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Connecting the Culm

This is one of 15 case studies informing the Infrastructure Systems Review.

System: River Culm catchment.

Systems contribution and value: Reframed flood risk and environmental challenges at whole catchment scale, co-creating a coordinated 25-year intervention portfolio. Potential to reduce flood risk and transport disruption, with wider environmental and social co-benefits.

Author
Neil Carhart

Contributors
Ursula Bryan
Phil Mccann
Will Varah
Tim Youngs

Summary

The River Culm is a principal tributary to the River Exe. It has a large catchment that is ecologically degraded. The lower Culm suffers from poor water quality and is prone to flooding.

The Connecting the Culm (CtC) partnership and its catchment-scale programme of interconnected actions uses nature-based solutions (NbS) to improve the resilience of critical transport infrastructure and the communities that rely upon it. The CtC project is based in the South West and is critical for regional connectivity and resilience. It spans local authority boundaries and involves multiple stakeholders who traditionally have not worked together. Since its start in 2019 the project has accrued £3 million in funding.

The South West peninsular, Devon and Cornwall, is especially vulnerable to climate change and faces interlinked issues from agricultural runoff, habitat decline, drought and flooding. The Great Western Railway has been closed by flooding annually since 2008. The M5 motorway is also at increased risk of disruption from flooding. With only one primary rail route in/out, and limited high capacity road connectivity, this has severe economic and social impacts for the region, with the effects of disruption cascading through the national transport network.

Challenges of flooding, water quality and degraded habitats arose "because the river has often been treated by policy-makers, land managers and individual residents as a series of disconnected units with disparate functions".[1] The focus of the case study is therefore on the project's central challenges and enablers: community co-creation, local authority cooperation and whole catchment planning. It demonstrates a fundamental use of systems thinking.

CtC began by applying adaptation pathway principles to identify infrastructure 'tipping points' in the 300km^2 catchment, from which the most effective NbS could be modelled. The co-creation of a 25-year blueprint with stakeholders, land managers and communities followed, setting the ambition and laying the foundations for installing multi-objective, co-designed NbS. This unlocked multiple synergistic interventions to improve wellbeing, cut peak flooding by up to 20%, reduce flood damage by an estimated 11%[2], and save the rail industry at least £96,000 pa in flood disruption costs.

Scope

CtC is a long-term integrated programme of activities within the 300km^2 River Culm catchment. This is the 'system of interest'. CtC's scope encompasses the catchment and all the systems affecting and affected by the Culm.

The area is home to ~30,000 residents and is earmarked for construction of an additional 5,000 homes. It also includes nationally important wildlife habitats that support

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endangered and protected species. CtC's approach is based around three pillars:

- Co-creation
- Nature-based solutions (NbS)
- Climate adaptation.

It aims to improve the wellbeing of people and nature by addressing flooding, drought, water quality, soil quality, biodiversity and infrastructure resilience as interconnected issues requiring joined-up interventions.

The catchment crosses administrative boundaries and the project is led by the Blackdown Hills National Landscape, in partnership with The Department for Environment, Food and Rural Affairs (Defra), Devon County Council, Mid Devon District Council, Somerset Council, the National Trust, National Highways, Network Rail and the Environment Agency. The project has additionally worked with local communities and over 80 landowners to co-design NbS.[3]

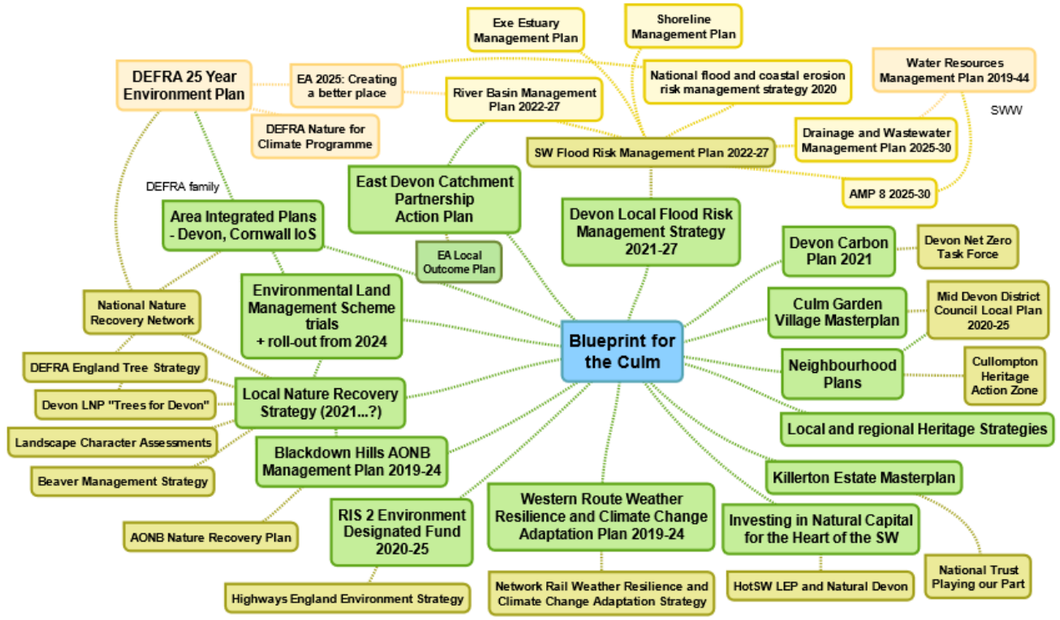
CtC's temporal and geographic scope has produced a 25-year blueprint for management and investment that includes all upstream land and tributaries that drain into the River Culm. This uses scenario forecasting and network mapping to identify intervention areas that would collectively deliver synergistic benefits from NbS and new governance solutions.

Fragmented responsibilities for interdependent issues within the catchment necessitate a systems approach. Interdependencies and systemic effects exist across scales, from local to national, as activity within the catchment affects national infrastructure resilience. Although no single named systems method has been applied, systems thinking principles are embedded implicitly throughout CtC's inclusive participatory workshops and mapping activities, its collaborative governance structures and its joined-up catchment-scale approach to intervention planning.

1 JBA Consulting (2023) Creating a better future for the River Culm | JBA Consulting. Available at: https://www.jbaconsulting.com/projects/creating-a-better-future-for-the-river-culm/
2 Connecting the Culm (2021) How is the River Culm performing? Available at: https://connectingtheculm.com/how-is-the-river-culm-performing/
3 Green Finance Institute (2018) Investment Readiness Toolkit – Milestone 5: Develop Business Case and Financial Model – Connecting the Culm. Available at: https://hive.greenfinanceinstitute.com/gfihive/toolkit/developing-a-business-case-and-financial-model/connecting-the-culm/

The evidence base for systems change Connecting the Culm

Figure 1. CtC blueprint policy and strategy map



How the Culm valley may look when CtC achieves maturity



Outcomes

Desired system outcomes are:

- a healthy, efficient and effective catchment that provides flood and drought resilience for critical infrastructure and communities
- a range of co-benefits including biodiversity and carbon storage, supporting a resilient local economy.

Residents, community organisations, businesses and statutory authorities co-created a shared vision:

"The River Culm will be celebrated as a lifeline that connects people with each other and with nature. Land across the catchment will be managed to protect and enhance the river, whilst sustaining people's livelihoods. Throughout the seasons and as the climate changes, the River Culm will have space to flow naturally and safely. The water will run clear, wildlife will flourish, and people will easily access and enjoy all of these benefits."[4]

Actual system outcomes at present are different. Human activity has changed the natural landscape, including tree removal and soil compaction, causing rain in the upper catchment to rapidly flow into the river, carving deeper channels, eroding farmland, lowering water quality, damaging aquatic ecosystems and increasing flood risk.

Water quality is further affected by farmland runoff and ageing sewer systems. All 11 water bodies in the Culm catchment are failing under the Water Framework Directive.[5] The Great Western Railway line has flooded more than 14 times since 2008 at the Hele crossing, at the extreme low end of the catchment, disrupting the main rail route serving Devon and Cornwall.

Desired outcomes are enhanced resilience to flood and drought, improved water quality and biodiversity, support for the use of NbS, and the involvement of local residents in decision-making.[6] The blueprint seeks to return the river to 'good' ecological condition, make around 200 properties and businesses more resilience to flooding, restore 3,000ha of degraded habitats[7], generate £2.6 million in carbon benefits[8], and reduce flooding at the Hele crossing by up to 10 hours per flood event.[9] This is achieved by overcoming fragmented management to co-create an integrated long-term plan.

Realisation of actual outcomes will be a long-term process. However, intermediate outcomes include the participation of over 80 landowners in the co-design of NbS intended to slow water flow and improve the quality of soil and water. The CtC project has created 172 leaky woody dams to retain and slow water flow in the upper catchment, and around 2,000m^2 of temporary water storage through landscaping to create scrapes and swales.

Beyond the system boundary, the catchment is influenced by climate change, national policy, agricultural markets, housing requirements, NbS funding mechanisms and regional transport demands.

The project has succeeded in engaging residents, communities and stakeholders across the catchment. In 2025, the Connecting the Culm Community Interest Company (CIC) was formed. The CIC can step in to support the Blueprint in ways that local authorities and statutory bodies cannot, for example by entering long-term private green finance arrangements, raising and holding funds, and leasing or buying land.

While the physical measures separately provide benefits to water retention, soil quality and habitats, the additional contribution of systems thinking allows them to be planned and implemented in a way builds stakeholder support and coordination, and allows their effects to combine at catchment scale.

Systems

The 300km^2 River Culm catchment spans south Somerset, and mid and east Devon. It is approximately 87% agricultural, 9% woodland and 4% built environment. Natural elements of the system include waterways, soils, hedgerow networks, woodlands, wetland habitats and aquatic ecologies. The built environment includes farms, communities, their supporting infrastructure, the M5 motorway and Great Western Railway.

These elements interact across landowner and governance boundaries. For example, upstream land management affects soil quality, water runoff, flood characteristics and the downstream resilience of transport services. The treatment of these as disconnected issues is an underlying cause of the barriers to achieving the desired outcomes.

Beyond the system boundary, the catchment is influenced by climate change, national policy, agricultural markets, housing requirements, NbS funding mechanisms and regional transport demands.

Systems approaches are manifest in co-creation with local stakeholders, co-ordination of governance agencies and catchment-scale modelling. They influence systemic understanding through the blueprint for the River Culm and the 'Potential areas for improved resilience (PAIRS)' framework.

The blueprint was developed through participatory workshops and interviews, producing a policy map (Figure 1), coordinating a portfolio of work across the catchment and enhancing integration of public and private sector actors. For example, encouraging housing developers to collaborate in catchment flood risk management supports action beyond legislative requirements for neutral flood risk impact.[10] Such collaboration is required when costs of improvement fall to landowners upstream, and benefits are seen to be accrued by those downstream.

The PAIRS framework combined geomorphology, hydrology, land surveys, expert knowledge and local lived experience to identify NbS intervention points. It forms an information/data layer of the system of interest – the catchment.

Three scenarios (restoring soil to reduce runoff, creating features that intercept runoff and riparian tree and hedge planting) were considered to identify the best programme of intervention to achieve the desired outcomes, rather than deciding on a site-by-site basis.

By combining datasets on soil, land use, runoff, habitats and rivers, modelling identified areas where interventions can deliver greatest impacts. This enabled the mapping of opportunity areas that can deliver multiple significant impacts, allowing for the prioritisation of interventions that deliver resilience alongside environmental benefits. This understanding underpinned access to Environment Agency flood grant in aid (GiA) funding for NbS that delivers further environmental and societal benefits.

Collectively, the systems thinking principles that underpin the blueprint and PAIRS framework unlock value by advancing understanding, facilitating collaboration, addressing root causes and directing potential investment at interventions that deliver multiple and synergistic benefits to the natural and built environment.

Interventions

The PAIRS framework and blueprint are key to the design and implementation of interventions. The process begins by working with key stakeholders, including infrastructure operators, to understand the desired outcomes, such as a 20% reduction in peak flooding. The best combination of NbS can then be identified through modelling of options.

By adopting a holistic catchment-wide perspective, founded on place-based community co-creation, the project was able to design a portfolio of nature-based interventions in a single, coherent, joined-up programme. As part of the longer term two-year blueprint, over 1,000 interventions have been implemented, valued at £1 million.

Examples of specific interventions considered are shown in Table 1. But the added value emerges from their interaction and synergy. It is important to note that these NbS are expandable and scalable, should environmental conditions or desired outcomes change, in ways that traditional 'grey' infrastructure interventions are not.

Interventions are split into two strands:

- Headwater NbS to slow runoff and increase infiltration (for example, woodland planting and soil management)
- Floodplain reconnection for railway resilience (slowing water flow through vegetation and temporary storage)

Assessment of the portfolio of nature-based interventions in the blueprint suggests the cumulative result would see an overall eight hour reduction in the duration of railway flooding incidents at the Hele crossing. This represents a significant improvement in performance and transport resilience.

Economic assessment

There is no direct conventional comparator that would deliver the same outcomes as CtC. However, business as usual would likely mean reactive disruption management and/or separate, asset-specific interventions. Addressing risks while leaving upstream causes and wider downstream benefits out of the economic investment case can be inefficient or even ineffective. For example, carrying out interventions to improve downstream soil quality while ignoring the upstream causes of its degradation could be costly and futile. Failing to value and capture the wider benefits of an intervention in its business case may constrain access to finance. As climate risks increase, the cost of action or inaction are likely to also rise.

The benefit of adopting a holistic, catchment scale approach across local authorities becomes clearer when looking at traditional, discrete interventions implemented to deliver similar outcomes.

Valuing biodiversity gains, habitat improvements and the health benefits of access to nature can be challenging. While flood resilience is only part of CtC's aims, it is nevertheless the area of impact where traditional economic appraisal may facilitate easier comparison to business as usual. In 2020 the government committed £5.2 billion to flood defence between 2021 and 2027 and Network Rail, as an owner of at-risk assets in the Culm catchment, committed £2.8bn between 2024 and 2029 to make the railway more resilient to climate change impacts.[11]

A systems approach supported catchment-wide modelling that links upstream and downstream interventions and outcomes, while the PAIRS framework prioritised a portfolio

4 Groom, Clare (2022) Connecting the Culm – bringing vision to life. Available at: https://blackdownhills.org.uk/news/connecting-the-culm-bringing-our-vision-to-life/
5 Connecting the Culm (2023) The Water Framework Directive – results for the Culm. Available at: https://connectingtheculm.com/water-framework-directive/
6 Blackdown Hills National Landscape (2018) Connecting the Culm. Available at: https://blackdownhills.org.uk/project/connecting-the-culm/
7 Green Finance Institute (2024) Financing Natural Flood Management. Available at: https://connectingtheculm.com/wp-content/uploads/2024/04/GFI-Financing-NFM-Full-Report-2024-compressed.pdf
8 Connecting the Culm (2022) Green Finance for the River Culm. Available at: https://connectingtheculm.com/green-finance-for-the-river-culm
9 Network Rail (2024) Annual State of Nature Report. Available at: https://www.networkrail.co.uk/wp-content/uploads/2026/01/Annual-State-of-Nature-report-2024.pdf
10 Connecting the Culm (2025) Forum #7 – Managing water for nature and people. Available at: https://connectingtheculm.com/connecting-the-culm-forum-7/
11 Network Rail (2024) Weather Resilience and Climate Change Adaptation (WRCCA) Summary of Regional plans for 2024-2029. Available at: https://www.networkrail.co.uk/wp-content/uploads/2024/04/CP7-WRCCA-Plans-combined-summary-of-all-regions-April-2024.pdf

Table 1. Examples of considered interventions

Interventions	Impacts
Restoring hydrological function to spring-line and valley mires	Providing a range of ecosystem service benefits including flood attenuation and carbon storage in peat rich soils
Damming streams and drainage channels using natural woody debris to create attenuation ponds and silt traps	Reducing flood peaks and reducing downstream sedimentation
Innovative flood alleviation features on land associated with new, large developments	Showing how multi-use green infrastructure is deliverable, and unlocking significant co-benefits
Coppicing and laying bank-side trees to imitate beaver activity	Improve water oxygen levels and reduce livestock disturbance of the river bed
Reconnecting the river to its floodplain and restoring more natural floodplain function on intensive agricultural land, by re-creating floodplain attenuation features,	Restoring wetland habitat and unlocking other ecosystem service benefits such as carbon sequestration and biodiversity; enhancing access and recreation
Restoring agricultural soils	Enabling them to achieve their natural hydrological function
Restoring historic leat systems and ponds that hold flood-peak waters	Improving flood resilience and generating renewable electricity at their outlets

Table 2. CtC Systemic assessment

CtC has been assessed against seven 'success factors' and scored on a four level scale:
0 – Not met | 1 – Partly met | 2 – Mostly met | 3 – Fully met.

Success factor	Score	Discussion
Outcomes clarity	**3**	Outcomes are co-produced with diverse stakeholders and clearly stated in the blueprint. These are accompanied by medium- and long-term objectives which measure outputs as leading indicators of desired outcomes.
Systems capability	**2**	Definition of boundaries, co-production approaches and shared representations support system capability, with a holistic approach to catchment management fundamental to the project. Specific system approaches and capabilities are implicit.
Leverage focus	**2**	Despite the previous score, the blueprint and PAIRS modelling explicitly address leverage points and trade-offs to identify a portfolio of interventions with synergistic benefits. There is less clarity on the project's approach to paradigms, mindsets, incentive structures and behaviours that drive the observed actions and resulting symptoms.
Authorising leadership	**3**	The project's partnership model facilitates working across local authorities, while co-creation activities are designed to work across system boundaries, organisations and lifecycle stages.
Incentive alignment	**3**	CtC utilises system-level outcome performance measures and approaches that reinforce collaboration across diverse stakeholders. Consideration has been given to incentives and funding arrangements that support these outcomes, such as landowner payments for resilience gain units related to additional water storage and vegetation roughness.
Decision quality	**2**	Through the PAIRS modelling, decisions are made with transparent links to the desired outcomes of the project.
Adaptive learning	**2**	While the project has demonstrated the ability to experiment, learn and adapt, the formalisation of these processes is less clear.

The evidence base for systems change Connecting the Culm

of measures, providing an alternative to fragmented, piecemeal approaches to siloed asset protection and outcome delivery. It engaged and motivated multiple beneficiaries around shared outcomes, identifying a wider scope of potential funding sources and mechanisms, enabled by the formation of the CtCCIC.

A traditional 'grey' infrastructure solution was originally proposed by Network Rail, rebuilding two bridge structures to prevent overflow onto the railway, but this remains unfunded by the Department for Transport, hence Network Rail investigating 'green' solutions with CtC.

In 2022, CtC commissioned JBA Consulting to assess the economic value of a wider programme of NbS in the catchment (ie, a greater number of interventions than currently being implemented). This concluded that the time the rail line is closed to traffic could be reduced by up to 10 hours, delivering an annual benefit of £96k in terms of avoided disruption costs. Disruption from one in 10 year flood events would be reduced from six hours at present to just one hour.

Benefits to property, agricultural performance, biodiversity, water quality and health are yet to be economically assessed.

Starting in 2019, CtC was provided with 60% of its initial £1 million funding under the EU Interreg 2 Seas 'Co-Adapt' programme. The CIC is currently exploring new green finance mechanisms to support delivery of the blueprint, which is projected to cost £36 million over the next 20 years.[12] Around £15 million of this may come from publicly funded agri-environment schemes, with the balance from blended public/private sources. The systems approach has translated individual, disparate costs and investment opportunities into a single programme with synergistic and wider benefits than if they were they pursued separately. It demonstrates the potential to deliver a broader value stack from an integrated portfolio, attracting coordinated investment from diverse beneficiaries.

Systemic assessment

Systemic inefficiencies arise because catchment processes do not align with administrative boundaries.

The current system requires upstream actors to fund interventions for the benefit of downstream stakeholders and communities, including national networks. It disincentivises action by those who are closest to the root of the problem because they bear the cost but receive little reward. This then requires those at risk downstream to protect or improve their assets, which they do in silos. This is to the detriment of the whole system, and the loss of opportunity to generate synergistic co-benefits.

Approaching the Culm's problems at catchment scale, and joining up across organisational boundaries, allowed for better consideration of causes and effects, and the development of more effective interventions. It built relationships, trust and legitimacy, leading to effective co-creation. Shared mapping and a portfolio of interacting intervention and investment opportunities supports conversations about their ability to deliver better value than isolated actions.

Systems capability could be considered a binding constraint due to the lack of explicit reference to systems approaches and tools. However, CtC has utilised systems thinking implicitly and as part of its underpinning mindset.

Tools can facilitate and support a systems approach, but this project demonstrates they are not always necessary. Systems thinking capability should be developed first, before selecting the most appropriate tools.

Additionally, more efficient and effective funding can arise through valuing stacked benefits across temporal and organisational boundaries. Decision making is more efficient and effective if it goes beyond short term, site level neutrality to catchment wide benefit. This requires mechanisms that allow stakeholders to co-invest and take long-term financial decisions and responsibilities.

Recommendations

The Connecting the Culm case study suggests that place-based solutions should start with a clear understanding of the desired outcomes and the root causes of the problem, not just visible symptoms and traditional, pre-determined interventions.

By defining desired outcomes, such as reduced peak flows and increasing infrastructure resilience, and understanding the behaviour of the whole catchment, the PAIRS approach enabled identification of the combination of interventions required to deliver them.

It is necessary to work with stakeholders at the earliest opportunity. Co-creation with landowners, national infrastructure operators, farmers and local communities helped CtC understand key tipping points, what needs to change and what interventions are feasible.

Efficiency should be judged against place based outcomes rather than narrow asset-specific performance. Effectiveness is as important, if not more so. Iterative co-design helps identify and recalibrate opportunities with landowner insights.

Replication is not about implementing specific systems tools, nature-based solutions or funding mechanisms. A systems mindset is the transferable key learning point. The definition of boundaries through critical reflection, the motivation to work across silos, the construction of willing coalitions, an understanding of interdependencies, and shared decision making are all embodied in this mindset.

Strong, systems-oriented leadership is critical. Replication relies on developing these capabilities within institutions.

12 Connecting the Culm (2026) Green Finance. Available at: https://connectingtheculm.com/green-finance/

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