

Catchment Restoration and Freshwater Sciences

Local knowledge, global expertise





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CATCHMENT RESTORATION AND FRESHWATER SCIENCES

Understanding the challenge

River basin systems have encountered much historic damage and now face an uncertain future due to the impacts of climate change and population growth. Extreme events such as flooding and droughts are becoming more frequent and severe, whilst an ever-growing demand for water is putting additional strain on resources and ecosystems.

Land has been drained and deforested, rivers have been straightened and canalised. This alteration of natural processes has reduced system sustainability, causing habitat degradation, increased flood and drought risk, and ultimately poor social, economic and environmental conditions.

A robust, scientific understanding of the interactions between water, sediment, nutrients and ecology within a river basin is required in order to develop sustainable solutions that can repair and improve degraded systems. When done successfully the environmental, social and economic potential of catchment ecosystem services can be realised.

Our team of specialists have successfully delivered a wide variety of river basin and river channel restoration projects across the globe. By thinking holistically, and at the river basin scale, we are able to deliver innovative solutions that deliver multiple benefits and optimise sustainability.

OUR SERVICES

- Advisory
- Baseline surveys
- Bespoke morphological surveys
- Covered waterways
- Climate change adaptation and catchment planning
- Ecosystem services
- Environmental monitoring
- Environmental flow studies
- Environmental Impact Assessment
- Fish passage feasibility and design
- Fluvial geomorphology
- Fluvial audit
- Freshwater ecology
- Geospatial Analysis
- Hydropower
- River restoration feasibility and design
- Survey App Development
- Webmapping and Storymaps
- Wetland restoration feasibility and design
- WFD compliance assessments
- WFD mitigation investigations



LOCH ARD

The Trossachs National
Park, Scotland



TREGARON FLOOD ALLEVIATION SCHEME

Using geomorphological assessment to provide improved ecological habitat alongside flood alleviation.

THE REALITY OF CATCHMENT PROCESS RESTORATION

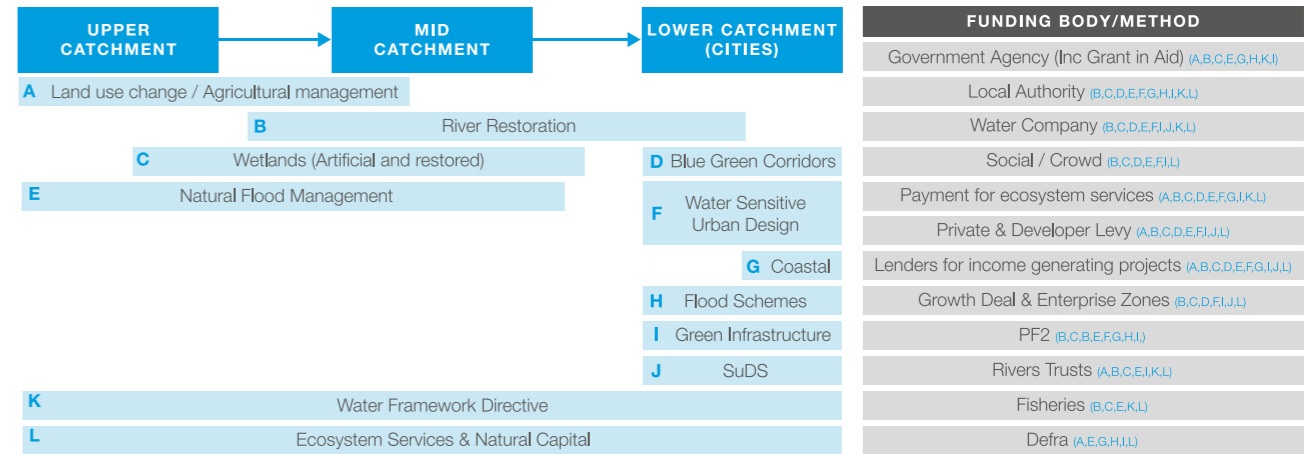
Restoring catchment processes can seem like overwhelmingly difficult task due to the myriad of challenges and constraints that can be exacerbated by technical complexities. However, by considering restorative actions iteratively and within the context of the wider catchment system, it is possible to achieve more sustainable process states. In reality, it would be near impossible to restore an entire catchment back to its pre-modified state, but it is useful to use this hypothetical ‘reference condition’ as a target to aim for.

Each catchment initiative is unique, and is associated with its own set of motives, objectives and ‘language’. Consequently, these factors can result in a complex scenario that is difficult to unravel.

By thinking across scales and about the associated types of process improvement it is possible to formulate an idea of what might be realistically achievable in damaged catchments before planning restoration initiatives.

Additionally, by understanding the scale and nature of interventions, it is possible to make links to various potential funding sources that could enable process restoration.

These notions link to Arup’s ‘‘design with water’’ approach that aims to seek common ground between stakeholders and then to formulate a clear business case to move opportunities from concept through to implementation.



CATCHMENT PROCESS RESTORATION

Approaches and drivers to process restoration, and relevant potential funding sources.

SCALES OF PROCESS RESTORATION AND ASSOCIATED CLIMATE CHANGE RESILIENCE BENEFITS	SCALE	TARGET/DIFFICULTY
Complete Catchment Rewilding (physical, ecological and chemical restoration to a pre-artificial state). Maximum ‘natural’ capacity to adapt to a changing climate and maximum resilience. Long term sustainability.	CATCHMENT	7
Catchment Process improvements (physical, chemical and ecological improvements that replicate/emulate pre-artificial conditions). Significant climate change adaptation and mitigation benefits felt at the catchment scale. Long term sustainability.		6
Catchment hydrological process restoration (using land use change and NFM) alongside river restoration and natural recovery. Meaningful climate change adaptation and mitigation benefits felt at the catchment scale. Medium term sustainability.		5
Reach scale process restoration (with flood plain restoration). Meso-scale/regional climate change adaptation and mitigation benefits related to widespread habitat and process improvement. Benefits potentially felt directly in nearby urban areas. Long term sustainability.	REACH	4
Reach scale habitat improvement (in channel improvements). Meso-scale/regional climate change mitigation benefits related to widespread habitat improvement. Medium term sustainability.		3
Localised habitat improvement (gravel addition, riparian planting, fencing etc). Local adaptation and resilience benefits related to improved biodiversity, flood risk management and process continuity.		2
Artificial structure removal. Very local adaptation and resilience benefits related to improved flood risk management and process continuity.	LOCAL / UNIT	1

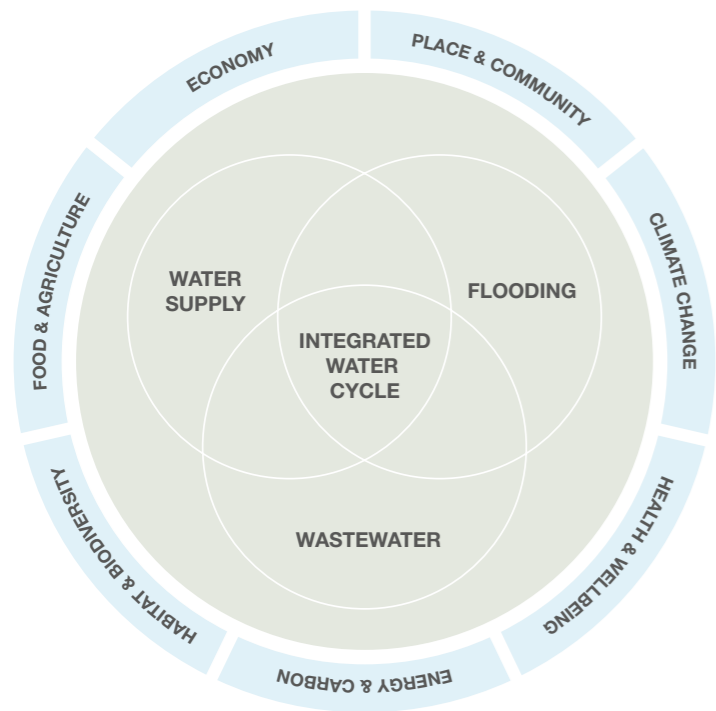
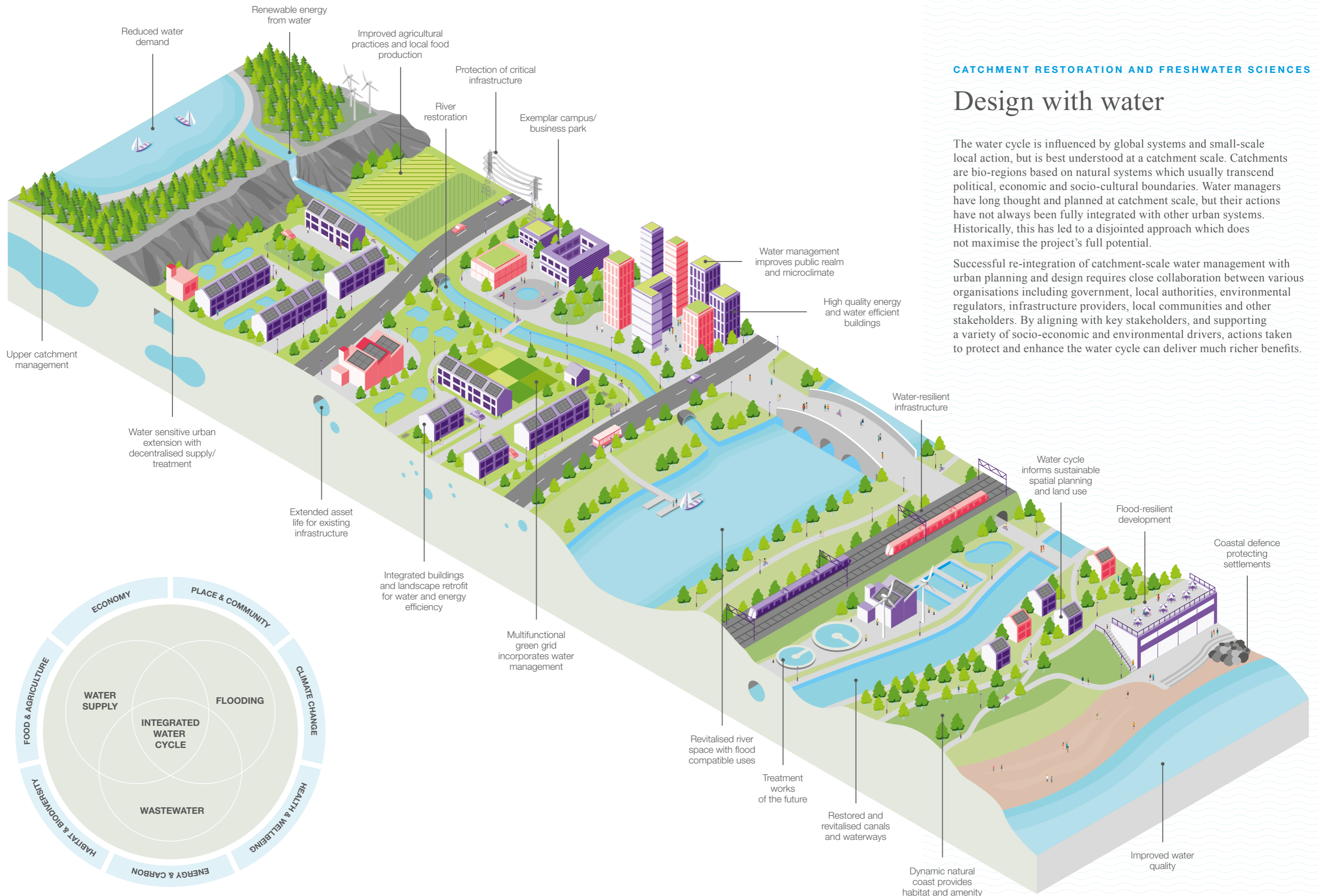
SCALES OF PROCESS RESTORATION

Providing climate change resilience across all catchment scales.

Design with water

The water cycle is influenced by global systems and small-scale local action, but is best understood at a catchment scale. Catchments are bio-regions based on natural systems which usually transcend political, economic and socio-cultural boundaries. Water managers have long thought and planned at catchment scale, but their actions have not always been fully integrated with other urban systems. Historically, this has led to a disjointed approach which does not maximise the project's full potential.

Successful re-integration of catchment-scale water management with urban planning and design requires close collaboration between various organisations including government, local authorities, environmental regulators, infrastructure providers, local communities and other stakeholders. By aligning with key stakeholders, and supporting a variety of socio-economic and environmental drivers, actions taken to protect and enhance the water cycle can deliver much richer benefits.





Our approach

Successful catchment management and the restoration of healthy and sustainable processes requires a holistic understanding of complex catchment systems, and human and environmental needs. The principles of hydrology, landscape processes, fluvial geomorphology and aquatic ecosystems are key components of this understanding. Across an extensive portfolio of projects, Arup has used robust catchment science to develop sustainable solutions that work with natural processes, repair environmental damage and leave a lasting legacy.

PROJECT PLANNING

We provide advice and design support during the planning stages of a wide range of projects. Projects range from large-scale natural flood management schemes, more conventional hard flood alleviation schemes, new reservoirs, fish bypass channels and multi-use site developments to small reach based river restoration and weir removal schemes. We also provide WFD compliance assessments, mitigation advice and input to Environmental Impact Assessments (EIA).

Our teams provide effective project support at the early stages of hydropower planning projects in order to develop environmental flow studies that are specific to local needs across the flow regime.

FEASIBILITY

During project feasibility stages we work to gain an understanding of the current and historical catchment, and site. We conduct extensive hydrological and geomorphological assessments and ecological surveys to inform a process restoration strategy. Graphic visualisations play a key role at this stage of a project.

DESIGN

Our team of experts regularly deliver outline and detailed designs for a range of catchment process specific developments. These include natural flood management schemes, river restoration and fish pass design through to fish friendly culverts, wetland creation and restoration, and river diversions.

DELIVERY

We offer an on-site presence during construction providing support to clients and contractors through on-site ecological, geomorphological and engineering supervision and developing methods for post-project monitoring and appraisal.



RIVER SURVEYS

Conducting baseline geomorphological surveys in Scotland.

Natural flood management

Arup's highly qualified team of catchment scientists and engineers are skilled at undertaking assessments, feasibility studies and design work for natural flood management schemes across a range of different catchment types in the both the UK and Europe.

SHEFFIELD NATURAL FLOOD MANAGEMENT (NFM)

Arup has developed a modelling tool for assessing NFM and other storage features in the River Sheaf and Porter Brook catchments, which both drain into the City of Sheffield. The model is part of the project appraisals for flood risk mitigation in Sheffield and has been used to assess the location and size of NFM storage features required to achieve desired flow rates further downstream. The modelling was directly related to the mapping, which created huge efficiencies in the feasibility and optioneering process, allowing high level costing of options to be explored alongside increasing catchment storage.

RIVER HULL NFM

Arup has modelled the extent to which NFM can reduce peak flows in a highly constrained, tidally influenced, and slow percolating catchment by combining an integrated catchment study with the latest rainfall-runoff model. NFM opportunities were then mapped using an evaluation matrix, prioritising sites based on ecosystem service provision, costs and maintenance of NFM and impacts to existing land cover for Hull City Council. A weighted scoring system enabled the impact on the hydrograph and overall benefits of NFM to be effectively assessed and prioritized depending on funding streams being exploited.

INTEGRATED CATCHMENT MANAGEMENT (ICM) INTRODUCTORY COURSE

Arup, supported by other project partners, offered a series of one-day introductory courses on NFM with access to online resources and pre-course webinars. The course equipped delegates with an overview of ICM and an awareness of the design, planning and engagement activities required for its effective implementation. Delegates left with a toolkit of implementation techniques to support their day-to-day role.

VILLAGE BROOK OUTLINE BUSINESS CASE

Arup worked in partnership with Staffordshire County Council to determine the feasibility of options to reduce flood flows into the village whilst mitigating the impact upon, and incorporating aspirations of, the local community. Hydrological, hydraulic and economic modelling was used to inform a five-case model outline business case. A hybrid solution of both NFM and traditional measures was highlighted as the preferred option and added to the medium-term Region Plan by the EA.



LUSTRUM BECK, STOCKTON-ON-TEES

The Lustrum Beck Flood Alleviation Scheme (FAS) is a £3 million flood defence scheme that aims to reduce the risk of flooding to over 150 properties in Stockton. Arup has undertaken geotechnical surveys, detailed design drawings and construction design management documentations. The second phase of the scheme involved the design of NFM to raise the standard of protection from 1:75 to 1:100 year by temporarily storing floodwater throughout the catchment without exceeding impoundment restrictions of the Reservoir Act or compromising Great Crested Newt habitat. The scheme is the first of its kind in the UK to receive Flood Defence Grant in Aid funding for NFM features.

MARAZION MARSH, CORNWALL

Arup was commissioned to undertake a feasibility study to assess the potential of using natural flood management and sediment traps to mitigate deposition of silt for pollution control in Marazion Marsh. The marsh is a designated site of special scientific interest (SSSI) and a special protection area (SPA) which is currently at risk due to the large volumes of silt and nutrient deposits resulting from arable and horticultural activities. Drawing on results from the desk study assessment, site visits and expert judgement; a number of sediment ponds and other attenuation features have been proposed. The outputs will be used by the Environment Agency to inform the selection of options and support land-owner engagement.

FLOODPLAIN

Inlet control structure on a floodplain storage pond in Middlehope Burn, Weardale (Client: Environment Agency).

Natural drought management

Water scarcity affects 40% of the global population, largely in rural, poverty stricken areas of Asia and Sub Saharan Africa. Anthropogenic interference with the hydrological regime in these areas has resulted in linked poverty and ecosystem harm, with communities unable to sustain a productive landscape and reliable income.

Arup's catchment scientists are working in arid regions to improve the sustainable management of water resources using a combination of scientific and traditional approaches. This work is helping to improve linked environmental and social processes, natural capital value and is alleviating poverty.



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TRADITIONAL ENGINEERING

A johad in rural Rajasthan, India.



DROUGHT MANAGEMENT

Retention of monsoon water positively impacts communities and the local environment.

WATER^{UP}

In cooperation with *The Flow Partnership*, Arup is helping to tackle Sustainable Development Goal 6 – clean water and sanitation through the production of language neutral, universally accessible educational materials on catchment management. Working with rural communities in Rajasthan, India, traditional rainwater harvesting features have been studied, mapped and recorded. Hand-built and maintained by villagers, these features capture and store monsoon rainfall to enable infiltration. The result is recharged aquifers which

provide a perennial and reliable source of clean water from local wells for drinking, bathing and irrigation purposes. This has increased food production and greatly improved the health of the local population.

The Water^{UP} team have analysed, mapped and modelled these approaches using Arup developed mobile GIS tools and hydrological models to replicate the work and create a new and maintain an existing rainwater harvesting feature. This data and footage of the process of construction has been used to produce language neutral, free and accessible educational tools

to guide the implementation of similar interventions and catchment management principles around the world.

The digitally enabled, language-neutral educational materials have been tested in La Guajira, Colombia to ensure their applicability across contrasting geographies and cultures. A site has also been identified to build a new feature with the local communities in La Guajira. The educational materials will then be published through the Water School online platform as a free and globally available resource.

Digital water

Adopting a data-driven digital approach is increasingly important in providing a comprehensive understanding of the water environment and the challenges that it faces.

Our teams have been exploring new, innovative approaches to tackle a range of catchment science issues, including the use of geospatial survey apps and interactive web-mapping. Our approach utilises the latest in GIS, modelling and coding technologies to provide our clients with a singular source of data and computational analysis through digitised catchments. The digital services we offer are ever evolving to the demands and needs of both our clients and the environment to streamline processes and provide holistic, modern solutions.

WEARDALE NFM

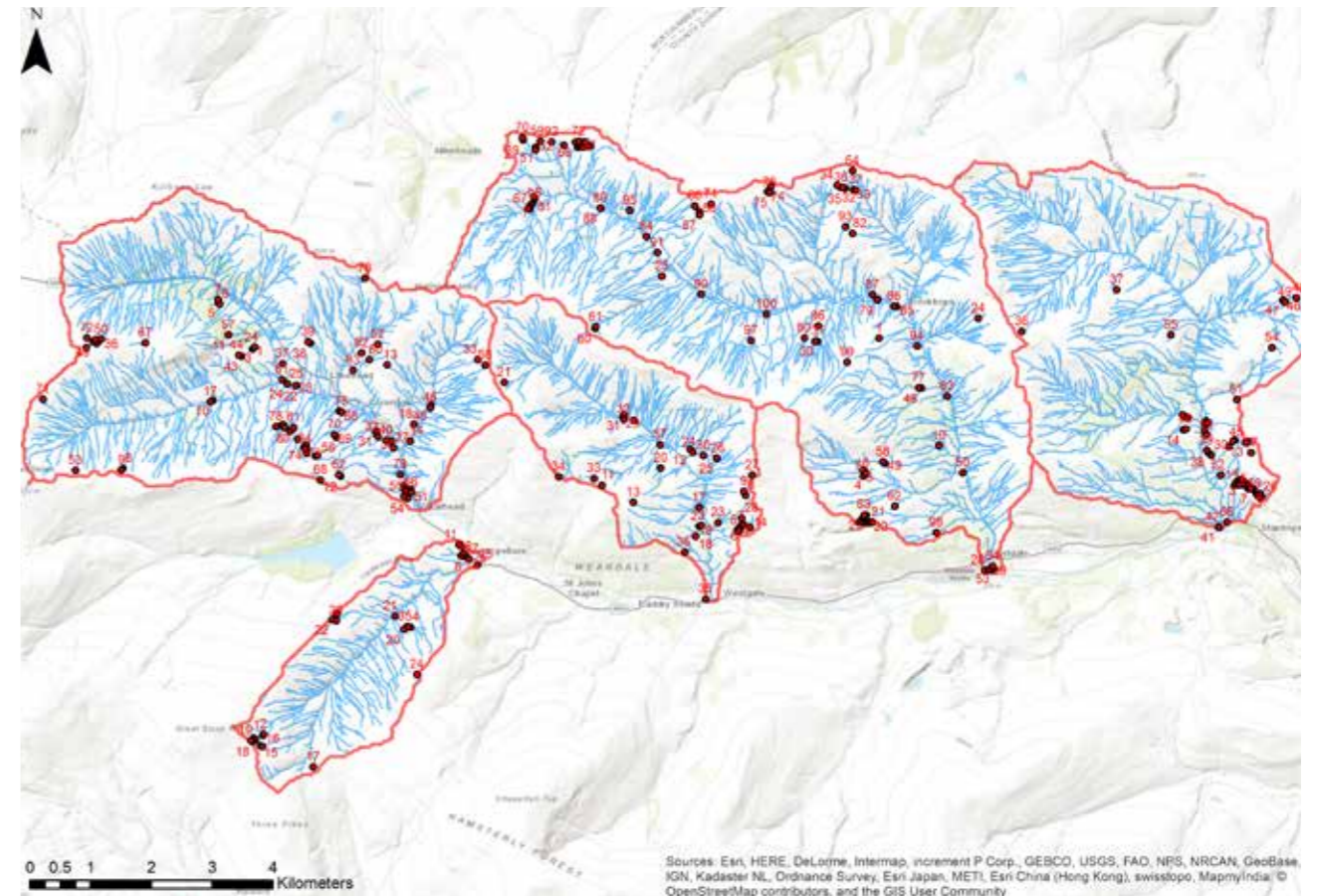
Following the successful implementation of a nationally important NFM demonstrator in Weardale, 100km² of the steep, moorland catchment was analysed for NFM potential. Using advanced catchment modelling and “blackbox” optimisation algorithms, GIS and FME analysis, locations suitable for NFM features were identified. The proposed locations and feature types were optimised to maximise potential storage in the form of runoff attenuation or floodplain storage equating to over 90,000m³ of storage spanning 43km². Arup developed five standard designs of different NFM features and the suitability of each design at each location was specified using advanced spatial analysis.

STAKEHOLDER ENGAGEMENT

Geospatial portal using data visualisations for use in stakeholder workshops.

WEBMAPPING FOR STAKEHOLDER ENGAGEMENT STUDY

Our team of data scientists have used web-mapping to facilitate meaningful stakeholder engagement on projects with multi-faceted and complex issues. Through data visualisation we can bring information to life, to communicate insights and tell stories, and allow a wide range of stakeholders to understand and interact with data. This eliminates the need for extensive paper mapping and inefficient post-consultation digitisation of data, providing a single source of truth and allowing stakeholders to input their own data in a straightforward manner.



UNLOCKING THE POTENTIAL OF NATURAL FLOOD MANAGEMENT WITH MACHINE LEARNING

Our catchment and digital scientists have developed cutting-edge deep learning techniques to produce high resolution land use maps to increase resilience to climatic and seasonal extremes. The tool develops risk maps to identify levels of resilience to high flows, droughts and climate change across river catchments. It can also be used to monitor and make recommendations on landscape-scale biodiversity or habitat corridors, and other ecosystem services. This innovative solution won first prize at the Digital Transformation Awards (DTA) Grand Final in 2019.

OPTIMISATION ANALYSIS FOR STORAGE-BASED FLOOD MITIGATION

Arup has developed a tool that analyses topographic data (e.g. LiDAR) and surface water runoff pathways

to determine the most feasible locations for storage-based flood mitigation.

The tool is designed to provide the fewest NFM features required to achieve the target total storage volume. The tool can be further extended to include other variables; for example, length and height of feature which also directly impacts overall cost. As a next step in the generative NFM scheme process, the optimal dam locations and extents can be converted into a suitable geographical coordinate system and loaded into GIS for visualisation and mapping purposes. Furthermore, the resulting storage volume from the optimal dams can be input to an Arup designed aggregate storage model to estimate the effect of the dams on the downstream catchment hydrograph.

NFM

Suitable NFM intervention locations identified at Weardale using catchment modelling and “blackbox” optimisation algorithms, GIS and FME analysis.

River and wetland restoration

Arup's accomplished team of fluvial geomorphologists, aquatic ecologists and catchment specialists have extensive experience of designing and delivering river restoration projects across the UK and beyond. Our approach utilises designs that work in harmony with natural processes in order to improve the ecological statuses of water bodies.

AFFINITY WATER FRAMEWORK

Arup, in partnership with Salix, was appointed to Affinity Water's framework (AWF) to deliver a river restoration programme driven by WFD requirements. The project focusses on water bodies within Affinity Water's area of action which fail to meet "good" ecological status due to morphological modifications and abstractions.

The schemes within this framework aimed to achieve a "good" status for these water bodies. As part of the AWF, work on the River Mimram at Tewin Water was undertaken to remove an existing weir and narrow a channel, restoring the natural chalk stream processes, improving fish passage and enhance habitat diversity. Additionally, remeandering works, habitat creation and bank re-profiling was completed for the Upper Lea at The Moor, improving habitats and morphological diversity.

YWS PILOT INVESTIGATIONS

Arup and Salix worked in close collaboration to deliver two river restoration pilot schemes, addressing low flow impacts resulting from impoundments. The objectives of the projects were to establish the technical feasibility, economic cost and benefits of generic mitigation measures on heavily modified water bodies and to test the extent that river restoration can be used to mitigate the negative impacts of artificially reduced flows.



HABITAT RESTORATION

River Mimram channel narrowing and habitat restoration works.

WETLAND RESTORATION

Ricknall Carrs concept design visualisation based on proposed river and wetland restoration techniques along the watercourse.



GREAT NORTH FEN

Arup have been commissioned by the Brightwater Landscape Partnership to provide detailed design for river and wetland restoration at Bishop's Fen and Woodham Fen, and feasibility and concept design for Ricknall Carrs and Cocker Beck. The Water Environment team are supporting the BWLP, Durham Wildlife Trust and Environment Agency objectives to implement actions to restore priority habitats in the Skerne catchment, whilst ensuring that future resilience is provided with a wider range of solutions focussed on restoring natural processes, such as reinstatement of historical channels and improvement of floodplain connectivity and mosaic wetland habitats. The schemes fall within wider initiatives by the BWLP supporting enhancement of and access to the local heritage and natural, built and farmed landscape around the River Skerne, to inspire the current and future communities.

COOMBE MILL

Wiltshire Wildlife Trust commissioned Arup to undertake the detailed design for their proposed river restoration works at Coombe Mill on the Upper Avon. The scheme involves changing the flow apportionment between the mill leat (main channel) and the original, more natural channel. The restoration supported stream habitats and provided good fish passages for salmon and other fish species. To aid the design, hydraulic modelling was undertaken.

RIDGEWAY WETLANDS

Alongside Arup's work with Highways England to dual the A30 between Chiverton and Carland Cross, the catchment team is delivering environmental enhancements across Cornwall to reduce detrimental effects associated with the road scheme. River restoration techniques being employed include field-corner ponds, scrapes and the placement of large woody debris in channels. The interventions will be implemented across three catchments to reduce flood risk and improve water quality and biodiversity.

Our team of specialists have successfully generated solutions for a variety of river basin and river channel restoration projects by understanding system needs.

Morphological surveys

Arup has a strong background in conducting morphological surveys, including geomorphological dynamics assessments, fluvial audits, habitat mapping and Morphological Impact Assessment System (MImAS) surveys. These services and skills are being used on a range of schemes, including standalone projects and as part of analysis for delivery on projects such as river restoration and fish passage feasibility and design.

YWS FLOW TRIALS HABITAT MAPPING

The project comprised a bespoke fluvial audit and habitat mapping walkthrough survey of rivers downstream of Yorkshire Water Services reservoirs, where the introduction or modification of compensation flows is being trialled to ensure WFD compliance. Arup undertook an assessment of morphological response, alongside ecological monitoring. To reflect the varied behavioural characteristics and habitat requirements of key target aquatic species at different stages in their life-cycle, information on habitat reaches was recorded prior to and after flow regime changes. Arup conducted a detailed geomorphological dynamics assessment involving an appraisal of flow, sediment and channel morphology data. Although further work is planned to assess long term impacts, initial results indicate signs of an early positive response within the system.

MORPHOLOGICAL SURVEYS

Conducting morphological impact assessment surveys in rural Scotland.

SEPA MORPHOLOGICAL SURVEYS

Arup has conducted detailed morphological surveys of over 5500km of rivers in Scotland with sub-consultants. State-of-the-art survey techniques were used to deliver the largest set of fluvial surveys ever undertaken within one project. These surveys confirmed the classification of water bodies currently failing to meet the requirements of the WFD and identified the reasons for the failure and the likely mitigation required. A purpose developed mobile GIS application was used to capture survey outputs in the field for direct download onto a server, with data compatible with SEPA's MImAS.



MORPHOLOGICAL IMPACT ASSESSMENT SYSTEM (MIMAS) DEVELOPMENT

Arup have been working with SEPA in recent years to help to develop their MImAS tool so that it has an improved technical basis and functionality. This project has involved a series of complex technical tasks related to geomorphological science, all of which then feed into different aspects of the system. The final output of the project is a standalone tool that allows users to undertake various types of calculations and assessments that will allow better planning, and an improved appreciation of waterbody status and potential impacts.

ADVICE ON CATCHMENTS

We offer high value advice on digital systems, catchment planning, funding and strategy.

Advisory services

Arup's experienced team have a growing track record on providing high value advice and support on an extensive range of projects related to catchment management and the maximisation of ecosystem services. This work can include support on utilisation and development of advanced digital systems to bring efficiencies, advise of funding and transactions, input to important strategic projects and the design of post project appraisal and monitoring services.

ACORN BANK FEASIBILITY ASSESSMENT

Commissioned by the National Trust, Arup undertook a high-level study to consider concept options for weir repair, fish passage improvements, channel enhancement and scour repair at Acorn Bank Mill Weir, Penrith. Following initial inspections and data gathering, analysis and discussion with stakeholders, options have been outlined and appraised for client consideration. In addition to engineering considerations, the proposed options acknowledge geomorphological and habitat constraints and opportunities, as well as WFD requirements.

Water Framework Directive compliance assessment

Arup's Water and hydromorphology team has proficient experience delivering environmental impact assessments (EIA) and water framework directive (WFD) compliance and assessments for a range of schemes. Such assessments ensure that potential negative impacts of proposed schemes are addressed and that they comply with environmental regulations.

HIGH SPEED 2

Arup, in partnership with ERM, was appointed as the civil engineering and environmental services consultants for the Phase 2a section of the route (West Midlands to Crewe) responsible for ensuring the sustainable design of the project and its associated infrastructure. A full Environmental Impact Assessment was undertaken including the production of the route-wide WFD compliance assessment. This has included conducting stakeholder engagement with relevant parties such as the Environment Agency, local authorities and water companies.

The Water and Flood Risk Team also provided significant input to options appraisals for the preliminary design and production of a mitigation management strategy.

In February 2017, Arup was appointed by HS2 Ltd as the civil designer and environmental services consultant for the East Midlands to Leeds and York section of Phase 2b and are currently undertaking the Environmental Impact Assessment for this section. The WFD compliance assessment will also form a part of this assessment. Arup was also awarded the Environmental Overview Consultant role for the whole of the Phase 2b scheme and are responsible for quality assuring and compiling the WFD compliance assessment for the entire Phase 2b route.

Arup has used robust catchment science to develop sustainable solutions that work with natural processes, repair environmental damage and leave a lasting legacy.



HIGH SPEED 2

WFD Assessments for linear assets. High Speed 2 viaduct visualisation.

YORK CENTRAL

Arup was commissioned by Network Rail and Homes England to prepare a Water Framework Directive (WFD) compliance assessment for the York Central Development.

This involved a screening assessment to identify the WFD water bodies potentially affected and a scoping assessment to identify the potential impacts of the proposed Development on the current status and status objectives of the relevant water bodies.

The catchment science team assessed the viability of options to help achieve future Heavily Modified Water Body mitigation measures by conducting a preliminary assessment of the technical feasibility and cost-effectiveness of opening-up a section of existing culvert. Although this was deemed unviable, other feasible measures were identified during this process, including improving culvert channel beds and invasive species removal.

SKIPTON FLOOD ALLEVIATION SCHEME

Arup completed the options appraisal, design and WFD Assessment for the Skipton Flood Alleviation Scheme in North West Yorkshire.

As part of the WFD Assessment for this scheme, Arup undertook baseline fluvial geomorphological surveys of the Eller Beck and Waller Hill watercourses affected by the scheme, in order to inform impact assessment and scheme design.

Mitigation was identified to ensure that the proposed works would not deteriorate the current WFD status of the water bodies or stop them from achieving good status in the future. This included localised river restoration works and measures to ensure that culverts beneath two proposed flood storage reservoirs were designed appropriately to reduce impacts on fish passage and sediment transfer.

CHEDDAR RESERVOIR 2, SOMERSET

Arup undertook a Geomorphological and WFD Assessment for the proposed Cheddar Reservoir 2 scheme. The assessment included a characterisation of the baseline geomorphological condition of the various watercourses affected by the proposed works and a detailed evaluation of the potential impacts of the scheme, including effects on flow regime and aquatic habitat features. Relevant mitigation was recommended to address the identified impacts in order to ensure that the scheme would be compliant with the objectives of the WFD.

Fish passes

Arup's expertise in delivering feasibility assessments and designs of fish pass structures has led to tangible improvements to fish passages and wider infrastructure schemes, throughout the UK and internationally.

CORRIE BURN AND CREAMERY WEIR FISH PASS FEASIBILITY ASSESSMENT

The Rivers and Fisheries Trust of Scotland appointed Arup to conduct a feasibility study for fish pass improvements at two sites in Scotland – Dumfries and Speyside. In order to identify site constraints and potential opportunities, Arup undertook initial site inspections and surveys at each location. A series of feasible options were then assessed and put forward to the client, including cost planning for implementation.

RODLEY FISH BY-PASS CHANNEL

To improve fish passage on the River Aire, Yorkshire Water Services enlisted Arup to design a fish pass at Rodley Weir. Arup conducted the feasibility and design and provided site supervision of this viable and sustainable naturalised fish pass. The natural channel, similar to that of an upland stream, incorporates a meandering layout to maximise the biodiversity potential of the development. The project was completed in September 2013 and recent results show that fish are successfully migrating upstream with a number of trout being tagged as part of the Post Project Monitoring.

RODLEY WEIR FISH PASSAGE

Improving fish passage along the River Aire by creating a fish by-pass channel around Rodley Weir.

LEEDS FLOOD ALLEVIATION SCHEME

Working for Leeds City Council, Arup oversaw the replacement of two historical masonry weirs with new mechanical features. The mechanical weirs are lowered in advance of a major flood to reduce flood risk but the award-winning design has also had an ecological benefit. The inclusion of fish passes, along with the creation of new fish spawning habitats and diverse flow conditions, has resulted in salmon being spotted in the city centre for the first time in over 200 years.



Covered waterways

Historically, many rivers have been built over to allow for urban development and hide what had become unsightly open sewers. However, with a growing appreciation of the ecosystem services and landscape value provided by rivers, as well as opportunities to unblock channels and prevent flooding, there is a growing trend to uncover these rivers. Arup's team of urban water management specialists have won awards for their work on deculverting projects to daylight 'lost streams'. They have extensive experience of covering watercourses in a way that retains the connectivity and diversity of aquatic ecosystems without increasing flood risk.

COVERED WATERWAYS BELOW INFRASTRUCTURE

Arup are investigating how naturally functioning rivers can be retained beneath national critical infrastructure where diversions are not possible. We have researched how natural and/or artificial lighting can be utilised in covered rivers, supplying the energy needed for plants and animals to thrive. Our team are leading the way on thinking around sustainable covered waterways and are actively conducting research on their design and effectiveness on small-scale local sites through to nationally important, critical infrastructure projects.

PORTER BROOK, SHEFFIELD

Daylighted streams offer a range of benefits.

The scope also includes investigation into the thousands of culverts under existing infrastructure that cannot be deculverted. Solutions here involve lighting and other techniques, as a retro-fit solution until they become possible to open up fully in future generations.

PORTER BROOK, SHEFFIELD

Arup developed the options for various river restoration projects, including the daylighting of 50 m of redundant culverts in Sheffield city centre and an accompanying 'pocket park' on the river bank. The resulting restoration project improved biodiversity and basin connectivity, resulting in the re-emergence of brown trout and reducing flood risk. The development appeal of the whole area has been boosted, as people are able to relax by the river and even go for a paddle.



Aquatic ecology

Arup is able to provide a suite of freshwater ecology services from technical surveying and WFD assessment through to planning, habitat design and project management. Our breadth and variety of skills combined with our commitment to a co-ordinated cross discipline approach mean we can add value and efficiency to projects, providing a cost effective source of integrated ecological advice and expertise.

GOUTHWAITE SSSI

Arup were commissioned by Yorkshire Water to investigate the relative efficacy of control methods for the invasive non-native species, New Zealand Pigmyweed *Crassula helmsii*, which occupies large areas of Gouthwaite Reservoir SSSI. Following a detailed literature review, Arup designed and implemented a multi-year field trial to test the relative efficacy of traditional (glyphosate-based herbicide) and innovative (hot water and hot foam) control methods.

The trial methodology, which was developed with Natural England, consisted of twelve 100m² test plots and was designed to test both the treatment success of each method and the practicality of scaling the methods for long-term treatment of the entire site.

As a result of this successful trial, Arup identified herbicide treatment as the only feasible method for large scale management at the site. Hot foam and hot water treatments were also shown to be effective control methods, but, were considered to be impractical for the site and posed a greater biosecurity risk due to the complex equipment required for application that would need to be cleaned to avoid spreading *Crassula* between sites.

RIVER LOXLEY FLOOD ALLEVIATION SCHEME (FAS)

Arup were commissioned by Sheffield City Council to undertake a Preliminary Ecological Appraisal (PEA) of the River Loxley to support the planning application for the proposed FAS.

Given the potential risk to freshwater habitats, a freshwater ecologist joined the survey team and undertook fish habitat mapping and protected species scoping surveys.

The precise location, extent, condition and juxtaposition of aquatic habitats were mapped, including sensitive habitats such as juvenile lamprey and salmonid spawning gravels. This data informed the EIA and WFD assessment and fed into the construction and operation phase mitigation design.



MASTERPLAN

A visualisation of the Eco-wetland Masterplan Design in Shang Qin Hai, China, intended to enhance biodiversity and provide water quality improvements.

SHANG QIN HUI

Arup's UK team of ecologists worked closely with water engineers and landscape architects to develop ecohydrological strategies, a pollution control strategy and an eco-wetland masterplan design. Services provided aimed to improve water quality, enhance biodiversity and alleviate flooding over an 11km² area of Yangtze River floodplain to the south of Nanjing city, restoring waterways to a more natural state, reducing pollution inputs and improving water quality.

The strategies developed were grounded in baseline surveys and included options for ecological enhancement of man-made watercourses and wetlands, pollution control measures

via topographic remodelling, guidance on planting, and designing aquatic habitats to attract target fauna species. The team also produced a method statement to prevent pollution impacts during construction.

Arup's work resulted in a robust masterplan landscape, resilient to future flood events and other climate change impacts. The strategies also incorporated recommendations for sustainable agriculture, eco-tourism and local community involvement to ensure long-term sustained environmental improvements.

Environmental flows

The definition of appropriate environmental flow regimes through hydropower schemes and water storage reservoirs is a key part of mitigation. Insufficient (magnitude and variability) environmental flows can be detrimental to the environment, specifically for the effected morphology, ecology and society. Arup's work planning new reservoirs, such as those at Cheddar near Bristol and Havant Thicket in Portsmouth, and in advising on hydropower projects across the UK and Europe has involved detailed consideration of how these adverse impacts can be mitigated.

The design of environmental flow regimes should be unique for each specific water resources or hydropower development. Suitable environmental flow regime development and prescription needs to be informed by thoroughly understanding the nature of the proposals, the dynamics of the catchment system affected and the needs of downstream receptors.

This involves consideration of catchment hydrology, dynamic geomorphology, ecology and anthropogenic uses including culture and heritage all in the context of a changing climate and population. Monitoring and the potential for adaptive management are key considerations to account for uncertainty, and to reduce environmental risk in general.

We take a holistic and system-focused approach to environmental flow definition, meaning that environmental flow regimes can be tailored to the specificity and complexity of any given location to provide more sustainable forms of resource management and reduce environmental harm as far as is reasonably possible. In the last two years we have worked on environmental flow related projects at approximately 25 locations in the UK and abroad.

YWS PILOT INVESTIGATIONS

Arup and Salix worked in close collaboration to deliver two river restoration pilot schemes, addressing low flow impacts resulting from impoundments. The objectives of the projects were to establish the technical feasibility, economic cost and benefits of generic mitigation measures on heavily modified water bodies and to test the extent that river restoration can be used to mitigate the negative impacts of artificially reduced flows.



Ecosystem services

The Monetary Value of Catchment Restoration Natural capital and ecosystem service provision have become prominent features of policy and guidance documents in recent years. This is a response by government and business organisations to the growing acceptance that there are negative feedbacks associated with the exploitation of the natural environment. Arup's services include identifying the policies driving ecosystem services assessments, investigating the potential to monetise ecosystem services and exploring how the catchment management offering can deliver ecosystem services.

There is a political and social will to recognise and value the benefits human society derives from ecosystem services. This is likely to be formalised within the planning application process through environmental impact assessments. Arup undertakes catchment management work with the view to delivering and enhancing a wide range of ecosystem services.

Further research is being considered for an ecosystem services analysis tool which could be incorporated into a cost benefit analysis. This will enable monetisation to translate into non-equivalent values associated with different ecosystem services into a single, comparable metric. Using this metric, the entire ecosystem services impact of different options for a single project could be evaluated and the option offering the highest 'monetary value' identified.

ECOSYSTEM SERVICES

Natural landscapes offer a host of ecosystem services with social, economical and environmental benefit.



HYDROPOWER FEASIBILITY

Environmental flows surveys in the Caucasus Mountains, Georgia.

Our core team



Dr Alex Nicholson



Dr Adam Broadhead



Prof Alastair Driver



Anna Lavelle



Annie Moore



Dr Chris Mellor



Katie Atkinson



Dr Lizzie Gardner



Laura Foden



Louise Bingham



Martyn Tattersall



Matthew Brennan



Chris Procter



Cat Dixon



Daniel Newton



Dan Bevan



Donald Daly



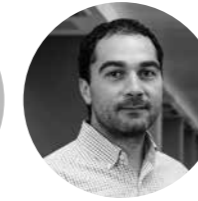
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Dr Rhodri Thomas



Ruth Green



Sian Leake



Simon Flemming



Dr Sally German



Tom Styles



Dr Irantzu Lexartza-Artza



India Rayner



Jack Bellingham



Jo Nelson



Justin Abbott



Jodie Hall



Tom House



Tom Wardley



Tasmin Chisnall



Will McBain

About Arup

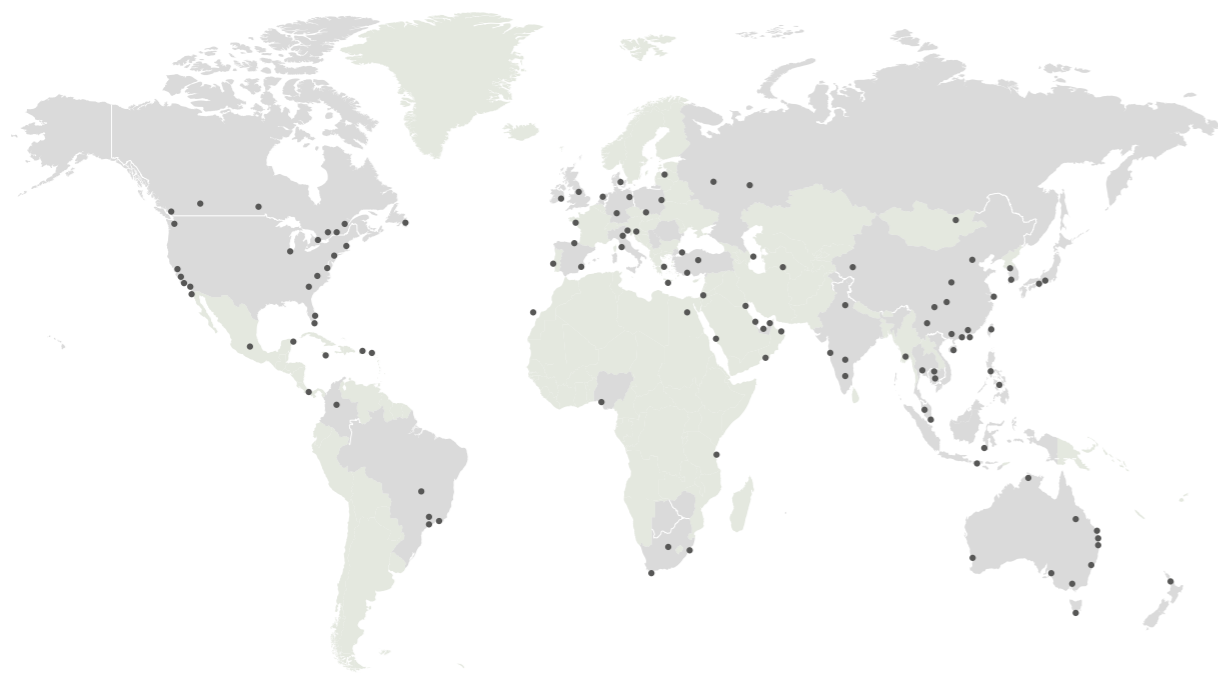
Arup is a firm of designers, engineers and business consultants providing a diverse range of professional services to clients. The firm is the creative and inspirational force behind many of the world's most innovative and sustainable planning, building and infrastructure projects.

We believe that talented people and collaborative working relationships form the basis of successful project delivery. By sharing knowledge and expertise with colleagues across the globe, our local teams can draw upon a wide range of specialist skills. Through bringing together an unrivalled range of technical, design, creative and management expertise we create real value for our clients.

We are a wholly independent organisation owned in trust, giving us the freedom to work on some of the most challenging projects in the world. We have more than 15,000 staff working in 96 offices in more than 38 countries. Arup's multidisciplinary approach means that any given project may involve people from any or all of the sectors or regions in which we operate. Our fundamental aim is to bring together the best professionals to meet our clients' needs.



▲ Arup are proud partners of the 2020 UK River Prize.



We shape a better world

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