenge of reducing the over-use of the planet's natural resources

Our focus on projects that benefit people and the environment is illustrated with examples from the Glasgow area including:

- Tollcross Burn - uncovering a buried river through Sandyhills Park in the east of Glasgow, improving ecological status, reducing flood risk and restoring a blue/green river corridor.
- Garrell Burn - restoring a meandering river on the outskirts of Kilsyth, northeast of Glasgow, improving ecological status, benefiting flood plain biodiversity and improving active travel infrastructure
- Levern Water - working with multiple partners in Barrhead, to the southwest of Glasgow, to restore the river channel improving ecological status, reducing pollution risk and repurposing vacant and derelict land to create a more pleasant place to live.

The presentation describes how we are building these projects through partnerships with local authorities, to deliver benefits beyond the banks of the river. Projects adopt the Plan of Work framework developed by the Royal Institute of British Architects (RIBA) which has been adapted to provide a robust delivery mechanism for river restoration work.

We conclude with a look to the future, considering how SEPA can help drive a net zero carbon approach to delivering river restoration. This has included exploration of procurement strategies including use of client requirements, specifications and evaluation questionnaires to promote and reward the use of more sustainable approaches to developing, designing and constructing river restoration projects.

## GETTING DELIVERY DONE: FUNDING STREAMS, UP-SCALING AND PAYMENT FOR OUTCOMES

D. BROWN[1]

*1 Environment Agency*

We are accused of working in silos, but why do we do this? Because there are advantages to this, and we focus on the things within our control, that we can influence and can deliver. It's only negative if we do not integrate. If we join up this can lead to integrated, collaborative multi-objective projects with multiple funding streams, and multiple outputs. Up-scaling – what's the most efficient way of delivering NFM? The Stroud model? Local wildlife/River trusts? Larger contractors? I'll discuss some of the findings from the Northwest's £15m NFM catchment scale fund projects about delivery efficiencies and lessons learned. Local partnership delivery and using live material in any large woody debris interventions have been important factors in delivery. Finally, the future – the Agriculture Bill, promising payment for outcomes and a chance to be selective with intervention locations, not just take available opportunities.

# Session 2: Workshops

## Workshop A – Restoring connectivity between the stream & its floodplain

### WORKING WITH NATURAL PROCESSES - A NATIONAL TRUST PERSPECTIVE

S. J. CLARKE[1]

*1 National Trust*

There is an increasing recognition of the importance of natural processes in ecosystems. In addition to the growing interest in 'rewilding', the statutory conservation agencies have been developing guidance around priority freshwater habitats focused on natural function. One of the indicators for the Defra 25 Year Environment Plan is concerned with tracking the 'natural functions of water and wetland ecosystems'.

In this presentation I will explore what this means for the National Trust, a major landowner in England, Wales and Northern Ireland, and how a philosophy of working with natural processes is shaping the range of projects we are delivering from 'Stage Zero' river restoration, reintroducing beavers to establishing naturalistic grazing regimes. I will discuss the potential benefits and consequences of such a philosophy in a densely populated landscape like much of the UK and highlight the scientific uncertainties associated with what is fast becoming the new nature conservation paradigm.

## Workshop D – Application of NFM modelling

### INTEGRATING MONITORING AND MODELLING OF NFM AT THE WHOLE CATCHMENT SCALE – EMERGING RESULTS FROM THE EDDLESTON WATER

C. J. SPRAY[1], L. COMINS[2], A. Z. BLACK[1], B. HAWKINS[3], D. GARFT[4] & R. RICHARDSON[5]

*1 University of Dundee, 2 Tweed Forum, 3 JBA Consulting, 4 Scottish Government, 5 Scottish Environment Protection Agency*

There is increasing evidence that Natural Flood Management (NFM) measures can provide flood risk reduction at small scales, alongside a range of potential ecological benefits. However, how and whether such NFM measures can be made to work effectively at larger scales is less certain, and there is a dearth of empirically-based, robust scientific studies.

The Eddleston Water project is Scottish Government's long-running empirical study designed to assess how a range of NFM measures perform within a larger scale catchment (70km2). Managed by Tweed Forum and chaired by SEPA, the project began with a Scoping Study produced by the University of Dundee in 2009. The partnership aims to assess the effectiveness and cost benefit of introducing a range of NFM measures across the catchment, and their impact on downstream flood risk and on the ecological status of the water course, whilst at the same time maintaining sustainable farming and forestry within the valley.

The study is underpinned by a detailed hydrometric network, weather stations, groundwater studies and extensive hydro-geomorphological and ecological surveys. Using a BACI design to explore the impact of re-meandering, hydro-geomorphological and ecological surveys cover sediment characteristics, aquatic macro-invertebrates, macrophytes and fish populations. Together with the wider network, this provides robust hydrometric and ecological evidence of the effectiveness of NFM measures on flood risk and habitat improvement. NFM measures so far introduced include: in Upland (Source) areas - 116 high-flow log structures to restrict flow and recreate a basin mire; 207 hectares of woodland with >330,000 native trees; 28 upstream run-off attenuation features and ponds; and in Valley/Floodplain (Pathway) areas - 1 km contour planting hedges; one floodplain pond; Re-meander 2.8 km of river, and reconnect with the floodplain

We report on the latest stage of the study, including the impact of engineered wood structures in the upper catchment on the timing and height of peak flood flows; and details of the hydro-morphological and ecological benefits of the re-meandering of previously straightened water courses.

We also report on the development of a new whole-catchment model of the Eddleston Water. This aims first to reproduce the observed performance with the emerging empirical data, and then to test the effectiveness of the deployment of a range of NFM measures across the catchment

In addition, we report early results from environmental cost-benefits studies of the utilization of NFM measures

A key element of the work will be the eventual development of suitably robust methods and modelling guidance that can be utilised by river restoration and flood risk managers across other catchments in Scotland and elsewhere.

## NATURAL FLOOD MANAGEMENT IN PRACTICE: MANGING ENVIRONMENTAL RISKS TO IMPROVE RESILIENCE

C. L. RODGERS[1] & I. A. DENNIS[2]

*1 Environment Agency, 2 Royal HaskoningDHV*

Natural flood management (NFM) is becoming widely recognised as an effective mechanism for restoring resilience to our river catchments and floodplains, allowing them to adopt to changing conditions including climate change.

However, NFM measures are not suitable in all locations and some come with their own risks to the environment (including interrupting geomorphological processes and altering sensitive habitats). Alongside this is the challenge of handling stakeholder (mis)perceptions regarding relevant sources and solutions for flooding.

Our presentation will discuss these issues and how they can be managed, drawing on Royal HaskoningDHV's recent experience of NFM projects for the Environment Agency and local authorities. We will propose a tailored approach to environmental assessment for NFM schemes that is robust and proportionate to the spatial extent and budget of these schemes.

## MODELLING BENEFITS OF NFM IN LOWLAND CATCHMENTS - RIVER HULL CASE STUDY

J. L. FOX[1], A. NICHOLSON[2] & C. SKINNER[3]

*1 Hull City Council, 2 Arup, 3 Energy & Environment Institute, University of Hull*

There has been an increase in the number of NFM case studies in upland catchments but there is still an evidence gap of NFM in lowland catchments. Much of England is characterised by lowland areas that are at an increased risk of being affected by flooding and sea level rise. Furthermore, given the recent climate change predictions, there is a greater need for us to re-evaluate existing land use management practices to help reduce the effects of climate change and work towards a more sustainable and resilient future.

This study quantifies the hydrological benefits of implementing a range of NFM measures in a lowland catchment, the River Hull catchment, in terms of reduction and attenuation of peak flows. The River Hull catchment is characterised by being located on a chalk aquifer and is predominantly lowland, pumped and heavily managed. The NFM measures modelled included leaky dams, large woody debris, contour ploughing, tree planting, wet woodland, floodplain reconnection and buffer strips. Bespoke NFM opportunity maps were created for two upper sub-catchments of the River Hull catchment, which show the potential locations of specific NFM measures based on hydrological flow patterns. The modelling and maps showed that the most effective NFM measures were leaky dams, because more water can be stored on a gradual slope behind a wide and short leaky dam structure, with around 13% peak flow reduction and 2 hour delay at the sub-catchment scale. This study also presents evidence of properties benefiting from NFM measures through modelling and flood depth mapping in line with current government flood and coastal erosion risk management appraisal guidelines.

A novel evaluation matrix has been developed through partnership working with Natural England, Environment Agency, Yorkshire Wildlife Trust and others to combine multiple benefits of NFM. The evaluation matrix allows the user to assign weighting of a number of factors, including flood risk benefits, ecosystem services benefits, costs and maintenance for assessing the most suitable NFM measure by taking into account local information, such as slope inclination and the size of NFM measures. The evaluation matrix identified that leaky dams (defined in this study as earth bunds slowing down overland flows as well as in-channel flows) are the most likely measure to reduce peak flows, and wet woodland and floodplain reconnection provide the most ecosystem services benefits. This study provides evidence that there is great potential for practical implementation to alter current land use practices to deliver multiple benefits in the River Hull catchment.

## SHARED LEARNING EXPERIENCE IN DEVELOPING APPROPRIATE MODELLING FOR NATURAL FLOOD MANAGEMENT IN FOUR CATCHMENTS IN YORKSHIRE

R. NGAI[1], S. VANICAT[2], V. COATES[1] & S. ROSE[1]

*1 JBA Consulting, 2 Environment Agency*

Two years on from the publication of the Environment Agency's (EA) Working With Natural Processes (WwNP) Evidence Base, the EA are looking to progress gathering evidence to support and fill in knowledge gaps that had been identified. In particular, the EA in Yorkshire were looking to improve

their understanding of modelling methods for WwNP or natural flood management (NFM) measures and use extensive engagement to aid and learn in the process. Four catchments of varying scales in Yorkshire were examined – Backstone Beck, Ilkley (~3km2); Gargrave, Upper Aire (~20km2); Helmsley, Rye (~215km2); and Whiston Brook, South Yorkshire (~9km2). The guiding principle of this work included learning and training for the EA staff and stakeholders in the catchments in modelling NFM measures and wider multiple benefits such as natural capital, partnership working, and engagement.

Each catchment included a site visit and three workshops which incorporated a learning session, demystifying the methodology for modelling NFM in the catchment, disseminating any results of the modelling and providing a feedback loop for key stakeholders in the catchment, such as lead local flood authorities and River Trusts. Feedback from stakeholders was pertinent to the development of the project and catchment models as they identified culverts that had not been modelled, flow paths, farming practices, and potential opportunities to deliver multiple benefits. The examination of the off-the-shelf data provided for the models exposed a number of lessons learned for the catchment, including the importance of the resolution and accuracy of Digital Terrain Model (DTM) for 2D models, learning to survey and merge together DTMs, looking beyond the river channel, and the mysteries of Victorian engineering.

The smaller scale catchments such as Backstone Beck and Whiston provided more impactful results for stakeholders. Modelling current and potential future peatland restoration at Backstone showed a possible reduction in peak flow of about 50% and a time to peak delayed by 75 minutes. Modelling different options of the Whiston Storage area (engineered structure) showed that upstream Runoff Attenuation Features (RAFs) could potentially provide an additional peak flow reduction of nearly 20% and slight delay in time to peak by 5 minutes.

The Gargrave and Helmsley modelling results provided more of a strategic understanding of these catchment, presenting more learning lessons and outcomes on prioritising sub-catchments for NFM implementation, potential to calibrate and validate model outputs, and the linkage to downstream models with high risk receptors.

Upon reflection of the project, our stakeholders have been essential to delivering the project, highlighting the importance of consistent stakeholder engagement within the project team and its partners, and the value of local knowledge, in terms of identifying constraints, issues and opportunities for NFM implementation within the catchment.

## NATURAL FLOOD MANAGEMENT (NFM): BIGGER IS NOT ALWAYS BETTER, PRIORITISATION IS KEY

C. BLEASDALE[1], E. BROWN[2] & E. LANCASTER[3]

*1 Atkins, University of Southampton, 2 Atkins, University of Nottingham, 3 Atkins, Durham University*

Natural Flood Management (NFM) is increasingly popular, yet the Environment Agency's Evidence Directory highlights the uncertainties regarding the effectiveness of NFM measures, especially at larger spatial scales. By combining the results and discussion points from three separate university dissertations, we present an overview of the benefits and disadvantages of scaling up our ambition with NFM. These focus around some key issues presented in the EA Evidence Directory:

- Where is best to implement NFM measures to ensure the optimum results, at local and catchment-wide scales?
- The optimum spatial scale at which to implement NFM measures
- Considering peak synchronisation when determining the types and number of measures required

Firstly, we will consider the importance of determining where within the catchment NFM measures are best implemented, and the catchment properties that need to be considered. We will discuss the

use of SCIMAP-Flood in the Wear catchment to identify target areas using remote sensing data, how this can be supported with ground-truthing fieldwork, and the importance of the fieldwork to consider the spatial variability in catchment properties that are not well-represented in models. Using a case study from a 3km2 Upper Wharfedale catchment in north England, we will consider the importance of soil compaction for NFM, and the need for an alternative method to quickly estimate the spatial variability of compaction at larger catchment scales. This will enable the prioritisation of the most compact areas of the catchment.

We will also discuss catchment scale hydrological modelling results to ascertain the predicted impact of NFM measure implementation on river flows, and the variability in flow changes with different types and magnitudes of NFM measure installation. Our results suggest that implementing NFM measures throughout a catchment may provide significant benefits to flood risk, when compared to the minimal impact predicted under small-scale NFM implementation. Additionally, modelling in the Ffrwd Wyllt catchment highlights the importance of location with regards to NFM implementation, as some combinations of measures had the potential to potential to cause peak flow synchronisation.

The science underpinning NFM is still in its relative infancy, leading to some large research gaps and uncertainties. These three studies demonstrate the importance of field-based ground truthing measurements to reducing the uncertainty of scaling up the ambition of executing NFM at the catchment scale. Without an appreciation of complicated processes on the ground, catchment scaled hydraulic models could potentially incorporate erroneous simplifications and uncertainties that misinform the predicted impacts of NFM and thus hamper the effectiveness of incorporation NFM to the larger scale.

## PRIORITISING NATURAL FLOOD MANAGEMENT OPPORTUNITIES FOR THE THAMES REGIONAL FLOOD AND COSTAL COMMITTEE

G. HAUGHTON[1] & A. DINSDALE-YOUNG[1]

*1 Environment Agency*

The EA has used ArcGIS to correlate soil types, topographic attributes, areas of flood risk, and river networks. This has then identified opportunities for woodland planting, riparian buffer strips, earth bunds, retention ponds, floodplain reconnection, and gully blocking.

These opportunities are then used to prioritise water bodies by their ability to provide protection for homes at risk of flooding. Water bodies are linked so that areas at risk of flooding without the space for NFM can utilise upstream water bodies' NFM opportunities. The prioritisation also takes account of different NFM schemes effectiveness for reducing either surface water flooding or fluvial flooding, as well as the multiple benefits provided by NFM.

This research funded by the Thames Regional Flood and Coastal Community results in an online map available to Lead Local Flood Authorities that highlights what water bodies could provide the greatest benefit to homes at risk if the suggested NFM opportunities were developed.

## Workshop E – Landowner engagement & communication

### FAR FROM THE WATER'S EDGE: A NEW FOCUS FOR NEAR NATURAL RIVERS?

J. OLD[1], L.WELLER[1] & G. MAAS[1]

*1 Environment Agency*

Our rural landscapes will play a crucial role in achieving our ambitions of `near natural` waters. We continue our story from last year – `letting rivers do the work` - and outline current and future opportunities for nature-based restoration within our rural communities, farms and woodlands. Every kilometre of river drains on average 50 hectares of adjacent land - 70% of this land is classed as rural. Actions here can offer additional ecosystem services: not only for the local rural communities and their businesses, but also for neighbours in villages, towns and other urban areas.

We`ll focus our attention on:

- Our emerging aspiration for river restoration in our rural environments – letting rivers do the work.
- Integrating actions and land management activities in rural environments – thinking big but perhaps….doing less?
- Rural policy and planning needs – an emerging picture and opportunities for the future.

We'll bring these core themes to life though case studies and first hand experiences of working with our rural land managers, catchment partnerships and communities.

### RESTORING THE UPPER WENSUM: KICK STARTING NATURAL PROCESSES

S. KNIGHTS[1] & I. P. MORRISSEY

*1 Five Rivers Environmental Contracting Ltd*

The Upper Wensum Restoration Project formed part of the wider River Wensum Restoration Strategy (RWRS) which aimed to restore the hydromorphology and ecology of the river through physical habitat restoration within the sections of river which had been designated as a SSSI and SAC. The objectives were to improve the ecological condition of the river to 'favourable' condition and to restore the river to Good Ecological Potential under the WFD. Restoration measures were selected and applied on a reach-by-reach basis to address specific constraints identified as currently acting to limit the river's ecology, form and function.

Initially the landowner had no concept of river restoration; Atkins invested a lot of time during the design stage to gain the trust of the landowner, which involved stakeholder engagement, topographic and ecological surveys, and flood modelling. There were potential implications on land use and the Raynham Estate, therefore the design needed to ensure that arterial drainage and flood risk was not compromised.

Although we worked rigidly within strict design parameters (Adhering to rigid design elements with regards to the floodplain reconnection aided stewardship), the flexibility built into the design enabled a modular approach, which was applied by Five Rivers during construction working with Atkins in the field. Applying a flexible and pragmatic approach meant that Five Rivers could apply their 25 years of practical knowledge and experience of river restoration to benefit biodiversity value. This included moving features where necessary and adding features which were not in the original design such as, backwaters.

As we moved through the phases of the project, we built a relationship with the landowner and the client that was critical for its success. At Phase 1 we were using a 'light touch' approach such as, daylighting and installing woody debris. On Phase 2, we were slightly more ambitious, adding berms

and scalloping banks. And by Phase 3 we bed raising, reinstating the historical river channels and lowering embankments to reconnect the floodplain. Five Rivers reduced disturbance to the adjoining habitat by undertaking all works consecutively from upstream to downstream rather than splitting elements out.

Atkins and Natural England worked hard to secure stewardship agreements for the landowner alongside the restoration scheme and further improve wider biodiversity in the catchment, which came as a direct result of the restoration works.

The success of the project would not have been possible without the combination of a high-quality design, a flexible approach to delivery in the field and good relationships with the client, landowner and land managers.

These relationships contributed to a natural evolution of restoration techniques through the timeline of the project. As the project evolved, the restoration became bolder and more ambitious delivering a project that was more successful than initially anticipated.

## SLOWING THE FLOW IN DORSET STREAMS; WORKING TOGETHER FOR POOLE HARBOUR

A. MAXWELL[1], F. J. BOWLES[2], A. BROOM[3] & N. HOPKINS[4]

*1 Environment Agency, 2 Poole Harbour Catchment Initiative, 3 Dorset Wildlife Trust, 4 FWAG SW*

The Poole Harbour Catchment initiative was one of the first partnerships piloted to help deliver water framework directive goals in 2011.The catchment is heavily designated and the initial action plan prioritised problems with excess sediment, nitrogen and phosphate. The nutrient management strategy that was developed in 2013 was subject to a Judicial Review Order which confirmed that in addition to nitrate reductions in this ground water catchment, reductions in Phosphate was needed and potentially an additional 250Ha of wetland.

Partners also identified flood risk issues as well. This paper reviews the evolution of natural flood management through the review of 5 projects delivered within the Poole Harbour Catchment and Dorset; The Hooke and Win (tributaries of the Dorset Frome), the River Piddle and the Asker (a tributary of the River Brit). Natural flood management was incorporated into these projects to deliver flow improvements but increasingly the multiple benefits for reducing nutrient and sediment input and transfer was targeted. The presentation reviews the range of measures that have been implemented, on sources, pathways and within the river channels.

It looks at how the initial work on the river Hooke has expanded to multi-partnered projects for the Lead Local Flood Authority to resolve rural flooding and finally to a community project facilitated by the AONB. The presentation reflects on how best to ensure landowner commitment to NFM measures and looks at future delivery mechanisms including reverse auctions.

## Session 3: Keynote

# Session 4: Parallel Sessions

## Restoring resilience

### REVITALISING CHALK RIVERS, TO AFFINITY AMP7 AND BEYOND

J. E. EVERETT[1] & D. WATTS[2]

*1 Five Rivers, 2 Affinity Water Limited*

Affinity Water is the largest water-only supply company in the UK. We provide on average 900 million litres of water each day to a population of more than 3.6 million people.

The communities we work within are at the heart of what we do, and along with supplying high quality drinking water we are committed to ensuring our activities' impacts on the environment are minimised and that they promote sustainability and enhance the ecology wherever possible. We know that a large proportion of our customer base are passionate about the environment and their local rivers, this is a passion that we share as an organisation.

Our ongoing commitment to the environment includes encouraging biodiversity on our 600+ landholdings, working with farmers to reduce pesticide use and promote sustainable farming methods, reducing the amount of water we abstract from groundwater sources and undertaking river restoration schemes across our supply areas.

Since 2015, Affinity Water has worked closely with landowners, stakeholder groups and our regulators to improve flows, hydromorphology and habitats in revitalising six chalk rivers in our supply area to meet good ecological potential/status under the EU Water Framework Directive.

We have completed 12 restoration projects, reduced abstraction by 42Ml/d leaving more water in the environment, installed 274,363 water meters since April 2015, provided free water efficiency devices and learnt many lessons along the way including:

- Engaging early with local planning teams, some approving works as permitted development while others require full planning permission
- Consequences of Landowner apathy, changing their minds and/or refusing works on their land causing delays and increased costs to project
- Length of time required to be factored in to obtain the approvals for works, i.e. street works, Environmental Permits and access agreements
- The challenges of working in Partnership, this is easier said than done. Unless all Government bodies and local authorities have a common regulatory goal i.e. working towards improving the environment and WFD Status, then stakeholder priorities understandably lie elsewhere
- Education of the water cycle linking our customer taps to their local rivers and their Per Capita Consumption

In AMP7 we are scaling up our Revitalising Chalk Rivers programme greatly, as we aim to deliver a whopping 56 projects across 13 rivers and reduce abstraction by a further 33Ml/d! Our vision, to work holistically within each catchment engaging with farmers, regulators, stakeholders, landowners and local communities, bringing everyone along on the journey with a shared vision and goal.

To realise this ambitious programme of works Affinity will hold workshops with the EA and Local Authorities to emphasise the importance of working collaboratively and with flexibility. We all need to be more pro-active, with complete stakeholder buy in and a willingness to work together for the benefit of the environment.

## INCREASING INFRASTRUCTURE RESILIENCE TO FUTURE CHANGE BY RESTORING NATURAL PROCESSES

T. J. STYLES[1], R. THOMAS[1], O. STANDAVID[1] & T. CHISNALL[1]

*1 Arup*

Climate resilience is the ability of the socio-ecological system to absorb stresses and maintain function in the face of external strain imposed upon it by climate change whilst improving sustainability of the socio-ecological system. A growing number of communities are experiencing climate change impacts, including flooding and water scarcity and additional funding is needed to increase the resilience of essential infrastructure so that such impacts can be mitigated. With many traditional environmentally-focused budgets having suffered cuts and over demand from multiple directions, the role of other asset owners (highways authorities, water companies) in mitigating impacts both directly and indirectly, is becoming an increasingly essential part of river and floodplain resilience.

We present case studies and lessons learnt from our work across the infrastructure sector where re-introducing natural processes is increasing resilience to the predicted effects of climate change. Arup is working with highways authorities, water companies and other asset owners to ensure that their assets are working with, rather than against, natural processes to increase climate resilience. We will discuss how the restoration of natural processes, using techniques typically defined as Natural Flood Management, aim to benefit flood risk, water quality and habitat restoration at a catchment scale.

## IMPROVING RESILIENCE TO LOW FLOWS WITH INTEGRATED, NATURE-BASED SOLUTIONS

N. NINEHAM[1], J. BARLOW[1] & T. BARDEN[2]

*1 Mott MacDonald, 2 Severn Trent Water Ltd*

Flow in the Cinderford Brook, Gloucestershire, is impacted by Severn Trent Water's groundwater abstraction, the impact of which is compounded by a legacy of mining in the area and past interventions to prevent stream leakage. The discharge from Crumpmeadow STW provides a significant proportion of flow in the brook, but also results in water quality concerns. Mott MacDonald, with the support of Wildfowl and Wetlands Trust and Five Rivers Environmental Contracting, have been commissioned to establish the feasibility of using nature-based solutions, including river restoration, wetlands, NFM techniques and habitat enhancement, to meet Severn Trent Water's flow obligations under the AMP7 WINEP. This project, aligned with the wider 'Wild Towns' project led by Gloucestershire Wildlife Trust (GWT), is an exciting opportunity to consider the application of integrated nature-based and catchment-orientated solutions and address water resource drivers with secondary water quality benefits.

The aim of this project is to assess the feasibility of, then carry out outline and detailed design for wetlands and river restoration to mitigate low flows in Cinderford Brook. Alongside this, opportunities for wider habitat enhancement and water quality improvement are considered. Stakeholder engagement is a key component of the project, and stakeholders are involved throughout the design process to capture local knowledge and ensure buy-in of the scheme.

Initially, key opportunities and constraints for work in the study area are identified, based on a review of available information and a site walkover with local stakeholders, including the Environment Agency and GWT. The feasibility of river restoration, wetlands and other solutions is assessed, and initial concepts for these solutions developed, capturing stakeholder feedback, concerns, aspirations and expectations in a workshop. For wetlands, detailed studies including hydraulic and water quality modelling are used to determine the feasibility of a range of wetland features. For river restoration,

the feasibility assessment integrates geomorphology, hydrology, ecology and engineering/construction feasibility for a hydromorphologically-led design. Based on the outcomes of the feasibility assessment, the options will progress to outline concept design, then to detailed design. Throughout design development, interactions across the whole catchment are considered, aligning river restoration and wetland schemes, rather than considering them as independent interventions, and wider benefits to the catchment are captured in assessment of ecosystem services.

This project applies nature-based solutions to deliver environmental improvements, achieving Severn Trent Water's low flow WINEP obligations, whilst also bringing water quality improvements and additional benefits, such as wider environmental gains through biodiversity enhancement, and social benefits through the creation of recreational space and community engagement.

## Geomorphology for river restoration

### WILL THE RIVER DO THE WORK? A PRACTICAL GUIDE FOR ASSESSING RIVER RECOVERY POTENTIAL TO ASSESS WHEN PASSIVE RIVER RESTORATION MEASURES CAN BE USED TO ALLOW RIVERS TO SELF-HEAL

H. E. REID[1]

*1 Scottish Environment Protection Agency*

Many rivers within Scotland are failing Water Framework Directive (WFD) objectives due to morphological pressures, which have oversimplified and degraded habitat. Significant river restoration has been carried out to remedy this, often based on intensive techniques that actively design and construct new channels. While this delivers the desired results, such an intensive approach to restoration is expensive, making it unfeasible to use on all the degraded rivers across Scotland.

To remedy this, a framework was created which uses geomorphic principles to identify where more passive approaches to restoration - which encourage the river to adjust and self-heal – can be applied. The tool was designed to be used by non-specialist river managers (i.e. restoration specialists, rivers trusts, RBMP), and provides guidance on how to accurately assess geomorphic variables to predict recovery potential. This identifies where recovery can occur within reasonable timescales, and therefore the degree of intervention needed to achieve objectives. Ultimately, rivers with higher energy and sediment loads can adjust and therefore recover quicker than lower energy systems. In these more active systems, passive approaches can be successfully applied including techniques such as removing bank protection and installing wood and to kick-start erosion and recovery (e.g. Assisted Natural Recovery (ANR)).

This framework can be divided into 3 steps;

1. Recovery potential is assessed based on the energy and sediment load characteristics of a reach. This involves assessing geomorphic variables including valley setting, river type, bed material, bar frequency, bank material sedimentology, bank erosion distribution and geomorphic-flow units. Field sheets and an assessment framework are provided to standardise recording and results. This determines whether the river has a High, Moderate or Low potential to recover.
2. Recovery tables have been created which predict the time it takes for a river to reach good condition based on i) the recovery potential, ii) the type of pressures on the system (i.e. straightening or embankments) and iii) the restoration approach (active, ANR or passive). This allows restoration approaches to be selected based on what length of time is acceptable for recovery.
3. Finally, the document describes active, ANR and passive approaches to restoration including case studies of existing restoration schemes assessed based on their recovery potential.

This framework provides a process-based, geomorphic approach to identify where less intensive, cheaper river restoration approaches can be applied. In lower energy or complex scenarios, more intensive restoration will still be necessary. However, in areas where energy is high, constraints are fewer and longer timescales of recovery are appropriate, less intensive and lower cost passive approaches can be used to maximise the lengths of river able to be restored.

## THE BENEFITS TO SALMONID HABITAT RESULTING FROM PROCESS-BASED RIVER RESTORATION

H. MOIR[1] & E. GILLIES[1]

*1 cbec eco-engineering UK Ltd*

Process-based restoration aims to reinstate the natural physical functioning within river environments impacted as a result of historical human interventions (e.g. engineering, land-use change, flow management etc). Such an 'assisted recovery' approach removes/ reduces constraints to natural geomorphic process, providing a more sustainable and diverse physical environment. However, it is often implicitly assumed that habitat availability and utilisation by instream species will respond positively to such interventions, without subsequent validation. We present a case study from an implemented project that involved the realignment of a previous canalised section of channel, embankment removal, implementation of Large Wood Structure (LWS), gravel augmentation and wetland enhancement. Detailed per- and post-implementation monitoring allowed for the development of habitat availability models based on hydraulic and sedimentary preferences of spawning and juvenile salmonids. These models are presented for pre- and post-restoration conditions and validated by field evidence of utilisation by salmonids (spawning and juveniles). Results demonstrated significant increases in spawning habitat availability post-restoration, closely associated with enhanced physical diversity. Increased physical diversity was shown to be greatest in the realigned section of channel proximal to implemented LWS (i.e. 'bar apex' type structures on alternate banks). Observed spawning utilisation was closely associated with predicted 'high quality' habitat. Furthermore, the availability of juvenile habitat (fry and parr) was also shown to markedly increase, most significantly in 'online' wetland areas that were reconnected as part of the restoration scheme.

## SALTY LEDGES: TRAPPING ESTUARINE SEDIMENT TO RESTORE URBAN ESTUARY MARGINS: THE ESTUARY EDGES PROJECT

R. CHARMAN[1]

*1 Environment Agency*

Working with an urban estuary's geomorphology is critical to it's restoration, as has been looked at in 17 cases studies in the Tidal Thames through London where the creation of fringing mudflat, reedbed or saltmarsh habitats has resulted in a lot of learning. Varying from creeks in small managed realignments where the use of timber brushwood has been used to help accrete sediment to narrow timber ledges bolted onto walls with or without a retaining element, almost all depend on low currents and low wave energy to accrete cohesive sediment. However, additional factors such the slope of the manufactured ledge and the degree of drainage beneath have also been found to have a significant effect on both retaining and accreting sediment and thus if a feature at the right elevation to vegetated actually does so. The angle of a feature to wave energy also make a significant different to how much litter gets washed in. In most scenarios it is possible to aid the conditions to accrete sediment but in scenarios where it is not, a cobble or gravel foreshore still has biodiversity benefits. The findings of this work are on a new web site www.estuaryedges.co.uk designed to encourage developers to create such features.

## Community Engagement

# ENGAGE, ENGAGE, ENGAGE - THE KEY TO DELIVERING SUCCESSFUL HABITAT CREATION

K. SKINNER[1], D. GASCA[1], M. HUBAND[1], I. MORRISEY[1], S. GREEN[1] & D. LAWRENCE[1]

*1 Atkins*

Successful habitat creation requires many different things coming together at one time. How a scheme develops from original concept through to options appraisal and design will determine how smoothly it passes through environmental permitting and how much of the original project ambition is realised on the ground. This presentation illustrates a variety of approaches that can be used to support the development of habitat creation designs whether this be schemes on river restoration, wetlands or Natural Flood Management. Illustrated approaches use examples from a range of case studies at different stages of a project process.

Examples of different techniques will show masterplans, digital photomontages/virtual reality, storybooks and standard design details. Masterplans are most suited to medium or large-scale projects. They are a powerful vehicle for visualising how works may change a landscape and provide a platform from which optioneering can be taken forward. Masterplans not only show the location of habitat creation features but also how these fit with wider recreational, amenity and landscape features to create truly integrated green infrastructure. Digital photomontages are often most useful when presenting an individual scheme or measure. Aerial imagery or stylised graphics laid over digital designs create a photo-realistic scene that can be used at stakeholder events to provide an immediate and realistic impression of how a scheme will look once complete. A storybook uses clear graphics and minimal text to guide the reader through the evolution of a scheme from concept to design and implementation. They can be used to detail baseline information and chart key decisions. A good story book will be interesting, engaging and help stakeholders readily understand the scheme and the logic of the critical decisions that governed its outcome. Visual standard design details are an effective and efficient way of presenting the detail of habitat features. They are particularly powerful when they include an evidence base to demonstrate the success of such techniques. This evidence base needs to be reinforced through monitoring of scheme performance to inform future design and improve knowledge of technique application. Sound evidence of success engenders confidence within the client and stakeholder communities who commission, fund and support habitat creation projects.

All these approaches detailed in this abstract can be used to engage people into any habitat design process and help them understand how a project may look once the scheme is delivered on the ground. They equally enable key constraints and opportunities to be identified and talked through with stakeholders. Increasing evidence base for a variety of habitat creation techniques provides improved confidence in the various approaches. In conclusion, engagement is an essential part of any design process and there are now a variety of different techniques to aid its delivery.

# UNLOCKING THE SEVERN AND RECONNECTING WORCESTER WITH ITS RIVER

J. LEACH[1], A. BALL[1] & H. PASQUET[1]

*1 Canal & River Trust*

A three year collaborative partnership between; the Severn Rivers Trust, the Canal & River Trust, the Environment Agency and Natural England has led to the development of, Unlocking the Severn, a project to reopen the UK's longest river, the River Severn. The project has secured almost £20 million of funding – £10.8 million from the National Lottery Heritage Fund and £6 million from the European Union LIFE programme. The removal of weirs and installation of four state-of-the-art fish passes on

the River Severn and its major tributary, the River Teme, mark this as the largest project of its kind in Europe.

Over the next two years this project aims to;

1. Bring back the shad – this important rare fish will reach its former freshwater habitats and all fish will have improved access to the upper reaches of the River Severn
2. Encourage more people and a wider range of people to care about, visit and enjoy "Our Severn", making it a vibrant and exciting place to be
3. Deepen people's connections with the River Severn through uniquely engaging learning opportunities and improved well-being
4. Bring the huge potential of volunteers at the heart of heritage and science; so that we can discover, share and celebrate the stories of the River Severn, and create an amazing legacy for the future

The project predominately focuses on providing passage for the once abundant and now threatened twaite shad (Alosa fallax) but will also benefit other critically declining species such as sea lamprey, salmon and the European eel.

Along with the UK's first 'Shad Fest', England's only fish viewing gallery at Diglis Weir in Worcester, World Fish Migration Day events and hosting a project conference, a major citizen science program will also get people involved in the preservation of this lesser-known UK fish. In reconnecting people with the river, the project will raise awareness of the value of UK rivers, not only for enhancing biodiversity, tourism and fishing, but ensuring the River Severn system is protected for future generations to enjoy as part of our natural and historic heritage.

The Programme Director and Community Engagement Manager will present current thinking on how Unlocking the Severn will gain maximum positive impact in the towns and cities within the project area. They will use Worcester as an example; the city where the major part of the capital works is being delivered. They will consider how the fish pass viewing gallery will bring opportunities for city residents and visitors to come close to fish in their river environment. The team is working with an evaluation consultant on ways to assess the impact on communities, plus they are working with university researchers to look at how young people change their perception of global environmental issues through engagement with major restoration projects. The presentation will also give an overview of the engagement activity at a range of hubs in other key towns in the catchment.

## HURDLING NFM BARRIERS IN RURAL CATCHMENTS: RESEARCH AND PRACTICE

R. NGAI[1], J. BROOMBY[1], K. CHORLTON[1], S. ROSE[1], S. MASLEN[1] & C. BURMAN[2]

*1 JBA Consulting, 2 Schofield Sweeney*

Natural flood management (NFM) often involves installing multiple distributed measures and features on privately owned land and therefore involves working with a variety of stakeholders on the ground to generate realistic solutions and offer multiple benefits. This complex process has consequently exposed various barriers to date which have prevented NFM from being adopted more widely. The barriers are not unique to NFM and are typical of many desirable river and catchment restoration activities.

Over the past year, JBA Consulting has been working closely with Defra to investigate these barriers as well as the enablers of the delivery of NFM. Using a comprehensive research methodology including in-depth stakeholder interviews, farm focus groups, a legal analysis, funding case study reporting and a deep-dive analysis of large landowners, we have gathered valuable information from key stakeholders to better understand cultural, institutional and social barriers to NFM. A wide range of

stakeholders participated in the project including NGOs, landowners, farmers and land managers, government and regulatory organisations, local communities, funders, land agents and representative organisations. The findings of the report are based on stakeholder dialogue and an examination of available literature (academic and grey). Now published, it is hoped the research and its recommendations from stakeholders will be used to shape future policy, including agriculture and land management, and inform approaches taken by organisations wishing to deliver NFM. We will discuss the research findings, in particular, we will look at the legal issues of NFM and land ownership, the relationship between NFM and agriculture and how approaches can be shaped to encourage cooperation and longevity in a scheme.

JBA has taken the opportunity to put the learnings from this research into practice through their work with two large country estates in North Yorkshire: Harewood House and the Broughton Hall Estate. Both are seeking to explore NFM opportunities on their land to bring about multiple benefits, including river restoration, biodiversity enhancement, water quality improvement and the provision of better recreational opportunities. The two estates are home to tenant farmers and lease land to businesses, though differing in size significantly. We will discuss our approach and experiences to date working with these two estates, exploring further the barriers and enablers to delivering NFM and wider catchment management, specifically in the context of large country estates.

# Session 5: Parallel Sessions

## Mitigating effects of dams & reservoirs

### IT'S ROCK 'N' ROLL: REINTRODUCING A COARSE SEDIMENT SUPPLY TO DRIVE ECOLOGICAL IMPROVEMENT DOWNSTREAM OF AN IMPOUNDING RESERVOIR

C. TATTERSALL[1], A. HOUSE[1], P. DOWNS[2], D. GILVEAR[2], J. PHILLIPS[3] & M. HEALEY[4]

*1 Wessex Water, 2 University of Plymouth, 3 Environment Agency, 4 Westcountry Rivers Trust*

Under the EU Water Framework Directive, Sutton Bingham reservoir and its downstream watercourse are designated as Heavily Modified Water Bodies required to meet 'good ecological potential' (GEP). GEP is achieved through the implementation of mitigation measures that address ecological pressures caused by the designated 'Use' – in this case 'Public Water Supply'. This eutrophic reservoir acts as a barrier to the downstream movement of coarse sediment and macroinvertebrate indices indicate a significant impact of the impoundment on flow, morphology and water quality in the downstream water body. The macroinvertebrate biomass immediately downstream of the reservoir is higher than at upstream and downstream monitoring sites and dominated by detritivores and predators; an imbalance that appears to be linked to the rapid settlement of phytoplankton present in the compensation flow that feeds the downstream watercourse. Erosion of finer gravels from the channel has degraded the ecological potential of the bed exposing bedrock clays and creating a heavily armoured surface. In consequence, an Adaptive Management approach to the reintroduction of a gravel substrate was identified as a mitigation measure and is being trialled between 2017 and 2020.

In September 2017, 50 tonnes of gravel were introduced at three sites to replace substrate eroded and not replenished since reservoir construction, with the aim of improving macroinvertebrate habitat and geomorphological function in the water body. Gravel movement was monitored using Radio Frequency Identification (RFID) tags, seismic impact plates, visual fluvial audit and time lapse cameras to ascertain sediment transport following significant flow events. Flow was recorded in the reach where the majority of gravel was introduced. Bimonthly Surber samples were collected through summer 2018 to monitor the colonisation of the new material by the invertebrate community. This will be compared to the community present before the gravel introduction and to the community in an adjacent 'control' stream.

Analysis following the first winter season indicated some local redistribution of augmented material but no larger reach scale mobilisation. Dispersal was limited to (artificially) narrow channel sections with locally high shear stresses or to locally steep reaches with low roughness where movement of up to ≈10 metres has been observed. In other locations, dispersal was <2 m, due to relatively low winter spills from the reservoir being insufficient to mobilise the size of material introduced. The findings were used to adapt the approach in autumn 2018, with a further 36 tonnes of finer material introduced and monitored in the same way.

Findings from the trial will be presented, which inform whether Adaptive Management can be used to drive improvements in the WFD status of water bodies downstream of impounding reservoirs.

### HAFODTY RESERVOIR - DAM REMOVAL AND CHANNEL RESTORATION

K. SKINNER[1], I. MORRISSEY[1] & N. LOWDEN[1]

*1 Atkins*

Hafodty Reservoir, near Corris Uchaf, Gwynedd, was a former on-line water storage reservoir managed by Welsh Water. The dam itself was no longer required, or deemed necessary, as a water

resource and would have required significant investment to bring up to current safety standards for reservoirs. The best and only option was that of "naturalisation" and so the dam was removed, and the narrow valley restored to a more natural state. This included the restoration of the headwaters of the Nant Hafodty, a tributary of the Afon Dulas.

Initial assessments of the site included a Water Framework Directive (WFD) assessment, ecological constraints and opportunities assessment and geomorphological investigation. These studies were used to assess the implications of the removal on the surrounding water body and gather valuable baseline information from which to base the new channel design once decommissioning had been undertaken.

To originally form the reservoir the channel was dammed. This led to the establishment of a 65m long reservoir. The dam face was around 50m wide and 7m high. The decommissioning of Hafodty Reservoir necessitated the design and construction of a new reach of the watercourse. It was not possible to undertake restoration design in advance of the de-watering and de-silting of the reservoir basin. As a result, a pragmatic approach to the design and construction was undertaken. It was agreed that an on-site geomorphologist would be present to support the appointed contractor in re-establishing the channel. This method was approved by the regulator, Natural Resources Wales.

The geomorphological survey undertaken prior to the works revealed that the existing channel had typical step-pool sequences, a general width of around 1-2m and waterfalls in places. Sediment movement through the system was prevalent, with sediment being of a range of sizes but was typically cobble/boulder and platy in nature reflecting the underlying slate geology.

A design philosophy was developed to re-establish the channel following dam removal. This included the following:

- Use the existing uncovered profile as a basis for the new channel alignment location;
- Work with the natural form to develop the longitudinal profile of the new channel;
- Use large pieces of slate, excavated from the dam face, to form a series of step-pools;
- Raise the slate on either side of the step to try and prevent outflanking;
- Use the natural gradient to determine the spacing of the step-pools and runs;
- Create a pool upstream of each step;
- Develop diversity within the system by creating some run features, particularly in the less steep areas, as well as pools; and,
- Make use of any natural bedrock outcrops and the old dam base to form steps in the new channel.

The construction took place in the Summer and Autumn of 2018. Upon completion of the works the channel was functioning as a natural, upland watercourse exhibiting all the types of features that would be expected.

## Citizen Science programmes

### HOW TO PROMOTE CITIZEN INVOLVEMENT IN PERI-URBAN RIVER MANAGEMENT

P. VALL-CASAS[1], M. BENAGES-ALBERT[1], X. GARCIA[2], A. RIBAS[2], A. CÚELLAR[1] & D. PAVON[2]

*1 Universitat Internacional de Catalunya, 2 Universitat de Girona*

There is a gap between the increasing social use of urban rivers and limited citizen participation in river management under the EU Water Framework Directive (WFD). A pilot participatory process aimed at promoting the active involvement of the general public in the management of an urban

stream in the Barcelona Metropolitan Region was designed and tested. The participatory process was supported by web-based Public Participation Geographic Information Systems and face-to-face workshops. The opinions of the general public were collected and citizen decision-making and self-organization were promoted. Reflection on the pilot allowed to compare and contrast the bottom-up participation model with the top-down WFD model.

TOP-DOWN PARTICIPATION MODEL. Main objective: Consensus achievement among influential actors

1. Approach
   - River concept: river as ecological system
   - River diagnosis: based on expert knowledge cyclically collected
2. Participants
   - Key actors: influential actors
   - Recruitment: deductive (based on influential actors' map)
3. Methodology
   - Grouping: specialized groups
   - ICTs role: to enhance transparency in decision-making
4. Scale
   - Participation unit: regional unit based on ecological and managerial vision
   - Communication: through institutional websites

BOTTOM-UP PARTICIPATION MODEL. Main objective: Active citizen involvement through empowerment

1. Approach
   - River concept: river as socio-ecological system
   - River diagnosis: based on citizen knowledge collected at daily basis
2. Participants
   - Key actors: local volunteers
   - Recruitment: inductive (led by local volunteers)
3. Methodology
   - Grouping: transversal groups
   - ICTs role: to enhance transparency in decision-making and to create a pool of citizen knowledge
4. Scale
   - Participation unit: local unit based on ecological and social vision
   - Communication: through local media and social networks

The pilot was particularly optimal for promoting self-organization of local volunteers unconnected to WFD planning cycles. The assessment of the pilot results provided key learning points that support the creation of catchment volunteering groups to protect urban rivers: 1) setting participation in the context of a socio-ecological understanding of the river, attentive to general public perceptions and expectations; 2) involving local volunteers in leadership and dissemination of the participatory processes; 3) supporting participants' learning and networking by combining citizen diagnosis of the river status based on ICTs and face-to-face workshops; and 4) connecting municipal-scale and basin-scale environmental interests and institutions by means of intermediate catchment volunteering groups. These learning points offer a baseline for a bottom-up participation model aimed at empowering riparian communities. This model may complement the current top-down WFD participation model and make river management more multi-level and multi-actor.

## FRESHWATER WATCH (CITIZEN SCIENCE PROJECT)

K. SCOTT-SOMME[1], L. CECCARONI[1], S. PARKINSON, I. BISHOP & S. LOISELLE

*1 EarthWatch*

FreshWater Watch is a methodology for citizen science water quality testing which has been used globally for over 8 years and has collected over 23,000 data points. Freshwater watch uses simple tests for Nitrate (NO3-N) and Phosphate (PO4-P) combined with environmental observations to get a snapshot of water quality. The methodology is simple, replicable and scientifically robust, and has been used by small scale community groups, as well as large scale projects, to answer specific questions. This methodology is currently being used by some large-scale EU projects, including Ground Truth 2.0 and MICS.

For Ground Truth 2.0, FreshWater Watch has been used as part of the Swedish case study, to look at water quality management in socio-ecological systems in the Mälarendalen region. The aim of this project was to identify the key challenges in addressing water quality deterioration. From a governance level, the key challenges were found to be that existing data on water quality in Sweden are dispersed, and environmental monitoring by citizens is disconnected from decision-making. We will further discuss lessons learnt and results from GroundTruth 2.0, and how these lessons will then be applied to river restoration projects being run through MICS.

MICS is another large-scale EU funded project, which has created four citizen science projects to monitor the success of nature-based solutions in Hungary (creek Rakos), Romania (Carasuhat wetland), Italy (Marxenego river), and the UK (site tbc). This will be developed as a co-design process at the various sites, and FreshWater Watch will be used to monitor water quality where desired.

The aim of FreshWater Watch is to allow citizens more of a role in monitoring water quality, allowing communities to be stewards of their own environments. FreshWater Watch has huge potential to be used by communities to monitor the effectiveness of river restoration, to allow best practice to be scientifically backed up and to provide evidence for communities to defend and implement projects.

# Using data to inform progress

## MAKING THE MOST OF OPEN BIODIVERSITY DATA FOR RIVER RESTORATION PLANNING

M. WILKES[1]

*1 Coventry University*

In recent years, environmental, ecological and genetic data have been increasingly shared in global repositories. There are now >1 billion species' occurrence points recorded in the Global Biodiversity Information Facility (GBIF), and >1.7 million sequences publicly available in the Barcode of Life Database (BOLD). The Open Tree of Life (OTL) contains >2.6 million tips in its synthetic phylogenetic tree. High-resolution climate (e.g. WorldClim) and other environmental data are openly available and readily integrated into large-scale statistical models. This opens up new opportunities for ecological applications at large scales that, until now, have not been fully seized.

By combining openly available environmental data and species' occurrence, trait and genetic records with computational modelling, a new analytical framework for quantifying biodiversity-environment relationships at large (river basin) scales is introduced. Its application is demonstrated with a case study on freshwater macroinvertebrates, a model group in basic and applied freshwater ecology.

Subsequently, the present capabilities and future directions in applied ecology using open biodiversity data are discussed, with a focus on applications to river restoration planning.

## THE RIVER CONDITION ASSESSMENT: A KEY COMPONENT OF RIVER ASSESSMENT WITHIN THE BIODIVERSITY NET GAIN CALCULATIONS

A. GURNELL[1], S. SCOTT[2], L. SHUKER[3], J. ENGLAND[2], R. JEFFRIES[2] & D. GURNELL[4]

*1 Queen Mary University of London, 2 Environment Agency, 3 Cartographer/Thames21, 4 Cartographer*

River Condition assessment is a key element of the Rivers and Streams Component of BioDiversity Net Gain calculations (http://publications.naturalengland.org.uk/publication/5850908674228224).

River Condition assessment involves two stages: (1) data collection; and (2) data entry and analysis in an online River Condition Assessment Information System, which produces outputs for use in the biodiversity net gain calculations.

Data collection is at two spatial scales: at a larger contextual scale of a geomorphologically homogenous reach in which a proposed development sits (up to 10km long); and at a smaller sub-reach scale where field data is collected.

For the larger contextual reach, a desk study is used to quantify the river and valley gradient, river planform and valley confinement.

At a smaller scale, field observations on physical habitat are collected within subreaches that are scaled to the river width; such observations cumulatively cover at least 20% of the total river length within the area of the proposed development. Observations are made of the physical habitat in the river channel and its margins up to 10m from each bank top.

Data from the desk study and field surveys are entered into an online River Condition assessment information system. The system uses an empirically-tested decision tree to predict an Indicative River Type for the larger contextual reach. Field data are used to calculate Condition Scores for each subreach by comparing expected attributes for the river type with field observations.

The River Condition assessment information system outputs a Condition Score of 5-Good, 4-Fairly Good, 3-Moderate, 2-Fairly Poor, or 1-Poor. The information system also allows scenario modelling of the likely consequences of management and restoration actions on the Condition Score.

Scores for the current situation and any proposed scenario are then used within the Biodiversity Net Gain calculator to determine how river condition can be uplifted to achieve Biodiversity Net Gain.

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## FLOODPLAIN GRASSLAND RESTORATION - A 3-YEAR STUDY OF FLOODPLAIN MEADOW RESTORATION ATTEMPTS IN THE UK - RESTORING RESILIENCE IN FLOODPLAIN AGRICULTURE

E. ROTHERO[1], A. SKINNER[2], I. TATARENKO[3], D. GOWING[3], C. LAWSON[3]

*1 Open University Floodplain Meadows Partnership, 2 River Restoration Centre, 3 Open University*

Species rich floodplain meadows have declined by 97% in the past 100 years, and now cover just 3000 ha of land, and less than 1 % of floodplain area. However, such meadows are an example of a multifunctional floodplain habitat that can store and filter water, use nutrients in a productive way, store carbon in soils and deliver rich biodiversity. All this and they are still a productive and nutritious agricultural crop that can provide red meat in a low carbon, no input system. More intensive floodplain landuses do not deliver such a wide range of ecosystem services and do not represent a sustainable or climate resilient option.

Ecological restoration of floodplain grasslands is therefore a major tool that helps us to develop resilient floodplains and adapt to the impacts of climate change.

This talk will present the findings from a three-year study funded by the John Ellerman Foundation, undertaken from 2015 to 2018 into floodplain meadow restoration attempts in the UK by the Floodplain Meadows Partnership. The study covered 163 restoration sites in England and Wales, covering 20 counties, totalling 733 ha of floodplain. 70 % of the projects were started after 2006, with 12 % starting in the 1990's.

The survey results have revealed that 25% of restoration sites demonstrated a good degree of success and were achieved mainly by private landowners. Restoration failed or had very poor progress on another 25% of sites, managed predominantly by public organisations.

About half of the sites showed some signs of improvement, but moving further towards a successful outcome is dependant on consistent and appropriate management. The degree of restoration success depended neither on the size of the restored fields, nor on their state prior to restoration, or restoration method applied. Ownership of the site and management both significantly influenced restoration success, which strongly correlated with the consistency of management and whether the management activity undertaken was sufficient. Flexibility of management is also critically important for restoration in such a dynamic ecosystem as floodplain meadows. Restoration of floodplain meadows to the required diversity and structure of natural plant communities is a long-term process which requires both suitable management and determination.

The talk will cover the range of benefits that this habitat can offer and include an assessment of the extent of data available to support arguments on ecosystem service and benefits provided by this habitat. A number of floodplain meadow restoration case studies will be presented.

# Session 6: Parallel Sessions

## Woody dams for NFM

### IMPLEMENTING LEAKY WOODY STRUCTURE GUIDANCE AT A CATCHMENT SCALE

P. MILLARD[1], E. HALE[1] & M. BARNES[1]

*1 Mott MacDonald*

As part of Leeds Flood Alleviation Scheme Phase II, the Environment Agency and Leeds City Council are undertaking a programme of Natural Flood Management (NFM) works across the 700km2 catchment of the River Aire to reduce flood risk in the city. To support the delivery of the scheme, Mott MacDonald is developing a suite of web-based GIS (Geographical Information System) tools to implement NFM measures at a catchment scale. Following the release of the industry guidance 'Assessing the Risk: assessing the potential hazards of using Leaky Woody Structures for NFM' the authors have developed a GIS tool to enable the implementation of this research and to steer the placement and design of leaky barriers on the project so that the risk and consequences of failure is

managed appropriately. The guidance has been interpreted into a two-step process; using accessible mapping, followed by simple surveys. The tool is currently undergoing review and is anticipated to be completed in early 2020.

## DO LEAKY DEBRIS DAMS WORK? IMPLICATIONS FOR NATURAL FLOOD MANAGEMENT SCHEMES

J. PHILLIPS[1], A. McBRIDE[2] & S. McEWAN[2]

*1 Environment Agency, 2 FWAG (South West)*

Artificially constructed leaky woody debris dams are promoted as an effective natural flood management measure (NFM) that work with natural processes. The potential for these structures to provide wider positive ecological outcomes is commonly cited as an additional benefit, however there is little evidence to assess to what extent they are effective in modifying the flood hydrograph or their long-term sustainability with respect to maintenance needs and their impact on natural channel form and function. This study represents the first detailed systematic assessment in England of the geomorphic and hydrological response of a gravel bed river to a series of constructed dams. The five monitored structures in the Merriott Stream, Somerset, U.K. were designed to mimic naturally occurring debris dams with differing extents and forms of blockage. Over an 18-month period, repeat photographic and topographic survey captured the geomorphic response of the channel to each structure and in particular the impact of the dams on sediment transport, bank stability and bed forms. Water levels were also continuously recorded upstream and downstream of the structures to support a quantitative assessment of the effectiveness of these types of structures in attenuating the downstream flood hydrograph and 'slowing the flow'. The data identified locally environmentally detrimental channel change including bank erosion (up to 0.4m at one structure) and siltation of the gravel bed whereby the silt content increased from a background level of 6% to 28%, however these changes were within the range of naturally occurring debris dams in the study reach. Positive impacts were observed though the formation of bed scour pools under all the structures and associated outwash bars of clean gravels providing valuable habitat for fish and invertebrates as well as ensuring longitudinal continuity was preserved. The flood storage volume of each structure was estimated by combining topographic data with the recorded water levels from which an average maximum storage volume of 5.8 m3 was derived which equates to 0.1% of the estimated 1:10 year total flood volume indicating that these structures need to be combined with other measures such as floodplain reconnection to make a meaningful impact on larger flood events. Deposition of gravels and silts upstream of the structures resulted in bed aggradation of up to 0.67m at 2 structures effectively reducing flood storage capacity over time. The measurement of water level variations over time through the study reach identified significant inter-event variability but was inconclusive with respect to 'slowing the flow'. Recommendations regarding site selection and design principles highlight the need to avoid the 'one size fits all' approach to leaky dams and the paper concludes that these structures will often require repeated maintenance to ensure that they do not fail to meet their stated flood risk and environmental objectives.

# Evaluating urban rivers

## ASSESSING THE IMPACTS OF URBANISATION ON THE LOW ORDER STREAMS OF BELFAST LOUGH

A. MOORE[1]

*1 Queen's University Belfast*

In urban areas, rivers have often been seen as a barrier to development and a challenge to be addressed, often with heavy engineering. This has resulted in some river catchments becoming badly degraded, with activities such as channelisation, culverting, storm water discharge and pollution negatively impacting the environment and the ecosystem services these rivers and streams provide. This project brings together hydrological processes, water quality, river ecology and the use of novel eDNA technology on low order streams in the Belfast Lough catchment, to determine the effects of urbanisation. Combining detailed mapping of the drainage infrastructure and hydrological features, with assessments of water quality and the community structure will identify key sources of stream degradation and challenges to improving water and habitat quality. This project will identify opportunities to improve stream management and increase the ecological and societal worth of our urban streams, and will help shape best practice for future urban river restoration and management.

## LIVING WATER CITIES: MAKING A DIFFERENCE IN OUR CITIES AND TOWNS

G. FULFORD[1]

*1 Biomatrix Water Solutions*

Most of the UK's major rivers pass through one or more significant towns and cities. Restoring rives in this urban context presents a unique set of challenges often requiring a multi-disciplinary approach and innovative solutions to achieve tangible river restoration objectives in the urban environment.

Urban Wetland technology and science has evolved considerably and is increasingly recognised as a beneficial solution, integrating engineering with wetland ecosystems and plantings to help manage the increasing loading from storm water, CSO's and diffuse pollution entering urban watersheds while also providing amenity and habitat benefits.

Some of the challenges of urban river water restoration can include:

- Over deep channels and lack of shallows
- Heavy sediment loads limited access to gravel substrata
- Vertical edges / no riparian zone
- High flow velocities
- Variable water levels
- Elevated nutrient levels
- Elevated BOD, COD and metals loads
- Reduced Dissolved Oxygen Levels

In response to these challenges and the overall ecological importance of habitat connectivity a range habitat structures and water restoration techniques is rapidly evolving. Approaches for River Restoration in the urban context range from the Bioengineered riverbanks as published by the Thames Estuary Partnership 2018 to modular approaches such as textured subsurface fish shelters and floating wetland habitats etc.

Example techniques include:

- Bioengineered designs
- Biotechnically engineered designs
- Structurally engineered designs
- Textured Modular Habitat Reefs
- Spawning brushes / and textiles
- Elevated gravel beds
- Suspended Gravel Beds
- Floating Emergent Wetlands
- Floating Riverbanks

- Floating Islands
- Floating Submerged Wetlands

This case study focused presentation will explore six examples of some of the latest developments in urban river restoration, with a particular focus on robust on modular bio technical engineered designs which can be efficiently implemented by local urban catchment community groups and voluntary organisations without disruption to surrounding infrastructure.

In the evaluation of the efficacy of these various approaches we examine six example projects. For example in Rennes France the municipality has recently installed 268 interlocking floating river bank modules in a new floating river bank wetland planted with 6800 native aquatic plants, the installation forms largest Floating Riverbank of its kind ever constructed and provides emergent riparian wetland habitat in constant deep water with regular flood events rising over two meters. As a second example In the USA in Chicago the NGO Urban Rivers has installed series of Floating Wetlands have been installed with funding from sponsors including the Shedd Aquarium, National Geographic, Patagonia and Whole Foods Market with plans set to expand the project in to a mile long engineered urban wetland park "The Wild Mile".

## REWILDING 'LOST' URBAN RIVERS FOR HEALTH AND WELLBEING

A. T. BROADHEAD[1] & P. SIMKINS[1]

*1 Arup*

This paper considers two emerging concepts – rewilding and health and wellbeing – and considers how these could shape future urban river restoration.

Urban rivers have been modified, contained and polluted over centuries. Many have been buried in culverts and even completely eradicated from the surface. Despite this, urban riverscapes can still be vital refuge for wildlife, providing aquatic and riparian habitat, and acting as connective blue-green corridors. In an urban design context, the value of healthy urban rivers for public wellbeing is also being increasingly recognised, through access to greenspace, climate change amelioration, amenity value of riverside walks, flood resilience, as well as economic regeneration linked to urban riversides.

Around the world, lost urban rivers are being restored, uncovered, cleaned, and redesigned as key assets for cities of the future. We argue that concepts of rewilding from the conservation community could be directly relevant to maximising the ecosystem benefits of urban rivers, despite some constraints. This could bring major benefit for both natural environment outcomes in cities, and also have the potential to deliver key outcomes for people – access, amenity, play, safe spaces for urban childhoods, nature prescribing for mental health, as well as economic regeneration, natural flood risk management and future climate adaptation. All of these are important for delivering social resilience, which is an emerging concept that we believe will be increasingly applied to urban planning and environmental projects in future.

However, there are clearly tensions between rewilding and nature in cities. Humans occupy riverspace, so what would it mean to truly co-exist with "wild" rivers? And to what extent can we really make space for water, let alone embrace "wilder" urban spaces for health and wellbeing? Urban design craves control and certainty, but where rivers are unleashed from human control they are inherently messy. Perceptions of "wild" or "natural" riverscapes can often be rose-tinted; post-disturbance rivers can and do have multiple values for the environment and society.

Understanding these different views is vital to helping to interpret and deliver urban river restoration in a way that maximises the opportunities for health and wellbeing. We argue that the future of rivers in cities requires the best of both worlds and we seek to encourage discussion across disciplines – ecological conservation led expertise to help to restore or conserve habitats and wildlife, and also

consideration of the human aspects of urban space, carefully balancing where, when and how interventions should be made to urban rivers.

## Monitoring, evaluation & evidence

### EVALUATION OF AQUATIC MACROINVERTEBRATE COMMUNITIES POST-WEIR REMOVAL ON RIVERS IN CUMBRIA, UK

A. MARTINEZ-CRUCIS[1]

*1 AECOM*

Rivers in United Kingdom have been intensively modified over the years by physical modifications. Weir removals is one of the common restoration measures used to improve the hydro-morphological characteristics and recover their life communities. For the purpose of this study the rivers Lyvennet, Lowther, Eamont and Caldew were selected at the east of Cumbria. River Habitat Surveys (RHS) and macroinvertebrate sampling were carried out to compare the status of the rivers with the location prior to the removals based on historical data. Some improvements were observed in three of the rivers in the RHS and macroinvertebrates scores, except in the River Lyvennet still being used as a crossing point. Although many studies have assessed dam removal outcomes, it is difficult to predict general responses about range or magnitude. A well-designed monitoring programme could be implemented to accurately assess improvements to macroinvertebrate community and hydro-geomorphology.

### DEVELOPING AN EVIDENCE BASE FOR THE IMPLEMENTATION OF PHOSPHORUS AND SEDIMENT AGRI-ENVIRONMENT MEASURES AT THE FARM-SCALE IN THE EVENLODE CATCHMENT, A HEADWATER TRIBUTARY OF THE RIVER THAMES

J. STOPPS[1], B. HANCOCK[1], J. NEALE[1], D. GASCA[1], M. BARKER[1] & S. OLNEY[2]

*1 Atkins, 2 Natural England*

Understanding the land use factors affecting WFD condition of our watercourses and catchments requires an understanding of hydrology and water quality at the field or farm scale. This paper will describe the design and implementation of a water quality and hydrological monitoring network developed with landowners in the Evenlode catchment, a rural headwater of the River Thames. The monitoring network has been designed to quantify the flows of water, phosphorus and sediment from fields and farmyards into watercourses. The data being collected are providing a local evidence-base to target investment in farm-scale mitigation measures and to assess post-implementation effectiveness.

Over 15 landholdings are being monitored using a variety of techniques. Landholdings are delivering different agri-environment measures that are being promoted across the water industry, from arable reversion, farmyard management, fencing and buffer strips to wetland creation and Natural Flood Management. Different monitoring techniques are being used for different mitigation measures and

will be described as part of the paper. The monitoring approaches have been designed to be adaptable to individual farms and their landscape setting and are delivered using readily available products and materials or market-ready suppliers. They have also been designed to be easy to understand to help scheme participants and other stakeholders understand why monitoring is being undertaken. By working closely with landowners to develop and implement the monitoring network, the importance of monitoring pre- and post-measure implementation at the field or farm scale is fully realised. The costs associated with each monitoring method has also been quantified and will be discussed as this is frequently one of the main barriers for more targeted monitoring of farm scale schemes.

Farm scale monitoring is part of the broader Evenlode Catchment Laboratory initiative that hosts and coordinates a large number of data collectors across the Evenlode catchment including monitoring specialists from government organisations, water companies, agri-environment specialists, local landowners and their agronomists, academic researchers, students, and citizen scientists. These data collectors are all working on individual projects that help to understand the nature of diverse catchment issues including flood risk, water quality, ecological condition and climate change and can define an integrated catchment management strategy using an evidence-based approach.

As part of the paper, we will provide a range of materials including a farm scale monitoring handbook and helpsheets to help other practitioners working in the field of catchment management.

## MASTERING THE MONITORING: FISH COMMUNITY RESPONSES TO A LOW-COST PASSAGE EASEMENT AT A BRIDGE CULVERT

T. J. MYERSCOUGH[1] & J. GREY[2]

*1 Wyre Rivers Trust, 2 Wild Trout Trust*

Working in partnership, Wyre Rivers Trust and Wild Trout Trust delivered a low-cost solution to fish passage at a culvert on Woodplumpton Brook (Lancashire, UK) in early 2017. A series of green oak baffles were attached to the flat concrete, either in pairs or offset, to increase the water depth and break up the previous fluming flow, thereby improving access for a wider range of species and of greater individual size to the brook upstream, particularly under low-flow (typical) conditions. The site has been subject to annual monitoring (December 2016 pre-works to 2019 and ongoing) which is supported by cohorts of Freshwater and Marine Ecology MSc students from Queen Mary University of London as part of the practical element of a field-course. The students gain valuable hands-on training and experience of monitoring and analysis techniques (e.g. 3-pass electrofishing, fish handling and identification, appropriate statistics) as well as reporting and science communication skills (via the Wyre RT newsletter and WTT blog), and the exercise provides the co-conspirators with invaluable data for 'free'.

In 2019, the project was supplemented by extra sampling in late spring by another MSc student from Lancaster University as part of a wider dissertation on fish passage at barriers, and the intention is to try and extend sampling at this 'alternative' time period to glean extra information. Various metrics (e.g. biodiversity indices, fish length) have demonstrated change in the fish community. Prior to intervention, the fish community upstream of the culvert was dominated by smaller species and typically comprised smaller individuals. Post intervention, fish biodiversity has increased both upstream and downstream. Moreover, the average length of several fish species is now more comparable up and downstream, indicating that larger individuals can move more freely through the culvert. It is still too early to draw conclusions from seasonal comparisons but there are some hints of possible issues to flag for future consideration. In addition, the monitoring has revealed the return of brown trout to the system and the impact of a pollution incident, and so a valuable exercise all round for relatively little financial outlay.