Revitalising Eden
The Eden Catchment Plan

By the Eden Catchment Partnership
(Catchment Management group and CaBA group)

Edited by Eden Rivers Trust

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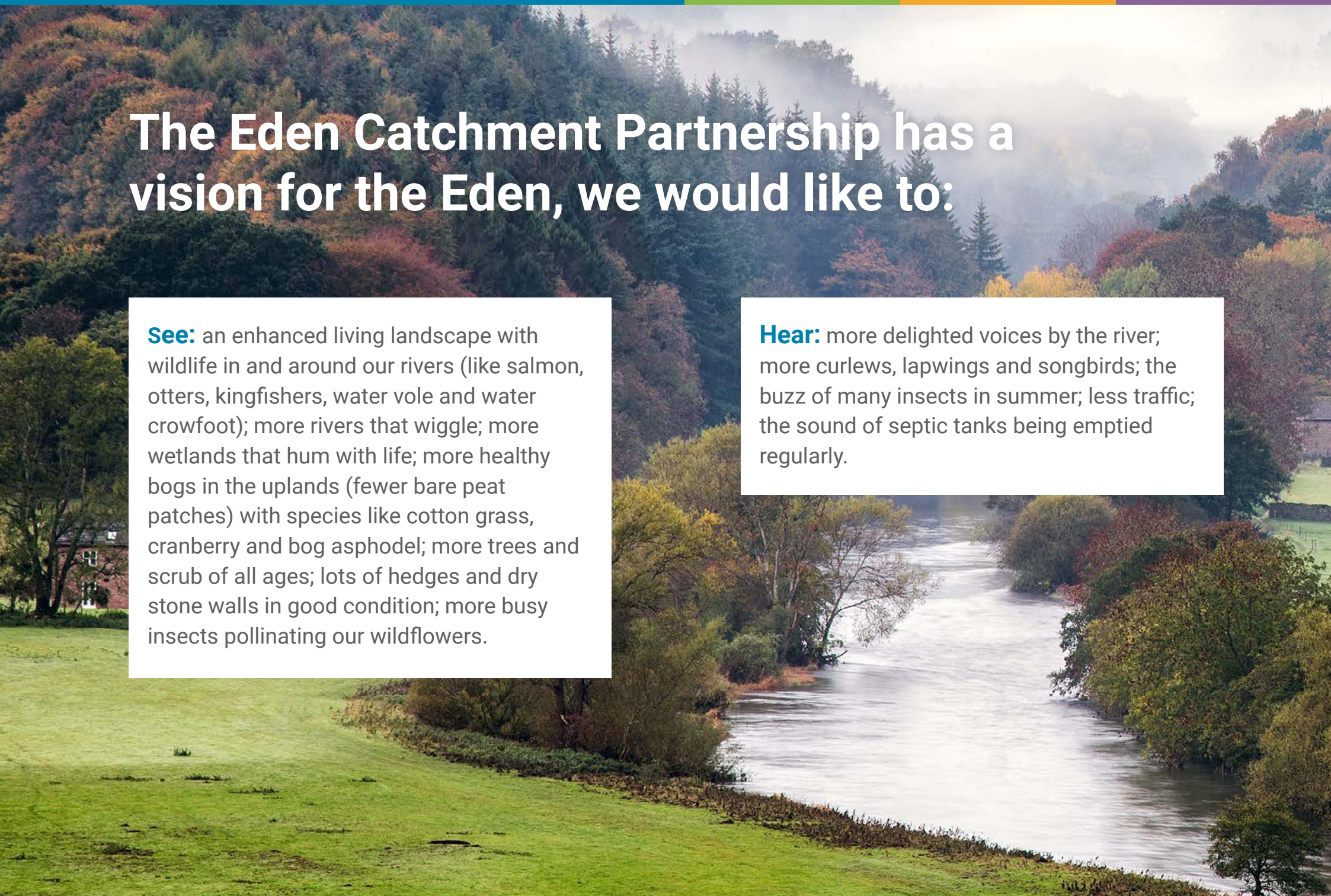
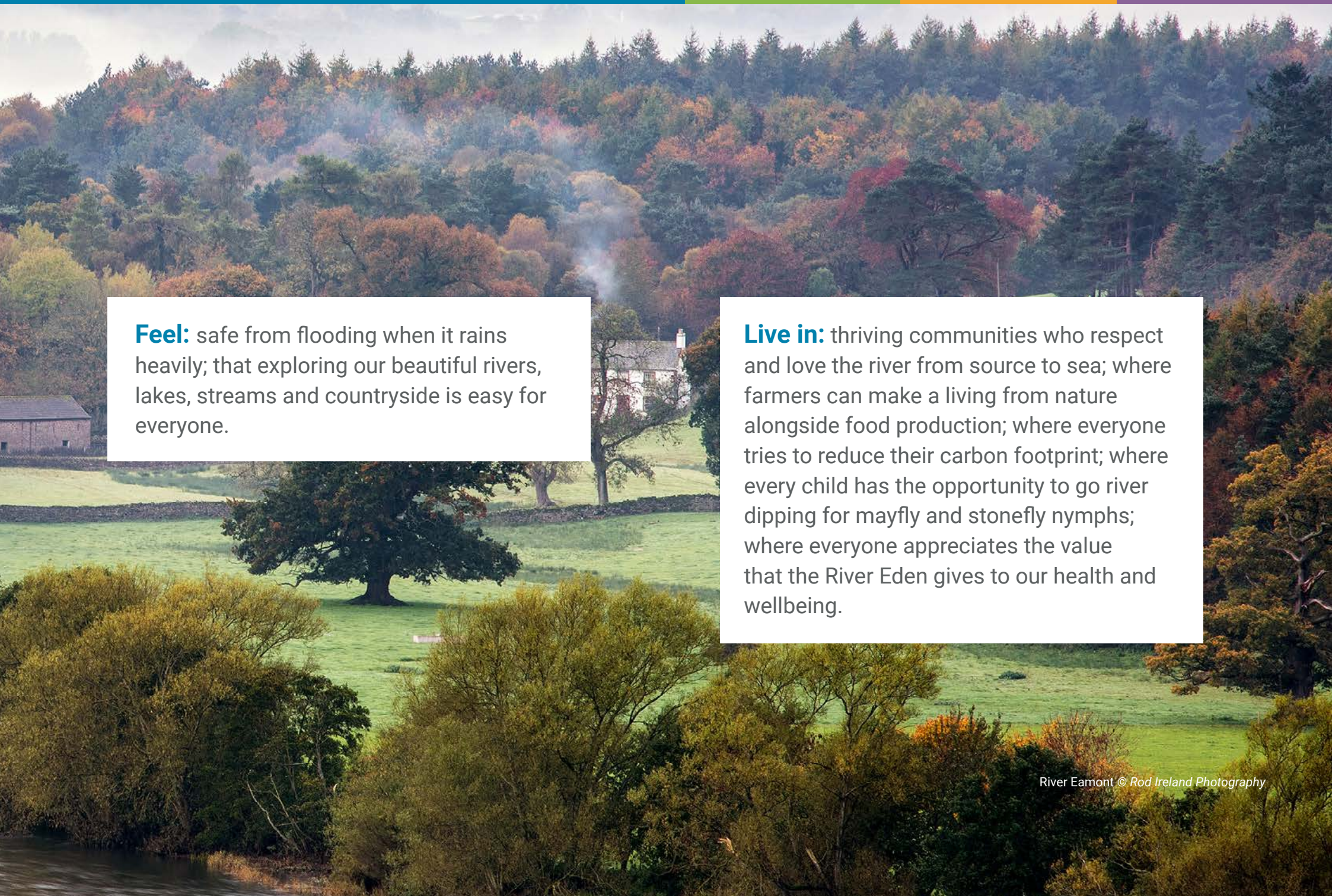


The Eden Catchment Partnership has a vision for the Eden, we would like to:

See: an enhanced living landscape with wildlife in and around our rivers (like salmon, otters, kingfishers, water vole and water crowfoot); more rivers that wiggle; more wetlands that hum with life; more healthy bogs in the uplands (fewer bare peat patches) with species like cotton grass, cranberry and bog asphodel; more trees and scrub of all ages; lots of hedges and dry stone walls in good condition; more busy insects pollinating our wildflowers.

Hear: more delighted voices by the river; more curlews, lapwings and songbirds; the buzz of many insects in summer; less traffic; the sound of septic tanks being emptied regularly.



Feel: safe from flooding when it rains heavily; that exploring our beautiful rivers, lakes, streams and countryside is easy for everyone.

Live in: thriving communities who respect and love the river from source to sea; where farmers can make a living from nature alongside food production; where everyone tries to reduce their carbon footprint; where every child has the opportunity to go river dipping for mayfly and stonefly nymphs; where everyone appreciates the value that the River Eden gives to our health and wellbeing.

River Eamont *© Rod Ireland Photography*

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PART 2: **Sub-catchment Action Plans**

A note about maps

All maps shown in this report were produced using the ESRI ArcGIS Pro software with the following credits

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Appendices

Data used to create maps:

Other datasets are credited through the report with all the opportunity maps datasets listed in Appendix 1 along with the relevant credits.

Perspectives

"What difference can one hedge make? You'd be surprised.
Just one new hedge, planted in the right place can do all this: improve shelter for wildlife and livestock, increase biodiversity such as pollinators and crop pest predators, reduce flooding by improving water infiltration and providing a physical barrier to slow water flow, protect water quality and river wildlife and maintain soil health by preventing slurry, ammonia and top soil drifting into rivers; and
store carbon.

That one hypothetical hedge sums up the principle behind this plan to Revitalise Eden - working with nature and natural processes to provide multiple benefits for the environment and people across the Eden. Working with nature has time and again shown to be cost effective and essential for long-term success when aiming to improve the quality of water and the way it is managed.

It requires investment in people as much as nature itself. Investment in time, to listen and understand social contexts and culture, to make connections, share expertise and find common goals.

Thankfully, we are not starting from ground zero in the Eden, much has already been achieved to improve catchment management by the many people who in their own way share our vision. But we need transformational change, and for this we need to scale up on all fronts. We need more political will, good will and a willingness to change. We hope you will join us in our endeavours.

Just one hedge, imagine what 40 could do."

Elizabeth Radford. Chief Executive of Eden Rivers Trust and Chair of the Eden Catchment Partnership

Litter picking with Sustainable Carlisle © *ERT*

"Eden's communities have always shown great ambition to improve the environment of this fabulously diverse catchment that stretches from the fells around Mallerstang to the expanses of the Solway Firth.

I am delighted to see so many stakeholders continuing to collaborate with the development of this new Catchment Plan. Its detailed, targeted actions will help to address the multiple water management challenges we face in the Eden - not least the increasing frequency of flooding, a shadow that many of Eden's inhabitants live under.

The Environment Agency is a strong supporter of the catchment based approach to water management which is at the core of this plan, one that recognises that processes on land and water are interconnected and must all be considered to enable better water management.

As a key member of the Eden Catchment Partnership, the Agency will continue to play our part in the Plan's delivery, to bring genuine environmental improvement for all communities to enjoy, whilst reducing the risk of life-changing fear and misery that flooding can bring. I really look forward to working with others to deliver our collective ambition for a healthy environment, supporting important and successful businesses and valued by everyone."

Keith Ashcroft
Environment Agency, Area Director for Cumbria and Lancashire

"I have lived here in our small village on Eden's fellside for 44 years, but it is only in the last 20-25 years that the beck has caused problems, possibly getting worse in the last 10 years.

Initially we had meetings with the Local Flood Risk Management (LFRM) team from the County Council who were working on an investigation/report on flooding problems on the fellside.
This created an important connection with the LFRM team, mainly to keep information flowing between the County Council and the Parish Council.

We were told we must also help ourselves, which we have done by starting a small flood group that reports to the Parish Council and involving other villagers when needed e.g. keeping the beck clear of blockages, keeping drains and culverts clear. We've done work to our properties, laying drains, installing pumps and generators, gradually learning what works. We very much appreciated the leaky dams and a pond installed on the beck with the help of Eden Rivers Trust, and we've put cameras up to help monitor them.

We think it's helping, but we need measurements to be sure – it's certainly not making things worse. We need more leaky dams to take this beyond a trial. It's frustrating to hear, "your community has too few houses to receive funding", because surely what we do up here on the fell could slow the water and help others downstream. We know now we've got otters on the beck! Maybe we need beavers too, to build some more leaky dams!"

Lynne Robinson and the Cumrew Flood Group

Executive Summary

The Eden Catchment Partnership has developed this Catchment Plan to identify and prioritise the action needed to manage Eden's rivers sustainably whilst improving the natural (ecosystem) services of the catchment.

This plan brings together the flood mitigation and the environmental protection aspects of water management. It recognises the fundamental role of sustainable water management in maintaining Eden's ecosystem services, and its importance in delivering the reshaped environmental policy described within Defra's 25-year Environment Plan; as well as addressing issues resulting from the climate crisis.

The state of, and pressures on Eden's ecosystem services have been analysed using spatial data, expert opinion and local evidence.

These services are categorised as water quality, water quantity (high and low flows), ecological networks, carbon capture and storage, and recreation and leisure.

The response required to improve ecosystem services and locations where interventions are urgent or will have the greatest potential for improvement has been identified, along with specific actions and projects that Partnership members and other interested parties should undertake.

Opportunities to improve every ecosystem service exist in all parts of the Eden catchment, so every stakeholder group has a part to play in delivering this plan.

Key findings

- The Eden is an internationally important river for biodiversity and geology known as a Special Area for Conservation. Despite this, in a UK wide classification of water bodies, **none of Eden's 86 official water body units have 'high' water quality status, and 21% are classed as 'poor' or 'bad'.**
- The whole catchment contains numerous sites designated for wildlife, landscape and heritage value, however nearly half of these Sites of Special Scientific Interest (SSSIs) are in unfavourable condition and 14 are declining.
- Flooding affects communities throughout the Eden as a result of climate and topography. It is exacerbated by land management changes that have fragmented and reduced the quality and extent of natural habitat, particularly woodland and wetland (including peatland). These land use changes – both current and historical – also affect the provision of ecological networks and carbon capture and storage.
- The greatest threat to Eden's water quality is agricultural pollution in the form of excess nutrients in run off and sediments.
- Poor septic tank management is acute in some areas.
- Whilst upland carbon stores are significant compared to lowland areas, they are largely in poor condition and continue to diminish.
- Access to Eden's many fine recreation areas (the sixth category of ecosystem service) is a real challenge without private transport.

The way forward

Across the catchment, woodland and wetland habitat creation, river restoration, peat restoration and improved soil and nutrient management have the potential to improve multiple ecosystem services.

Interventions that slow water flow, reduce nutrient input to water bodies, increase water storage capacity, capture carbon, extend ecological networks and increase diversity and abundance of native species all enhance the landscape.

Improvements to water quality are required throughout the catchment. Areas showing great potential for improvement are in the upper and mid Caldew sub-catchment, the Irthing, the upper Eamont and the upper Eden.

Flood management opportunities using Natural Flood Management techniques are also applicable in many of Eden's upper catchments. Flood alleviation interventions in Brunstock, Glenridding, Low Crooks Gill and the Upper Petteril's becks could also have an effect in improving the management of high flows, as well as along the main River Eden.

Some areas have greater opportunity for improving multiple ecosystem services; the areas around Ullswater, the Upper Petteril catchment, the flood plain of the Lower Eden near Carlisle and the eastern edge of the Irthing catchment.

Alongside interventions, proper enforcement of relevant regulations across the Eden is recognised as an essential part of achieving the vision of the Catchment Plan. Statutory agencies responsible must rise to the challenge and be adequately resourced to do so.

About the Eden Catchment Partnership

The Partnership represents everyone involved with the waters of the Eden; over twenty organisations (statutory agencies, local government, private, non-government, community and academic) working together as a catalyst for integrated catchment management in the Eden.

The Eden Catchment Plan has been developed collaboratively with all Catchment Partnership members, led by Eden Rivers Trust. The plan provides a framework agreed by the Partnership that identifies, prioritises and begins to address the major issues affecting ecosystem service provision within the catchment. Whilst not an exhaustive list of all partners' priorities; the activities proposed are supported by the Partnership members as contributing to the change necessary to revitalise the ecosystem services of the Eden Catchment.

Introduction

Revitalising Eden: **The Eden Catchment Plan**

Why a new Catchment Plan for the Eden?

Despite there being no single body responsible for water management in the Eden catchment (or indeed in any catchment in England and Wales), Eden has a history of bringing those who have an interest in working together to improve the quality of the water management.

In 1995, the first integrated catchment management plan for the River Eden was developed by the National Rivers Authority, and in 2012/13 the first holistic plan for managing water in the catchment was developed by a diverse group of stakeholders (conservationists, farmers, statutory agencies, water companies and community volunteers) through a process led by Eden Rivers Trust. The result was a manifesto called *Saving Eden* which focused on improving the ecological and social value of the River Eden and resulted in the formation of a Catchment Partnership. Partnership members agreed to work more closely together on projects following the principles of integrated catchment management (see *right*).

In December 2015, Cumbria was rocked by devastating floods caused by Storms Desmond and Eva that flooded 5,200 homes across Cumbria and Lancashire.

These storms followed weeks of wet weather which had left the whole of the Eden catchment saturated. 341mm of rainfall was recorded in 24 hours at Honister Pass and 2,128 properties flooded in Carlisle alone.[1][2]

With an estimated £1.6 billion of physical damage to homes and livelihoods and an incalculable long term effect on the mental health and wellbeing of those affected, the need to pay much greater attention to flood mitigation within the context of water management was rightly demanded of the Catchment Partnership, requiring it to refocus, adopt new projects and involve a wider stakeholder base.[3][4]

This work was carried out under the umbrella of the Cumbria Strategic Flood Partnership (CSFP) and contributed to the delivery of the 2016 *Cumbria Flood Action Plan*.[5] The Eden Catchment Partnership is represented on the CSFP and actively contributes to the development, delivery and revision of Cumbria's flood action plans.

Since 2015, there has been a much deeper recognition, both nationally and internationally, of the fundamental importance of maintaining intact natural processes and ecological networks to combat many of the issues associated with what has become a climate crisis, including flooding. This recognition is reshaping environmental policy (including water management) and is reflected within Defra's *25-year Environment Plan* which may soon be embedded in new laws for the environment and agriculture in England and Wales.[6]

Integrated Catchment Management (ICM)

ICM is a form of environmental planning which aims to achieve sustainable management of resources from the whole catchment perspective, considering the management of land and water and recognising the role of natural systems in providing services to people and regulating the environment.

ICM considers the complex relationships within ecosystems when managing the environment including the relationships between flora and fauna, between geology and hydrology, between soils, living systems and the atmosphere.

It recognises the cyclical nature of processes within an ecosystem, and values scientific and technical information for understanding and analysing the natural world.

A plan for whom?

Like those before it, this new Catchment Plan is developed by, and for the Catchment Partnership members who are all actively engaged in the sustainable management of water in the Eden catchment for the benefit of people and wildlife.

The Partnership hopes that the aspirations within this plan may also serve as a call to action for other water stakeholders and any citizens who care about improving the environment of the Eden catchment. Our vision for the Eden has universal appeal and to be achieved will require more than the Catchment Partnership members acting alone.

The core aims of this Catchment Plan, like those before it, are to set priorities for sustainable water management in the Eden that will assist Catchment Partnership members in targeting their activities to places which will have the greatest benefit; and in doing so to make the most of the collective resources available by working together.

In doing this, the Partnership will gain from the experience of previous projects, promote the fundamental importance of integrated catchment management and reiterate the message that every citizen is a stakeholder in this process and has a part to play in improving the management of Eden's water resources.

However, this plan goes further than those before it. It has been updated to reflect the change in the external environment and perspectives since 2013 - particularly the increase in intensity and frequency of flooding that threaten the livelihoods and communities of people living in the catchment.

This catchment plan is a renewed effort to target very specific activities to those areas where the greatest difference can be made that will make the Eden catchment more naturally resilient. These are activities that should result in a noticeable improvement in the quality of Eden's natural capital, which in turn will sustain the essential services such as clean air, pure water, flood management, that we rely on for 'a good life'.

Volunteers building leaky dams © *ERT*

Revitalising Eden: ***The Eden Catchment Plan*** **has three parts:**

PART 1: **Ecosystem services assessment**

Analyses of the current status of, and pressures on Eden's ecosystem services and the response required to improve them. This has been informed by the latest data available as well as local knowledge. The following ecosystem services were assessed:

1. **Water quality**
2. **Water quantity - management of high flows and flood risk**
3. **Water quantity - management of low flows and drought alleviation**
4. **Ecological networks - the provision of habitat for wildlife and biodiversity**
5. **Carbon capture and storage**
6. **Recreation and leisure**

The detailed methodology and the datasets used for each ecosystem service are described in Appendix 1.

PART 2: **Action Plans for each operational sub-catchment**

Provides greater detail on the six operational sub-catchments in the Eden, current, completed and selected aspirational projects, the opportunities to improve ecosystem services in the catchment and key sites where urgent action is required.

PART 3: **Dynamic Project list on the Eden Catchment Portal**

Shows the status and progress of all projects, including aspirational projects for the future and is held online. Project partners are responsible for updating this information to illustrate the progress or the blocks with those projects. The results are mapped here: https://edenriverstrust.org.uk/eden-catchment-partnership/

How long will the Plan run?

The aspiration for change contained in this plan covers a lifetime and the suggested projects will keep partners busy for 20 years if the resources remain at current levels.

The Catchment Partnership will review progress annually.

Good governance suggests a major review of priorities should be undertaken between 5 – 10 years from now, alongside the inevitable change in external pressures and perspectives as the climate crisis begins to unfold.

Armathwaite © *Rod Ireland Photography*

The climate crisis and Cumbria

Global emissions of carbon dioxide (CO_2) have increased by almost 50 per cent since 1990. Emissions grew more quickly between 2000 and 2010 than in each of the three previous decades.

The UN has warned that,
"As greenhouse gas levels continue to climb, climate change is occurring at much higher rates than anticipated, and its effects are evident worldwide… If left unchecked, global temperatures will rise by 3 degrees – affecting every ecosystem." (7)

What does this mean for the Eden? The Met Office has modelled two climate scenarios – one based on high emissions and one on low. They predict that within 80 years, all areas of the UK are projected to be warmer, more so in summer than in winter. Hotter, drier summers and warmer, wetter winters are predicted to become more common.(8)

In a high emissions scenario, precipitation is projected to change with up to 47% drier summers and up to 35% wetter winters. However, it is the changes in type of rainfall that could be a real cause for concern for Cumbria.

The Met Office projects that by 2070, more rain in winter will come from frontal rain events of higher intensity and in summer from short-lived, high-intensity showers.

In summer, these predicted changes in weather patterns will impact on the frequency and severity of surface water flooding, soil moisture and its vulnerability to erosion. In winter, Cumbria's location means that it will bear the brunt of westerly frontal systems.

The Eden Catchment in a nutshell

The Eden catchment is bordered by Lake District hills (west), the North Pennines (east), the Yorkshire Dales (south) and Northumberland (north). At 80 miles long, the River Eden is one of England's finest examples of a limestone and sandstone river. It flows north-west from its source in the fells near Kirkby Stephen to the Solway Firth and is a fast-flowing active system with habitats and wildlife of international importance. There are five principal tributaries, three of which converge with the main river Eden near Carlisle.

The Eden catchment covers an area of 2400km^2 with an elevation range of 950m. The landscape is dominated by small farms as soils are largely productive and woodland cover is limited to around 260km^2 (approx. 10%), with non-woodland canopy areas (hedges and field trees) being important landscape and ecological features.

Farming and tourism are crucial to the economy. Even though only 161,000 people live in the catchment, the Eden catchment received 14.2 million visitors in 2018 and tourism activity supported 14,300 full time equivalent jobs in 2018.(9)

The Upper Eden catchment receives an average annual rainfall of 2800mm which is 3.5 times the national average. This falls on a relatively small area of land - much of which is very steep, leading to the water quickly entering watercourses and therefore leading to a high flood risk. Managing this amount of water sustainably in such a landscape presents huge challenges for Eden's communities.

PART 1: **Ecosystem Service Assessment**

Water Quality

Catchment Partnership Goal:

Eden's water is pure enough to support sustained populations of our diverse and iconic wildlife (e.g. Atlantic salmon, White-clawed crayfish, otters, kingfishers and Water crowfoot); provides the basis for high quality drinking water; and is fit to swim in.

State

The quality of water in the Eden catchment can be measured using **Water Framework Directive (WFD) status of waterbodies.** This is a UK-wide measure which combines information on the chemical and ecological status of each waterbody which are then classed as having **High, Good, Moderate, Poor or Bad** status.

In the Eden catchment, there are 86 separately assessed water bodies (including watercourses). None are classified as 'High' status, 35 (41%) are classified as 'Good', 33 (38%) are 'Moderate' and 17 (20%) are 'Poor'. There is one waterbody classified as 'Bad' (Gillcambon Beck on the Caldew).

Poor quality waterbodies are found within every part of the catchment (refer to orange areas on the WFD status map shown in *Figure 2)* and these waterbodies, alongside Gillcambon Beck, are in need of concerted action now to improve water quality[10]:

Upper Eden: Morland Beck, Lyvennet and Low Gill Crooks Beck.
Eamont: Glenridding Beck.
Irthing: Crammel Linn, Butterburn, Quarry Beck, Gelt, New Water.
Caldew: d/s Caldbeck, Pow Beck, Ive, and
Lower Eden: Pow Maughan Beck, Cairn Beck, Briggle Beck and Lower Croglin Water.

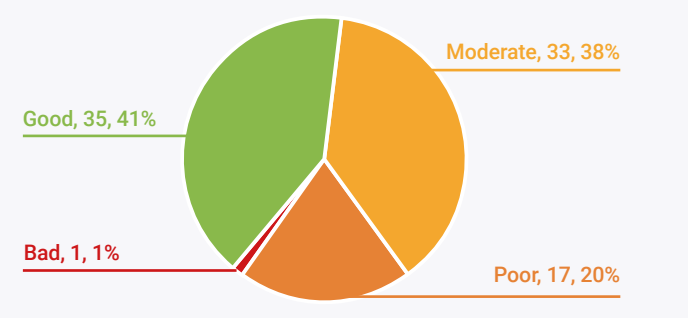


Figure 1. Water Framework Directive Status.[11]

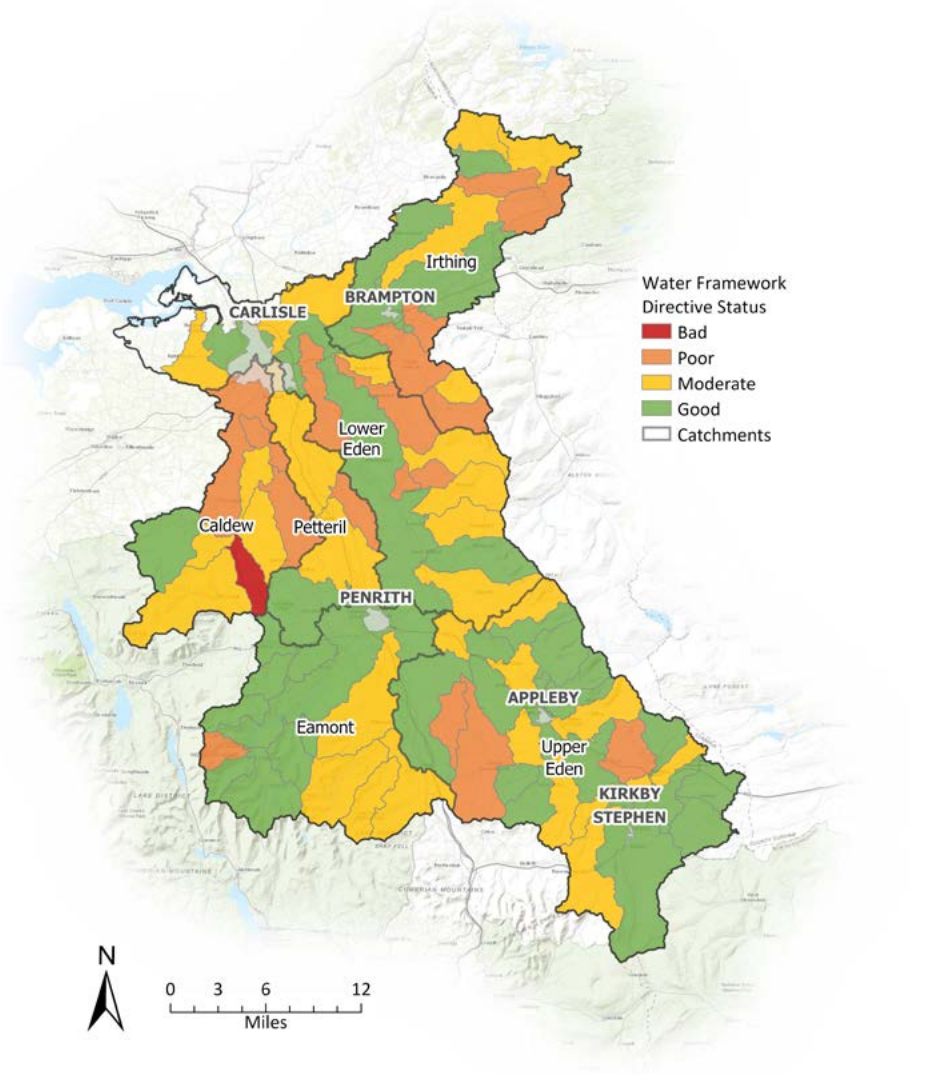


Figure 2. Current Water Framework Directive (WFD) status of each catchment.[11]

Pressures

Of the waterbodies in the Eden which do not achieve 'Good' WFD status, over 70% of these are due to pollution from agriculture and rural land management activities. This is unsurprising, given the significance of farming in the Eden. The second most significant contributing sector is the waste water industry with 13% affected by this (see *Figure 3*).

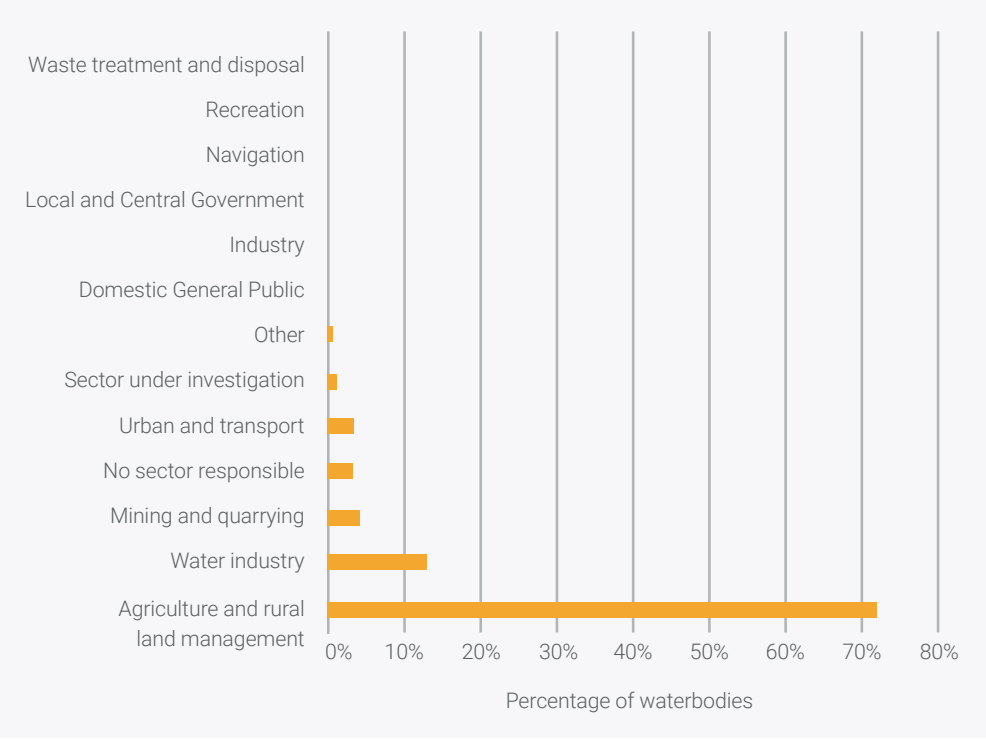


Figure 3. Reasons for Eden's waterbodies not achieving Good WFD status (Environment Agency analysis).[10]

CASE STUDY

The Cumwhinton Safeguard Zone

The Cumwhinton Safeguard Zone has been identified as being at risk from colour (dissolved organic carbon) and pesticides. Recent monitoring now indicates that the pesticide levels have reduced sufficiently to remove it as an at-risk substance. However, the levels of nutrients in the water are now causing issues with Geosmin (derived from algae) and this will be monitored.

Erosion of upland areas results in the release of dissolved organic carbon into the water supply, negatively impacting on water quality. The response to this (peat restoration) is discussed as a benefit for flooding (see analysis of the ecosystem service – Water Quantity*: high flows*), however it will also have a benefit for water quality.

Water Quality

Agriculture and rural land management pollution

Agricultural pollution in the Eden is largely the result of excess nutrients entering the water from fertilisers and animal waste which contain large amounts of nitrogen and phosphorus in various forms (e.g. nitrate and phosphate). These nutrients cause **eutrophication** - a process that depletes the available oxygen in the water required for healthy rivers.

Agricultural pollution is frequently **diffuse** (from multiple sources) and can be:

- **Water-based ammonia gas emissions** that disperse from dairy, pigs and poultry sheds and during slurry spreading.
- **Air-based ammonia gas emissions** that disperse from dairy, pigs and poultry sheds and during slurry spreading.

Ammonia can combine with nitrogen oxides and sulphur dioxide to produce ammonium compounds that combine with particulate matter. In this form they are longer-lived and may be deposited far from the original source through rain or snow, further enriching land and water (including very sensitive habitats) with nitrogen. Modelled data shows higher ammonia emissions are found in the middle/lower Eden valley with the highest emissions around the Lower Caldew and Carlisle.[12]

In the upper catchment, the limestone geology accentuates the problem as it contains natural fissures through which dirty water can pass quickly, entering the rivers with limited filtering, and sometimes many hundreds of metres from its source making it very difficult to locate the source of pollution.

Sediment entering the watercourse also carries nutrients. Soils associated with land used for arable or improved grassland are exposed to rainfall, making them vulnerable to erosion with surface water run-off. Arable and improved land also tend to require higher nutrient inputs.

Digestate spreading using a spreading bar *© ERT*

Generally, areas of higher risk in relation to arable land in the catchment are centred on the Eden Valley, whereas the rough pasture areas of the North Pennines, Lake District and Yorkshire Dales pose a lower risk to water quality. Soil loss can also result in a reduction of stored carbon (see analysis of the ecosystem service – Carbon).

Water Quality

Wastewater pollution

Wastewater pollution is often **point source** (one known source).
Point source pollution incidents add to the pressure on water quality in the Eden Catchment. The source of these can be from a wide range of sectors, but may be from agriculture, septic tanks and private sewage treatment systems, sewage from the wastewater network or treatment works, or road and rail incidents.

Reported pollution incidents on waterways and the locations of all consented discharges in 2016 have been combined with the locations likely to have septic tanks in *Figure 4.* This shows that point source pollution occurs throughout the catchment, but there are places that had high numbers of point source pollution inputs in that year. These places are a good indication of where incidents may reoccur and where the threat level is high.

Pollution hotspots identified are in the Lyvennet, Upper Eamont, Cairn Beck and Brunstock Beck sub-catchments and around the Solway Firth and should be targets for interventions to improve water quality.

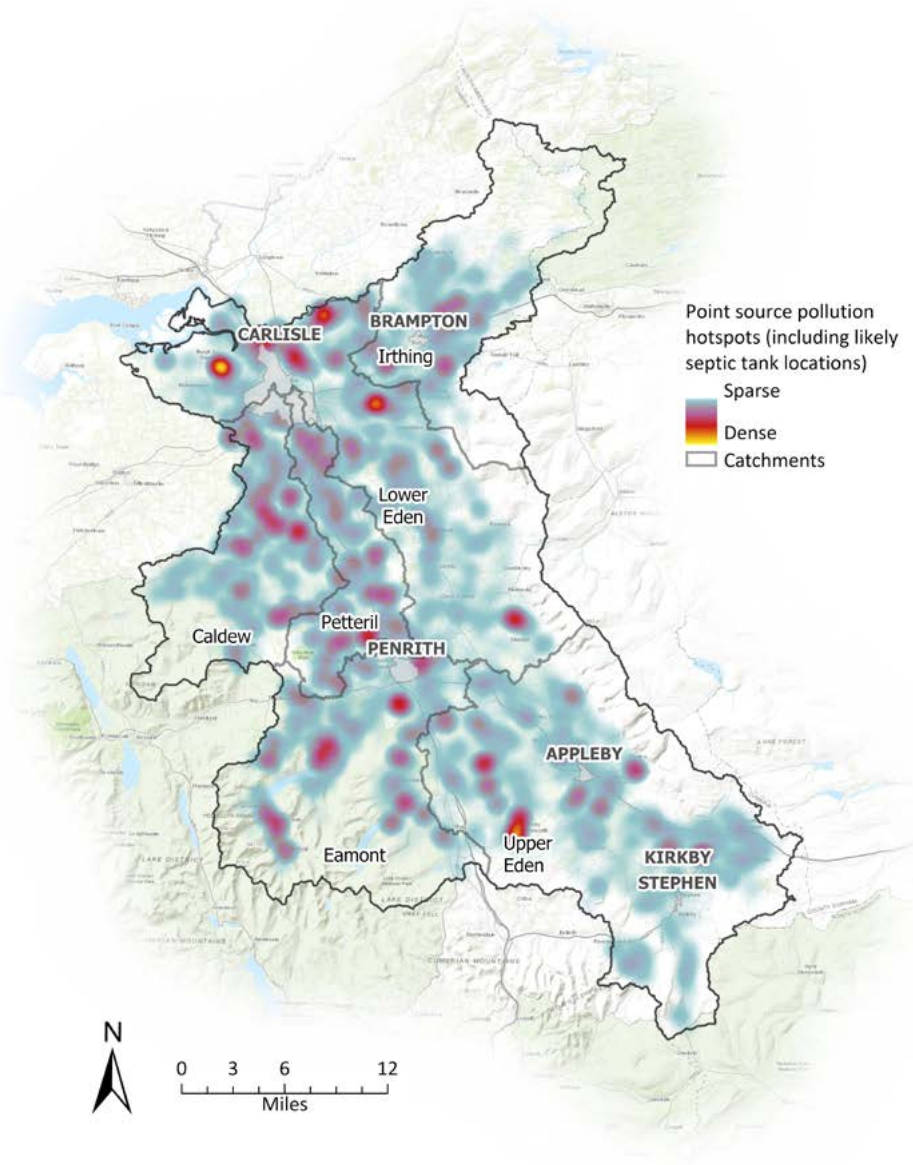


Figure 4. Point source pollution hotspots in the Eden catchment 2016.

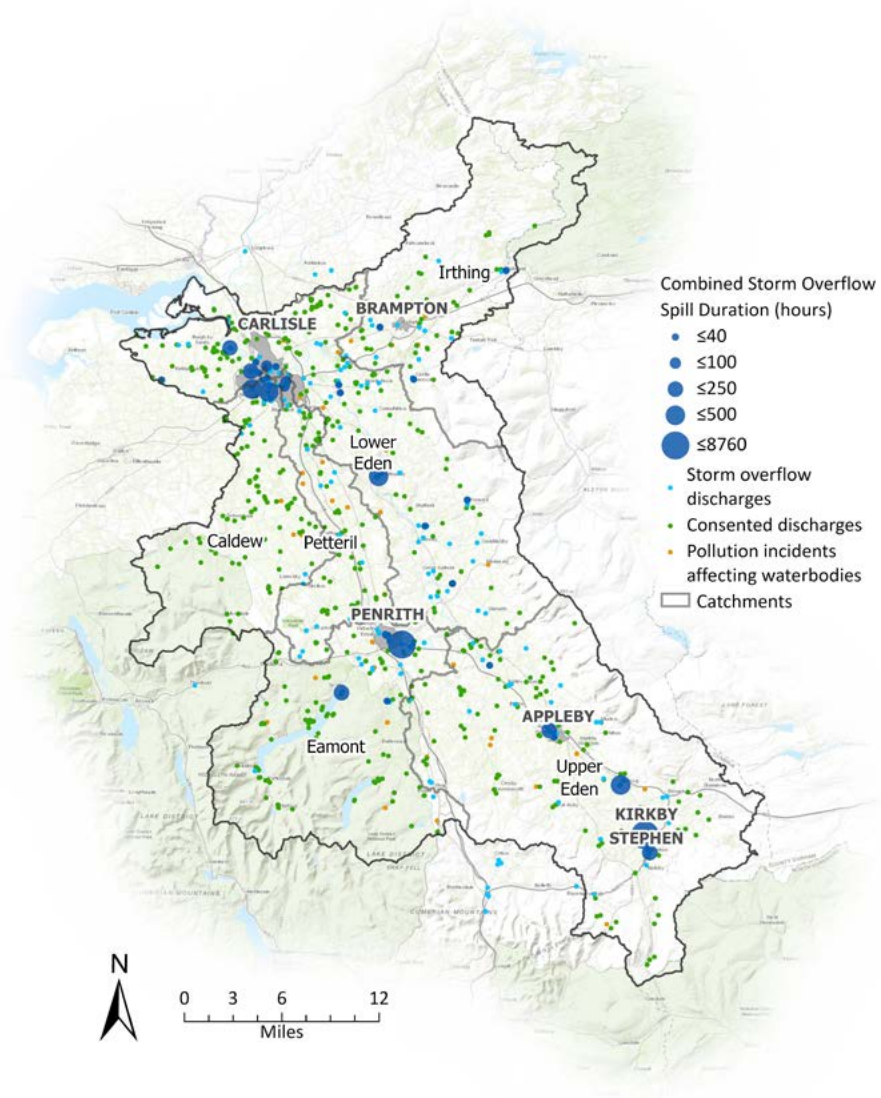


Figure 5. Consented discharges and pollution incidents in 2016 and combined storm overflow durations in 2019 in the Eden catchment.

Sewer storm overflow locations extracted from Consented Discharges to Controlled Waters with Conditions (Aug 2019), available under Environment Agency Conditional License via https://data.gov.uk/dataset/55b8eaa8-60df-48a8-929a-060891b7a109/consented-discharges-to-controlled-waters-with-conditions#licence-info.

Sewer Storm Overflow Spill Duration Data was acquired under FOI request by The Guardian and matched to the consented discharges data to identify locations as far as possible. Some of the spill duration data records were not able to be matched to a location in the consented discharges database, so have been excluded from the map. The Rivers Trust has endeavoured to clean and check the data, but cannot be held responsible for any missing data or locations which are not accurately recorded in the consented discharges database.

Opportunities

In addition to the existing pollution hot spots described on *page 19*, the following datasets have been used to map opportunities for improving water quality in the Eden catchment:

- field proximity to watercourse
- slope
- soil (erosion potential)
- hydrological connectivity, and
- landcover.

(The detailed methodology for opportunity mapping can be found in *Appendix 1*).

Figure 6 and *Figure 7* show that opportunities to improve water quality are well distributed throughout the Eden catchment, as would be expected with farming being so widespread.

Concentrations of opportunities to improve water quality exist in the Upper Caldew, Eamont and parts of the North Pennines.

Other more local parameters also influence areas that should be targeted in future to improve water quality. These data are not available for the whole catchment but are easy to ground-truth in areas targeted for future work. For example, in existing point source pollution hotspots, by observing the location and density of animals (particularly dairy cows, poultry and pigs), the presence of poorly designed farmyards and the influence of roads and regular livestock tracks.

Actions to improve water quality are highly necessary throughout the catchment that respond to:

1. **existing pressures;**
2. **rivers identified as 'bad' and 'poor' in the Water Framework Directive waterbody analysis; and**
3. **opportunity areas identified through mapping vulnerable topography and land use features.**

Water Quality

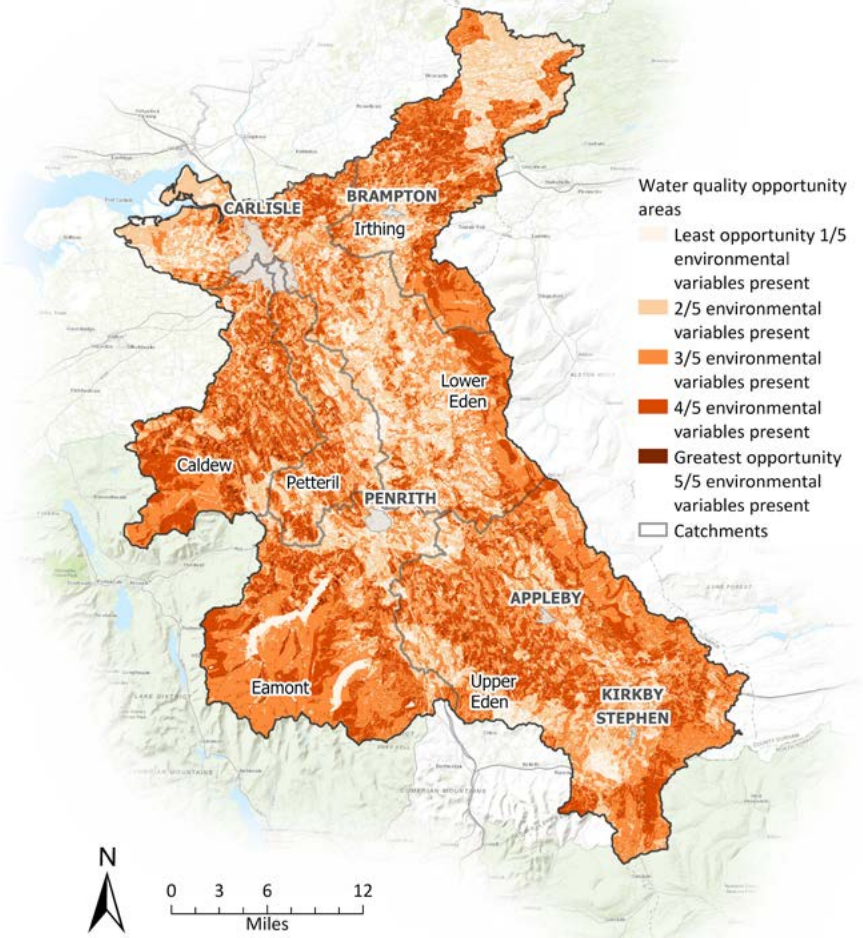


Figure 6. Detailed opportunities map for improving water quality in the Eden displayed at 25m^2. Darker areas show greatest opportunity for improvement, where opportunity is represented by mapping the following environmental variables weighted according to their effect on water quality: the proximity of fields to watercourses, slope, soil erosion potential and hydrological connectivity and landcover. (For weighting see Methodology section *page 109*).

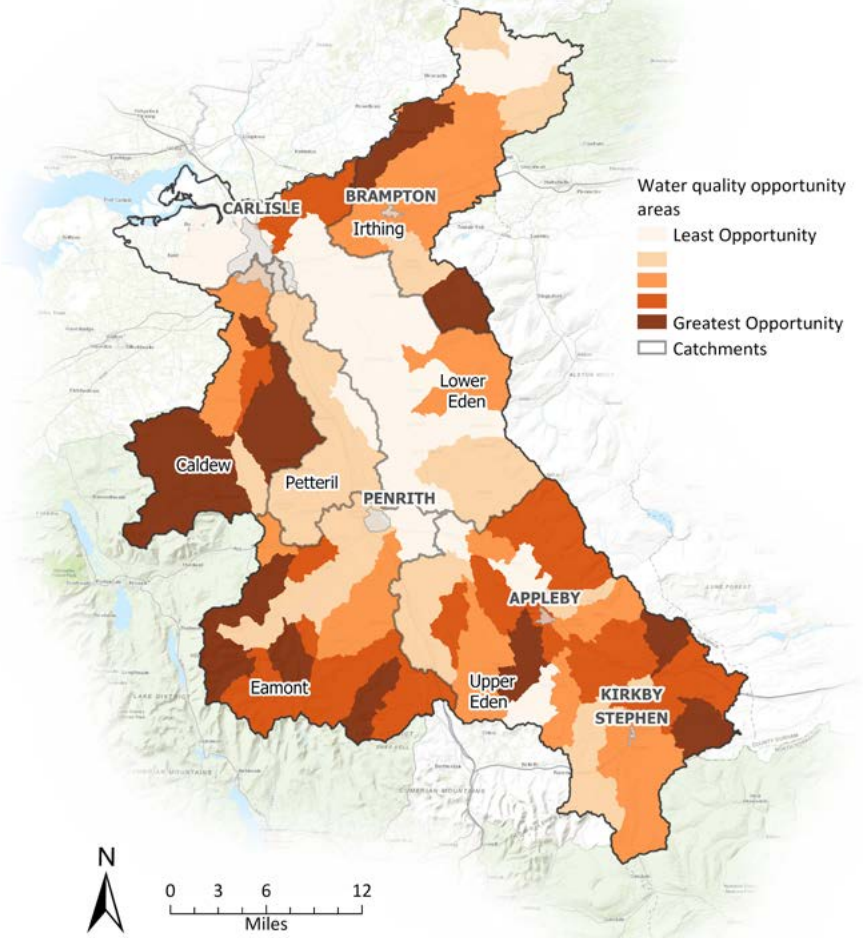


Figure 7. Opportunities map for improving water quality in the Eden, (calculated as for *Figure 6*) but displayed as an average across the sub-catchment. Darker areas show greatest opportunity for improvement.

Response

The Catchment Partnership will develop and support activities and projects that reduce pollution across the catchment. These are:

- **Improvement of farm infrastructure and management:**
  - nutrient plans to prevent excess nutrient application;
  - restoration of soils;
  - clean and dirty (nutrient loaded) water separation;
  - better management and targeting of pesticides;
  - in-field mitigation measures to minimise diffuse pollution and trap silt and nutrients (phosphate and nitrate) e.g. wetlands;
  - maintenance of walls and hedgerows and building and planting new ones; and
  - creation of riparian buffer strips.
- **Campaigns for better management of private and small-scale wastewater treatment works (package plants and domestic septic tanks).**

There is also a widely recognised need for better enforcement of water quality regulations in the Eden (led by the Environment Agency) which requires adequate resourcing by government. See right. Currently only the most severe incidents are fully investigated.

The public can assist with reporting using the Environment Agency pollution hotline 0800 807060.

Existing regulations to improve water quality active in the Eden catchment

The Farming Rules for Water (England) 2018. Farmers are required keep soil on the land, match nutrients to crop and soil needs and keep livestock, fertilisers and manures out of water. Enforced by the Environment Agency. England wide.[13]

Nitrate Vulnerable Zones (NVZs) under the Nitrate Pollution Prevention regulation 2015, areas designated under the regulations as being affected by or at risk from nitrate pollution. There are nine NVZs in the Eden.[14] Four have been designated for groundwater and five for surface water where rules apply to certain activities to safeguard water quality.

Source Protection Zones (SPZs). These are areas around large potable groundwater abstraction sites (boreholes springs etc, public and private) where activities that may impact upon drinking water quality are constrained. There are ten SPZs in the Eden.[15]

Drinking water safeguard zones. These are designated areas in which the use of certain substances must be carefully managed to prevent the pollution of raw water sources that are used to provide drinking water. These zones are areas where the land use is causing pollution of the raw water. Action is targeted in these zones to address pollution so that extra treatment of raw water can be avoided. There are three in the Eden.

The Clean Air Strategy 2019 targeting ammonia emissions – England wide.[16]

General Binding Rules for Small Sewage discharge to the ground were introduced in 2015 and updated in 2019. If you have a specific septic tank that discharges to surface water (river, stream, ditch, etc.) you are required to upgrade or replace your septic tank treatment system to a full sewage treatment plant by 2020, or when you sell property, if it's prior to this date. England wide.[17]

Water Quantity: management of high flows (including flooding)

Catchment Partnership Goal:

The high volume of water in the Eden is managed using natural as well as human led processes to create a more resilient landscape where people feel safe from flooding.

Flooding 2009 at Brougham © *ERT*

State

The Eden is susceptible to flooding due to the area's topography and high rainfall. The floodplain of the River Eden floods regularly and extensively. Localised flash flooding is frequent and has been experienced by many communities.

The convergence of rivers at Carlisle (where the Petteril and Caldew flow into the Eden) puts the city at greater risk from major flood events, especially if the peak flow of these rivers synchronise. The extent of flooding in the city depends when the rivers' flood peaks arrive in Carlisle (which in turn depends on when and where in the catchment heavy rain falls).

The Eden catchment receives considerable precipitation (rain and snow). Average annual precipitation varies around the catchment. Penrith (mid-catchment) = 950mm, Maulds Meaburn (upper catchment) = 1140mm, and in the fells of the headwaters, the averages are: North Pennines = 1310mm, Yorkshire Dales = 1500mm, and in the Lake District, more than 2000mm is recorded in some locations. These compare to a UK average of around 885mm per year.

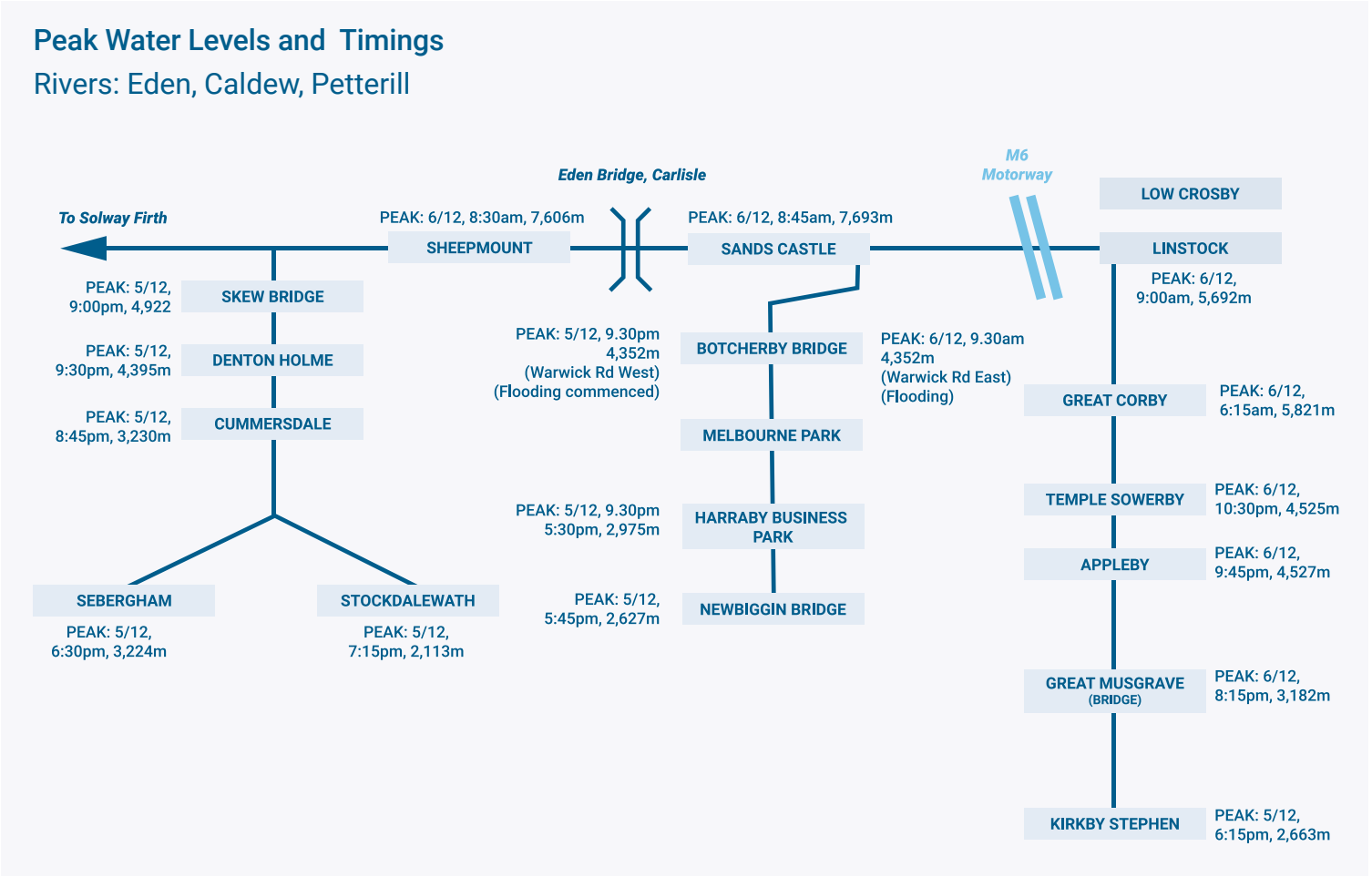


Figure 8. River Flood Peak Diagram from Storm Desmond 5-6th December 2015.[4]

Water Quantity: management of high flows

Connectivity

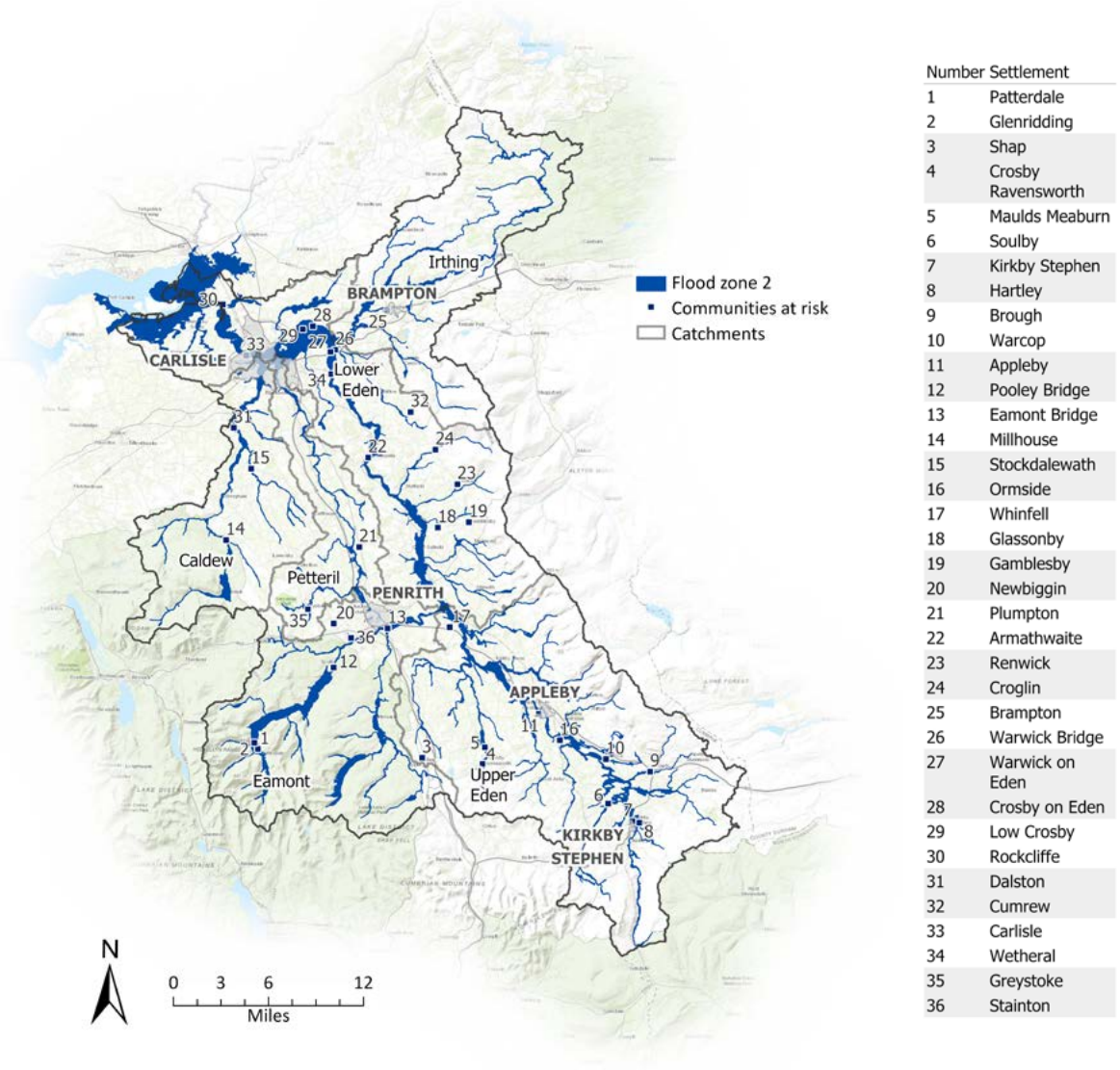
Hydrological connectivity is calculated from the shape of the land (which influences how likely water is to collect or run over the surface), along with the accumulation of water over an upstream catchment area (from rainfall). Connectivity is a critically important factor in the regulation of water flow as this shows where water has the greatest chance of being slowed as it moves through the landscape.[18]

The steep and grazed fells of the upper catchment (North Pennines, Lake District Fells and the Howgills) along with the wide flood plains in the lower, means that water is transported over the surface very quickly from the uplands but tends to collect in the lowlands. These features, along with high rainfall are a critical indicator of the extent of flooding. High run-off plus a high tendency for water accumulation both contribute to **high connectivity**; these lowland areas are at risk from flooding.[19]

Communities at risk

A **community at risk** is a term used by flood risk authorities to describe villages, towns and cities at risk of flooding (see *Figure 9* for those communities identified for the Eden). The map also shows the extent of Flood Zone 2 in the catchment (blue) which shows the areas that have a 1 in 1,000 annual probability of river flooding (0.1% chance of a flood occurring in any given year).[20]

Eden's unique landscape, coupled with high annual rainfall means that a significant number of lowland communities are at risk of flooding.



Number	Settlement
1	Patterdale
2	Glenridding
3	Shap
4	Crosby Ravensworth
5	Maulds Meaburn
6	Soulby
7	Kirkby Stephen
8	Hartley
9	Brough
10	Warcop
11	Appleby
12	Pooley Bridge
13	Eamont Bridge
14	Millhouse
15	Stockdalewath
16	Ormside
17	Whinfell
18	Glassonby
19	Gamblesby
20	Newbiggin
21	Plumpton
22	Armathwaite
23	Renwick
24	Croglin
25	Brampton
26	Warwick Bridge
27	Warwick on Eden
28	Crosby on Eden
29	Low Crosby
30	Rockcliffe
31	Dalston
32	Cumrew
33	Carlisle
34	Wetheral
35	Greystoke
36	Stainton

Figure 9. Communities at risk from flooding and the extent of flood zone 2 - the model of a 1 in 1000 annual probability of the river flooding.[20]

CASE STUDY

The devastating Storm Desmond (2015)

The devastating Storm Desmond (2015) saw heavy rain that was ubiquitous across a saturated catchment. The peaks of the Rivers Caldew and Petteril arrived in Carlisle at almost the same time followed by the Eden peak water level some 10-12 hours later (see *Figure 8*). Despite this time-lag the flooding was still extensive in the city.

Critical assets at risk

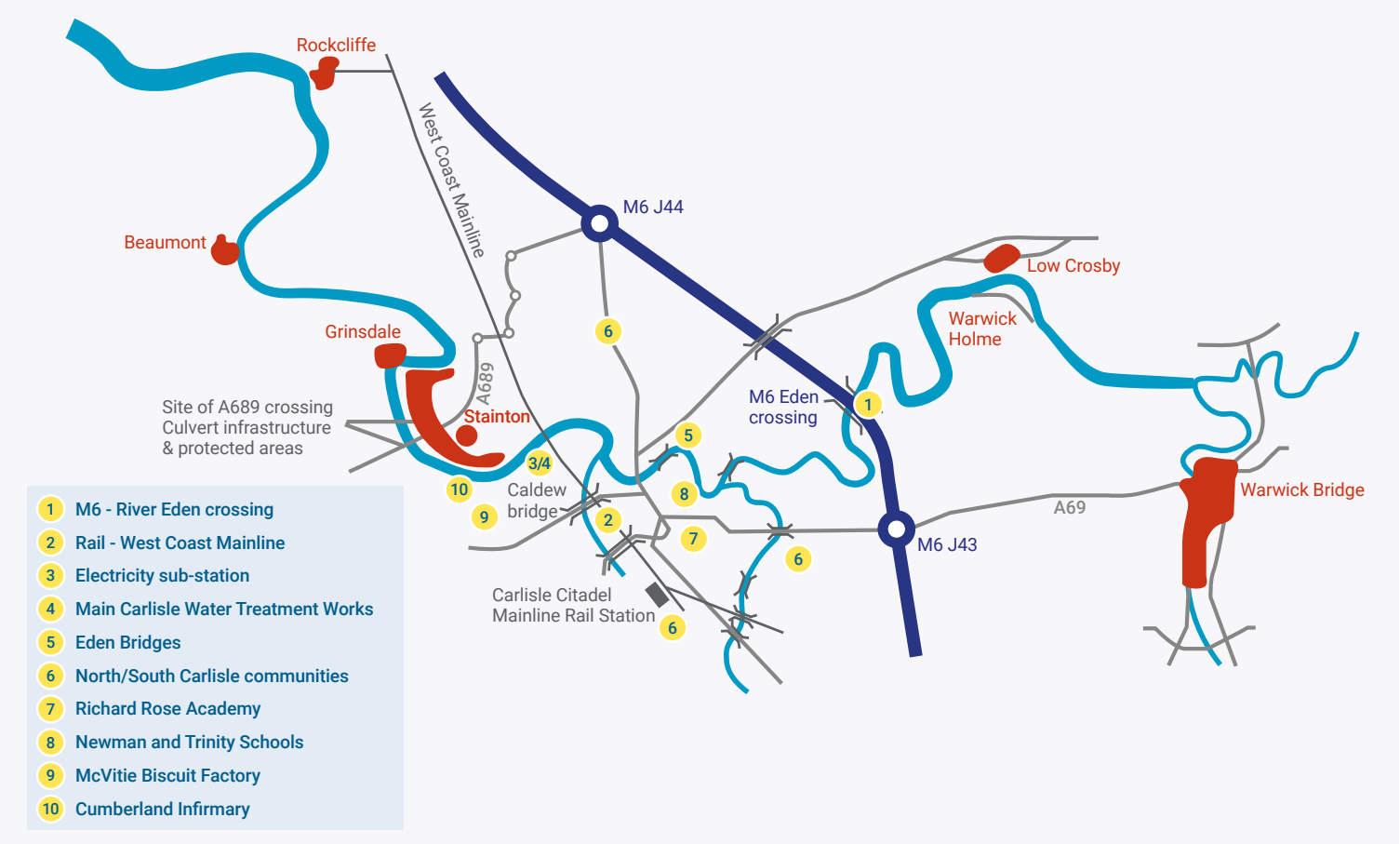


Figure 10. River Eden Floodplain - National, Regional, and Local Strategic Infrastructure.[4]

Pressures

Climate change and land use change are the two major and inter-connected factors that exacerbate flooding.

Climate change

Climate change is bringing increased rainfall and extreme weather events to the Eden. The most recent UK climate projections for North West England show that by the 2070s, winters could be up to 35% wetter under a high emissions scenario.[21] This increased winter precipitation is highly likely to increase the risk of flooding.

Changes in land use

Historic reductions in blanket bog and tree cover (including hedgerows) have reduced the Eden's natural capacity to absorb water. The disconnection of rivers from their floodplains and extensive agricultural land drainage (which speeds up water movement through the landscape) add further flood risk, along with any activity that prevents floodplains storing water.

Soil compaction caused by compression from vehicles and livestock grazing and trampling can result in increased rates and quantity of surface water run-off mixed with any chemicals/nutrients applied to the ground. This in turn may result in increased soil erosion, flooding and a reduction in crop yield.[22]

Modelling data suggests that soil compaction can increase peak discharge during flood events. EU Soils database maps suggest that over 50% of Eden's soils are susceptible to compaction and there is considerable anecdotal evidence of significant surface water run-off after heavy rainfall throughout the Eden.[22]
This can often result in serious disruption, for example the closure of the West Coast main line in August 2019.[23]

Changes in land use have affected every part of the Eden over the last 100 years. One of the main changes is the increase in field size due to the removal of hedge and wall boundaries.

Other major changes include the expansion of settlements like Penrith and Carlisle, sealing of permeable surfaces, deforestation and channel modification (such as straightening).
However, it has not been possible to attribute past changes in flood risk to any land management change at catchment scale.[24]

There are increasing numbers of development proposals within the catchment, which will increase the rate of surface water run-off. All new development should be located outside of floodplains and have adequate **sustainable urban drainage** (known as SUDS) in place.

In England there is an expectation that SUDS will be provided within all new developments and a set of non-statutory technical guidance exists for this. Anecdotally though, enforcement is lacking and there isn't a consistent approach to allocating the long-term responsibilities for SUDS maintenance and adoption. (In Wales SUDS became mandatory in 2019 and must be signed off by an approved body).

Changes in land use have affected every part of the Eden over the last 100 years.

Opportunities

The following datasets have been used to map opportunities for improving the management of high flows in the Eden catchment. (The detailed methodology for opportunity mapping can be found in Appendix 1).

- Connectivity
- Floodplains
- Catchments suitable for Natural Flood Management, and
- Working with natural processes.

Unsurprisingly, there are opportunities for improving (natural) flood management throughout Eden's upper catchments along watercourses crossing steeper ground. There are also opportunities in the floodplains along the length of the main River Eden and the mid and lower reaches of the Caldew and Petteril.

Opportunities for natural flood management are found in the small catchments above communities at risk, including: **Low Gill above Warcop, Glenridding Beck above the village, the Upper Caldew above Millhouse/ Hesket Newmarket, the Petteril above Greystoke and Plumpton, the Lower Eden above Renwick and Warwick Bridge, and along Brunstock Beck north of Carlisle.**

The key areas identified should be considered alongside local parameters that will influence the suitability of areas to be targeted for inventions to prevent flooding, especially when working with natural processes.

Leaky dams in Cumrew *© ERT*

Water Quantity: management of high flows

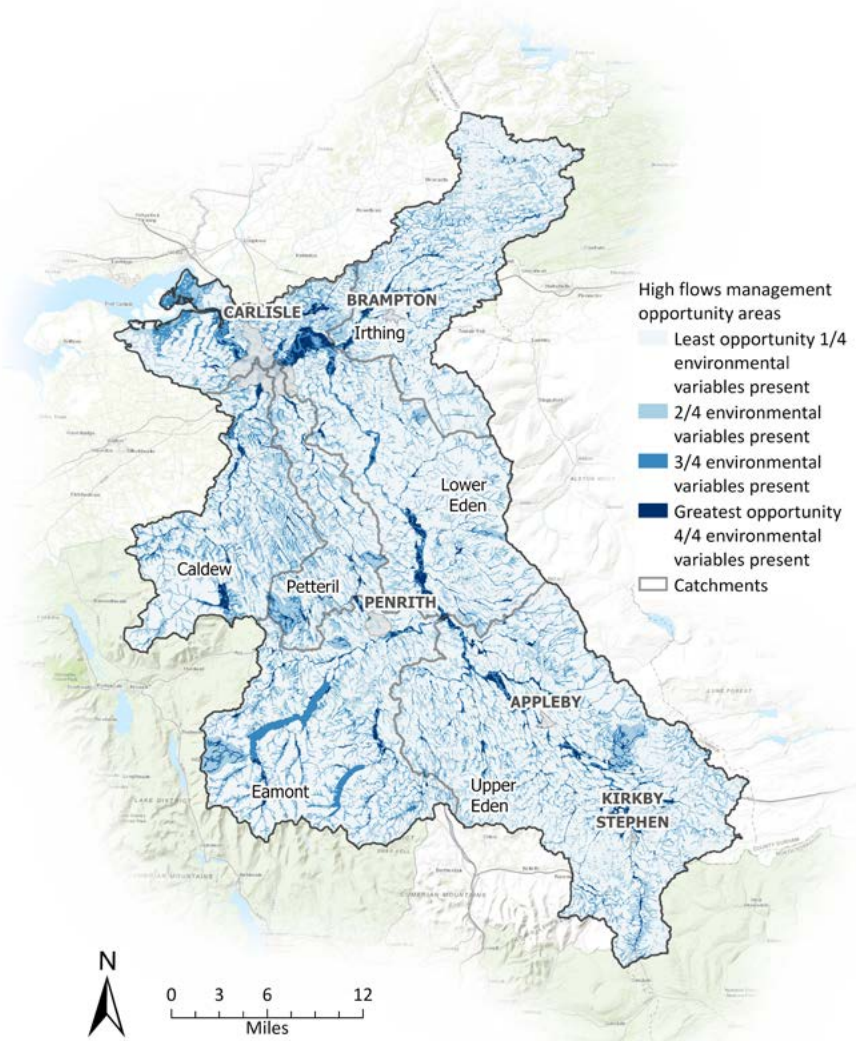


Figure 11. Detailed opportunities map for improving the management of water quantity at high flows in the Eden displayed at 25 m^2. Darker areas show greatest opportunity for improvement, where opportunity is represented by mapping the following environmental variables weighted according to their effect on management of water at high flows: landscape connectivity, floodplains, areas suitable for working with natural processes and catchments suitable for natural flood management. (For weighting see Methodology section *Appendix 1).*

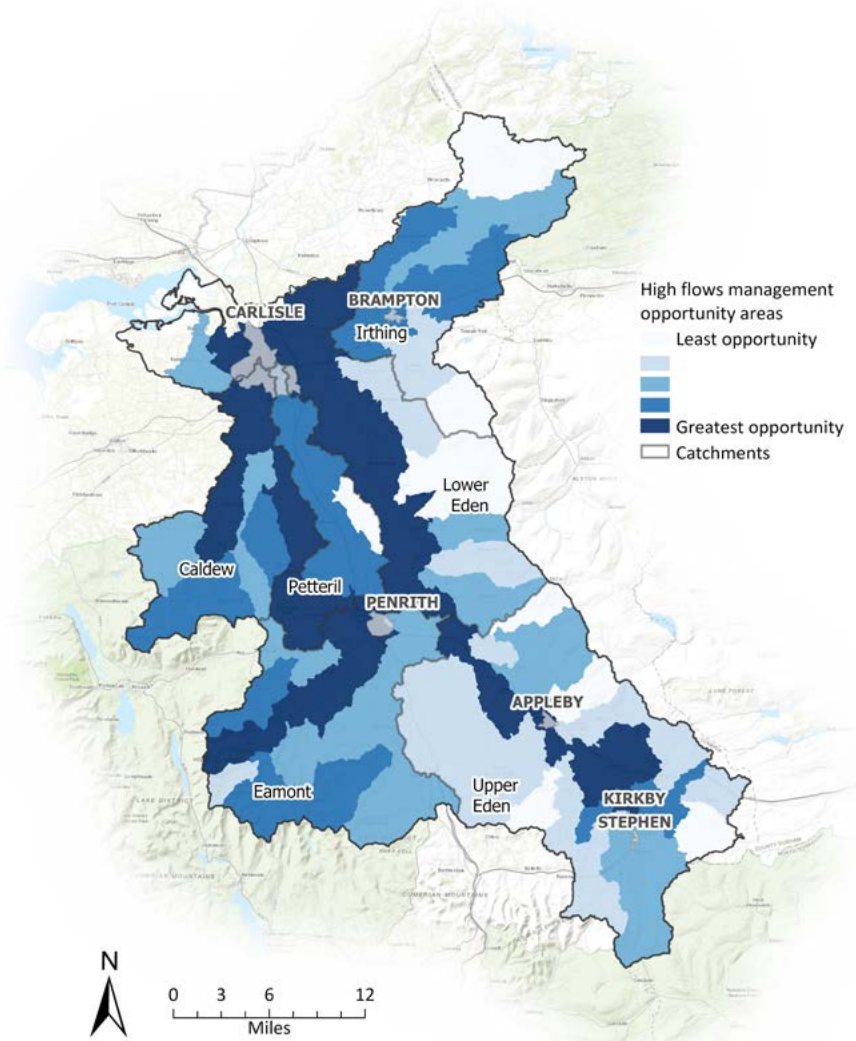


Figure 12. Opportunities map for improving the management of water quantity at high flow in the Eden, (calculated as for *Figure 11*) displayed as an average across each sub-catchment. Darker areas show greatest opportunity for improvement.

Response

The Catchment Partnership will develop and support activities that improve the management of water at high flows in the Eden through:

- **Natural Flood Management projects that aim to slow the flow of water and reduce flood peaks such as:**
  - peat restoration;
  - large scale woodland planting (native broadleaved and conifer plantation) and better management;
  - natural features and processes that promote roughening of surfaces: tree, hedge and scrub planting, changing grazing regimes;
  - wetland and woodland creation;
  - water storage/silt traps;
  - kested hedges (hedges on earth banks);
  - river re-meandering;
  - soil management and restoration; and
  - natural structures to hold back water such as leaky woody debris dams on smaller channels.
- **Engineered structures and urban flood defences as designed by the Environment Agency and Cumbria County Council.**
- **Promoting understanding and increased use of sustainable urban drainage (SUDS) for new and existing developments. This includes encouraging the use of the new North West SUDS proforma by Local Planning Authorities (in consultation) allowing clear allocation of responsibility for adoption and maintenance of SUDS post development.**
- **Supporting the adoption of mandatory standards for SUDS in England (e.g. through adoption of Schedule 3 of the Food and Management Act 2010 as in Wales).**
- **Ensuring downstream/urban 'pinch points' (where obstructions regularly cause flooding that threaten strategic assets) are maintained to prevent dangerous water accumulation.**

Natural Flood Management – slow the flow and reduce flood peaks

Natural flood management (NFM) involves working with natural processes to slow the flow of water and reduce flood peaks. This can be achieved by creating habitat which roughens surfaces, increasing infiltration capacity of soil and storing and slowing water upstream. Interventions that do this include:

- tree and hedge planting;
- reducing grazing close to the river;
- re-meandering straightened river channels;
- creating temporary ponds and wetlands;
- reconnecting channels with floodplains; and
- installing leaky dams.

Further detailed information on natural flood management can be found in a guide produced by West Cumbria Rivers Trust.[25]

Evidence is building on the efficacy of NFM and there are localised examples from across the country where NFM is working on a small scale e.g. Exmoor, the Peak District (Kinder Scout), River Otter in Devon, the North York Moors (Pickering) , Northumberland (Belford Burn), Mid Wales (Pont Bern), South London (Sutcliffe Park).[26][27]

While relatively small-scale natural flood catchment management interventions can reduce risk on minor

Water Quantity: management of high flows

watercourses, it requires widespread actions and many features to make appreciable differences to flood flows on the major watercourses. Research is still needed to be able to quantify the magnitude of the impact of NFM interventions at large catchment scale, such as that currently been undertaken within the Q-NFM project led by Lancaster University.(28)

Measuring the benefit of NFM remains easiest on catchments that are less than 20 km^2; at this scale there is the most evidence that upstream interventions have an impact on flood response.(29)

Those Communities at Risk in the Eden where NFM may show a measurable impact are **Cumrew, Gamblesby, Glassonby, Glenridding, Greystoke, Plumpton, Renwick, Rockcliffe, Shap, Stainton and Warcop.** It is notable that many actions taken to improve flood management on agricultural land will also improve water quality.

There is a fundamental shift in managing flood risk from simply building concrete barriers at sites of flooding to a blend of soft and hard engineering across the whole catchment that will build long-term resilience for more communities at risk.

People being rescued during Storm Desmond *© PA Images / Alamy Stock Photo*

Water Quantity: management of high flows

A case to quicken the flow

Within Carlisle, Appleby and other settlements, it is clearly evident that flood waters accumulate at pinch points during high flows. In these areas water backs up and/or cannot escape quickly, exacerbating local flooding and the subsequent damage to property and critical assets, such as those shown in *Figure 10*.

CASE STUDY

Flood water accumulation in Carlisle

Following Storm Desmond, Warwick Road West in Carlisle showed average water levels of 2m over 1km^2 (2 million cubic metres of water) which stayed for two days and had dire consequences for 1,800 homes, 3 schools and numerous small and medium-sized businesses.

Whilst NFM upstream aims to slow the flow and reduce flood peaks, it needs to happen on a massive scale to register in downstream settlements or on a whole catchment scale. There remains a more immediate need to relieve these pinch points, especially in Carlisle, and to enable flooded areas to drain quickly.

Many groups argue there is a need to quicken the flow through settlements and local dredging (channel deepening) is often advocated as a solution. This should be on a ***case-by-case basis*** as there is evidence to suggest this may not always be effective (see ***A note about dredging***) as there will be a negative environmental impact through the removal of gravels and riverside habitat.

Clearing pinch points can make a difference locally in the Eden, for example clearing a blocked arch on the Eden Bridge at Lazonby reduces flooding at medium flows. Quickening flows by smoothing channels is also advocated by flood-affected communities. This may lower flood peaks in some locations, but may result in increased flooding and erosion downstream.

Key regulations and policies linked to flood risk management are listed in on *page 33*.

As for successful water quality regulation, successful flood risk management requires political and institutional will to enforce the regulations, including adequate resources to enable it.

Water Quantity: management of high flows

Existing policies regulation to support management of flood risk in the Eden catchment

The National Planning Policy Framework (NPPF) 2019 includes policies on avoiding and managing the risks from flooding, based on the central role of local planning authorities in preparing local plans and in deciding applications for planning permission.

Inappropriate development in areas at risk of flooding should be avoided or made safe.

Local Plans should be supported by Strategic Flood Risk Assessments and develop policies to manage flood risk from all sources.

In 2015, a new expectation was introduced; that sustainable drainage systems would be provided in all new major developments, regardless of location, unless demonstrated to be inappropriate. The guidance produced is non statutory, however in Wales SUDS standards became mandatory in 2019 under the Flood and Water Management Act (see below).

Flood and Water Management Act 2010 identifies Lead Local Flood Authorities (LLFAs) who are required to work together to address flooding. The EA has a statutory duty under this Act to develop, maintain, apply and monitor **a national flood and coastal erosion risk management strategy** (for England). Schedule 3 of this Act requires **all proposed new developments to include SUDS** which must comply with ministerial standards and be signed off by a SUDS Approval Body (SAB). Schedule 3 has only been enacted in Wales, in England guidance remains non statutory.[30][31]

Building Regulations Part H covers drainage. It requires that surface water is infiltrated into the ground if practicable. If not, it should be disposed into a watercourse or, less preferably, to a surface water sewer. Combined sewers are the last resort. Currently there are no requirements in the Building Regulations themselves for flood resistant and resilient construction but there is a **British Standard BS 85500.**[32]

The Flood Risk Regulations 2009 which transpose the **EU Floods Directive into law in England and Wales.** A six-year cycle of requirements for LLFAs to prepare, then review flood risk management plans to manage significant flood risk in their Flood Risk Areas and state outline measures for achieving these objectives.[33]

Flood debris *© Rod Ireland Photography*

Water Quantity: management of high flows

A note on dredging

At times of flood, frequent calls are made for dredging of river channels (enlarging channels). Dredging may increase channel efficiency (and thus the conveyance of water) locally, in the *immediate* area of the action, moving water away from flood affected areas.

However, a dredged river (with an enlarged channel) will not hold as much water as its floodplain and will not be big enough to hold enough water to prevent a major flood following heavy rain. Enlarged channels will still overtop in flood conditions, and the water within them will move very fast, with the potential to increase erosion and flooding downstream. Dredging may provide no benefit in large flow events when the channel is already constricted.[34]

Dredging the River Eden would also damage the river habitats and wildlife associated with this internationally important conservation site, increase sedimentation and could also undermine banks, increasing risk of their failure.

In natural river systems the floodplain temporarily stores, slows and absorbs flood water. The Eden is no exception, and historically this would have occurred along the becks in the catchment. Water would have also been slowed/stored by the greater expanses of intact peatland, woodland and 'rougher' vegetation. Changes in land use in the Eden have resulted in many deep straightened river and drainage channels that are disconnected from the 'safety valve' of the floodplains along the length of the river. Additionally, the settlements of Carlisle, Penrith/Eamont Bridge and Appleby have expanded onto these former floodplains.

The Catchment Partnership members are not in agreement on an approach to dredging. Some members of community flood groups (Carlisle Flood Action Group and Cumbria River Authority Governance Group) advocate for more widespread use to decrease flood risk, such as that carried out by Internal Drainage Boards outside of Cumbria. Others adopt a more cautious approach through concern for wildlife, water quality and the potential for an increase of both erosion and flood risk downstream.

All members support a case-by-case approach to flood sites, considering all the flood risk reduction tools available.

Water Quantity: management of low flows (including drought)

Catchment Partnership Goal:

Enough water flowing down the Eden throughout the year to support good riparian habitats and their species, whilst water supplies are maintained at reasonable levels.

River Caldew near Dalston © *Stuart Walker Photography*

State

Water supply is robust enough in the Eden to allow for the issuing of new abstraction licences. The flows are protected at low levels due to the presence of Hands off Flow conditions. Large abstractions in the Upper Eamont and Lowther catchments mean there are insufficient flows for further abstraction licences to be granted.

Despite high rainfall, Eden's rivers can suffer reduced levels of base flows, such as experienced in 2010 and 2018. This can reduce water availability for consumption and the flow can drop below the Environmental Flow Indicator (EFI), which is when levels start to have an undesirable impact on river habitats and species. The River Eden is recharged over most of its length from underlying aquifers, and whilst the proportion of groundwater compared to surface water in Eden's rivers is unknown, groundwater is likely to be significant in maintaining summer flows.

Abstraction areas

There are over 300 abstraction licences operational within the Eden catchment every year. Abstractions for public water supply account for the most significant volumes used; Castle Carrock reservoir is the main source of water for Carlisle which is fed from New and Old Water in Geltsdale, with contributions from the River Eden at Cumwhinton.

Rural communities in the Lower Eden in the north of the catchment use local groundwater sources (boreholes in the Penrith and St Bees Sandstones or Permo-Triassic Sandstone). Penrith and rural communities in the south and west are supplied by the integrated system fed by the Lake District fells via Haweswater reservoir (which can be topped up from Ullswater). This integrated system also provides water for much of Greater Manchester.

The many small-scale abstractions in the Eden are for agriculture, hydropower, campsites and private water supplies. The full Eden and Esk Abstraction Licensing Strategy can be read online.[35]

Wetlands

The role of wetlands and wet habitats (including peatlands) in recharging base flow of rivers is complex and there are few data on this specific to the Eden catchment.

Perceived wisdom states that all wetlands hold water and release it slowly over time; helping to maintain base flows by recharging ground water aquifers during time of lower rainfall. This assumes all wetlands are located on slowly permeable geology and connected to groundwater aquifers, which is not always the case.

In the uplands, headwater peatlands have limited water storage capacity as the water table is always close to the surface, and blanket bogs (a type of peatland) are only fed by rain and not necessarily connected to groundwater aquifers.

Pressures

Abstraction pressures

In 2015 there were two locations in the Eden catchment recognised as being under pressure from water abstraction. The first, Hayeswater reservoir, is no longer an abstraction point. The second, Old Water (in the Irthing), is under pressure due to excess surface water abstraction.[11] The Eden and Esk Abstraction Licensing Strategy notes that the River Lowther (prior to confluence with the Eamont) and the River Gelt (prior to confluence with the Irthing) have no water available due to being over abstracted.[35]

There may be a case for the Environment Agency and Natural England to review the abstraction licences that affect these locations.

The Environment Agency's water availability assessment classifies each Water Framework Directive (WFD) waterbody according to how much water is available at different flow levels.

In the Eamont sub-catchment officially there are more areas where abstraction is restricted at low flows than at very low flows. This bizarre situation is because large scale abstractors must stop abstracting at low flows, but small abstractors may still be granted a licence to abstract at very low flows.[35] (See the Eamont sub-catchment action plan).

Development, particularly housing development, increases demand and thus abstraction pressure. Water companies, in the Eden's case United Utilities, are statutory consultation bodies for local plans. They proactively search the 52 local planning authority planning applications records and make recommendations on those applications on sites with visible risks for water supply and management. The Environment Agency and Natural England are statutory consultees on housing developments.

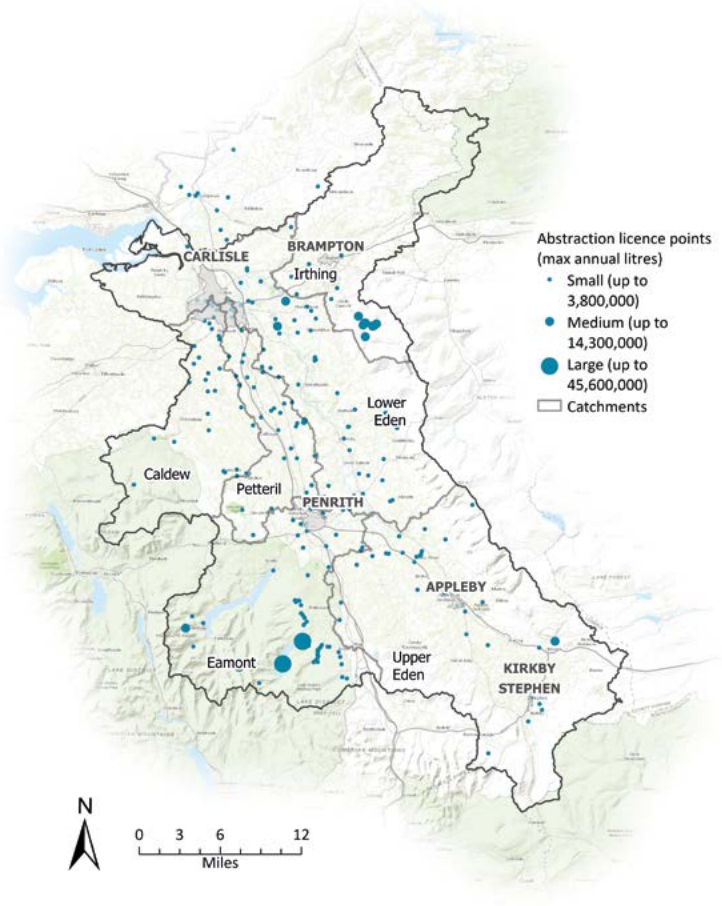
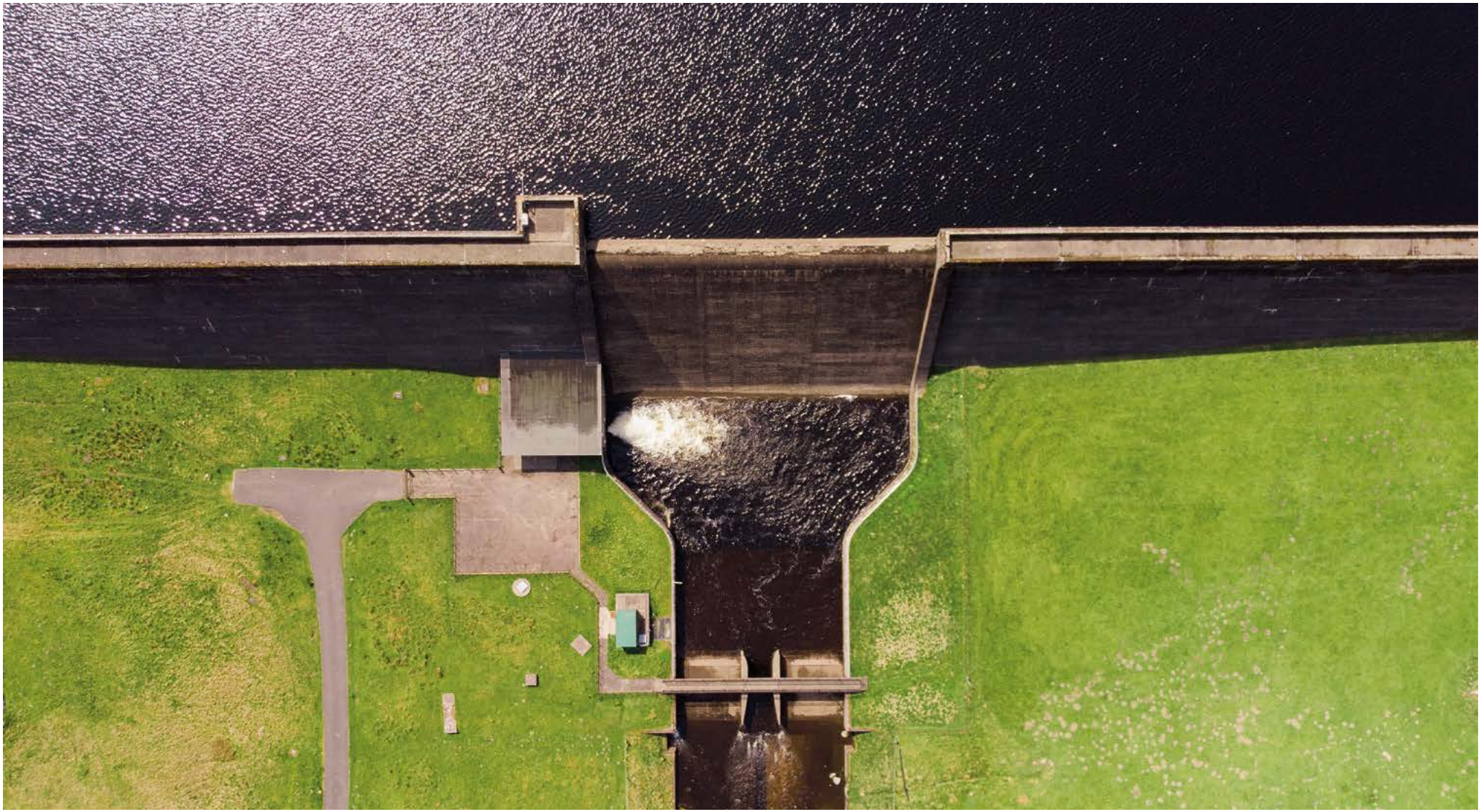


Figure 13. Abstraction licence locations with permitted maximum volume in the Eden catchment.

Water Quantity: management of low flows



Wet Sleddale © *Rod Ireland Photography*

Water Quantity: management of low flows

Changes in climate

The Met Office projects that by 2070 the North West of England is going to be up to 47% drier in summer with a temperature increase of up to 3.2°C relative to 1981-2000 in a high emissions scenario.[21]
These predicted changes in weather patterns will result in short-lived, high-intensity showers impacting on the frequency and severity of surface water flooding, changes in soil moisture content and the vulnerability of soils to erosion. Low flows are likely to become more common in the Eden during the summer than they are currently.

Overall climate predictions indicate that rainfall variation in the UK will become extreme, with Eden receiving more water than it can manage at certain times of year and much less than it needs at other times.

Over the last 20 years, the Eden catchment has experienced three prolonged periods of higher levels of precipitation than normal (1999-2002, 2007-2010, 2012-2015) as well as two periods of drier weather than normal (1996-1998, 2004) *Figure 14*. These data are only available up until the end 2015 so more recent precipitation levels are not recorded, although provisional data viewed show that the high levels of precipitation continue through 2016-2017.[36]

These data only show at precipitation levels and do not take into account any other factors that may also influence water levels. They do not examine the nature of drought on the wider water availability due to groundwater levels or abstractions, or the impacts of drought on the affected areas.

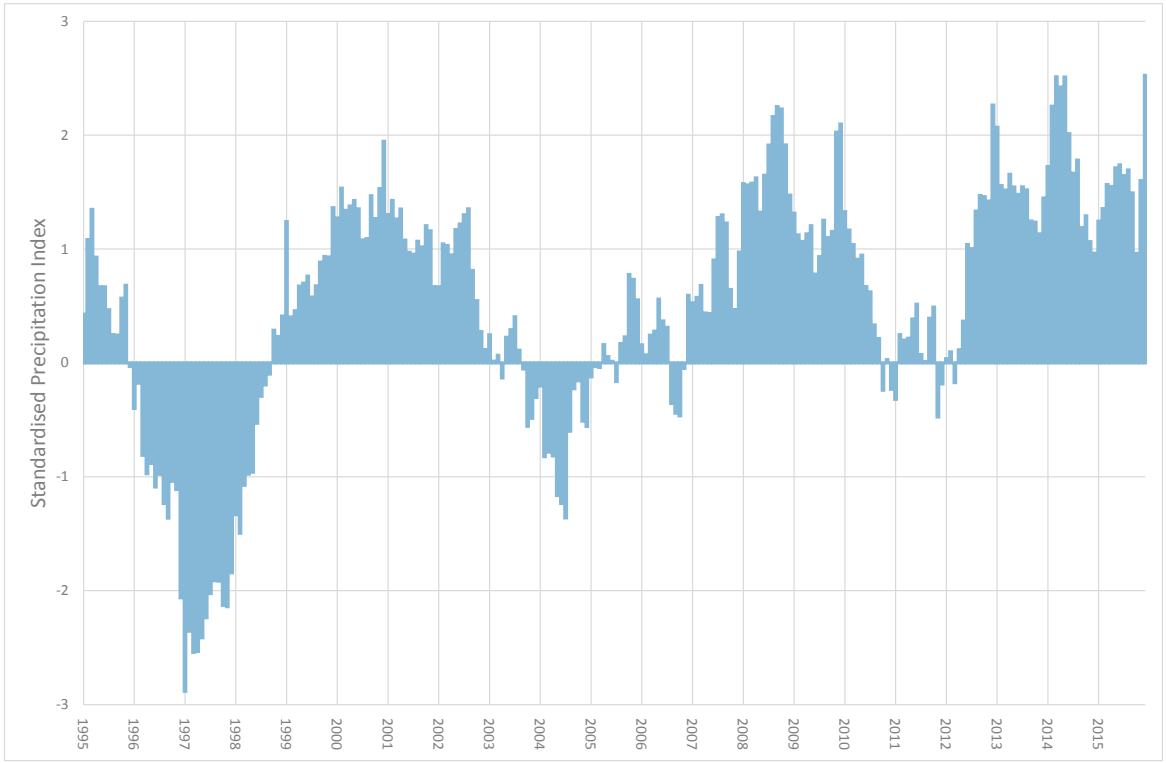


Figure 14. Standardised Precipitation Index (SPI) for the Eden Catchment from 1995 - 2015. This normalises rainfall deficits based on historic records identifying times when precipitation has been above or below normal precipitation levels for that location for the time of year.[36]

Water Quantity: management of low flows

Opportunities

Datasets to support robust opportunity mapping are not yet available.

Carlisle © *Stuart Walker Photography*

Response

The factors affecting base flows in the Eden catchment are not fully understood but increasing demand for water and subsequent increased abstraction is clearly a significant pressure in times of low rainfall. Balancing the needs of consumers without doing long term damage to other ecosystem services that those same consumers rely on, is critical.

The Catchment Partnership will develop and support activities that will improve the management of water at low flows in the Eden, particularly:

- **Investigation by appropriate authorities of waterbodies that are over-licensed and have fallen below the Environmental Flow Indicator and reviewing licenses as appropriate.**[35]
- **Improving the understanding of the impact of groundwater abstraction on the River Leith.**[35]
- **Research on the effect of low flows /abstraction on wildlife in the rivers.**
- **Campaigns to educate and engage all Eden's communities - all ages - on where their water comes from and why efficient use is so important.**
- **Water efficiency measures for all consumers (domestic and business).**

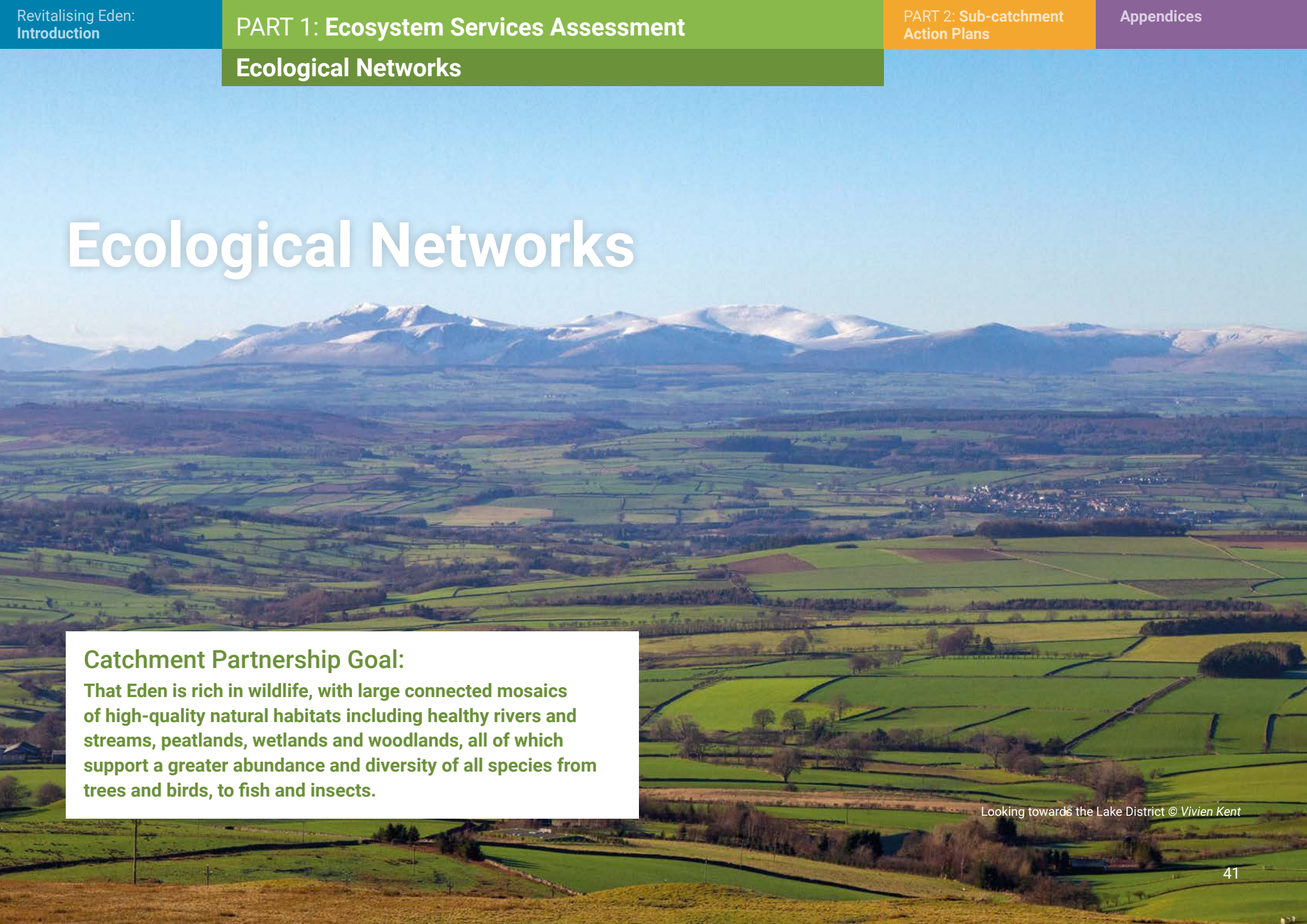
Projects to increase and restore wetlands and peatlands, and to improve soils have multiple benefits to ecosystem services (flood management, ecological networks, carbon storage). Their role in maintaining baseflow is not fully understood but are likely to contribute to improving this ecosystem service.

> It is critical that we balance the needs of consumers without doing long-term damage to other ecosystem services that those same consumers rely on.

Ecological Networks

Catchment Partnership Goal:

That Eden is rich in wildlife, with large connected mosaics of high-quality natural habitats including healthy rivers and streams, peatlands, wetlands and woodlands, all of which support a greater abundance and diversity of all species from trees and birds, to fish and insects.



Looking towards the Lake District © *Vivien Kent*

State

Eden's uplands contain the majority of intact natural habitat in the catchment, contributing to functioning ecological networks. Eden's lowlands show poor ecological connectivity with only small pockets of isolated semi-natural habitat, occasionally linked by hedgerows, road verges and river corridors.

Designated site network

An extensive designated network of important ecological sites exists in the Eden (*Figure 16*). Sites of Special Scientific Interest (SSSI) are some of the finest sites in the country due to their support of a range of rare species, habitats and/or geological features.[37] There are nearly 100 SSSIs in the Eden catchment.

The River Eden and its tributaries is a large and significant SSSI, designated due to the presence of floating vegetation habitat of plain and sub-mountainous rivers, White-clawed crayfish *Austropotamobius pallipes*, Atlantic salmon *Salmo salar*, Brook lamprey *Lampetra planeri,* River lamprey *Lampetra fluviatilis,* Sea lamprey *Petromyzon marinus*, Bullhead *Cottus gobio* and Otter *Lutra lutra*.[38]

Only 37% of Eden's SSSIs are in favourable condition with a further 47% being in unfavourable but recovering condition. 14 sites are not only in unfavourable condition but are declining, including part of Brothers Water due, to the presence of the invasive species Nuttall's waterweed *Elodea nuttallii.*[39][40]

There are three Local Nature Reserves in the Eden and 14 National Nature Reserves. The latter protect the county's most important species, habitats and geology and include Great Asby Scar, which is one of the best examples of limestone pavement in the county.

Eden has two Special Protection Areas (SPAs) and 16 Special Areas of Conservation (SACs), these are sites of European importance for birds, habitats and other species. The Solway Flats and Marshes and the North Pennine Moors are designated for waterbirds and selected birds of prey respectively, and other SACs include the Cumbrian Marsh Fritillary Site near Hutton Roof and the Solway Firth. The River Eden is also an SAC due to the populations of White-clawed crayfish, lamprey, salmon and otter among others.[41][42][43][44][45][46][47]

There are two National Parks within the Eden catchment both known for their "beautiful countryside, wildlife and cultural heritage". The Lake District National Park for its lakes, tarns and rivers as well as ancient woodland and a wealth of wildlife, and Yorkshire Dales National Park for its wildflower-rich hay meadows and pastures, open heather moorland and blanket bogs.[48][49][50]

Finally, two Areas of Outstanding Natural Beauty (AONB) fall within the boundary of the Eden catchment: the Solway Coast and the North Pennines, recognised for "distinctive character and natural beauty".[51]

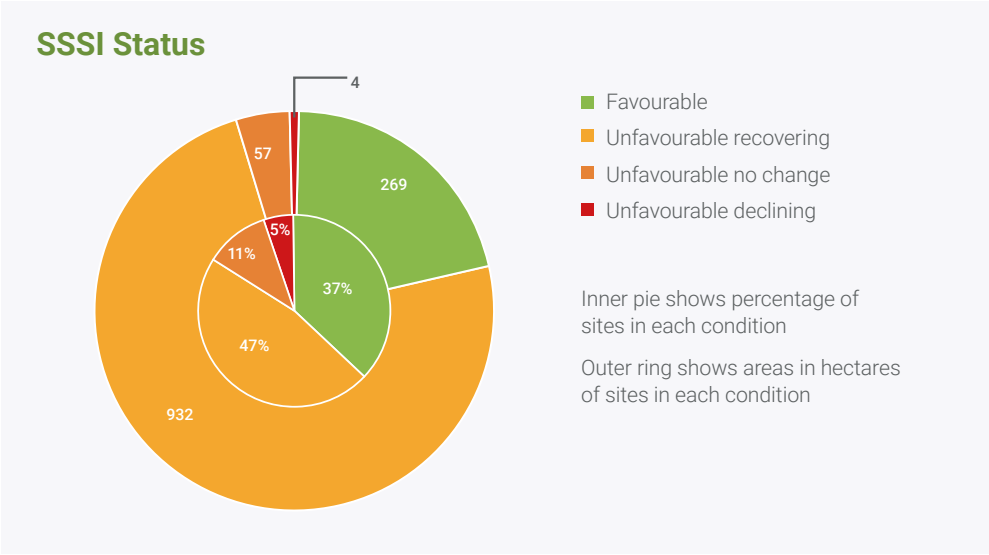


Figure 15. Chart showing the condition status of the SSSIs in the Eden catchment.[39]

Natural England Priority Habitats

Natural England has identified habitats they consider to be of considerable importance for the nation. They include areas of blanket bog, deciduous woodland, lowland heath, grass moorland and rivers.

In the Eden catchment, priority habitats are found mainly in the uplands of the Lake District National Park, Yorkshire Dales National Park and North Pennines AONB, with pockets of key habitats scattered throughout the main valley as well as the river itself and its tributaries.[52]

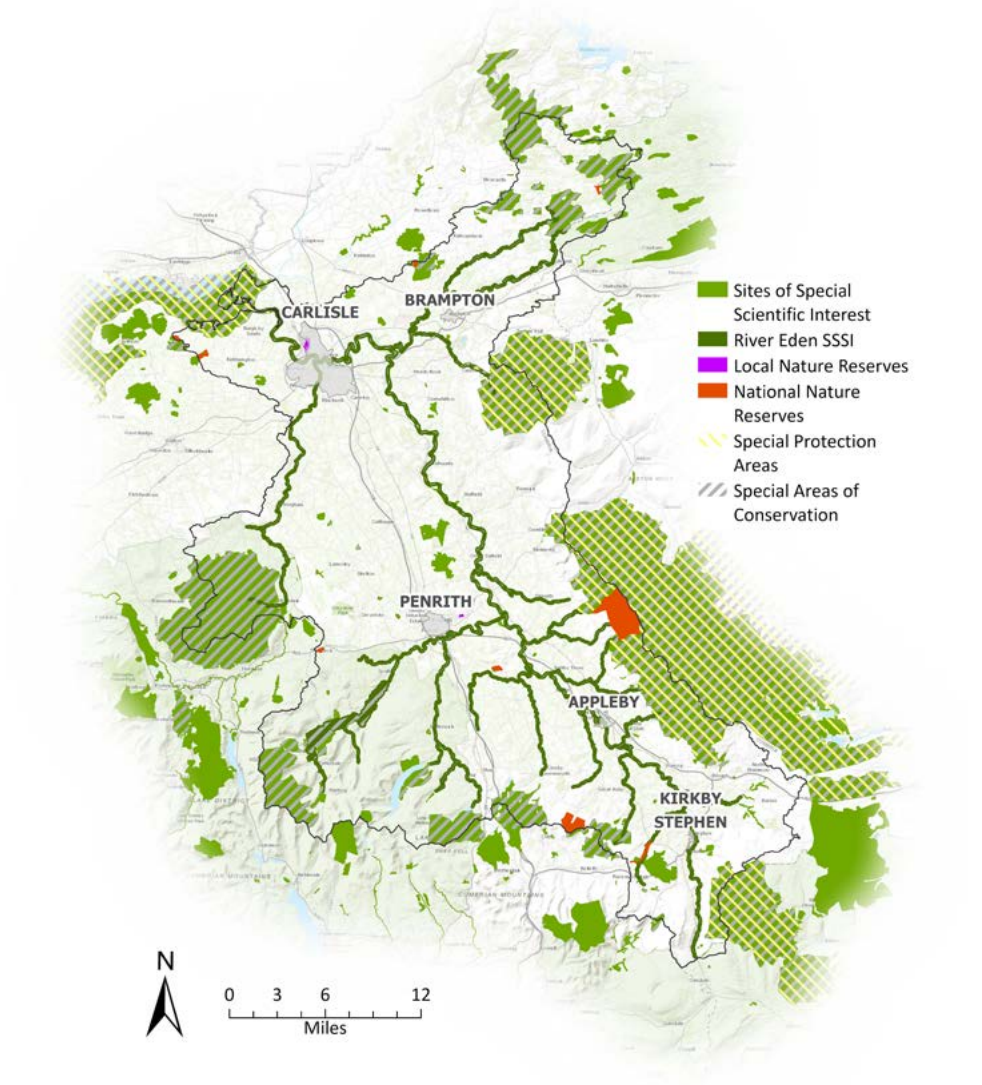


Figure 16. Designated nature sites in the Eden: SSSIs, SPA, SAC, and Local & National Nature Reserves (LNR NNR).

Fish as key indicators

Fish have long been regarded as iconic species of the Eden especially Atlantic salmon, Brown trout and lamprey, and these species are one reason for its designation as a site of international importance.

Whilst there are limited detailed data to estimate true population levels, the Environment Agency do collect catch return data from anglers and clubs. It is clear from rod catch data that fish have declined in the Eden over the last 25 years, but the decline is not continuous - there were high numbers of salmon caught in 2004 and 2005 but far less in 2012. In the Caldew system, less than 200 returning salmon were counted by the Environment Agency in a fish trap at Holme Head Weir (compared to returns of over 1600 in that system in 2004).[53][54]

Catch data are used by Natural England to detect trends, approximate egg deposition, assess whether targets are being met and to target action on the river that will benefit fish numbers.

The Fish Class System tool shows observed data on fish composition, abundance and prevalence which is compared to the values which would be expected if the river was in pristine condition. These two values are compared to calculate the Ecological Quality Ratio (EQR). The EQR score is then used as an indicator of the ecological health of the river for its Water Framework Directive (WFD) classification.[55] (See section on water quality). The WFD classification for the Upper Eden is generally Moderate to High, whereas Poor and Bad sites are more prevalent in the Caldew, Petteril and Lower Eden as the main river gets closer to Carlisle.[56]

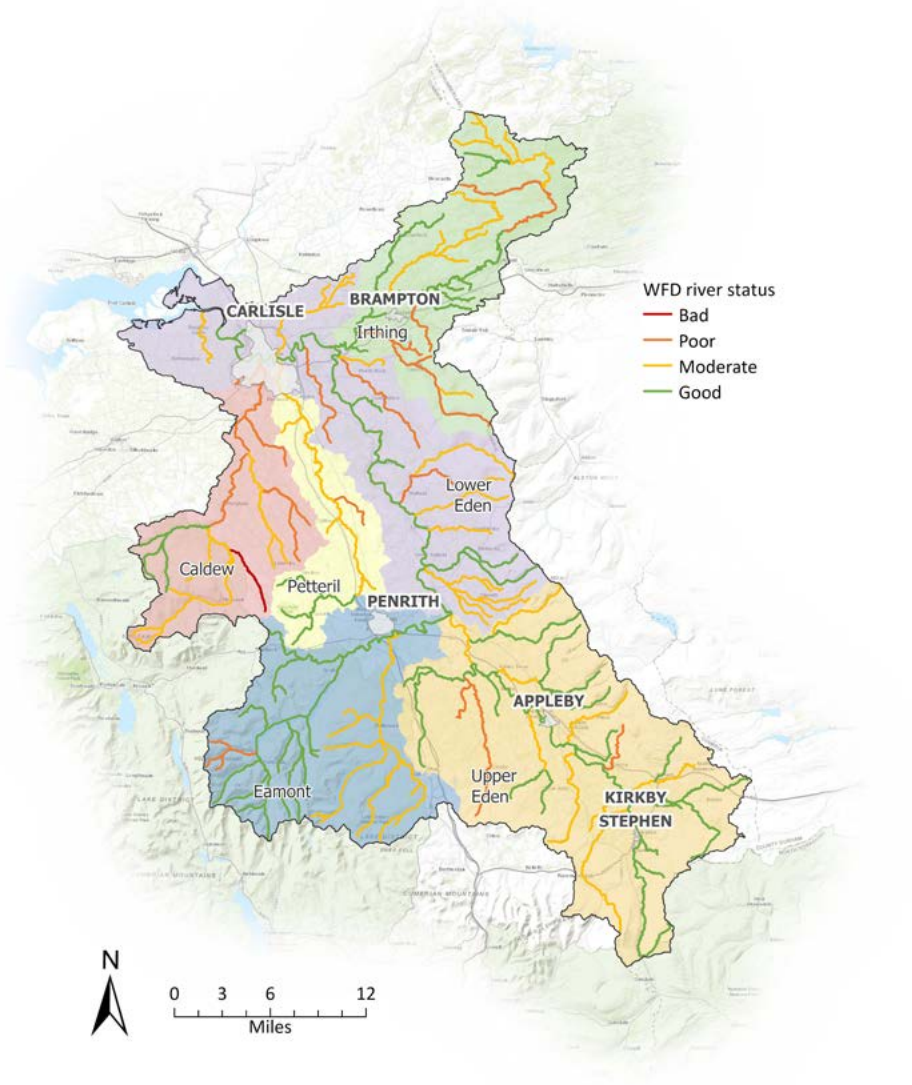


Figure 17. WFD status of each watercourse within the catchment.[11]

Pressures

All the threats to ecosystem services described in this document affect biodiversity and thus the integrity of ecological networks. The threats described below have specific impacts on biodiversity.

Land management threats

The integrity of ecological habitats in the Eden has, and continues to be adversely affected by, some specific land management practices, causing habitat loss and fragmentation.

In Eden's uplands (where the most intact natural habitat remains), land management practices have had a significant impact on ecosystem services. Historically, peat has been removed for fuel. More recently, extensive grips (drains) have been dug to allow opportunities for increased grazing and enable the planting of non-native conifer. These practices have decreased the overall cover of blanket bog, leaving large areas of semi-damaged peat that continue to dry out and erode, further fragmenting the upland habitat.

The consequences for ecosystem services are:

- A huge loss of stored carbon (carbon in the dry eroding peat oxidises and is released as carbon dioxide);
- Less carbon sequestration as peat can't form;
- Loss of biodiversity with the loss of habitat (overgrazing also causes a dominance of Mat grass - *Nardus stricta, and Purple moor grass - Molinia caerulea);*
- Increased flooding due to increased surface water run-off over bare ground; and
- Decreased water quality as peat erosion discolours drinking water.

Heather burning is used as a management tool on grouse moors. If properly managed, this can result in a mosaic of different age stands of ericaceous shrubs that benefit invertebrate and bird life and act as fire breaks for wildfires, but it can have a detrimental effect on blanket bog, especially recovering bog, as the peat forming sphagnum mosses are easily scorched and their growth set back by at least three years.

Barriers and other modifications to river channels

Modifications to the physical conditions of waterbodies adversely affects the extent, quality or diversity of habitats for all aquatic wildlife and the geomorphology/ natural functioning of the river system. Migratory fish (Atlantic salmon, eels and lamprey) in the Eden have been particularly impacted by these modifications (along with declining water quality and changing conditions at sea).

Most of the barriers in the Eden catchment are weirs, with some dams in the upper region of the catchment. Significant artificial barriers include Holme Head and Buckabank Weirs on the Caldew, Corby Weir on the Eden and Low Mill Weir on the Eamont.

Natural barriers are also present e.g. Stenkrith Falls near Kirkby Stephen.

The potential and feasibility of improving ecological networks through removal of barriers and other modifications to river channels was assessed in 2010 and formed the basis of the Cumbria River Restoration Strategy.[57]

The strategy was designed to target reaches of the River Eden SSSI that need improving with restoration projects that deliver the greatest improvements to natural processes and wildlife, including the enhancement of ecological networks e.g. projects on neighbouring stretches of the River Lyvennet.

Using river restoration to enhance wildlife, natural river processes and ecological networks remains a priority in the Eden, as well as fulfilling newer objectives of maximising other ecosystem services such as water quality and flood alleviation. The River Restoration Strategy for Cumbria would benefit from an update.

Invasive non-native species (INNS)

Over thirty invasive, non-native species (INNS) are known to exist in the Eden (and there are many locations yet to be formally recorded). Plant INNS present include Giant hogweed (*Heracleum mantegazzianum*), and New Zealand pygmyweed (*Crassula helmsii*), that are generally recorded along the rivers as they are spread downstream by the flow of the water.[58] INNS such as Himalayan balsam, Japanese knotweed and Giant hogweed all outcompete native species and leave exposed riverbanks open to soil erosion in the winter. This soil washes into the river where it can damage the habitat for aquatic species.

If New Zealand pygmyweed were to spread in lakes of the catchment, this would be a serious threat to the specialist native macrophytes.

The INNS American mink (*Neovison*) has decimated native Water vole populations, and there is one record of a Signal crayfish population (*Pacifastacus leniusculus*) on the Upper Caldew near Sebergham. if this should spread, it could become a serious threat to the native White-clawed crayfish as it spreads crayfish plague and outcompetes native crayfish for resources.[59]

INNS can also be spread by visitors who may inadvertently carry them between sites, particularly between lakes and rivers.

Ongoing public campaigns are necessary around potentially high-risk activity (boating, kayaking, fishing) to promote biosecurity and prevent further spread of INNS in the Eden.

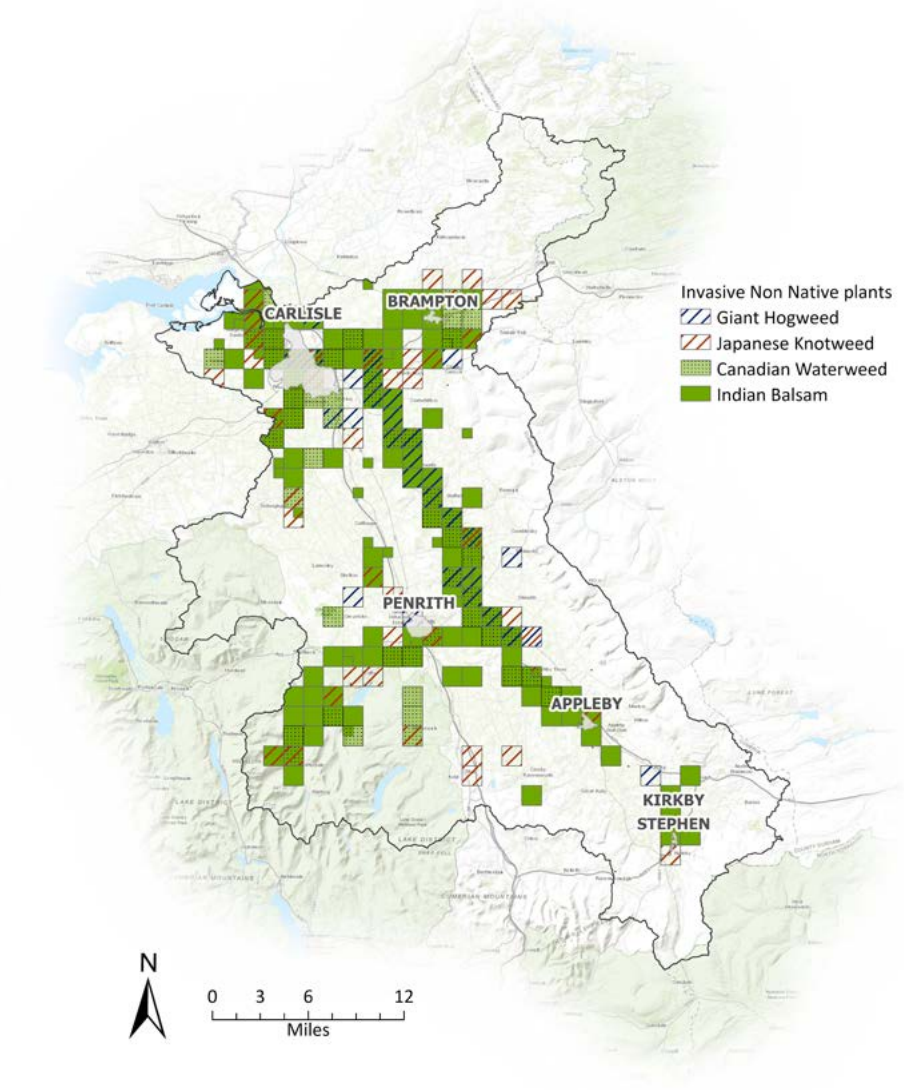


Figure 18. Invasive non-native plants in the Eden catchment.[58]

Avian predation

Avian predation of fish and other aquatic species occurs along the length rivers, principally by fish-eating birds such as cormorants and goosander. There is general evidence to show that sometimes avian predation can suppress fish densities locally, especially when the predators occur at high densities (the average daily intake of fish by cormorants and goosander ranges from 240 - 520g).[60]

However, quantifying causes of fish mortality throughout a river system due to avian predation or other factors is notoriously difficult; diffuse pollution, lack of suitable spawning habitat, flow levels and other predators may all have an effect.

Limited case studies (on the R. Ribble and R. Trent) show marked variations in percentages of fish removed by birds, depending on time, location along the river, diversity of habitats and patchiness of fish distribution; and the high levels of cormorant depreciation did not result in detectable reductions in fishery performance.[61]

An ongoing study in the Dee (Scotland) showed a potential high avian predation pressure on the fish population in 2017, when 37% of tagged smolts died in the river migration, and less in 2018 (20% mortality). In 2017 there were also lower water levels in the Dee.[62]

The River Eden District Fishing Association has bi-annual bird count data over c.60% of the main stem Eden with numbers averaging at 264 cormorants and 304 goosanders per count over the last 6 years (12 counts), with an increase in cormorants from 86 birds in 2004. These birds have the potential to affect fish stocks in the Eden.

Some control of avian predators is allowed under licence from Natural England in the catchment. Natural England are also undertaking a three-year study of mortality of migrating salmon smolts on the River Derwent in West Cumbria. This research, alongside DNA analysis of bird droppings and stomach contents of predating birds on the rivers Eden and Derwent to evaluate prey species in their diets, will inform future avian control measures within the catchment.

River restoration measures, particularly the removal of artificial barriers behind which migrating smolts congregate, alongside the improvement and protection of natural riparian habitat, is of great benefit to fish populations as well as resulting in multiple benefits to ecosystem services described elsewhere in this document, and thus are strongly supported across the Catchment Partnership.

Opportunities

Opportunities to improve ecological networks in the Eden catchment have been mapped by combining the following data:

- Soil hydrology (Wetland Futures dataset)
- Proximity of land to existing habitat, and
- Natural England's Strategic or Priority Habitat areas.

(For detail see Table 1 in the methodology section).

Increasing the value of ecological networks can be more effectively targeted in the Eden by habitat restoration at the edges of existing sites, exploiting potential wetland networks and through enhancing the ecological value of existing sites. *Figure 19* and *Figure 20* show these types of sites are concentrated in the Upper Irthing, Upper Eamont, Upper Eden and the North Pennines.

Other more local parameters also influence areas that should be targeted in future to improve ecological networks. These include:

- Barriers and modified channels identified as priorities through the Cumbrian River Restoration Strategy, and
- Key species expansion zones identified by the Cumbrian Biodiversity Data Centre (Arvicola Centre e.g. Water voles (*Arvicola amphibious*) and Great crested newts (*Triturus cristatus*).[58][63]

Kingfisher © *Margaret Holland*

Ecological Networks

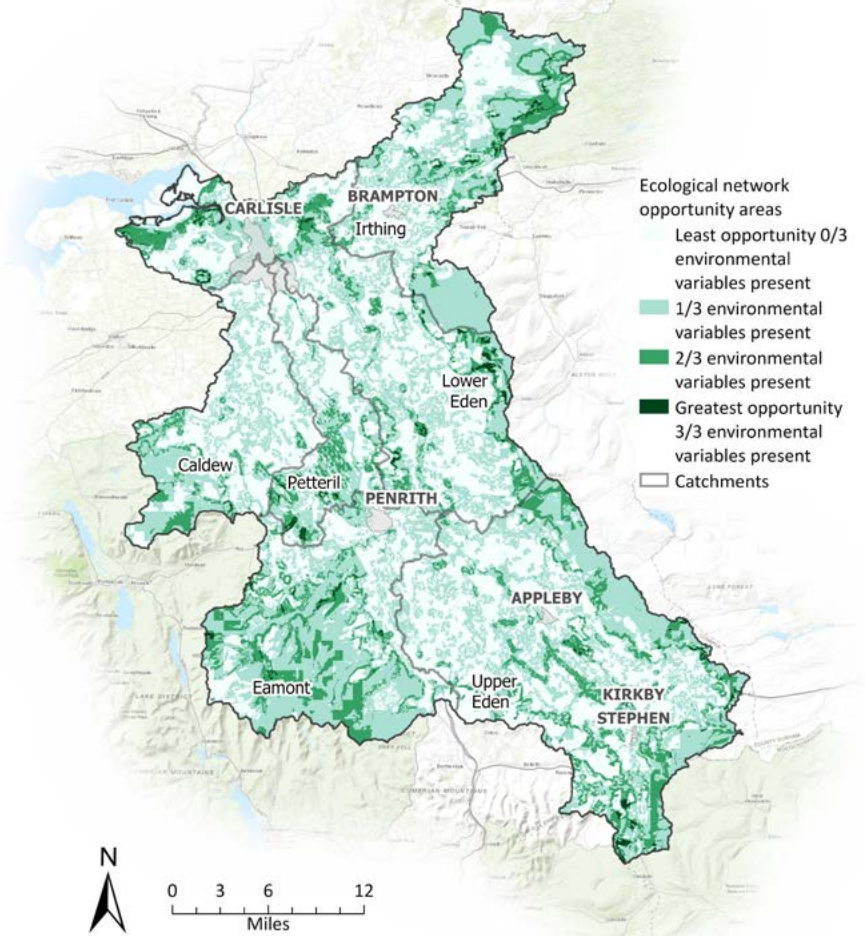


Figure 19. Detailed opportunities map for enhancing ecological networks in the Eden displayed at 25m^2 Darker areas show the greatest opportunity for improvement, where opportunity is represented by mapping the following environmental variables according to their effect on ecological networks: the potential for wetland creation (soil hydrology), the proximity of land to existing priority habitat or woodland, existing strategic or priority habitat areas. (For weighting see Methodology section *Appendix 1*).

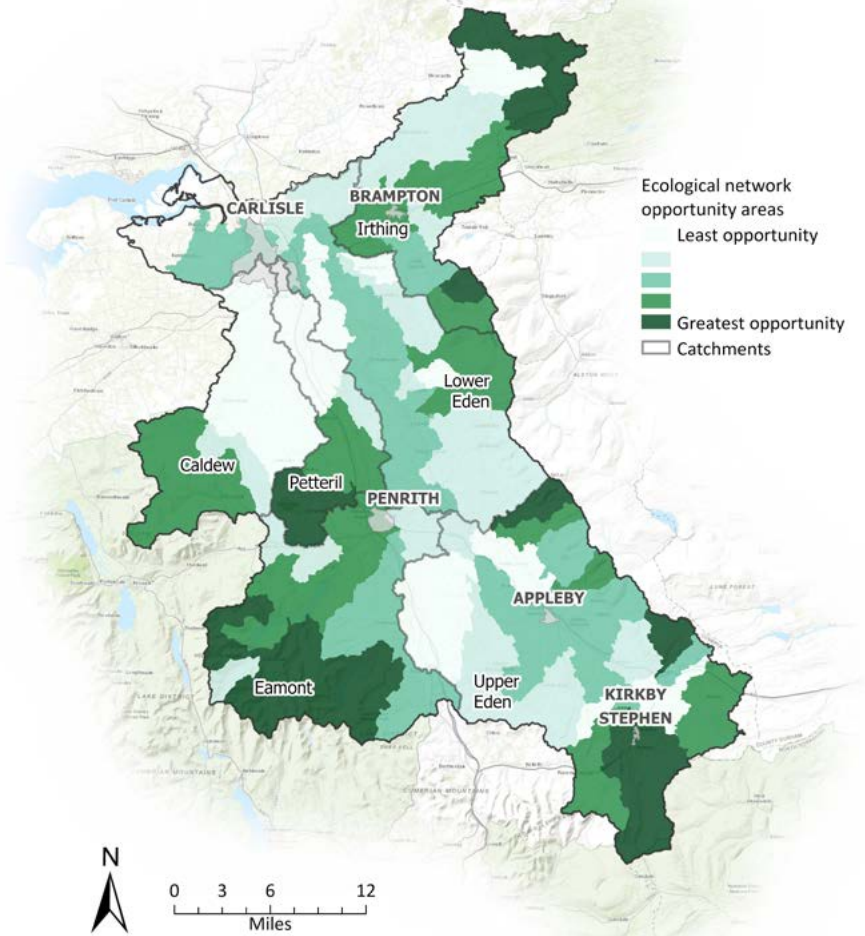


Figure 20. Opportunities map for enhancing ecological networks in the Eden, (calculated as for *Figure 19*) displayed as an average across the sub-catchment. Darker areas show greatest opportunity for improvement.

Response

The Catchment Partnership will develop and support activities that improve ecological connectivity within the Eden such as:

- **Restoration of damaged blanket bog across the uplands – re-wetting peatland soils.**
- **Restoration of natural river processes: re-meandering rivers, riparian habitat creation and the removal of barriers.**
- **Using agri-environmental and other schemes to improve riparian and upland management: tree/scrub planting and tree coppicing, hedgerow creation and management, wetland habitat creation and changes to grazing regimes to improve diversity.**
- **Beaver reintroduction trials to support the creation of more extensive wetland habitat.**
- **Targeted campaigns for invasive species removal and improving biosecurity.**
- **Research to understand key declining species in the Eden in order to develop targeted interventions for species recovery programmes. This would necessitate monitoring populations (e.g. migratory fish – juveniles, smolts, returning adults; Riverfly, White-clawed crayfish, and Water voles).**
- **A revision and update of the *Cumbrian River Restoration Strategy* 2010 for the Eden.**

The Partnership will continue to advocate proper implementation of relevant policies and regulations (see box) and adequate resources for the Agencies responsible to be able to do so.

Policies and regulations that maintain and improve ecological networks in the Eden catchment

The Conservation of Habitats and Species regulations 2017 (and subsequent amendments) which implement **the EU Habitats Directive** and require the protection and conservation of habitats and species within designated Special Areas of Conservation and Protection Areas.(64)

The Wildlife and Countryside Act 1981 (and subsequent amendments) for the conservation of SSSIs.(65)

The UK Marine Strategy Regulations 2010, which implement the **EU Marine Strategy. Framework Directive (MSFD)**, requires measures to achieve or maintain Good Environmental Status by 2020 through the development of a **UK Marine Strategy.**(66)

The Water Environment (WFD) England and Wales Regulations 2017 which implement the EU Water Framework Directive.(67)

The forthcoming England Peat Strategy with policies to re-wet all peatlands soils and stop the use of all peat in horticulture by 2030.

The Invasive Alien Species (Enforcement and Permitting) Order 2019 implementing EU Regulation (1143/2014) on invasive alien (non-native) species.(68)

Rod fishing byelaws for England and the north west including **2018 regulations to protect Salmon and Sea trout** (mandatory catch and release).(69)

Carbon Capture and Storage (sequestration)

Catchment Partnership Goal:

To ensure that carbon stored in the landscape of the Eden catchment is maintained and capture is increased; through improved soil health, increased restored peat and more connected native woodlands.

Restored blanket bog east of Red Crag © *ERT*

State

Carbon is stored in the soil and in biomass. Carbon stored within soils varies with biomass, temperature, wetness, land management and parent material (geology).

Soil carbon storage is complex and needs further research, but generally wet undisturbed soils with high organic matter store the most carbon. In the Eden those are the peat and peaty soils of intact blanket bog in the uplands, limited raised bog in the lowlands and undisturbed soils associated with Eden's woodlands and permanent pasture. Soils that are rarely disturbed on low tillage land also capture and store carbon. All soils in the Eden are frequently wet.

The woodlands and permanent grassland in the catchment also store and sequester (take up) carbon as biomass. Broadleaved woodland is distributed throughout the catchment in small pockets and there are larger blocks of mainly conifer plantations particularly in the Upper Irthing (*Figure 21*).

Round leaved sundew *© Bernard Dupont*

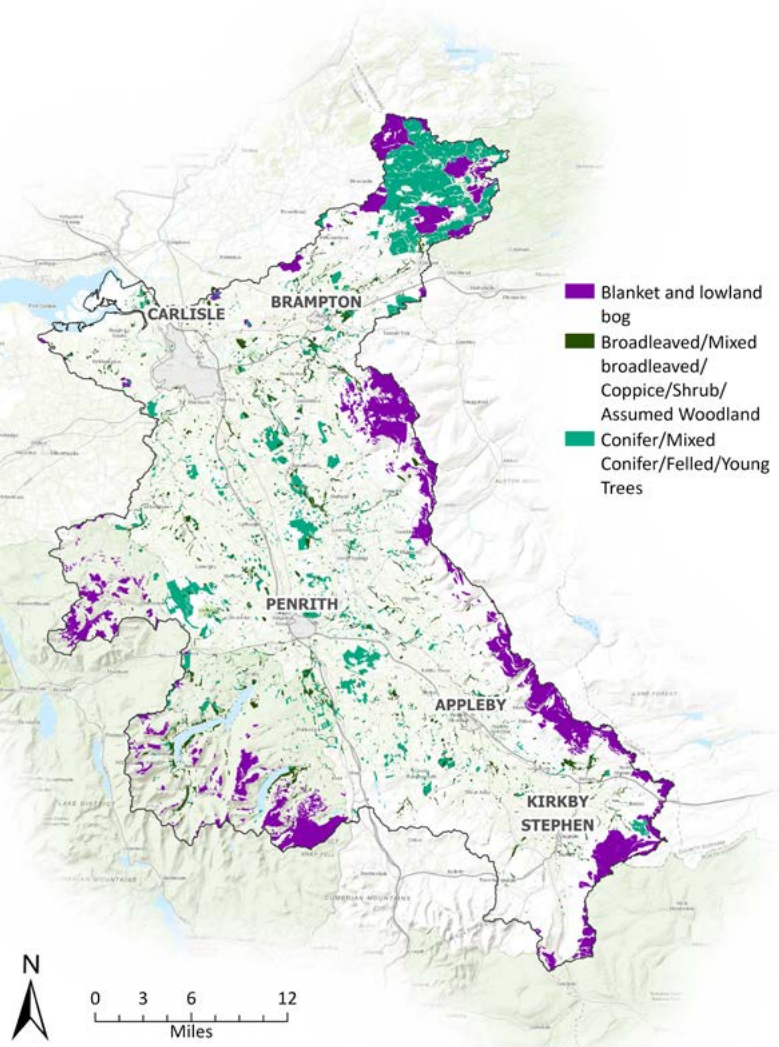


Figure 21. High carbon storage habitat in the Eden: (peatlands) blanket and lowland bog and woodlands.

Data was provided by the North Pennines AONB Partnership and Cumbria Wildlife Trust. Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey [100021242].

Pressures

The current threats to our carbon stores come through land improvement or conversion of permanent grassland and/or woodland to arable), drainage of organic soils and ploughing grassland in rotation.

Blanket bog decomposition

Historically the peatlands of the Eden (upland blanket bog and lowland raised bog) have been cut and drained, causing the peat to decompose and release carbon dioxide – a greenhouse gas.

Grazing by sheep and deer continues to be a threat to the recovery of damaged blanket bog habitats, largely through trampling of sphagnum mosses which prevents their recovery.

Warmer temperatures and increased high rainfall events predicted through climate change will increase peatland degradation in our landscape and a corresponding loss of an internationally important carbon store - as well as vital water storage capacity and valuable wildlife habitats.[21]

Protecting and improving our existing highest carbon stores in the peatlands of the upper catchment is of the greatest priority.

Land conversion

Permanent pasture stores more carbon than arable land.[70] Conversely, carbon is lost when land is converted from permanent pasture to arable. Accurate data on land conversion in the Eden over any period are not available.

At least 230 hectares of permanent pasture have been lost in the Lower Eden in recent years[71] - other anecdotal estimates vary from 0.5 – 1% loss over the last 35 years.

Since 2015, the Government requires the area of Permanent Grassland (or Pasture) to remain above 95% of the reference area (the total area of Permanent Grassland in 2015). In the Eden, the threshold has never been breached, though levels have come close. The emphasis to date has been on maintaining a minimum area of permanent grassland rather than increasing its percentage.

Opportunities

Opportunities to improve carbon storage and sequestration in the Eden catchment have been mapped by combining the following data:

- Existing peatland (blanket bog) habitat;
- Soil sequestration capacity;
- Potential for increased carbon sequestration due to land use change;
- Agricultural Land Classification; and
- Re-wetting potential (connectivity).

(for detail see Appendix 1 Methodology section).

There are opportunities for carbon sequestration throughout the catchment, with the greatest opportunity being in the uplands where rewetting and restoration of peat is possible.

Major opportunities also exist where it is feasible to undertake woodland creation in the gullies and valleys of the Lake District Fells and the North Pennines, or to create permanent grassland.

The darker areas in the Mid Irthing and Lower Irthing (Brunstock, Hether and Cam becks) and Mid to Lower Caldew reflect areas where soils have capacity to take up more carbon, connectivity is high, and there is more marginal/semi-marginal agricultural land with the potential to be converted to less productive land. (Conversion from arable to pasture will only occur when economies make it viable).

Caption: Peat bog © *Daniel J. Rao*

Carbon Capture and Storage (sequestration)

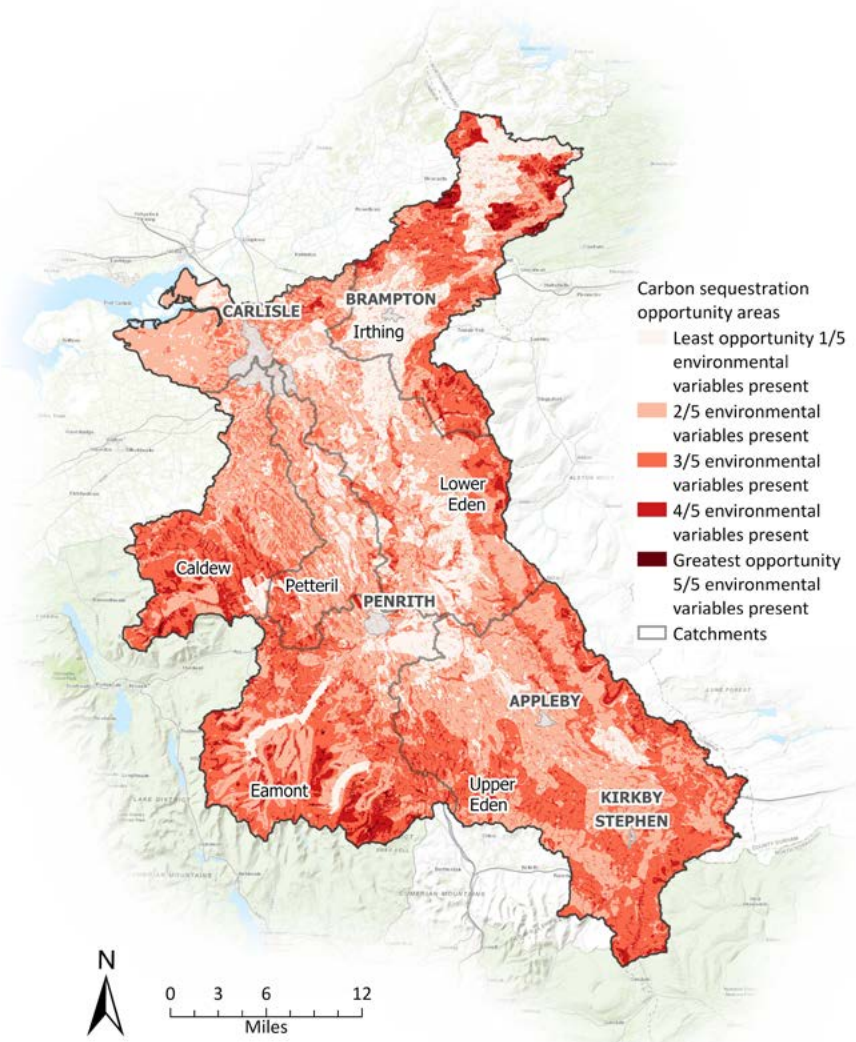


Figure 22. Detailed opportunity areas for carbon capture and storage in the Eden, displayed at 25m^2. The darker areas show the greatest opportunity for improvement, where opportunity is represented by mapping the following environmental variables weighted according to their effect on carbon capture and storage: existing peatland habitat, soil sequestration capacity, potential for increased carbon sequestration due to land use change, agricultural land class and re-wetting potential (connectivity). (For weighting see *Methodology section Appendix 1*).

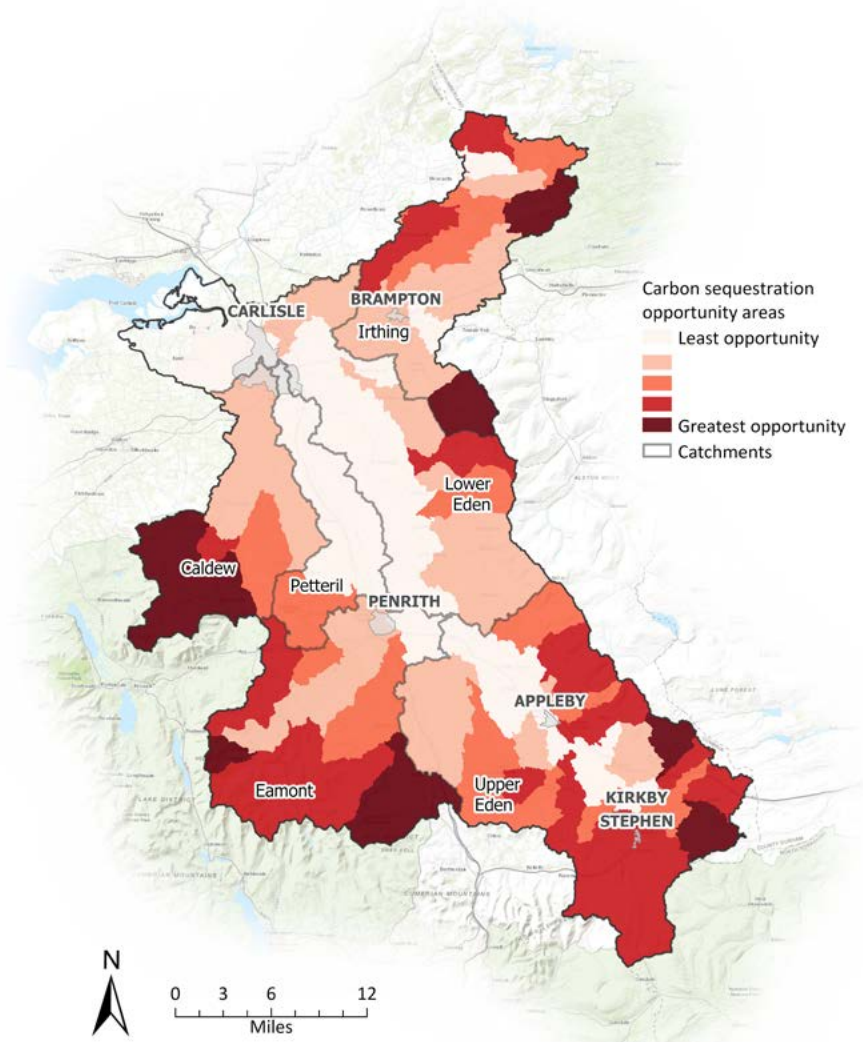


Figure 23. Opportunities map for improving carbon capture and storage in the Eden, (calculated as for *Figure 22*) but displayed as an average across the sub-catchment. Darker areas show greatest opportunity for improvement.

Response

The Catchment Partnership will develop and support activities to increase carbon storage and capture in the Eden through:

- **Protection of existing blanket bog and organo-mineral soils from disturbance and restoration of damaged peatlands; blanket bog in the uplands and limited raised bog in the lowland.**
- **Promotion of permanent pasture.**
- **Large scale tree planting/natural regeneration of scrub and native woodland.**
- **Soil health improvements e.g. through increasing no or low tillage farming, use of cover crops, soil aeration that improves soil health and prevents erosion.**
- **Promoting Natural Capital on farms as an asset to be rewarded (public money for public goods), promoting land use change whilst maintaining farm profitability.**
- **Advocating full delivery on local and national government net zero carbon emission targets.**

Many of these activities will also help flood mitigation and improvement in water quality and ecological networks.

Policies and regulations to protect and improve carbon stores in the Eden catchment

UK - Net zero target by 2050: carbon lost through emissions in the UK avoided or offset by tree planting and other carbon sequestration measures.

Eden District, Carlisle City and Cumbria County Council's targets of becoming carbon neutral (by 2030 for EDC and Carlisle City).

Cross-slope hedgerow © *ERT*

Recreation and Leisure

Catchment Partnership Goal:

Eden's communities and visitors can access and enjoy land and water-based recreation opportunities and all their benefits, without harming the environment.

Brougham Castle © Rod Ireland Photography

State

Natural heritage sites and landscapes

A myriad of outdoor focused recreation and leisure pursuits are on offer in the Eden catchment alongside the many natural heritage sites and landscapes such as World Heritage Sites, National Parks, and Areas of Outstanding Natural Beauty (*Figure 24*) as well as rivers and lakes.

Wayfinder post © *SupportITNI/Pixabay*

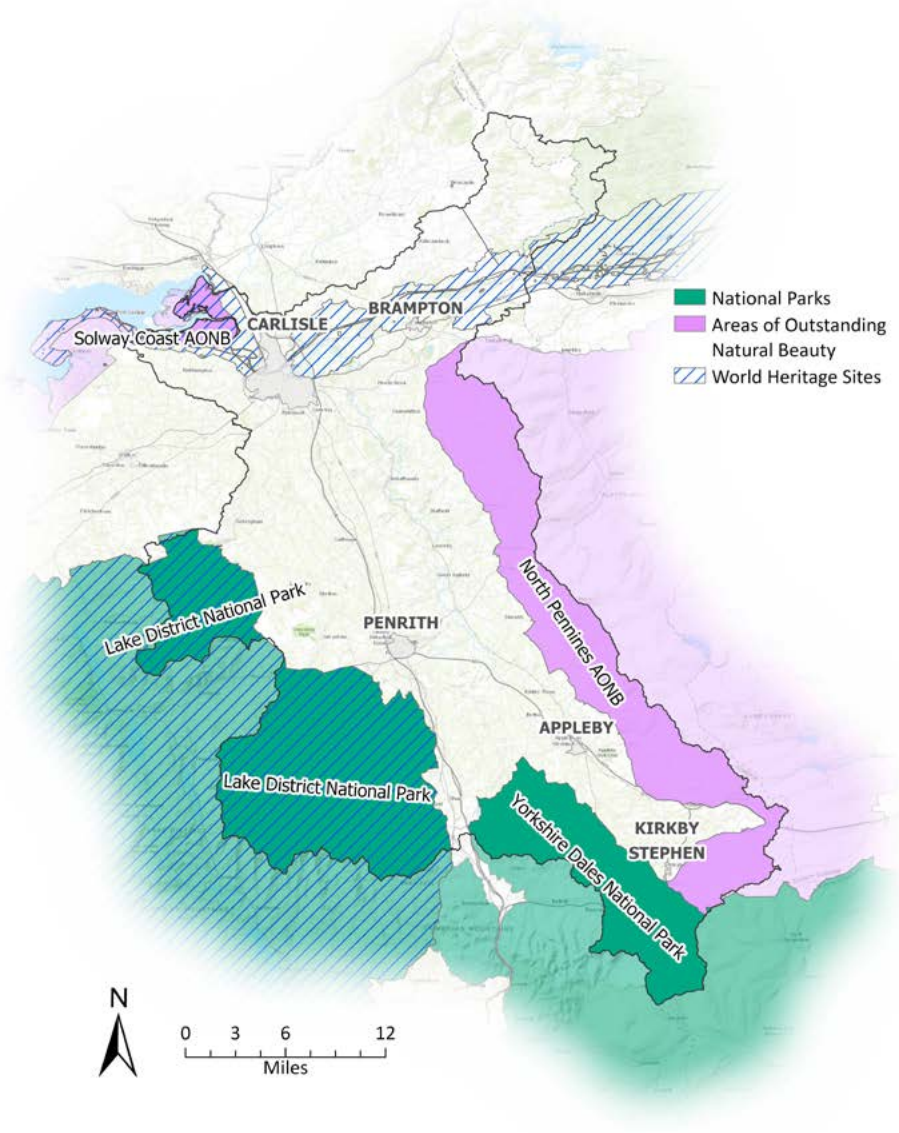


Figure 24. *World Heritage Sites, National Parks, and Areas of Outstanding Natural Beauty in the Eden.*

Access

Once in the countryside, access within Eden's open spaces is good. Open and common land is found around the edge of the catchment with a network of public rights of way, including national walking and cycling routes across the catchment. Some disagreements about access to parts of the River Eden exist between different user groups such as canoeists and anglers.

Enabling access is an important part of the management plans for both the Lake District and the Yorkshire Dales National Parks and for the North Pennines AONB.[72][73][74]

Angling on the Eden near Carlisle © *Rod Ireland Photography*

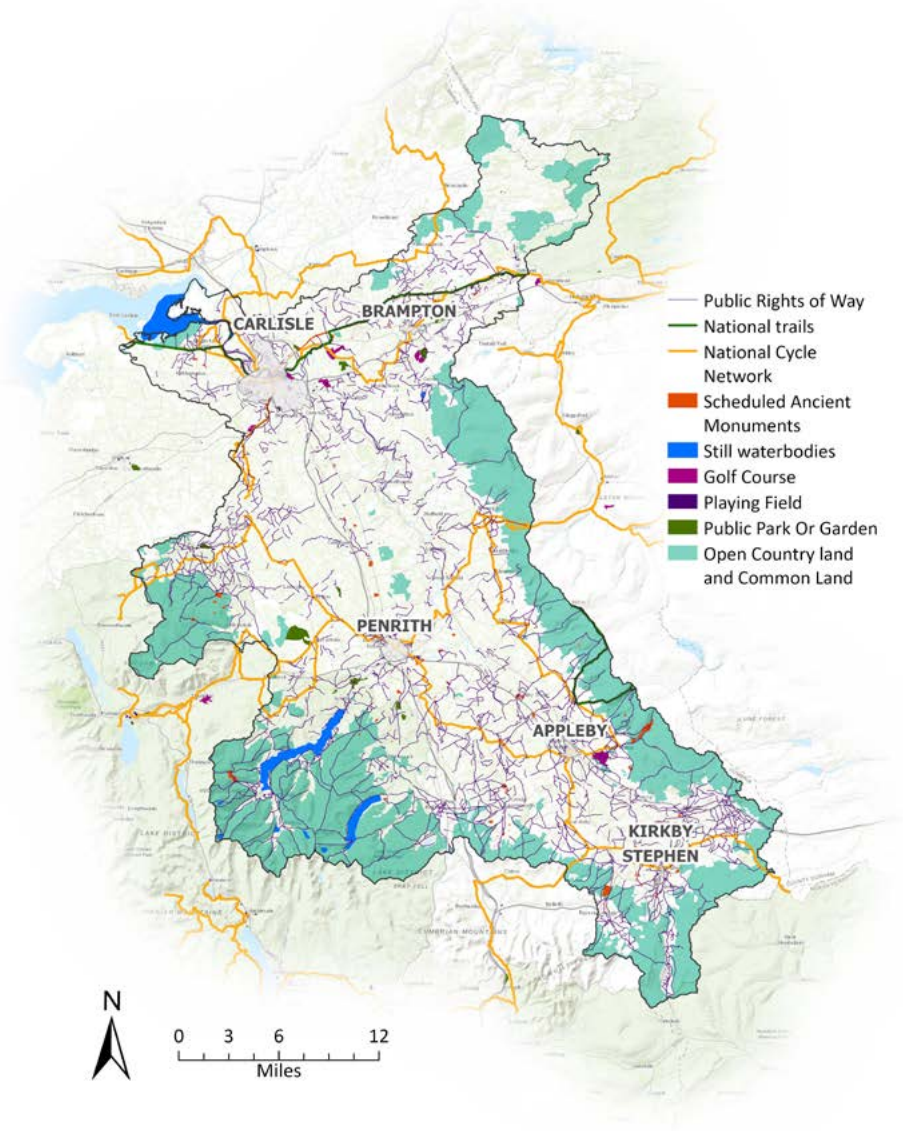


Figure 25. *Outdoor spaces for recreation and leisure activities in the Eden.*

Recreation and Leisure

Pressures

Tourism

Visitors and associated development are both a benefit and a potential threat in the Eden catchment. Visitors contribute to the local economy and development enables easier access to recreation services. Approximately 18,000 residents are employed in tourism-related industries, particularly in the National Park areas.

They also have the potential to overwhelm existing services and fragile natural sites if un-managed. Visitor numbers and trends can be found in the Carlisle and Eden Districts 2018 STEAM (Scarborough Tourism Economic Activity Monitor) reports and show a slight downward trend in visitor numbers across the Eden catchment to 14.2 million visitors. However, they resulted in an upwards step in income to £917.6 million, resulting in 14,300 full time equivalent jobs in the area.[9]

Private transport is essential for accessing rural Eden. Visitors increase traffic pollution, and congestion is a pressure in the Lake District National Park. In the Eden this is most acute in the Eamont sub-catchment around Ullswater. Local communities can be physically and culturally disconnected from those opportunities if they are without private transport.

Increasing use of open spaces also carries the risk of the spread of invasive non-native species if adequate biosecurity measures are not in place. (*Ecological Networks page 46*).

Development

Development brings benefits such as increased new residents, more visitors contributing to the local economy and easier access. It also bring potential pressures on existing services and the fragile natural environments of visitor hotspots that coincide with significant natural heritage sites. For example, from trampling and erosion, to inadvertent introduction of invasive non-native species.

There are two major developments planned for the Eden catchment for the next 5 years and a number of strategic schemes. St Cuthbert's Garden Village is a proposal for up to 10,000 new homes with education, employment and recreation services on the southern side of Carlisle and includes an east-west link road between junction 42 of the M6 and the A595. It is being built around the principles of a garden village, with green spaces and sustainable development planned for the village centre.[75]

Highways England have plans to bring the A66 to dual carriageway standard along the whole 50-mile route from Penrith to Scotch Corner to reduce congestion and provide easier access to work and tourism locations.[76] The River Eden Special Area of Conservation and SSSI will be affected.

Opportunities

Datasets to support robust opportunity mapping are not yet available.

Promoting sustainable tourism and development is critical to protect other ecosystem services in Eden.

Recreation and Leisure

Appleby Horse Fair © Bryan Ledgard / CC

Response

The Catchment Partnership will develop and support activities that improve recreation and leisure yet balance the right to access with the need to protect other ecosystem services within the Eden catchment. These include:

- **Facilitating constructive discussions between different recreational user groups for fair access to the river.**
- **More barrier free footpaths ('Miles without Stiles') and other accessible routes.**
- **Source to Sea and circular routes for walking, cycling and canoeing.**
- **Promotion of city to countryside access through improved recreational transport links (e.g. hiker's bus).**
- **Campaigns to raise awareness of biosecurity issues for recreational users of the catchment, particularly the river.**
- **Promotion, interpretation and improved (sensitive) access to key cultural and natural sites such as Long Meg and Her Daughters, Lacy's Caves, as well as the many castles and riverside paths.**
- **Campaign for appropriate mitigation responses to A66 dualling and other major developments affecting our water resources.**

Existing plans and strategies for recreation exist for various areas of the Eden catchment, as recreation is usually addressed according to administrative boundaries (County, Protected Landscape or District Council) (see box opposite) rather than by catchment.

These strategies and the agencies leading them are the most appropriate frameworks within which to place the types of activities suggested above.

Existing strategies that aim to maintain and improve recreational ecosystem services in the Eden catchment

Cumbria Countryside Access Strategy[77]

Cumbria Cycling Strategy[78]

Cumbria Landscape Character Guidance[79]

The Big Green City – infrastructure Strategy for Carlisle and District[80]

Lake District National Park Partnership Management Plan[71]

Lake District Landscape Character Assessment[81]

Yorkshire Dales National Park Management Plan[73]

North Pennines AONB Management Plan[74]

Eden Local Plan[82]

Combining the Ecosystem Services

Healthy rivers in a working landscape by Shap Primary School

Combining the Ecosystem Services

Examining each of these ecosystem services separately creates a series of interesting and valuable assessments but does not consider the combination of the ecosystem services at any one location, nor that one intervention might improve multiple ecosystem services. For example, woodland creation has the potential to provide benefits across all six ecosystem services in a single location.

Current data limitations mean that it has not been possible to produce reliable and accurate mapped analysis for two of the ecosystem services (water-management of low flows and recreation and leisure). Therefore to identify locations where multiple ecosystem services could be improved, the four available opportunity maps (water quality, water quantity-high flows management, ecological networks and carbon capture and storage) have been combined (see *Figure 27*).

Due to the complex nature of these data and the high level of detail available, they have been mapped at 25m^2 and summarised by Water Framework Directive sub-catchment, as throughout this document.

The darker areas highlight where interventions could result in changes to multiple ecosystem services potentially providing a clearer view of where to target projects to achieve the most effective results.

As might be expected, significant opportunities for multiple benefits exist near our rivers and becks, especially those in the upper reaches of the catchment.

The sub-catchments with the greatest opportunity for improving multiple ecosystem services are found in the Lake District fells: in the Upper Eamont around Ullswater and Haweswater and in the Upper Caldew, as well as along the North Pennine hills on the eastern edge of the Upper Eden catchment and the southern and eastern edges of the Irthing catchment.

Details of potential projects to address these opportunity areas can be found in the Sub-catchment Action Plan section of this document (*Part 2*).

There are opportunities to improve multiple ecosystem services *throughout* the whole catchment.

These are distributed widely and call for a catchment-wide approach rather than solely focusing work on one operational catchment.

Combining the Ecosystem Services

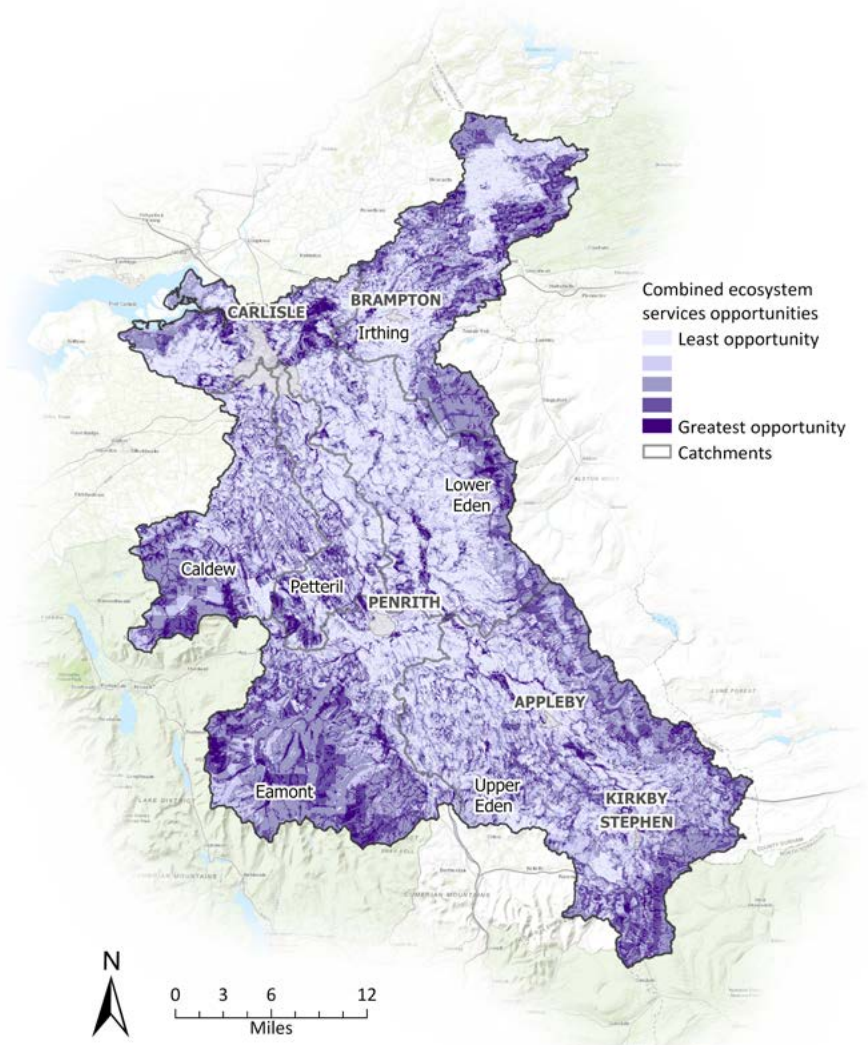


Figure 26. Detailed opportunity areas to improve the management of multiple ecosystem services (water quality, management of high flows, ecological networks, carbon capture and storage) in the Eden displayed at 25m^2. Darker areas indicate greater opportunity for improvement.

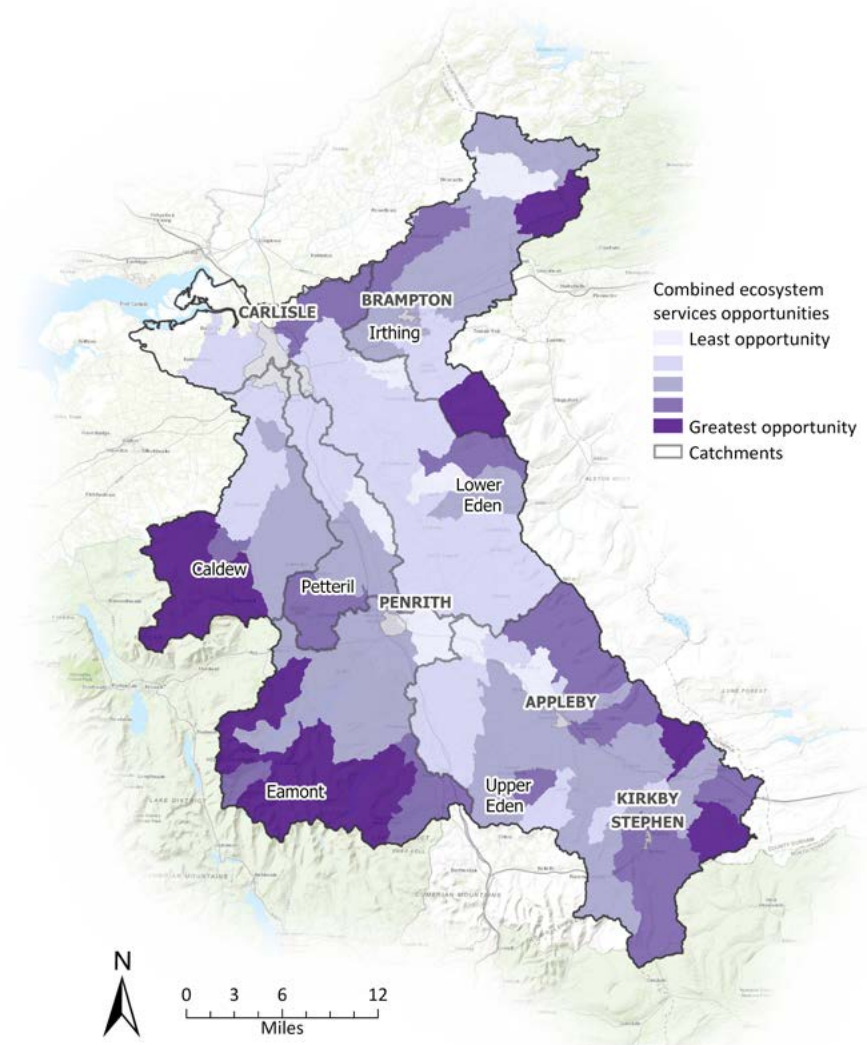


Figure 27. Opportunity areas to improve the management of multiple ecosystem services in the Eden, (as calculated for *Figure 26*) but displayed as an average across the sub-catchments – darker areas indicate greater opportunity for improvement.

PART 2: **Sub-catchment Action Plans**

PART 2: **Sub-catchment Action Plans**

Introduction

Action plans have been developed for each of the 'operational catchments' (Upper Eden, Eamont, Irthing, Caldew, Petteril, Lower Eden) targeting specific areas for interventions. They contain:

1. **A synopsis of the areas of opportunity for improving ecosystem services, and the main pressures in each sub-catchment.**
2. **Key sites where there are specific problems to resolve.**
3. **A selection of recently completed and current catchment management projects addressing these problems and selected aspirational projects the Catchment Partnership wish to implement in the next 5 to 10 years.**

A dynamic list of all Eden's completed, current and aspirational projects is mapped online in the Eden Catchment Portal along with an extended version of Revitalising Eden: the Eden Catchment Plan
https://edenriverstrust.org.uk/eden-catchment-partnership/

The projects and partners named are based on the information collected through the Catchment Plan process and on projects identified by Catchment Partnership members. Additional projects and partners will be added over time, with the most up-to-date list found online in the Eden Catchment Portal.

Considerable investment will be required if all the aspirational projects selected below are completed - in the region of £10-15 million over the next ten years. For transformational change three times more will be required.

This estimated figure excludes the funding available for capital works (hard engineering) for flood alleviation. Cumbria-wide there is c. £6million over seven years to be spent by through the Local Flood Authority capital programme; £250,000 over five years from the local levy; and c. £30million over five years from the Environment Agency. A proportion of this will be spent within the Eden catchment.

In order to implement the priority projects, Catchment Partnership members will need to:

1. Use the resources already available to provide the best solution at any particular location, and
2. Work together to source new funds where possible.

These priority projects will contribute to new and existing programmes, plans and strategies that manage land and water in the UK. Many of these programmes have their own funding streams and should provide an opportunity for partnerships, resulting in more cost-effective delivery.

Some of the programmes that the Eden Catchment Plan projects will contribute to are:

UK/England level :

- Defra 25-year Environment Plan and the proposed Environment Land Management Scheme to replace Country Stewardship funding (Basic and Higher-Level Stewardship payments for land managers).[83]
- The National Flood and Coastal Defence Strategy.[84]
- Improvement Plan for England's Natura 2000 Sites (IPENS) Site Improvement Plan River Eden 2014.[85]
- England Peatland Strategy (Defra 2019 still to be released).

Regional and local level:

- Tweed and Solway Firth River Basin Management Plan (in revision 2020).[86]
- The Cumbria Flood Risk Management Strategy (LLFA).[87]
- Diffuse Water Pollution Strategy for Cumbria (Natural England and Environment Agency).
- Eden District Council and Carlisle District Council Plans.[88][89]
- North Pennines AONB Management Plan.[74]
- National Park Management Plans (Yorkshire Dales and Lake District).[90][91]
- National Parks Local Plans (Yorkshire Dales and Lake District).[92][93]
- Cumbria River Restoration Programme.

Many of these plans do not currently come with any funding attached. Current funding such as Water Environment Grants (WEG), Grant in Aid and the Water Environment Improvement Fund (WEIF), Countryside Stewardship (CS) and National Lottery Heritage Fund grants are already assisting in the delivery of catchment management work, but these (and any successors) will only fund a tiny proportion of the activity that is required.

The Partnership needs to continue to source additional funding and develop innovative ways to deliver projects. Undoubtedly there is a huge role for private businesses large and small, who are not yet engaged in supporting sustainable catchment management activities in the Eden.

It is not only about money – the Partnership collectively and its individual members need to continue to work to change the culture and mindset of local communities, landowners and businesses about the benefits of integrated catchment management for securing ecosystem services. Close working relationships between Partnership members and citizens who live and work within the Eden is fundamental to success.

Governance - Who governs the implementation of this plan?

The Eden Catchment Partnership will advocate for the priority projects within the action plan. No individual partner organisation can deliver these alone, and the Partnership must work with other stakeholders and individuals who aim to improve ecosystem services in the catchment.

Eden Rivers Trust (host and Chair of the Partnership) will report on progress through the national CaBA (Catchment Based Approach) process and associated policy framework developed by Defra in 2013. Progress will be reviewed annually within the Eden Catchment Partnership.

Through working together on this Plan, the Eden Catchment Partnership, like other Catchment Partnerships across England and Wales, is acting as a de facto point of oversight of water management in the Eden catchment.

It has no official mandate to prioritise action and direct resources, or power to enforce those priorities; there is no one body that does – either here in the Eden or elsewhere in England and Wales. This apparent gap in England's water governance is being discussed nationally and regionally. If solved, such a body could be a huge step forward in achieving integrated catchment management in our river basins.

Tree planting on Birkett Common © *Rod Ireland Photography*

Upper Eden Action Plan

Hell Gill Beck © *James Palmer/ERT*

About

The Upper Eden holds the source of the main river which rises from the high limestone fells above Mallerstang and then flows north through the towns of Kirkby Stephen and Appleby, widening at Temple Sowerby.

The boundary with the Lower Eden is at Watersmeet (the confluence with the Eamont) just upstream of Langwathby. The main tributaries are the River Belah, Trout Beck, Scandal Beck, River Leith, River Lyvennet and Hoff Beck.

The River Eden is excellent for salmon and sea trout fishing and supports a range of wildlife. There is rough grazing on the high fells and mixed farming in the lower valley.

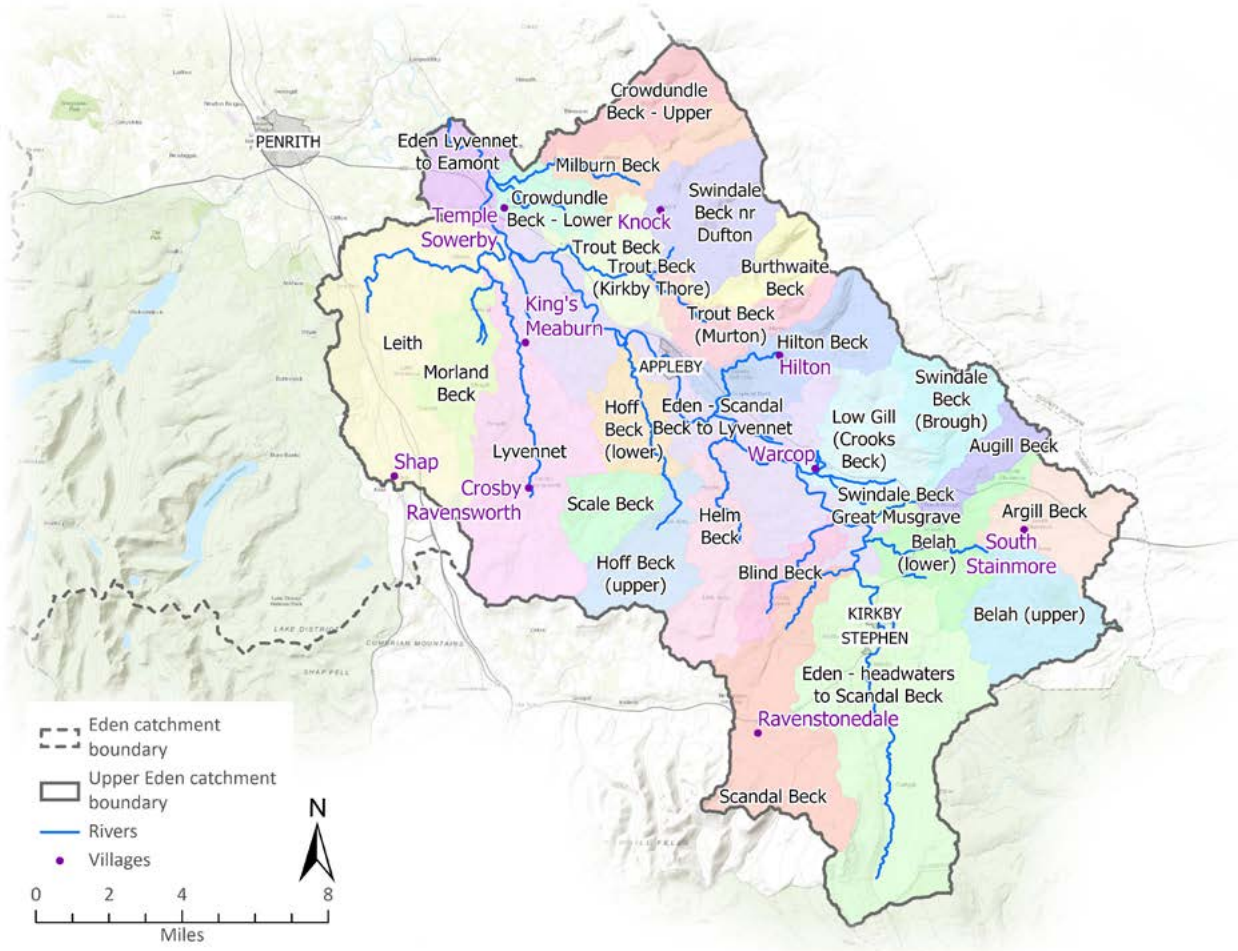


Figure 28. Upper Eden sub-catchment showing main rivers and the smaller sub-catchments as they are defined in the Water Framework Directive classification (colours are used for clarity).

Opportunities to improve ecosystem services

Multiple benefits to ecosystem services could be achieved in the Scandal Beck, Lyvennet and Scale Beck sub-catchments (limestone areas) and in the Upper Crowdundle catchment on the North Pennines. These are particularly in relation to improving water quality, natural flood management, carbon storage and ecological networks.

Key sites

Lyvennet, Morland and Low Gill becks suffer from poor water quality due to poor soil and nutrient management, with several other areas suffering to a lesser extent. Trout Beck and the Leith do not meet water quality targets.

Many Upper Eden tributaries show excessive poaching (ground disturbance by grazing animals) which affects water quality and aquatic life and are targets for riparian habitat restoration.

The Lyvennet and Augill Beck have historic point source pollution issues.

Hilton Beck and Keld Syke suffer from high conductivity due to discharge from a former lead mine and Kirkby Thore Gypsum mine respectively.

Appleby, Warcop, Shap, Hartley, Kirkby Stephen, Crosby Ravensworth, Maulds Meaburn, Morland Whinfell and Great Ormside are considered as communities at risk of flooding.

Scandal Beck, Leith, Lyvennet, and Trout Beck have straightened river channels, which are targets for river restoration to improve habitat, water quality and slow the flow of water.

Sheriffs Park Weir on the Leith and Bongate Weir on the Eden are partial barriers for fish and White-clawed crayfish migration and potential targets for removal. Bongate Weir is also a public safety hazard. In the Upper Eden, as elsewhere in the catchment, there are numerous smaller weirs and barriers that impact on the geomorphology of the river.

The North Pennines has damaged blanket bogs which need restoration.

The M6, A6 and West Coast Main Line railway intersect with the River Leith with drainage outfalls potentially impacting on water quality and ecological networks.

Fenced-off riverbank on the Lyvennet *© ERT*

A selection of current, completed and aspirational projects in the Upper Eden

Completed projects

Historic river straightening, barriers and degraded biodiversity: Lyvennet, Hoff and Helm Becks.

River restoration projects completed at Barnskew, Thrimby, and Kemplee, plus several fencing projects to improve riparian habitat around Hoff Beck. Includes projects completed as part of the Cumbria RRS Strategy. *EA/NE/ERT.*

Ecological networks, flooding, water quality, low flows, carbon storage: Leith and Lyvennet.

River Restoration Strategy. River re-meandering, new wetlands, riparian habitat and new rapids/riffles on formerly straightened river. *EA/ERT/Landowners/NE.*

Current projects

Historic river straightening, barriers and degraded biodiversity (fish): Lyvennet, Leith, Scandal Beck, Bessy Gill, Trout Beck.

Restoring natural river processes, removing barriers and protecting riparian habitat to increase biodiversity. These include the Cumbria RSS in the Eden and Westmorland Dales National Lottery Heritage Fund project which runs to 2023. *EA/NE/FoLD/YDNPA/ERT*.

Flooding and degraded biodiversity: Lyvennet, Eden Headwaters Scandal Beck.

NFM measures such as extensive tree planting and restoring natural river processes to slow the flow of water and increase biodiversity. Includes Mallerstang Defra NFM project. *EA/FoLD/YDNPA/ERT/FC/ Landowners/WT/Lancaster University.*

Agricultural (nutrient) pollution and flooding: Leith, Trout Beck.

Coordination of projects and communication of information to reduce silt and phosphate entering watercourses. Water Environment Grant. *ERT/NE/ Farmer Facilitation group.*

Historic river straightening, barriers and degraded biodiversity (fish): Invasive Species: Trout Beck.

Removal of Himalayan balsam from the entire sub-catchment. *ERT/NE/Oglesby Trust.*

Degraded carbon stores and ecological networks: Stainmore.

Blanket Bog restoration including drain blocking and re-vegetation of bare peat. *NPAONB/CWT/NE.*

Upper Eden

Aspirational projects 2020 – 2030

Landscape scale conservation in the North Pennines/Upper Eden. Working with community and landowners to demonstrate improved management of ecosystem services from fell top to valley bottom (protection and restoration of existing habitat, habitat creation and restoration of natural processes through grip blocking, tree planting, grazing management, river re-meandering and flood meadow creation) could be associated with potential A66 widening mitigation funding.

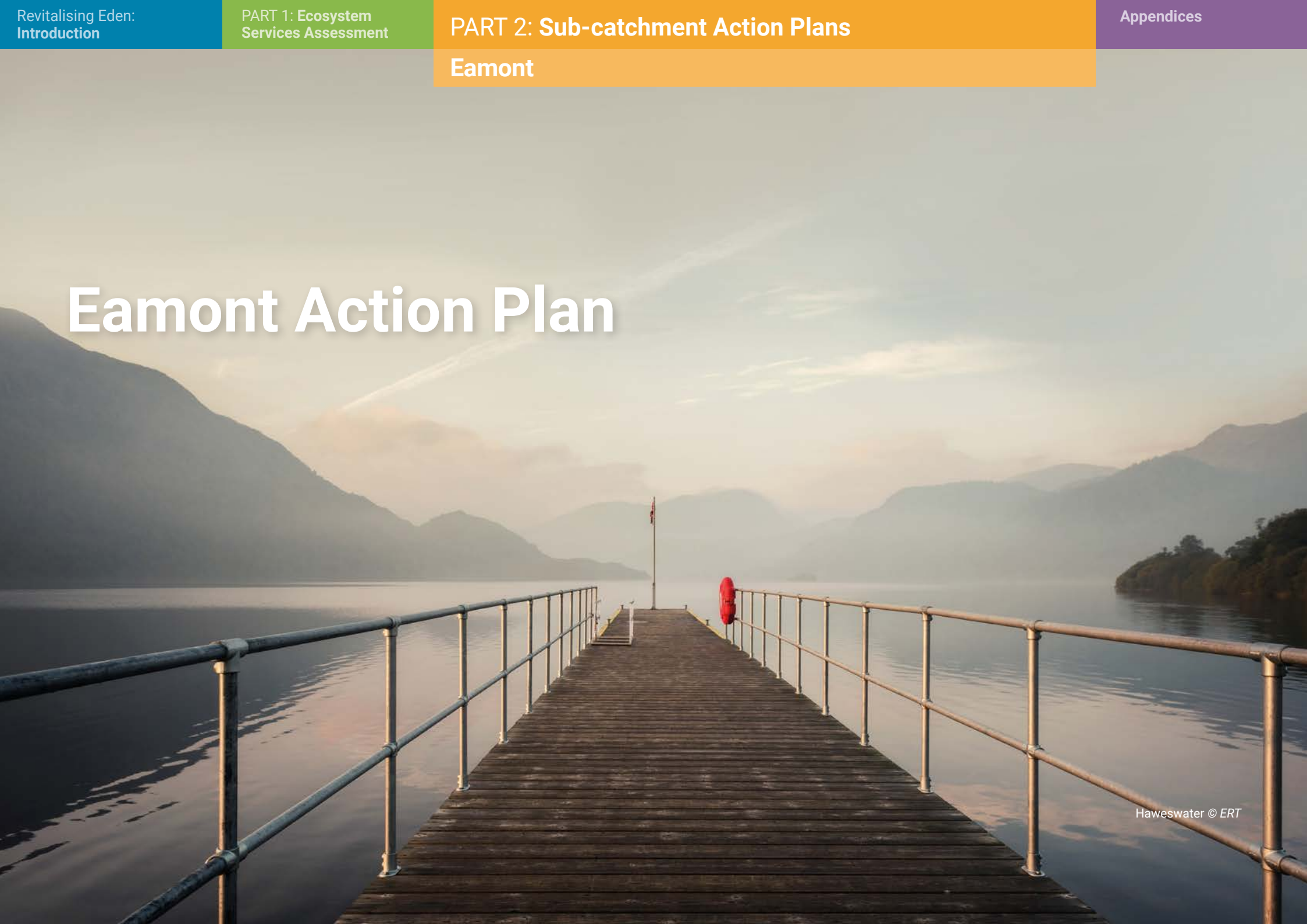
Flood scheme for Appleby and Natural Flood Management projects for Appleby, Warcop, Shap, Hartley, Whinfell and Great Ormside.

Restoration of historic straightened river channels on the Lyvennet connecting existing projects. Plus removal of weirs, e.g. Sheriffs weir.

Upper Eden Limestone nutrient management and establishing safe Crayfish Ark Sites.

Formalisation of shared boating and angling access on the Eden from Appleby to Watersmeet and on the Eamont from Brougham to Watersmeet.

Eamont Action Plan



Haweswater © *ERT*

About

The Eamont catchment contains two major tributaries of the Eden, the Lowther and Eamont. The Lowther's own tributaries rise in the Shap fells and High Street and feed Haweswater and Wet Sleddale reservoirs, before flowing north through Bampton, Askham, Lowther and joining the River Eamont at Eamont Bridge.

Smaller becks draining the high fell ranges of Helvellyn and High Street flow into Brothers Water and Ullswater, and water exits Ullswater at the River Eamont which flows north-east through Eamont Bridge, joining the main river Eden at Watersmeet. Dacre Beck is a smaller river draining the smaller fells in the north of the catchment.

Land use in the Eamont catchment consists of sheep farming in the uplands, and dairy, beef and some arable farming in the lowland.

Historically, mining took place at Greenside mine. Much of this catchment is in the Lake District National Park Authority. The area, particularly the Ullswater Valley is important for recreation.

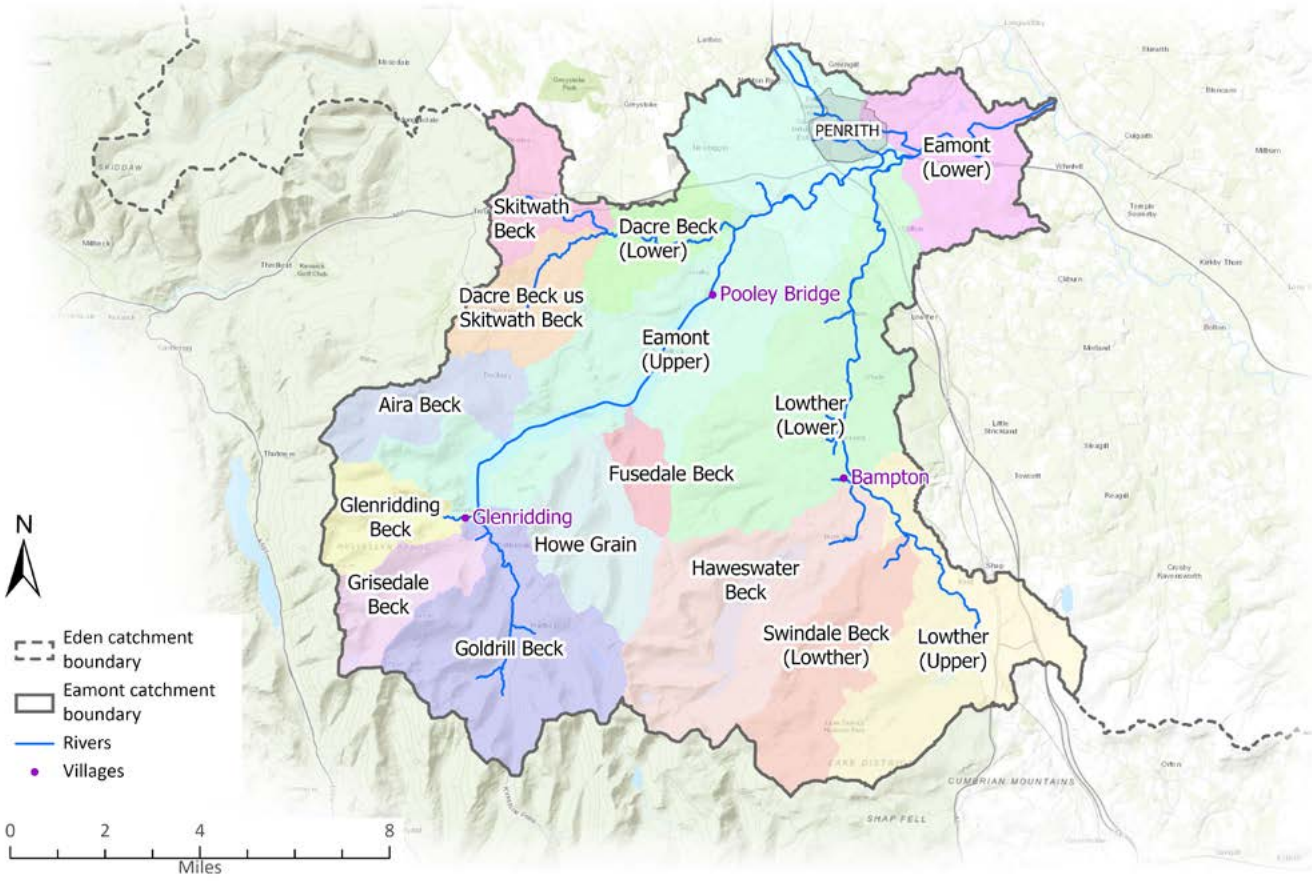


Figure 29. Eamont sub-catchment showing main rivers and the smaller sub-catchment as they are defined in the Water Framework Directive classification (colours are used for clarity).

Opportunities to improve ecosystem services

In the Glenridding and Dacre Becks, Eamont (Upper) and Skitwath Beck sub-catchments, the greatest opportunities exist to improve high and low flow management, water quality improvement and recreation, but opportunities for increasing ecological network integrity, carbon storage and water quality exist throughout the upper Eamont catchment.

Key sites

Glenridding, Pooley Bridge, Eamont Bridge, Shap, Bomby and Bampton were all severely impacted by Storm Desmond, largely due to the magnitude of the rainfall and the landscape topology. Continued efforts to slow the flow and reduce peak flows through interventions upstream of these settlements are needed.

Glenridding Beck has poor water quality status and critically suffers from pollution from mine waters and sewage discharge. Dacre Beck also has poor water quality.

In Ullswater, point source water pollution from non-mains drainage, (including outdated septic tanks) around the lake causes localised nutrient enrichment of the lake and smaller rivers.

United Utilities are permitted, through their conditional abstraction licence, to take water from Ullswater to Haweswater throughout the year as long as a specified minimum flow in the Eamont is maintained and the lake is above a certain level.

The invasive non-native species (INNS) Himalayan balsam is a widespread problem around Ullswater but interventions are only likely to have long-term impact if the problem is addressed from the top of the catchment.

Low Mill Weir and Southwaite Mill Weir at Eamont Bridge and Pooley Bridge water gauging weir are barriers to fish migration. Low Mill weir also exacerbates flooding on the Eamont.

Other modified becks requiring restoration include Goldrill Beck, Lowther, Swindale and Howegrain.

Himalayan balsam flowers and seed pods © *ERT*

A selection of current, completed and aspirational projects in the Eamont

Completed projects

Carbon sequestration, biodiversity and increased water retention: Mosedale and Shap Fells.

Sustainable Catchment Management Programme (2010-2015). Grips blocked, grazing removed over 1700 ha of blanket bog fell land. *UU/RSPB.*

Barriers: Carleton Hall (R. Eamont) and Low Gardens (R. Lowther).

Removal of weirs *EA/ERT/NE.*

Ecological networks, flooding, water quality, low flows, carbon storage: Swindale, Thackthwaite and Mellfell Becks, Leith and Lyvennet.

River re-meandering, new wetlands, riparian habitat and rapids/riffles. *EA/NT/ERT/RSPB/Ullswater CIC/ Landowners/UU.*

Flooding and ecological networks: Glenridding, Patterdale and Grisedale.

Flood management capital works. Extensive tree planting in fells above Ullswater, leaky dam installations. *EA/ERT/WT/Patterdale and Glenridding community flood groups.*

Current projects

Channel modification and flooding:

- **Goldrill Beck.** Re-meandering and removal of bank protection and embankments on sections of Goldrill Beck. *NT/EA/NE.*
- **Matterdale.** Re-meadering, re-connection of flood plain to river, tree planting. *Landowners/EA/ERT/ Ullswater CIC.*

Ecological networks, flooding, water quality, low flows, carbon storage:

- **Lowther.** Natural recovery of part of the River Lowther at Setterah Park. Wood pasture, wildflower meadow creation, large scale tree planting *NE/ Lowther Estate.*
- **Helvellyn.** Working to protect and enhance the ecosystem of Helvellyn while respecting its cultural traditions, including farming practices. *Glenridding Commoners/Landowners/LDNPA/John Muir Trust.*

Water quality, flooding, ecological networks: Leith and Lowther catchment.

Farmer Facilitation Fund - advice to improve the natural environment at a landscape scale. *NE/ERT*

Carbon sequestration, biodiversity and increased water retention: Bampton Common and Mardale Common.

Peatland restoration. *CWT/RSPB/UU.*

Invasive non-native species: Glenridding Beck.

Volunteer-led effort to manage Himalayan balsam, reducing infestations to a small site. *LDNPA.*

Eamont

Aspirational projects 2020 – 2030

Flood scheme for Eamont Bridge and Natural Flood Management schemes for Grisedale Beck, Goldrill Beck and Upper Eamont catchments.

Comprehensive farm nutrient management programme for Upper Eamont farms (Dacre, Skitwith, Aira, Glenridding, Grisedale and Goldrill Becks). Hedge, wall and pond creation, soil aeration, leaky dams, improved riparian habitats and buffers.

A restoration of Ullswater rivers. Removal of Low Mill and Southwaite Weirs.

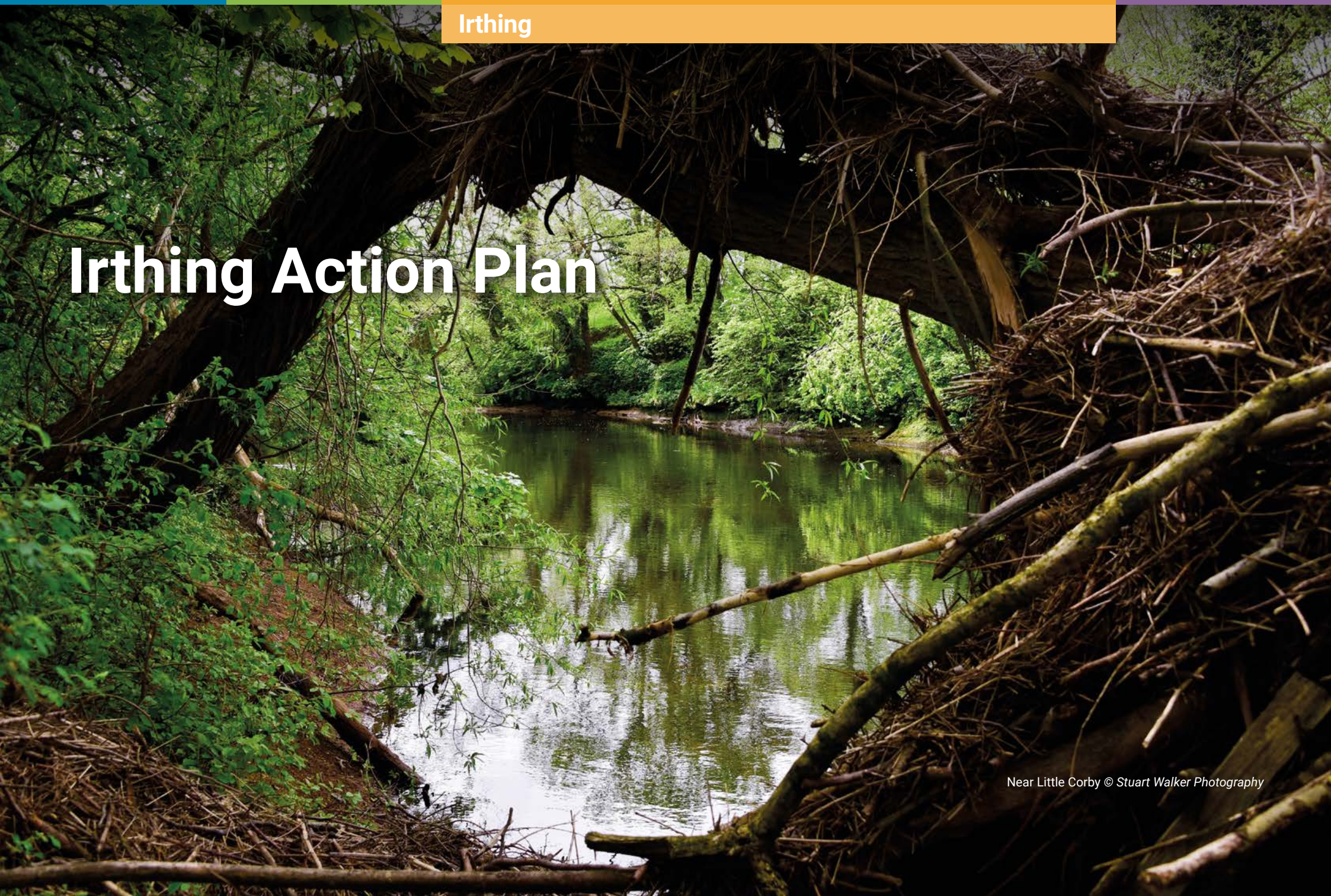
Blanket bog restoration survey and targeted restoration in the Upper Eamont Fells.

Water quality campaign on non-mains drainage, including septic tanks around Ullswater and surrounding villages, especially tourist hotspots.

Species recovery plans for Water vole and beaver. Feasibility for Water vole re-introduction, establish a mink free zone, enclosed beaver re-introduction trials in the Lower Eamont/Lowther.

Formalisation of shared boating and angling access for the River Eamont from Pooley Bridge to Watersmeet and walking access to the River Eamont from Pooley Mill to Sockbridge Mill and Brougham to Watersmeet.

Irthing Action Plan



Near Little Corby © *Stuart Walker Photography*

Irthing

About

The source of the River Irthing is in the Northumberland National Park within the conifer plantations and blanket bog around Butterburn (Spadeadam Forest).

It flows south-west to meet the Eden just north of Warwick Bridge.

Bolton Fell and Walton Moss (a part-restored lowland raised moss) drains into the Irthing near Brampton. The King Water and Gelt are important tributaries with the Upper Gelt and Old and New Water tributaries feeding the drinking water reservoir at Castle Carrock.

The uplands are managed for sheep, cattle and grouse and the lowlands for (intensive) beef, dairy, sheep and arable. Talkin Tarn, a small lake within the catchment, is popular for recreational activities. The Hadrian's Wall World Heritage Site crosses the catchment passing through Brampton and Gilsland and includes the Birdoswald Roman Fort.

Figure 30. Irthing sub-catchment showing main rivers and the smaller sub-catchments as they are defined in the Water Framework Directive classification (colours are used for clarity).

Opportunities to improve ecosystem services

These are greatest along the main river Irthing; particularly interventions to improve water quality (through better management of nutrient input and soil), flood management and carbon storage. There is opportunity to improve ecological networks along the riparian habitats of the Upper Irthing sub-catchment.

Key sites

The Irthing (upstream of Crammel Linn) and Quarry Beck are considered to have poor water quality because of poor agricultural nutrient management.

Soil compaction issues are also prevalent in these areas which, if alleviated, would benefit water quality and flood reduction. Butterburn sub-catchment is also poor for fish.

Brampton area suffers occasionally from flooding.

The Upper Irthing contains areas of damaged blanket bog which would benefit from restoration.

Many Irthing and King Water tributaries would benefit from connection and expansion of their riparian woodland habitat which have suffered from the effects of invasive non-native species such as Himalayan balsam.

Sward lifter *© ERT*

A selection of current, completed and aspirational projects in the Irthing

Completed projects

Degraded habitat: Gelt, Old Water, New Water.

Considerable habitat restoration work such as tree planting, heather moorland regeneration, peat restoration and on surrounding farms through Countryside Stewardship schemes. *Landowners/RSPB/NPAONB/NE.*

Flooding: Brampton Beck, Brampton.

Appraisal of properties at risk of flooding has taken place here and measures to improve run off investigated. Conclusion: no financially viable scheme. *EA/Highways England.*

Current projects

Degraded habitat, flooding, carbon storage: Border region.

Forestry Investment Zone. Government initiative - large-scale woodland creation and direct commercial investment in new productive planting for timber, which includes buffer zones of native species and productive woodlands of native species. *Forestry Commission.*

Degraded habitat: Gelt, Old Water, New Water.

Ongoing programme of habitat restoration and targeted countryside stewardship. *Landowners/RSPB/NE.*

Aspirational projects 2020 – 2030

Flood relief measures for Brampton subject to changes in funding arrangements.

A Farmer Facilitation Group for Irthing and Lyne to address water quality issues.

A septic tank awareness campaign for homeowners in Quarry Beck, King Water, downstream Irthing and Crammel Linn sub-catchments.

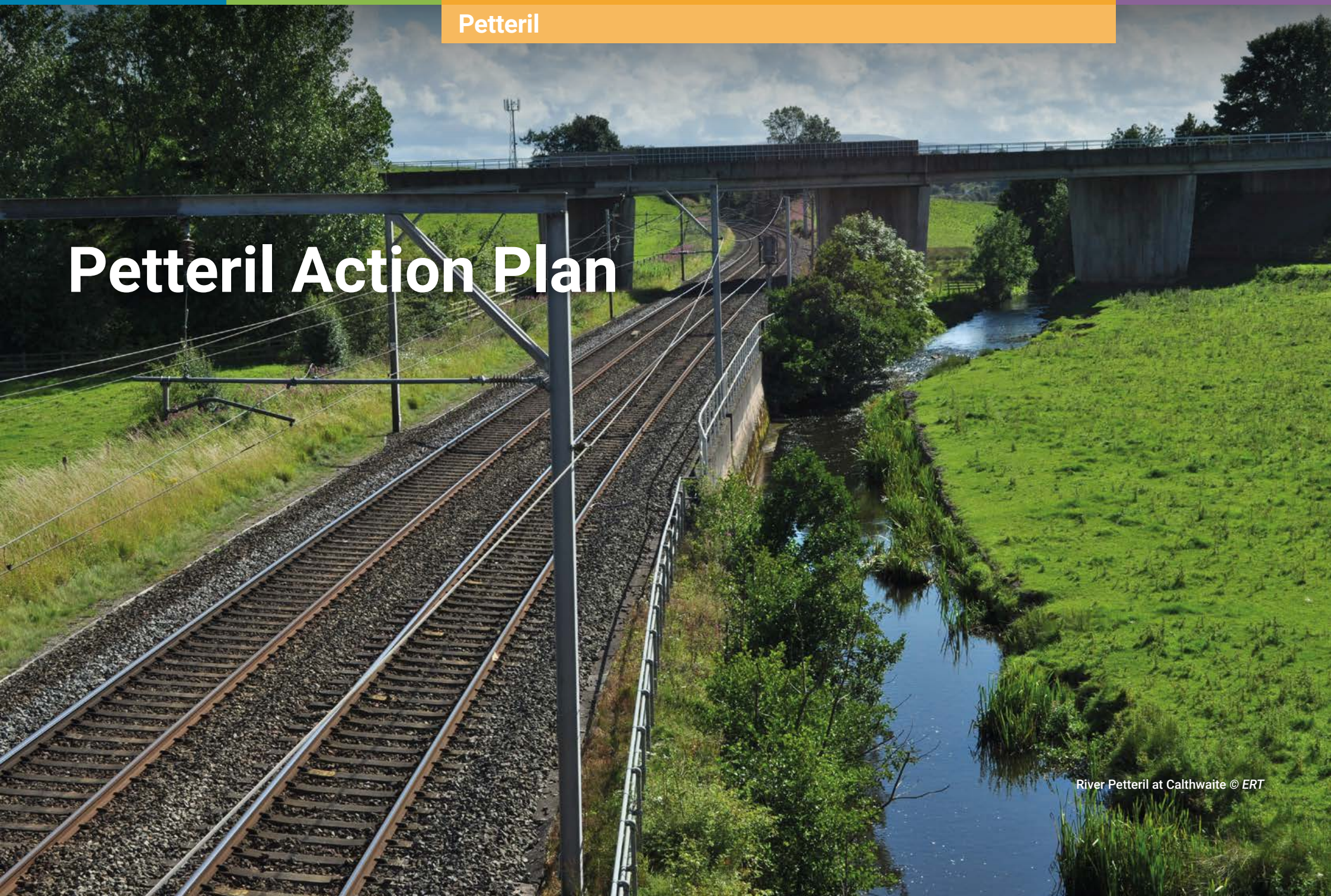
Riparian habitat restoration and management along the becks of Cam Beck (Eden & Esk), King Water, Downstream Irthing and Crammel Linn sub-catchments.

Increased public access for walking along the Irthing.

Irthing

Gelt Woods © *Paul Thomson Photography*

Petteril Action Plan



River Petteril at Calthwaite © *ERT*

About

The River Petteril begins close to the villages of Penruddock and Greystoke and flows north towards Carlisle, where it joins the River Eden.

It runs alongside the M6 motorway and West Coast Mainline railway for much of its length. The River Petteril's main tributary, Blackrack Beck, joins the Petteril north of Calthwaite. Land use in the Petteril catchment is mainly dairy and beef farming until the river reaches the city.

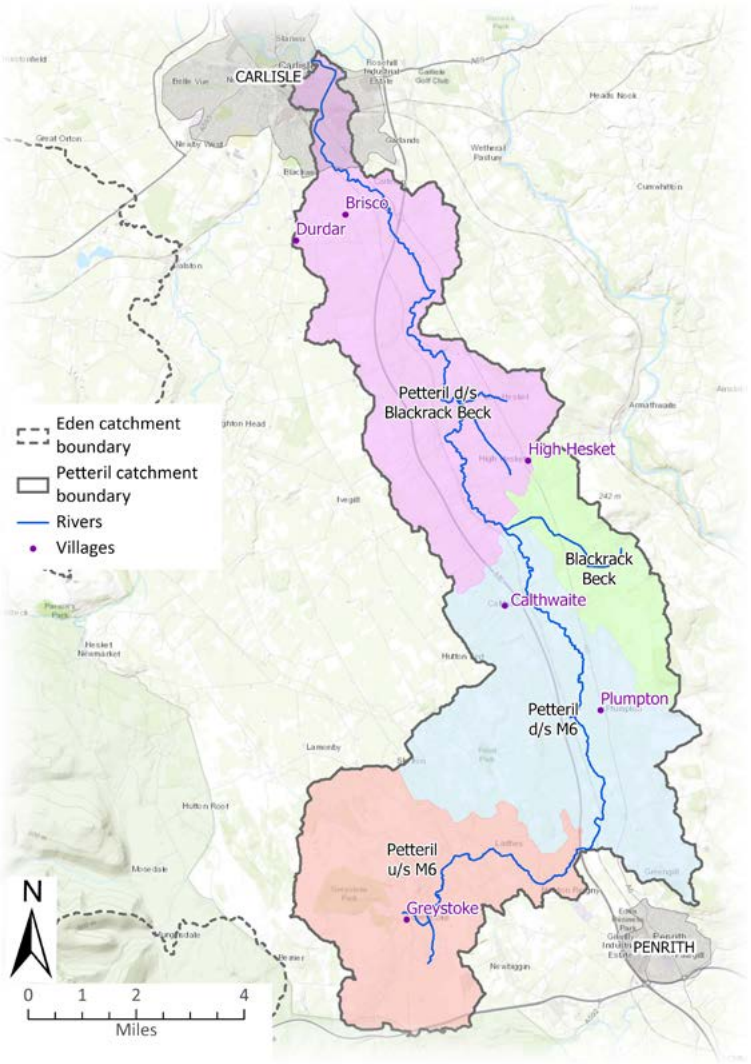


Figure 31. Petteril sub-catchment showing main rivers and the smaller sub-catchments as they are defined in the Water Framework Directive classification (colours are used for clarity).

Opportunities to improve ecosystem services

There are considerable opportunities to improve ecosystem services collectively and individually in the Petteril (water quality, flow management, ecological networks and carbon), especially in the upstream Petteril (M6) sub-catchment.

Key sites

Blackrack Beck's water quality is considered poor due to poor soil and nutrient management and poor land drainage; this causes eutrophication and sedimentation.

United Utilities' wastewater treatment works at Calthwaite, Greystoke and Motherby have been identified as locations for point source pollution, where there are increased discharges. This is a complex situation as phosphate monitoring includes agricultural phosphate from upstream.

Greystoke and Plumpton are both communities at risk of flooding and small enough to be impacted positively by NFM measures.

Fourteen in-river structures remain within the Petteril with a concentration on the main stem that includes a large structure at Barrock Park (north of Southwaite), and weirs at Melbourne and Harraby Parks (near Carlisle).

These are barriers to fish migration and targets for restoration. They also have poor river morphology due to historic river dredging that was undertaken to improve land management and flood water conveyance (the latter is now seen as a potential risk for downstream communities).

Removal of weir in Carlisle © *ERT*

A selection of current, completed and aspirational projects in the Petteril

Completed projects

Poor water quality: Calthwaite

Improvements to farm infrastructure on two farms for separation of clean and dirty water separation. *UU/ERT/EA/Landowners.*

Degraded habitats: Petteril and tributaries.

Early 2000 improvements to riparian vegetation and limiting poaching through fencing and tree planting along the Petteril and tributaries. *ERT/UU/EA.*

Current projects

Poor water quality - facilitation fund approach: Whole Petteril, (Calthwaite, Bowscar)

A coordinated Facilitation Fund farmers' group was set up to promote and discuss methods to improve the natural environment at a landscape scale with a focus on reducing silt and phosphate. Improvements made to farm infrastructure on two farms for separation of clean and dirty water. *NE/ERT.*

Poor water quality: Calthwaite, Motherby, Greystoke.

Investment in phosphate removal at all three sites is underway with Calthwaite and Motherby on track to be completed by 31/03/20 and Greystoke by 31/12/21. *UU.*

Poor water quality - 1:1 farm soil and nutrient planning approach: Whole Petteril

1:1 advice and assistance to improve whole farm planning with a focus on water friendly farming, including both NE catchment sensitive farming and ERT's water-friendly farming programme. Establish a series of good practice demonstration sites to begin in 2020. *NE/ERT.*

Petteril

Aspirational projects 2020 – 2030

Natural flood management intervention for Greystoke village and surroundings – including flood storage, sustainable urban drainage (SUDS) and woodland creation.

A (Commercial) Trading Platform for ecosystem services. Run trials for interventions to reduce phosphate in the Petteril.

Integrated wetlands for water treatment at point source pollution points along the Petteril to include riparian habitat re-instatement and re-linking with former wetlands and existing semi natural habitat.

A targeted septic tank awareness campaign for homeowners.

Removal or modification of weirs and culverts in Barrock, Melbourne and Harraby Parks.

Develop permitted access from the River Petteril source to Wreay Hall Mill.

Large woody debris installed to protect the riverbank in the Petteril *© ERT*

Caldew Action Plan

Holme Head weir © *Rod Ireland Photography*

About

The source of the River Caldew lies within the Skiddaw massif to the north of Keswick. The river flows north through Caldbeck, Dalston and Cummersdale villages, before joining the River Eden at Carlisle. Its main tributaries are Pow and Roe Beck, the River Ive and Gillcambon Beck.

Land use is mixed, with upland sheep farming in the headwaters and dairy and beef farming in the lower reaches; it is very urban through Carlisle.

The impact of mining can still be seen in the Mosedale valley near Carrock Fell (arsenic and tungsten) and near High Pike (lead). The heather on the flanks of the Knott and Great Calva Fells were until recently managed by rotational burning for grouse.

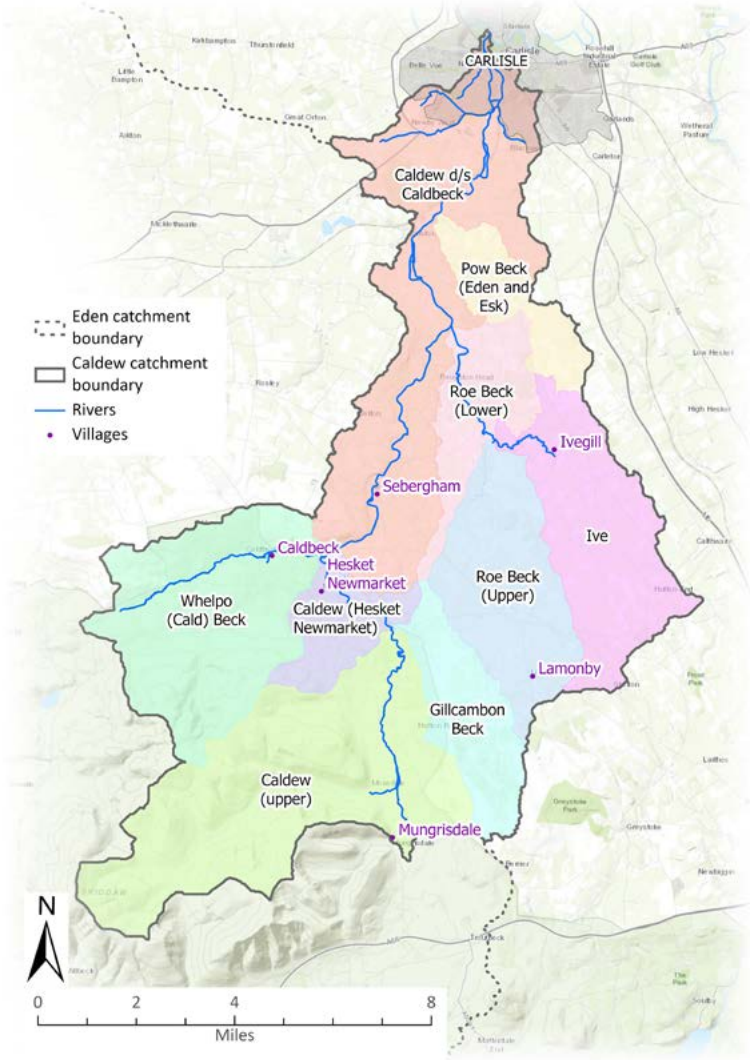


Figure 32. Caldew sub-catchment showing main rivers and the smaller sub-catchments as they are defined in the Water Framework Directive classification (colours are used for clarity).

Opportunities to improve ecosystem services

The greatest opportunities for interventions that will result in multiple benefits to ecosystem services are in the catchments of Pow Beck, Whelpo Beck and the Caldew, downstream of Caldbeck. Specifically, interventions are required to address agricultural pollution (nutrient management to improve water quality) and manage high flows (to prevent flooding) throughout the catchment.

Key sites

Gillcambon Beck has been identified as having bad water quality due to forestry and recreation related activity in Greystoke Forest and agricultural pollution (silt and phosphate).

The north-east flanks of the Caldbeck Fells and the Skiddaw Forest area have areas of damaged blanket bog. These, and the damaged lowland raised bogs (at White and Bowscale Moss) impact on flooding, biodiversity and carbon storage.

Holme Head Weir in Carlisle and the weir at Dalston are a severe impediment to the movement of Atlantic salmon and other migratory species, as well as affecting the river's geomorphology.

Some of the upper reaches of the Caldew have been very heavily modified through straightening and the creation of flood banks, which have a negative impact on the natural functioning of the river and its floodplain. More moderate river modifications are present throughout the catchment.

St Cuthbert's Garden Village, a large-scale housing development in Carlisle (south) is a critical site. Mitigation measures such as Sustainable Urban Drainage Systems must be integral to the plans and build of the development for the management of surface water and pollution and biodiversity net gain (consultation started 2019).

The proposed Carlisle Southern Link Road includes a major crossing of the Caldew at Cummersdale.

The Caldew catchment is currently the only catchment that holds a population of invasive Signal crayfish which carry crayfish plague – a huge threat to native White-clawed crayfish.

Signal crayfish found in the Caldew © *ERT*

A selection of current, completed and aspirational projects in the Caldew

Completed projects

Historic river straightening, barriers and degraded biodiversity: Whole Caldew catchment.

Fluvial Audit and river and floodplain restoration opportunities mapping. Desk-based survey investigating sediment dynamics and potential impact on flooding. Walkover investigations Upper Caldew (u/s of Hesket Newmarket) to identify river and floodplain restoration and NFM Opportunities. *ERT/EA/NE.*

Flooding, degraded blanket bog: Whelpo (Cald) Beck.

Peat bog restoration and drain blocking at Scales Farm near Caldbeck. *CWT.*

Flood alleviation and poor water quality: Roe and Ive.

Phase 1 Slow the Flow project working with landowners to increase use of flood options in Countryside Stewardship - leaky dams, kested hedges, soil aeration. *EA/ERT/Roe Catchment Community Water Management Group.*

Current projects

Barriers: Holme Head Weir Caldew d/s Caldbeck.

Investigations into removal, bypass or modification as part of the Cumbria RRS programme. *ERT/EA/Parish Council.*

Invasive species: Caldew d/s Caldbeck.

Signal crayfish – Surveys looking at DNA signatures in river water as a method for identifying stretches of the Caldew where Signal Crayfish have colonised. *NE/EA/ERT/others.*

Agricultural (nutrient) pollution and flooding: Caldew.

Incentivise farmers to improve soil, water and nutrient management and reduce negative impact on rivers. *Nestle/Dairy farmers supplying Nestle.*

Blanket bog restoration: Caldbeck Common.

Discussion underway with landowners (LDNPA) to facilitate this blanket bog restoration. *CWT.*

Caldew

Aspirational projects 2020 – 2030

Caldew local flood relief schemes for Dalston, Stockdalewath and Millhouse maximising natural flood management opportunities.

Survey to assess damage and targeted restoration of blanket and lowland raised bogs within Caldbeck Fells and Skiddaw Forest.

River restoration programme in the Caldew implementing opportunities identified in existing reports between Mosedale and Linewath and upstream of Sebergham to Carlisle for restoration/ reconnection with floodplain.

Removal or bypass of Holme Head Weir reconnecting river to the floodplain.

Habitat, open space and green amenity creation/ provision with integrated sustainable urban drainage (SUDS) for the Garden Village.

Improve water quality of Gillcambon Beck - identify source of silt and reduce its introduction to the river.

Awareness and eradication or containment of invasive Signal crayfish in the Caldew.

Sphagnum moss © *Shutterstock*

Lower Eden Action Plan

© ERT

About

The Lower Eden starts at Watersmeet where the Eamont meets the Eden downstream of Penrith. It flows north over red sandstone through the villages of Langwathby, Lazonby, Armathwaite and Wetheral; it is joined by the Esk and Irthing to the north east of the Carlisle, before flowing through the city and out into the Solway Firth in the west.

Water drains from the west side of the central North Pennines directly into the lower Eden via number of tributaries.

The predominant land use outside the city is dairy and arable farming.

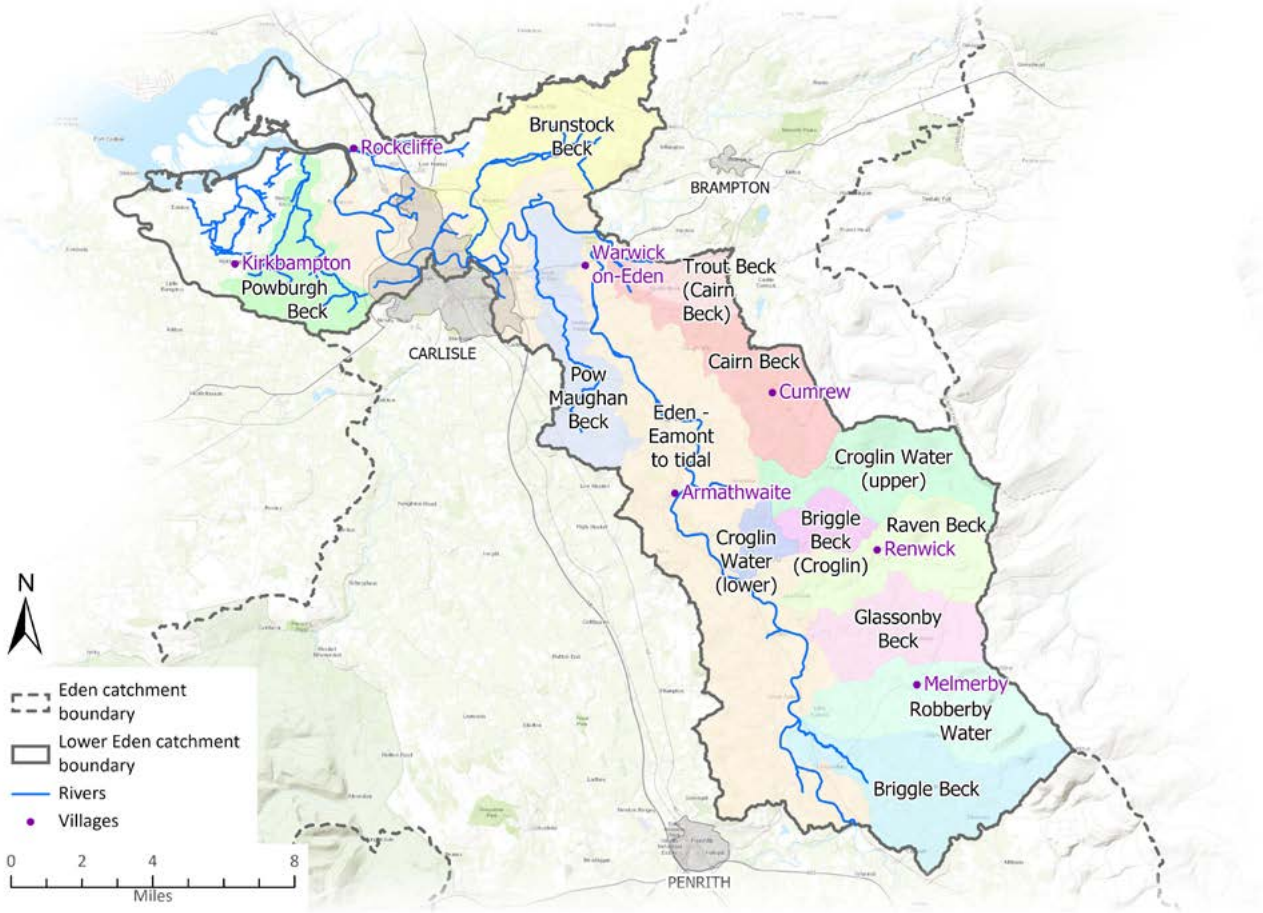


Figure 33. Lower Eden sub-catchment showing main rivers and the smaller sub-catchments as they are defined in the Water Framework Directive classification (colours are used for clarity).

Opportunities to improve ecosystem services

Opportunities resulting in multiple benefits to ecosystem services are greatest in Brunstock Beck and along the mainstream Eden (Eamont-Eden to tidal) and out to the coast (Powburgh Beck). This applies particularly for actions to improve nutrient management for better water quality, flood management and carbon storage.

Key sites

Brunstock Beck and Powburgh Beck suffer from point and diffuse agricultural pollution. Briggle Beck and Croglin Water (lower) tributaries originating in the North Pennines are also classified as having poor water quality due to poor soil and nutrient management. Point source pollution from septic tanks and farm discharge pipes is a problem on these becks, especially for fish spawning, for which the Pennine tributaries are most important.

Carlisle's flood defences were tested beyond limits in Storm Desmond and the Carlisle Flood Risk Management Scheme programme of works is planned for Rickerby Park, Botcherby Bridge and Sands Centre.

Renwick, Croglin, Gamblesby and Cumrew are communities at risk of flooding where natural flood management (NFM) measures may help lessen the impact of future flooding.

Corby Weir is a major barrier to migratory species especially lamprey species and Atlantic salmon.

Along the main river Eden there are numerous areas where the floodplain is disconnected from the river through various channel modifications. This has resulted in a loss of natural processes which decrease the quality of all services, from water quality and flow regulation to the demise of ecological networks and their associated species.

Cairn Beck NFM project 2019 *©ERT*

A selection of current, completed and aspirational projects in the Lower Eden

Completed projects

Degraded habitats, Water quality and flood prevention: Croglin catchment.

Various programmes to improve habitats through Countryside Stewardship and private planting schemes. *Completed and ongoing with NE/Woodland Trust/Landowners.*

Current projects

Flooding:

- **Carlisle.** Traditional flood defence schemes Phase 1, 2 & 3 of the Carlisle Scheme will raise and extend the flood defences along both from the River Petteril and the River Eden.
  The Rickerby scheme will provide a continuous raised defence around the north, west and south of the village. *EA/CCC.*
- **Cairn Beck** natural flood management project is ongoing in the Cairn Beck. *ERT/Landowners/EA/Defra.*

Degraded habitats:

- **Cairn Beck, Briggle Beck, Robbery Water and Glassonby Beck.** Ongoing programme of riparian habitat improvement with a focus on fisheries and water quality in the Pennine becks. *EA/ERT/Angling Clubs.*
- **Croglin.** Natural flood management including tree planting and leaky dams. *NPAONB Partnership/WT/ERT/.*

Poor water quality (pesticides): Cumwhitton Safe Guard Zone.

Ongoing works and interventions to prevent pesticides entering drinking water source. *UU/landowners.*

Multiple benefits to ecosystem services: Fellfoot Forward Landscape Partnership Scheme on the Fellside of the Lower Eden.

Natural flood management, landscape scale riparian conservation, woodland and scrub creation and management, peat restoration, farm advice and support, slow walking and cycling routes and raising awareness and skills across communities in managing of local wildlife habitats and species. *NPAONB Partnership/EDC/ERT/EA/UU/WT/CCC.*

Lower Eden

Aspirational projects 2020 – 2030

Removal or modification of Great Corby Weir to improve fish passage.

Identification and construction of greater riverside access from Watersmeet to Holmwrangle; Great Corby to Low Corby; Lazonby to Armathwaite. Development of Lower Eden cycle route. Develop shared access for boating and fishing from Watersmeet to the Solway tidal limit.

Croglin catchment crayfish project developing Eden's Crayfish Arc sites.

Natural flood management projects in Gamblesby, Croglin and Renwick catchments.

Enjoying the Eden at Armathwaite © *Rod Ireland Photography*

Eden Wide

Several issues affect all parts of the Eden and merit being addressed through catchment-wide projects.

Aspirational projects 2020 – 2030

Regular catchment-wide septic tanks awareness campaigns backed up by enforcement to prevent of pollution – building on experience from previous campaigns.

Regular catchment-wide 'Check Clean Dry' campaigns to prevent the spread of invasive species by river users (anglers, kayakers, walkers, swimmers) - building on experience from previous campaigns.

More initiatives to prevent plastic pollution in rivers

Continued and improved monitoring of popluations of iconic species and assessment of priority habitats to better target interventions.
Specifically:

- appropriate fish counters for migratory fish (salmon, lamprey, smolt, juveniles, redd counts etc);
- comprehensive crayfish and river invertebrate monitoring; and
- assessment of damaged peat bog across the Eden.

Appendices

Appendix 1: **Methodology**

For Ecosystem Services opportunity mapping

In order to understand the current status of ecosystem services in each part of the catchment, the pressures upon them and the opportunities for action, the Catchment Partnership employed a methodology originally developed by West Country Rivers Trust.[94]

The following six ecosystem service categories were used:

- Water quality;
- Water quantity - management of high flows and flood risk;
- Water quantity - management of low flows and drought alleviation;
- Ecological networks - the provision of habitat for wildlife and biodiversity;
- Carbon capture and sequestration; and
- Recreation and leisure.

Relevant spatial data were gathered from online sources and partnership members to build up a picture of each ecosystem service, this included existing features and significant areas, as well as threats and hazards affecting each ecosystem service.

Opportunity maps showing where interventions were likely to have the most benefit were created for four of the ecosystem services (water quality, water quantity - management of high flows and flood risk, ecological networks and carbon sequestration) using relevant data on existing features and showing its impact upon the service.

It has not been possible to produce reliable and accurate opportunity maps for two ecosystem services (water quantity – management of low flows and drought alleviation, and recreation and leisure) due to the limitations of current data availability.

Features could be location-based (e.g. within a flood zone or adjacent to an existing priority habitat) or risk-based, (i.e. the risk associated with the type of feature such as different soils or agricultural land uses) or related to landscape character (e.g. slope gradient, or hydrological connectivity).

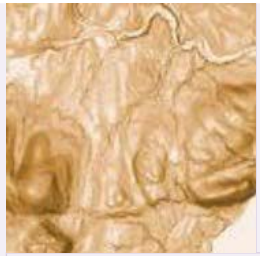
This allowed the different datasets to be combined into a single map displaying their cumulative effects for any particular ecosystem service.

In order to illustrate the maximum effects from catchment management interventions, the opportunity maps for each ecosystem service were then combined to create an overall priority map. This map identified areas of the catchment where there is great opportunity to improve multiple ecosystem services. A full list of the datasets used for the opportunity maps, along with details of how each feature was scored can be found in *Table 1*.

These opportunity maps highlight the priority areas where catchment partners could target appropriate catchment management interventions to achieve improvements in each ecosystem service.

Opportunity maps should not be used in isolation, but in combination with current threats, known hotspots and local knowledge, to prioritise action. They also illustrate the extent of the challenge we face.

Table 1. Data type and the scoring system used for calculating the opportunity to improve ecosystem services displayed in the Opportunity Area maps.

Description of dataset		Ecosystem service analysis where used	Score of that dataset (high score, more opportunity for impact)
Proximity to watercourse		Water Quality	Fields adjacent to waterbodies pose a higher risk to water quality as they provide a direct pathway for any pollutants to enter the river. **Low** ⟷ **High** Not adjacent to water course — Adjacent to watercourse
	© Environment Agency copyright and/or database right 2015. All rights reserved. © Crown copyright and database rights 2008 Ordnance Survey 100024198		
Slope (Calculated from a Digital Elevation Model)		Water Quality	Steep slopes pose an inherent risk to water quality due to increased mobilisation of water. **Low** ⟷ **High** < 3 degrees — 3 degrees - 7 degrees — > 7 degrees
	Contains Environment Agency information © Environment Agency and/or database rights. Some information used in this product is © Bluesky International Ltd/Getmapping PLC. Contains freely available data supplied by Natural Environment Research Council (Centre for Ecology & Hydrology; British Antarctic Survey; British Geological Survey). Contains OS data © Crown copyright [and database right] (2014)		
Soil typology		Water Quality	Soils with high clay contents have higher run-off risks because they have fine particles that prevent infiltration and are more likely to leach pollutants. **Low** ⟷ **High** Freely draining — Variable — Slightly impeded drainage — Impeded drainage surface wetness naturally wet
	Soil data © Cranfield University (NSRI) and for the Controller of HMSO 2018		

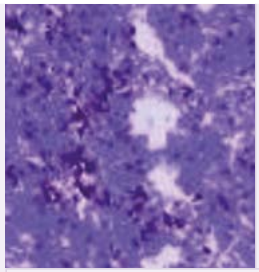
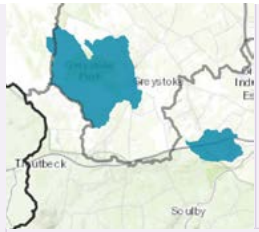
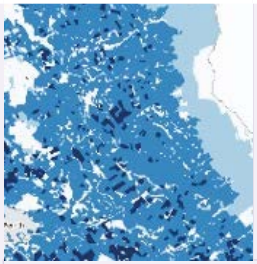
Description of dataset		Ecosystem service analysis where used	Score of that dataset (high score, more opportunity for impact)
Hydrological Connectivity - a measure of how readily water runs over a surface or accumulates Calculated from a digital elevation model		Water Quality Water Quantity Carbon capture and storage	High run off (steep slopes) and high tendency for water accumulation (floodplains and rivers) both contribute to high connectivity, and can be mapped as part of the Scimap modelling framework.(19) Not highly connected (0-90%) — 5-10% most highly connected areas — 5% most highly connected areas
			Lane, S.N., Brookes, C.J., Heathwaite, A.L. & Reaney, S (2006). Surveillant science: challenges for the management of rural environments emerging from the new generation of diffuse pollution models. Journal of Agricultural Economics. Vol 57, Issue 2, p239-257
Land cover		Water Quality	Land uses with greater frequency of exposed soil show a greater level of risk to water quality as this increases the likelihood of rapid surface water run-off, taking sediment and/or added nutrient into water courses. This can be mapped using reclassified land cover maps where darker areas show greater risk (arable and improved grassland). **Low** — **High** Woodland — Other grassland — Improved grassland — Arable
			Rowland, C.S.; Morton, R.D.; Carrasco, L.; McShane, G.; O'Neil, A.W.; Wood, C.M. (2017) Land Cover Map 2015 (vector, GB). NERC Environmental Information Data Centre. https://doi.org/10.5285/6c6c9203-7333-4d96-88ab-78925e7a4e73
Natural flood management (NFM) - watersheds above Communities at Risk of flooding which are less than 20km^2, as this is the area cited as being suitable for NFM		Water Quantity: high flows	NFM involves working with natural processes to slow the flow of water and reduce flood peaks. **Low** — **High** Catchment above Community at Risk greater than 20 km^2 — Catchment above Community at Risk less than 20 km^2
			Contains Environment Agency information © Environment Agency and/or database rights. Some information used in this product is © Bluesky International Ltd/Getmapping PLC. Contains freely available data supplied by Natural Environment Research Council (Centre for Ecology & Hydrology; British Antarctic Survey; British Geological Survey). Contains OS data © Crown copyright [and database right] (2014)

Table 1 (continued). Data type and the scoring system used for calculating the opportunity to improve ecosystem services displayed in the Opportunity Area maps.

Description of dataset		Ecosystem service analysis where used	Score of that dataset (high score, more opportunity for impact)
Working with Natural Processes		Water Quantity: high flows	Working with Natural Processes (WWNP) identifies areas in great detail where there may be landscape characteristics which would potentially enable the implementation of natural flood management features that help to protect, restore and emulate the natural functions of catchments: floodplains, rivers (including riparian planting), run-off attenuation features and floodplain reconnection.[95] **Low** ⟷ **High** Land in this location does not have the potential for woodland creation or run-off attenuation — Land in this location has the potential for woodland creation or run-off attenuation
	Open Data (OGL3). Environment Agency Flooding and Communities Research, JBA Consulting & Lancaster Environment Centre. Contains data (including indirect and derived data sources) from the Ordnance Survey, Forestry Commission & European Environment Agency		
Soil hydrology – wetland creation suitability		Ecological networks	The potential wetland locations in 50 years' time were identified by looking at soil suitability, topography and proximity to floodplains and mapped by the Wetland Visions project.[96] **Low** ⟷ **High** Soil in this location unsuitable for wetland creation — Soil in this location potentially suitable for wetland creation
	©Wetland Vision, a partnership between Environment Agency, English Heritage, Natural England, RSPB, and The Wildlife Trusts. Derived from data supplied by the Environment Agency © and Database Rights the Environment Agency 2008. Derived from data supplied by Natural England Natural England 2008. This map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. Natural England 100046223 2008		

Description of dataset		Ecosystem service analysis where used	Score of that dataset (high score, more opportunity for impact)
Propensity to be inundated		Water Quantity: high flows	Creation and restoration of wetlands is more achievable in areas subject to waterlogging. The floodplain maps can be used to highlight those areas which tend to be inundated regularly. **Low** ⟷ **High** Land not in flood zone 2 extent — Land within flood zone 2 extent
	© Environment Agency copyright and/or database right 2018. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). © Crown copyright and database rights 2018 Ordnance Survey 100024198		
Proximity to existing habitat		Ecological networks	Creating new habitat adjacent to existing habitat offers enhanced benefits compared to creating new habitat in isolation. This input was created by identifying all fields that are adjacent to existing areas of Priority Habitats (as identified by Natural England), or that are adjacent to existing woodland. **Low** ⟷ **High** Field not adjacent to existing Priority Habitat or Woodland — Field adjacent to existing Priority Habitat or Woodland
	© Crown copyright and database rights [2018] Ordnance Survey 100024198 © Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2018 Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey [100021242]		
Strategic or Priority Areas		Ecological networks	The Natural England National Habitat Networks dataset identifies locations where intervention would result in higher ecological benefit than if that effort was concentrated elsewhere (i.e. priority areas with potential for enhancement, restoration or habitat creation). **Low** ⟷ **High** Land not prioritised for enhancement or restoration — Land categorised as a network enhancement zone, restorable habitat or habitat restoration
	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2019]		

Table 1 (continued). Data type and the scoring system used for calculating the opportunity to improve ecosystem services displayed in the Opportunity Area maps.

Description of dataset		Ecosystem service analysis where used	Score of that dataset (high score, more opportunity for impact)
Soil sequestration capacity		Carbon capture and storage	In general, clay-based soils have a greater potential to sequester carbon than sandy soils and loams. Peaty soils are often close to maximum capacity for carbon sequestration and therefore may have little potential for sequestering additional carbon. **Low** ← → **High** Sandy/peat — Loams — Clays
	Soil data © Cranfield University (NSRI) and for the Controller of HMSO 2018		
Potential for land use change		Carbon capture and storage	Step-changes towards extensive land use have significant potential for increasing carbon capture and storage, and reduction in greenhouse gas emissions. **Low** ← → **High** All other values (incl. woodland) — Other grassland — Improved grassland — Arable
	Rowland, C.S.; Morton, R.D.; Carrasco, L.; McShane, G.; O'Neil, A.W.; Wood, C.M. (2017) Land Cover Map 2015 (vector, GB). NERC Environmental Information Data Centre. https://doi.org/10.5285/6c6c9203-7333-4d96-88ab-78925e7a4e73		
Agricultural Land Class		Carbon capture and storage	Step changes towards extensive land use are more likely to be achievable on land of lower productivity. The Agricultural Land Classification data can be used to identify these areas and exclude areas which are likely to be of too much value for landowners to consider land use change (lowest grades). **Low** ← → **High** Grades 1-2 — Grade 3 — Grades 4-5
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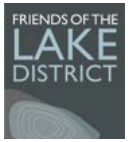
Members of The Eden Catchment Partnership

The Eden Catchment Plan has been developed collaboratively with all Catchment Partnership members, led by Eden Rivers Trust



Catchment Partnership organisations

Carlisle City Council
Cumbria Strategic Flood Partnership
CLA (Country Land and Business Association)
Cumbria County Council
Cumbria Farm Environment Partnership
Cumbria Wildlife Trust
Durham University
Eden District Council
Eden Rivers Trust
Environment Agency
Farmer Network
Forestry Commission
Foundation for Common Land
Friends of the Lake District
Highways England
Lancaster University
Lake District National Park Authority
National Trust
Natural England
Network Rail
Newground
National Farmers Union
North Pennines Area of Outstanding Natural Beauty Partnership
River Eden and District Fisheries Association
Royal Society for the Protection of Birds
Solway Firth Partnership
Ullswater Community Interest Company
United Utilities
Woodland Trust
Yorkshire Dales National Park Authority