



# Chief Scientist's Annual Review 2024

Chief Scientist's Group report

May 2025



We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra Group (Department for Environment, Food and Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

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## Foreword



#### **Dr Robert Bradburne FRSB** Chief Scientist and Director of the Chief Scientist's Group, Environment Agency

#### Welcome to this year's annual review, looking back at how science has supported the work of the Environment Agency to improve places across England for people and wildlife.

With weather records being broken throughout 2024, a new government with an ambitious agenda, and continued public interest in the work that we do, the Environment Agency needs science more than ever to help understand and prepare for future changes, achieve better outcomes in the present and analyse how interventions and investments are working.

Science in the Environment Agency rarely addresses only a single issue. That's why, in this year's review, we have grouped our work so that you can see how science is helping us innovate and implement change in a range of different areas. Whether that is protecting people from flooding, changing the way we understand our environment, or preparing for the transition to a net zero economy, the science and analysis showcased here demonstrates the depth of expertise in science across the Environment Agency.

The breadth of science that the Environment Agency needs drives our commitment to developing our scientists wherever they are in the organisation. We are always looking to attract new and diverse talent and to offer a range of opportunities for scientists to develop their expertise and careers. The review highlights our PhD network and the graduate training scheme that we support: these are just two ways that the science profession supports our scientists to grow professionally and personally as they provide such important services to the Environment Agency.

I hope you will find the insights and information in this review interesting and that it will inspire you to read some of our outputs in more detail or get in touch with us to discuss how we can work together to provide the science the environment needs now and for the future.

# Introduction

### The work we do

Science enables and enhances so much of what the Environment Agency does. As the world changes and demands on the environment increase and diversify, we recognise the need to nurture and grow our scientists, developing their capabilities, and providing them with the best tools and data so that the Environment Agency can tackle any scientific challenge. People are at the heart of our science strategy, and this annual review shows our progress this year in supporting our people, investing in our scientific assets and data, and doing excellent research.

Science in the Environment Agency is science with purpose. We have a duty to conduct research that supports our aims, and the legislative frameworks in which we work demand a high degree of evidence in their operation. To emphasise this link to our activities, the review is structured not around individual projects but the themes and issues which they collectively help to move forward. The examples set out in this way show why this science is so important and what it means not just to the work of the Environment Agency but to the environment as a whole. The review shows how science is used, how it helps address the risks and future opportunities we might face, and how we can adapt to and embrace change in the future.

#### People

Very many Environment Agency staff are scientifically trained. These scientists are embedded across the organisation, supporting our operational activities, conducting research and making a significant and valued contribution to many aspects of our work. They possess a great breadth and depth of knowledge, helping to manage everyday threats to the environment and provide the knowledge and evidence to help us prepare for future risks and challenges. Our scientists play a vital role in setting out what the future might look like, generating the insights that inform our choices, and guiding the decisions the Environment Agency must make about how to manage risks while supporting growth and improving the environment.

We have an active science profession with over 1,800 members. The science profession brings our scientists together in a vibrant scientific community, sharing information, learning from others and investing in their capability and growth. We are developing new technical and professional capabilities and expectations for all our scientists, ensuring they have the skills they need today and providing training to help them deliver now and prepare for their future careers.

We are attracting new talent, developing the scientists of the future through supporting PhD students and running our own Environment and Science Graduate Training Scheme. In this way we are growing our own scientists and providing the organisation with the specialist, technical skills it needs to ensure that we maintain our role as a leading science-based organisation and Public Sector Research Establishment.

#### Research

Most of our scientists work operationally supporting the business, but we have a core of experts exploring the future with their science. The research they do focuses on filling knowledge gaps to support our operational activities and help us to prepare for future challenges. This research can be lab-based, field-based or desk-based, and is often done in partnership with international, academic, industry and citizen scientists. Throughout this year our scientists have worked on a range of groundbreaking research. This has included looking at the environmental implications of moving to a net zero world and what this might mean for what we regulate. We have been researching how we build resilience and prepare for the impacts of a changing climate. Our research has also provided evidence to support the decision-making for the current flood and coastal erosion risk management strategy covering topics such as understanding risk, resilience and adaptation, and asset management. They have also looked at how nature-based solutions can contribute to flood prevention measures as well as providing other ecosystem services. And our social scientists have supported the Environment Agency by looking at the social aspects of many of our major programmes, including work on participative research and citizen science to create better engagement with science and improved outcomes.

This research is published online and in scientific journals, and continues to be accessed and referenced by a wide range of people interested in the environment. We are constantly looking to new ways to increase the impact of the work we do and to ensure that the insights we generate are shared widely so that others can use them to help improve the environment in the context of sustainable development.

#### Innovation

Research is one way that we can provide information on how to innovate our ways of working, but innovation runs through much of what we do in science in the Environment Agency. We innovate through investing in our science assets in the lab and field, reimagining the way we do our different science-based activities, reviewing our data needs and what we can do with the data, or upgrading our analysis and further developing the knowledge assets that we create. As an example of this, our newest monitoring programmes supporting the Natural Capital and Ecosystem Assessment are innovative in many ways. These programmes are looking in new places, with new technologies, employing novel analyses and improved scientific understanding of the systems that they are investigating to help us to understand how the water environment is changing and, most importantly, why, and why that matters. Critically, NCEA is enabling us to build data sets and fill evidence gaps in our water environments such as through our small streams network. The programme has also developed new analytical tools, tested new approaches and incorporated natural capital concepts into measuring the state and condition of our water ecosystems, so that we can link our work more closely to the economic and social pillars of sustainable development.

Innovation is not just for the future. It is also essential for how we use data and enable others to use that data to inform their decisions now. Our new Agricultural Land Environmental Risk and Opportunity Tool (ALERT) has provided a step change in our ability to target pollution mitigation measures in the landscape and our AI-driven citizen science endeavour called 'Hello Lamp Post' has empowered local communities to engage with the environment, providing valuable data and raising awareness about environmental issues.

It is impossible to capture everything we have achieved in 2024, so the series of themed case studies here represent just some highlights. They demonstrate multiple aspects of our organisational ambitions and we have used them to show how our science links closely to all aspects of delivery. A full range of our scientific publications is given, but again, this only scratches the surface of all that science has achieved for the Environment Agency this year, and many people will be experiencing the benefits of the work of Environment Agency scientists in their local areas. There is also a forward look to our plans for next year, and we will continue to be open and transparent about our science outputs so that many people can benefit from the results and insights generated.

### Supporting and developing our scientists

Now more than ever, Environment Agency scientists and the excellent science they carry out are recognised and valued for the contribution they make to achieving the organisation's goals.

Scientists are embedded within many parts of the organisation, supporting our work in flood risk management, policy, regulation and operational activities. They provide a unique service, enabling us to deal with day-to-day issues and look ahead, giving scientific advice to inform our plans and actions, and preparing the organisation for tomorrow's challenges.

Our scientists provide the data, evidence, analysis and interpretation that informs the actions the organisation takes to protect people and the environment. They undertake scientific research in topics as diverse as the impact of chemicals on the environment to understanding how new technologies used to achieve net zero might impact the wider environment. They also look to the future and fill gaps in our knowledge where others are not looking, such as where antimicrobial resistance might be present in the environment and what might be driving it. Innovation is also important, to ensure we have the best scientific assets at our disposal and are able to develop new ways of working with others so we can solve the problems we face.

Our science strategy describes how the depth and breadth of science we carry out underpins the Environment Agency's work and sets out our ambition going forward.

To help achieve all of this we have a fantastic science profession with over 1,800 members. The science profession brings our scientists together in a vibrant scientific community, sharing information, learning from others and investing in their capability and growth. We are developing new technical and professional capabilities for all our scientists, ensuring they have the skills they need now and providing training to help them prepare for their future careers.

Attracting new talent and developing the scientists of the future are essential if we want to maintain our role as a leading science-based organisation. We're supporting 30 PhD students this year and their work covers topics as diverse as biodiversity to radioactive substances. We hold an annual PhD Knowledge Exchange event, which allows the PhD students and our scientists to connect, learn and ask questions of each other, which they might not otherwise have the chance to ask.

The Environment Agency also run an Environment and Science Graduate Training Scheme for recent graduates. This aims to 'grow our own' scientists and provide the organisation with the specialist, technical skills we need. We do this through a structured training programme available across the business. Graduates develop through their role to gain skills and experience over a 4-year programme to become professionally chartered, with either the Chartered Institute of Water and Environmental Management or the Institute of Environmental Management and Assessment, before progressing into other core business roles.

Looking forward, it is essential that we continue to be innovative in our science. We recently held a series of seminars reflecting on the progress we have made in the last 12 months since our science strategy was launched. We focused on the 3 important areas of the strategy: people, research and innovation. Maintaining that momentum will be vital if we are to continue to be successful in protecting people and the environment, and helping our scientists have rewarding and fulfilling careers in the organisation.

Contact: <u>Rich Walmsley</u> Chief Scientist's Group



Environment Agency scientists and PhD students gather at the PhD Knowledge Exchange event.

### Scientist in the spotlight: Arron Watson



Since joining the Environment Agency, I've evolved from being an entomologist to a freshwater ecologist and co-host of the science profession's DNA Knowledge Transfer Group. My goal is to continue broadening my ecological and scientific expertise while helping advance the Environment Agency's methods through knowledge sharing and practical application. I'm undertaking a part-time PhD in machine learning for climate and DNA analysis, sharing learning with others in the Environment Agency. I also had the opportunity to work on assignment in the Climate Change and Resource Efficiency team in the Chief Scientist's Group, conducting data analysis and gaining new skills.

#### Arron Watson | Analysis and Reporting Officer



### A resilient nation: Advancing research in flood and coastal erosion risk management

Resilience and adaptation are important approaches for managing flooding and coastal erosion. These measures can also help create economic stability by accounting for future trends and uncertainty. We need to understand what the future could entail to prepare for and manage flooding and coastal changes.

To understand future trends and evidence, the Environment Agency has a collaborative Flood and Coastal Erosion Risk Management (FCERM) <u>Research and Development Programme</u> with Defra, the Welsh Government and Natural Resources Wales. The programme's work extends beyond the 4 organisations by bringing together academia, industry and government. It aims to collectively advance world-leading research that improves flood and coastal erosion risk management practices.

The research and evidence needs identified by programme partners focus on 31 <u>areas of research</u> <u>interest</u>, which the Environment Agency published in May 2024. These help us to tell others, including research councils and universities, what knowledge gaps we need to fill, and to target new partnerships.

In 2024, the Environment Agency published 8 research projects funded through the programme and worked in formal academic partnerships with 40 universities. We also <u>published case studies</u> describing how research has had an effect on flood and coastal erosion risk management. The evidence and research will inform decisions about how to implement the national FCERM strategies of England and Wales. Three examples of research projects and partnerships completed in 2024 are described below.

#### Understanding future flood and coastal erosion risk

On the coast, Environment Agency scientists have published new research to understand how coastal cliffs in England and Wales may recede due to increasing rates of <u>sea level rise</u>. Understanding the relationship between sea level rise and cliff erosion is important for flood and coastal erosion risk management. However, the data, approaches and knowledge to support decision-making are limited.

Environment Agency scientists and their partners used a model, called Soft Cliff and Platform Erosion (SCAPE), to simulate cliff erosion and sea levels at different locations around the coast. <u>Research</u> created new 'sensitivity indicators' in this model to predict how cliffs and shore platforms might respond to sea level change over time. The indicators now account for geological strength, how the shore platform underlying the beach can be reshaped, and the time needed for the profile to respond to changes in water levels. The indicators were applied to a range of climate change scenarios and 82 locations around the coast of England and Wales.

The indicators have been used in the updated national coastal erosion risk map (NCERM2) published by the Environment Agency in January 2025. Flood and coastal erosion risk managers can use the indicators to rapidly assess the potential effects of sea level rise rates on coastal cliff toe recession in their area. The indicators can also be used alongside numerical models to validate and improve confidence in erosion estimates.



Advancing research in flood and coastal erosion risk management helps us to understand how coastal landscapes may change.

# Resilience and adaptation to flooding and coastal change

The Environment Agency NCERM2 and national flood risk assessment maps now present the risks of today and in the future when climate change is considered. To help risk management authorities engage the public about this new information, Environment Agency scientists brought together evidence on how to <u>communicate climate change</u> information for flooding.

The work was informed by examples of good practice, so that it could be turned into practical information on how to effectively communicate with the public about climate change, flooding and coastal erosion risk. The topic is complex, so the findings were turned into simple messages to support flood and coastal erosion risk management authorities who work with communities at risk. The messages included:

- accepting that there is no generic public and understanding the audience
- making information engaging and accessible for audiences
- ensuring communicators are trusted by the intended audience
- actively connecting through participatory approaches
- using scenarios to talk about the future of the area and uncertainty

An evidence review found social and psychological processes work together to help people make sense of climate change information, which influences people's responses and actions.

Some evidence gaps were identified, including targeted communications around coastal erosion and understanding how timescales affect perceptions and actions. These are starting to be addressed by the Environment Agency and other organisations.

- an intergenerational approach to understanding flood risk
- analysing household level flood risk adaptation
- optimising gully blocks to reduce flood discharge
- extreme fluvial flood risk in groundwaterdominated catchments

The goal is to cultivate a new generation of researchers who can translate innovation into practical solutions, addressing the Environment Agency's needs and those of other partner organisations. These students represent the future of flood and coastal management, poised to have a significant effect not just in the UK, but globally.

#### What's next?

The areas of research interest are active until 2028 and will continue to shape the direction of the FCERM Research and Development Programme and research partnerships. Areas of focus for 2025 include:

- supporting appraisal of coastal schemes by valuing the mental health costs of coastal erosion
- supporting decision-making on coastal flooding schemes with joint probability information of waves and sea level rise
- supporting authorities to understand and improve the flood recovery process

All FCERM research completed by the Environment Agency supports the government's 2020 National Flood and Coastal Erosion Risk Management Strategy for England. This supports a nation ready for, and resilient to, flooding and coastal change – today, tomorrow and to the year 2100.

#### Contact:

#### **Hayley Bowman**

Flood Research team, part of the Risk Assessment and Research team in the Flood and Coastal Risk Management directorate

# How might the transition to net zero affect the environment?

The UK is legally obliged to reach net zero by 2050. In achieving this, the UK will see many societal and economic changes. These include:

- widespread electrification
- changes in the nature of fuels used for industry, transport and heating
- land use
- what we eat
- when we use energy
- the shift towards a circular economy

The transition to net zero provides an opportunity to improve many aspects of the environment as we move away from fossil fuels. However, new technologies and interventions need to be adequately tested and investigated to ensure that there are no unintended consequences for the environment. Potential negative impacts include emissions of pollutants to air, discharges to water, increased demand for water use, changes in volumes and types of waste, and the release of novel pollutants. On top of these potential impacts, we need to understand and account for a changing climate with warmer, wetter winters and hotter, drier summers, which will affect water availability. Our role at the Environment Agency is to create better places for people and wildlife and to support sustainable development. As a regulator, we have a duty to ensure that regulatory processes are fit for purpose and that regulation can adapt to changes in processes, technologies and interventions to protect the environment for generations to come. Our incident response duty requires us to respond to events and accidents like fuel spills, battery fires and other pollution events which could occur during or following the transition to net zero.

#### The net zero research theme

In 2021, the Environment Agency's Chief Scientist's Group received funding from Defra to research the environment and net zero. Our net zero research theme has since undertaken 24 research projects to provide underpinning evidence for the Environment Agency as it prepares new guidance for emerging techniques, permitting decisions and advice for incident management.

## At a glance



Projects in progress to develop new knowledge

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## 12 Specialists

working together across teams and disciplines



#### An overview of the net zero research theme

Our team sits in a unique position, both keeping up to date on novel industrial and academic research to help anticipate future developments, and also carrying out our own work to provide applied science to decision-makers in the Environment Agency. As a result, we've used a wide variety of approaches to undertake these projects. These have included reviewing and assimilating existing literature, modelling studies, systems mapping and producing interactive graphics. We work with academia and industry through facilitating workshops, surveying expert opinions and answering research questions together. We even had a secondee join us who was funded through the Industrial Decarbonisation Research and Innovation Centre.

Under the research theme, Environment Agency scientists are working across disciplines to understand the possible environmental and social impacts of achieving net zero. Our research explores different technologies that may feature in a net zero future, such as <u>heat pumps</u>, energy storage techniques, new nuclear builds and greenhouse gas removal technologies. We're looking at how we can monitor emissions like methane and potential small-scale hydrogen leaks, as well as how we regulate activities like adopting a circular economy in different industries. The net zero pathways project brings these different activities and societal changes together. This project explores the potential environmental implications of different ways (pathways) of achieving net zero. It considers the potential cumulative effect of multiple activities taking place in a particular location or during a specific time period. As this topic touches on so many possible different sectors and activities, we've drawn together academic experts in both net zero activities and environmental quality. The project considers how the net zero transition might affect air quality, water quality, water availability and waste. We've achieved this through a range of methods and are now working to understand how multiple technologies in a given place might affect the environment and interact with the local governance, economy and socio-demographics. This project will help us develop regulation fit for net zero and the future.

#### Looking ahead

The transition to net zero provides an opportunity to provide innovative, forward-looking solutions to improve and preserve our environment for generations to come. Through interdisciplinary research and engagement with the academic community, Environment Agency scientists have started to identify unintended consequences and provide underpinning evidence that will inform our regulatory and advisory role.

While we've advanced our understanding in many areas, more research is required to support the nation through a sustainable and equitable transition for all parts of society. Our research will continue to support the Environment Agency's regulatory and incident response roles to ensure that we are able to support and facilitate the shift to a net zero future.

Contact: Dr Helen Brooks Chief Scientist's Group

### Building resilience to climate change through research

Climate change is part of our lives. Over the last decade we experienced 40°C for the first time in England. The number of very hot days (>30°C) more than trebled. We also experienced a greater number of very wet days, particularly in autumn. An increase in extreme events is creating an environment with more dynamic hydrological conditions, which can have a real effect on people and the services they rely on.

Building resilience, the capacity to recover from difficulties, means that we have the ability to adapt and get on with life even when we experience shocks. In a changing climate, we will need transformational change to maintain expected outcomes. The future is different, and adapting how we do things will be part of all our futures.

The Environment Agency plays a role in understanding what to expect and how to prepare.

#### **Understanding climate effects**

Knowing how things are changing is useful – whether it's how chemicals will behave in warmer weather or if a particular species will survive. Understanding climate effects allows us to consider risks and vulnerability to what's coming.

The UK's transition to low carbon energy will require many developers to consider water availability perhaps for the first time. The Environment Agency's Chief Scientist's Group is working with the Department for Energy Security and Net Zero to understand future water resource reliability through the <u>climate services for a net</u> <u>zero resilient world (CS-NOW) programme.</u> Our scientists supported the development of the CS-NOW water resources tool by providing water resources data, technical advice and co-leading stakeholder engagement. The tool provides an estimate of water resources at one kilometregrid resolution across England through to 2080. Estimates consider climate change and future demand scenarios dictated by future energy combinations. These <u>publicly available data sets</u> of future daily river flow will also be useful for other sectors dependent on water.

Rivers are another area where the Environment Agency is working to build resilience to future change. While we expect rivers to warm in line with air temperature, rivers are complex – they warm and cool in variable ways, affecting freshwater habitats and species. Working with the University of Birmingham, the Chief Scientist's Group developed England's first national river water temperature projections. The projections showed that the average water temperature of the warmest summer month will rise by about 0.6°C per decade. By 2080, adult brown trout will be under threat from high summer water temperatures at almost all English sites, as their upper growth and feeding temperature range of 19.5°C could be exceeded. Salmonid fish eggs survive best at winter temperatures below 12°C, but this threshold could be exceeded at over 70% of sites by 2080. Environment Agency scientists are using these temperature projections to explore some of the potential effects of warming rivers.



All 90 English estuaries have warmed in recent years and we're exploring how they may change in future.

Planning ahead is also helped by observing change that is already in play. Estuaries are highly productive areas for biodiversity and industrial development. The Chief Scientist's Group evaluated long-term monitoring data, which showed that since 1990 most of England's 90 estuaries have warmed, and reduced nutrient pollution from rivers has altered estuarine water quality. More warming, combined with sea level rise, will alter these environments further. In collaboration with Bangor and Liverpool Universities, we are developing new knowledge about which estuaries will be most affected and in what ways.

#### Testing approaches to build resilience

Knowing what to expect is only part of preparing for climate change. Even where risks are well understood, there are uncertainties and knowledge gaps about which interventions will work, and indeed whether current practices will continue to provide expected environmental protection.

Understanding a place's resilience to pressures can be helped by considering specific 'thresholds'. Thresholds are the tipping points where, when exceeded, a place can no longer function in the same way. The Chief Scientist's Group reviewed the potential of <u>resilience concepts to</u> <u>improve environmental outcomes</u> in catchment management. Where catchment systems are well understood, we can explore how they can be moved closer to or further away from a specific water quality or other threshold.

While research scientists can provide evidence to inform adaptive decision-making, we recognise that working with others is more likely to lead to effective decisions. We explored <u>participatory</u> <u>approaches and co-development of research</u> with colleagues involved in incident management. Together, we explored what the future might look like and what we are resilient to, identifying how our research can better support the Environment Agency's management efforts. This is just one way we're ensuring we can understand and deploy the most effective approaches to maximise the usefulness of our research.

We are continuing to experiment through a range of projects, building a pool of practical examples to help scientists understand how and why to use participatory approaches. For example, we're exploring what nutrient futures might be possible for highly valued lake ecosystems where a wide range of human uses and expectations create regulatory challenges.

#### Translating climate science and information

Of course, new knowledge and approaches can only do so much in isolation – we must also ensure that this information can be used by others. Part of the Chief Scientist's Group's work includes translating our research for scientists and nonscientists alike.

The UK has some of the most advanced climate modelling capability in the world. The Chief Scientist's Group works with the Met Office to understand new insights and to shape information for use in decision-making. For example, the sea level will continue to rise around the UK, but there is uncertainty about how extreme this could be if, say, Antarctic ice sheets melt faster than expected. People involved in the long-term planning of flood risk shared how they interpret uncertainty around sea level rise over 2 metres. Understanding how others grapple with the concept of uncertainty helped our scientists refine the information they provide within and beyond the Environment Agency.

We are continuing to develop our research programme to support the Environment Agency and others in preparing for climate change and building resilience across the environments and communities we serve.

Contact: Dr Harriet Orr Chief Scientist's Group

### Science for incidents and emergencies

On average, over 200 incidents are reported every day to the Environment Agency: that's one every 7 minutes. We deal with floods, droughts, pollution to land, water and air, waste fires, industrial accidents, smelly landfills and fish diseases, as well as the consequences of other problems, like road accidents, major fires and power cuts. So how does science support the Environment Agency's incident management?

Much of the Environment Agency's work is about avoiding problems and incidents. We build flood defences and issue permits for activities like water abstraction or discharges, with the aim of reducing the effect on people, wildlife and the environment. Science underpins our regulation and environmental management. Science helps us understand the effect of different chemicals on the environment, lets us design and operate flood schemes, and allows us to work out how to manage river flows in dry periods. But however well we plan and manage, sometimes something happens that is outside the normal range – and that's what we call an 'incident'.

Incidents have 3 phases: before, during and after.

Before an incident is the time to prepare.

Our flood forecasting models are built on years of data, analysis and research. Before it rains, we're ready, with our partners at the Met Office through the Flood Forecasting Centre, to forecast when the weather might lead to flooding. We use science to review and improve flood forecasting methods and data, and to find better ways to encourage people to act on flood warnings.

In times of prolonged dry weather, we use digital groundwater and river flow models to understand how river systems will respond, informing our water management decisions.

Our laboratories have state-of-the art chemical and biological analysis equipment and – most

importantly – skilled, trained scientists who are ready, day or night, to analyse samples for whatever they may contain.

Working with partners across government, we're ready to understand and manage unintended releases of radioactive substances into the environment.

We practice all our responses so that when the next incident happens our scientists are ready to support operational colleagues with whatever they need.

**During** most incidents this preparation and practice means that our scientists can focus on forecasting and analysis, but don't need to develop new approaches as they go. On rare occasions, incidents go beyond what we anticipated in some way, and this is where trained and experienced Environment Agency scientists are essential.

Sometimes we must work from limited information. In August 2024, we received news of a major cyanide spill into a canal in Walsall in the West Midlands. Early information on the exact substance was sparse. Our Ecotoxicology Advisory Service worked through the options of what might have been spilt and provided essential scientific advice on the possible effect on wildlife, canal users and our own staff. As more information became available, we were able to refine this advice, protecting people and the environment from a very worrying situation.

During the COVID-19 pandemic, the work of the government's Scientific Advisory Group for Emergencies (SAGE) was in the spotlight. SAGE is called for serious major incidents, and, if the environment is involved, the Environment Agency's Chief Scientist, Rob Bradburne, will be there to support government decision-making. And behind Rob – through phones, emails and computer links – will be the right Environment Agency scientists, providing analysis and understanding in a way that only practising scientists can.



Environment Agency officer managing a diesel spill incident.

After an incident, our scientists are always ready to investigate exactly what happened and what we can learn from to improve our service next time. Often this is part of a wider review, but sometimes there's an unanswered science question. In August 2017, a cloud of unknown gas (described as a 'toxic mist') drifted towards the crowded beach at Birling Gap, East Sussex. In the absence of samples, scientists from the Met Office, Defra and the Environment Agency examined numerous lines of evidence and concluded that the most likely source was a ship, lost cargo or a wreck in the English Channel. Every incident provides new data for activities like improving numerical models which in turn can improve forecasts and incident response.

Environment Agency scientists aren't just interested in past and current events: we're also working to anticipate the way incidents may change in the future. We are using climate change research to understand what flooding from rivers, the sea and surface water may be like in the future – where, how often and what is likely to be affected.

Other research is seeking to understand and manage future drought, to predict future water temperature (warming waters may suffer from more algal blooms, leading to fish deaths), to examine the way that thermal winds affect local air quality (important for understanding local air quality near factories and landfills), and to understand the current and future pathogens in rivers and bathing waters.

No one wants to be affected by an incident or an emergency, but not all incidents can be avoided. Environment Agency scientists help to find novel ways to avoid, predict and reduce the effects of incidents on people, wildlife and the environment.

#### Contact: <u>Dr Glenn Watts</u> Chief Scientist's Group – Research

# Connecting communities to our research through science participation

Participatory science challenges the assumption that research should only be carried out by 'certified experts' from the academic community. Instead, it is based on the principle of engaging and collaborating with members of the public to produce better outcomes. Integrating participatory science within our work at the Environment Agency is important to protect and improve the environment in a way that meets everybody's needs.

Recently, we've seen a rise in participatory research methods being used in topics that are relevant to our work, such as climate change adaptation and pollution monitoring. We've also seen a rise in citizen science initiatives, a type of participatory science, based on empowering citizens to take on the role of researcher to varying degrees and directly contributing through data collection and other roles.

Increased participation in science has been widely studied and allows us to consider the wider implications for society. Including alternative perspectives increases the chances that the research will be understandable and acted on by other members of the public. It also allows the scientific community to engage with members of the public who might otherwise feel excluded.

#### SMARTWATER: An example of citizens participating in science

SMARTWATER is a 5-year project led by the University of Birmingham about better understanding river pollution. The Environment Agency is leading part of the research by engaging with local communities. We are using participatory research techniques such as co-design workshops to ask local stakeholders what they think is happening in the rivers. Traditionally, when scientists want to understand how pollution is affecting a river they would use technology, such as sensors placed in the river, that are able to detect pollution. They would then analyse the collected data to tell them what is happening in the river. Using only this method, we may miss valuable insight and expertise from local communities. Their knowledge could help us make sense of unexpected patterns in the data, or link observations to previous events we would otherwise be unaware of. They also hold knowledge for specific locations, that the sensors may not reach.

We are looking at 3 different rivers and will be inviting local communities to come to a workshop where we will ask them to show us what they have seen in their local area, and to tell us what they think is happening in the river. They will help us to build a 'perceptual model', which is a model of what the stakeholders perceive to be happening. This will help us better understand what is causing river pollution in those areas. By creating these models together with local stakeholders, we can make sure that their knowledge and experience is captured and is passed on to the other scientists and researchers working on the wider project.

One of the challenges of participatory research is finding and engaging the right people. We have seen that in catchments with popular citizen science initiatives, local people are encouraged to be involved and empowered to call themselves scientists based on their knowledge. In areas where there is no previous engagement, local people may not consider themselves to be experts. The risk is that they may not participate in the workshops and their expertise on the local environment is lost. Part of our work in SMARTWATER is to figure out the best way to engage with people and make sure we're effectively capturing their local knowledge. Another challenge when bringing scientists and members of the public together is to make sure that everybody in our workshops feels empowered and knows that their knowledge is valued. To do this, we will need to carefully plan the workshops and take steps to create an environment where everyone is comfortable and confident to contribute equally.

Although we are at the beginning of SMARTWATER, we have already seen, through preliminary conversations with stakeholder groups, that there is a wealth of knowledge and information that will be invaluable to the project. The perceptual model that is created together with local knowledge from stakeholders at the workshops will help us understand what is happening in the rivers and be better equipped to tackle pollution. The lessons learnt from SMARTWATER will inform future research in this discipline and we hope will encourage more experts in other fields to connect with communities through participatory science.

#### Contact:

#### Pete Bailey and Hannah Perriton

Social Science team, part of the Risk Assessment and Research team in the Flood and Coastal Risk Management directorate



### Chemicals in the environment

Chemical pollution is a global challenge. To take effective action we need to understand where and how the most polluting chemicals are released to the environment, what happens to them, and the consequences of chemical exposure for environmental and human health. The large number of chemicals used in industrial processes, food production and everyday life at home or work, means that this is a complex problem. We are working hard to tackle it.

One important example is our work to understand and manage the risks posed to the environment by per- and polyfluoroalkyl substances (PFAS). PFAS are a large group of synthetic chemicals that have attracted widespread international concern.

PFAS can have water and greaseproof properties as well as high thermal stability. As a result, they are used in a wide range of applications, such as firefighting foams, food packaging, stain repellents for soft furnishings and waterproof outdoor clothing.

Unfortunately, once PFAS enter the environment they can remain there for a very long time because they do not break down easily. Sewage works are not designed to destroy PFAS, and effective removal from water requires more expensive and energy-intensive treatment than other chemicals. Many PFAS readily move through water, soil and air, travelling far from their source. Concentrations in the environment may, therefore, increase over time without regulatory intervention. Even if all future emissions of PFAS from products could be prevented, there is a large legacy of environmental contamination which will last for many decades. Remediation is difficult and costly.

PFAS contamination can be difficult to measure, which means that there is limited information about how much PFAS is in sediment, soil, air or plants and animals. Despite this, our evidence based on environmental contamination by PFAS has expanded considerably in recent years. Our monitoring shows that some PFAS are widespread in our rivers and groundwaters, including drinking water sources. There are also reports of PFAS being detected in plants, animals (such as otters) and people.

Understanding the impact of PFAS on the environment and human health is a rapidly developing area of research. Although a handful of chemicals have been well studied, little is known about the toxicity of most PFAS. This makes it very difficult to develop regulatory limits for PFAS in water, soil and air, and managing the risks from PFAS is, therefore, challenging. The Chief Scientist's Group has been at the forefront of evidence gathering as well as advising on the UK's regulatory response.

#### Evaluating and reporting on the evidence

We continue to play a leading role in evaluating and reporting on the evidence on environmental contamination by PFAS. We are using our rapidly expanding evidence base to update our review on <u>PFAS sources, occurrence and environmental data</u> with data collected between 2020 and 2024.

In May 2024, the triennial report Interim H4 Indicator 2024: exposure and adverse effects of chemicals on wildlife in the environment was published, including environmental monitoring data for PFAS for the first time. The indicator is one of a suite of metrics developed to measure progress towards the targets set out in the Government's Environmental Improvement Plan. It tracks changes in wildlife exposure to chemicals in the environment over time and the potential risks to wildlife from chemicals in terrestrial, freshwater and marine ecosystems. It is a multi-organisational partnership, reporting on trends related to the exposure and effects of chemicals on wildlife and the environment.

#### Taking action to manage risk

We have worked closely with industry and other government agencies to publish soil guidelines for screening out low risk contaminated sites that may have been contaminated with legacy PFAS. We have published soil screening values for legacy PFAS that can be used to screen out low risk activities involving the recovery of wastes such as biosolids and compost to agricultural land.

Our Chemicals Assessment Unit co-authored a <u>regulatory management options analysis</u> for PFAS in 2023. Fire-fighting foams were identified as a major source of PFAS in the environment, and this year we began work with the Health and Safety Executive to prepare a restriction proposal under the UK REACH Regulation. This has involved identifying and consulting with a wide range of affected stakeholders. We have prepared an environmental hazard and risk assessment to justify the risk management actions required. A public consultation on the draft proposal will be held in spring 2025.

We are preparing for likely future restrictions of other PFAS uses by increasing our understanding of how they are used in Great Britain and the potential for environmental release during use, recycling and waste disposal. Many PFAS are imported into Great Britain in finished goods, but lack of information makes it difficult to estimate the amounts released from these products. This limits our understanding of which uses are a significant source of PFAS in the environment. To help address some of the uncertainties, we are planning a project to measure PFAS levels in stain-resistant clothing.

The Chief Scientist's Group will continue to work in partnership with colleagues in the Environment Agency and across government to understand the challenges posed by PFAS, and to develop effective regulatory approaches to manage risks to our environment, wildlife and health. This involves close working relationships with the Drinking Water Inspectorate, UK Health Security Agency, Health and Safety Executive, Food Standards Agency and Defra. We are also engaged in collaboration at an international level through bodies such as the Organisation for Economic Co-operation and Development and the United Nations' Stockholm Convention. This is vital to minimise the chances of cross-border pollution and to limit the amounts in imported goods.

#### Contact:

Dr Emma Pemberton and Steve Dungey Chief Scientist's Group

### Evidence and insights for agriculture

Agriculture accounts for 70% of land use in England, placing significant pressures on the environment. The government has set ambitious targets to transition to a more sustainable situation through the <u>Environment Act</u> and <u>Environmental</u> <u>Improvement Plan</u>.

Evidence and insights from the Environment Agency's Chief Scientist's Group are fundamental to this transition, helping underpin the provision of effective farm advice, incentives (including the new <u>environmental land management schemes</u>) and regulation.

## Building the evidence base through monitoring and evaluation

Policy evaluation is critical for understanding what does and does not work, driving continuous improvement of delivery, informing investment decisions, and supporting stakeholder communications and engagement.

Environmental monitoring and modelling provide essential information on the environmental impact of agricultural schemes and policies. Environment Agency scientists work with colleagues across the Defra Group and a range of other partners to ensure robust monitoring and evaluation is in place for the main agricultural policy areas, providing timely and accurate information to assess outcomes and impacts.

For example, we developed advanced statistical modelling to assess the impact of agricultural pollution mitigation measures on groundwater pollutant trends. Working with a number of partners, including environmental consultancies WSP and APEM, we applied this approach across 700 routinely-monitored boreholes in England. An environmental response was most evident in fast-response aquifers where we found a direct link between reductions in pollutant loadings and improvements in groundwater quality. Working with the UK Centre for Ecology & Hydrology (UKCEH), we established an air quality monitoring project at Wedholme Flow in Cumbria. It aims to evaluate the impact of agri-environment policies on airborne ammonia and ecology at a landscape scale. Wedholme Flow is an ideal study location, being an important raised bog habitat surrounded by intensive farmland.



An ammonia monitor in Wedholme Flow, Cumbria.

Environment Agency scientists worked with Rothamsted Research to identify the sources of sediment pollution within river catchments. We used rapid-assessment <u>sediment fingerprinting</u>, a novel approach that compares the properties of sediment retrieved from a river with its surrounding catchment. This approach has been applied to a range of catchments across England. The results have been used to target advice, inform the selection of mitigation measures and underpin natural flood management projects. We are currently working with colleagues across the Defra Group to develop a national soil health baseline map and indicator. These will be based on survey data from the <u>Natural Capital</u> <u>and Ecosystem Assessment</u> programme and will support understanding, safeguarding and restoration of precious soils.

# Developing innovative tools to inform decision-making

Decision support tools can be used to understand the efficacy of mitigation strategies at both local and national scales. The Chief Scientist's Group works with various internal and external partners to provide a range of useful tools.

The Agricultural Land Environmental Risk and Opportunity Tool (ALERT) represents a step change in our ability to target pollution mitigation measures in the landscape. It uses some of the very best spatial data to locate environmental risks and opportunities. For example, ALERT users can locate overland flow pathways and use contemporary remote sensing data to look at changes in the landscape over a season.



ALERT spatial data layers – flow pathways, soil type, slope.

We are working with environmental and agricultural consultancy, ADAS, on the further development and application of Farmscoper, a decision support tool for measuring agricultural pollution and assessing the effects of farm management practices on reducing environmental impacts. One of the main uses of Farmscoper is to assess potential environmental and financial benefits from on-farm mitigation measures from specific projects through to wider agri-environment schemes.

The Environment Agency developed the <u>CSF-HYPE</u> model with JBA Consulting and the Swedish Meteorological and Hydrological Institute. The model simulates changes to water quality, in both space and time, as a result of catchment mitigation measures. CSF-HYPE effectively 'translates' estimated reductions in farm pollution from Farmscoper into in-river pollutant concentrations.

#### **Driving continuous improvement**

As we build our understanding of what does and doesn't work, evidence and insights from the Chief Scientist's Group play an increasingly important role in improving the design and efficacy of schemes and policies.

Looking forward, the Chief Scientist's Group will further develop the data sets and decision support tools needed to support evidence-based policy and evaluation. Working closely with colleagues from across the Defra Group this evidence will support effective and efficient delivery of environmental outcomes.

Contact: <u>Phil Smith</u> Chief Scientist's Group

### Scientist in the spotlight: Aamer Raza



After earning an MSc in Environmental Health Sciences from Harvard University in 1989, I spent 14 years advising corporate America on health risks at heavily polluted 'Superfund Sites'. In 2003, I moved to the UK, managing environmental projects, focusing on agricultural air quality. After 30 years in the private sector, I joined the Environment Agency in 2022 as an Air Quality Advisor and recently became a Senior Air Quality Evidence Specialist in the Chief Scientist's Group. The role is well-aligned with my goal to improve air quality in agriculture by working across private and public interests to achieve shared goals.

Aamer Raza | Senior Air Quality Evidence Specialist



### Transforming the way we monitor England's environment

The Environment Agency manages a vast and intricate network of monitoring systems, constantly observing and assessing the health of England's rivers, lakes, coastlines and air. Dedicated scientists, technicians and analysts are spread across the country to collect samples of water, air and soil.

The scale and complexity of these systems means that the Environment Agency must be on the cutting edge of monitoring innovation. We are transforming from a business that relies on manual sampling and analysis of data to a flexible business enabled by digital tools.

#### From coasts to canals: Monitoring England's waterways

Monitoring England's watercourses is a complex logistical challenge. There are over 55,000 km of rivers, streams and canals in England, not to mention lakes, groundwater aquifers, coastlines and estuaries. The longest journey time for a sample to get to the Environment Agency's Starcross laboratory is from Lundy Island – a 7-hour trip involving 4 different modes of transport.

In 2024, our laboratory received 99,000 samples from across the country, resulting in over 1.7 million individual determinant measurements. The majority of these were collected by our 247 National Field Monitoring team members. We also rely on a number of other teams who are equipped with specialised skillsets. For example, our Analysis and Reporting teams specialise in assessing 3,000 invertebrate samples. They use these samples to understand the health of the local biodiversity and can even use the data to diagnose the most likely local problems. On the ground, Environment Agency officers visited 13,000 locations in 2024 to obtain data on water quality and ecology. We maintained a network of 11,800 water quantity sites, which provide vital data on river flow, water levels, rainfall and groundwater. The data is crucial for flood management activities and water resources planning that provide more than £8 billion of national socio-economic benefits each year.

Much of our monitoring efforts are focused on bathing waters. In 2024 alone, 7,510 samples were taken from 450 designated bathing waters – a logistical feat requiring careful planning to navigate tides, holiday traffic and the unpredictable English weather. These samples determine the quality of our bathing waters, helping to ensure enjoyable <u>summer swims</u> for millions.

Meanwhile, beneath the surface, a network of sensors monitor England's rivers and groundwater. Gauges and boreholes provide real-time data on water levels, which is crucial for predicting and mitigating the effects of both floods and droughts. In 2024, this network proved invaluable, providing early warnings of potential flooding risks and enabling proactive responses right across the country.

#### Providing information on air pollution

The Environment Agency's growing network of air quality monitoring stations, strategically placed across England, provides crucial data on airborne pollutants and tiny particles that can harm human health. This expansion, overseen by the Chief Scientist's Group, delivered by our Operations teams, will empower the government and the public to make informed decisions about air quality and public health, and to know with confidence whether we are tracking towards the government's 2040 targets for improved air quality. One pollutant we're monitoring is PM2.5, which encompasses any airborne particulate matter that has a diameter of less than 2.5 micrometres. They can come from any number of different sources such as industrial emissions from combustion, domestic heating and vehicle emissions. But they can also occur naturally.

Fine particulate matter poses significant health risks due to its small size, which means they can be inhaled deeply into the lungs. Sensitive groups like children, the elderly and those with existing heart or lung conditions are particularly vulnerable to the effects of PM2.5.

England needs a monitoring programme capable of tracking local PM2.5 levels. The Environment Agency is building 137 new air quality monitoring stations, with the aim of having a total of 200 air quality monitoring locations in our network by the beginning of 2028. This monitoring network will provide a sound scientific basis for developing cost-effective control policies.

Our aim is to provide the public with open and up-to-date information on air pollution, enabling them to take appropriate actions to minimise health effects. The programme will also allow us to evaluate potential effects on the population, ecosystems and our natural environment. All of this new data will be accessible to the public on the <u>air</u> <u>quality portal</u>.



The Environment Agency's 'Hello Lamp Post' project.

#### Moving towards a digital future

The past and current success of our monitoring programmes is providing the country with vital information. But the time for us to transform our monitoring is now. The cost of traditional monitoring equipment is on the rise and our digital assets need modernisation. Our mission is to turn every single sample and observation we make into an insight that people can use almost in real time. Automating data analysis is a main objective.

We are investing in a number of digital programmes, including testing the potential of artificial intelligence (AI). In summer 2024, we launched an AI-driven citizen science endeavour using the <u>Hello Lamp Post</u> initiative. This empowers local communities to engage with the environment, providing valuable data and raising awareness of environmental issues.

We are investing £9 million a year in a new digital platform for water data that will allow us to gain greater insights into the water environment more quickly and, therefore, make faster regulatory and planning decisions. The new platform will feature a huge range of raw monitoring data that will be interoperable and be much easier to search. We will also add a range of automatic analytical pipelines that will provide a stream of regular updates for our staff to use. Our long-term ambition is to provide this capability to the public too, so that we are regarded as a fully transparent organisation. We are already taking steps to ensure we can import data from other organisations into our analytics.

Whether we're monitoring water, air or what people observe in nature around them, these innovations will ensure the Environment Agency, government and the public are all equally well-informed about how the environment is changing.

Contact: Owen Lewis Chief Scientist's Group

### Scientist in the spotlight: Kerry Sims



As the Environment Agency's Monitoring Manager, I provide leadership in monitoring the water environment. I started my career focusing on ecological monitoring before working in fisheries and leading the organisation on chemicals of emerging concern. Eighteen years later I've gone full circle to focus on the organisation's monitoring which underpins all of our decision-making. My aim is to tell the stories of how we use our data to make a difference on behalf of the 1,000 people who work in monitoring in the Environment Agency, so our monitoring evidence is transparent and understood by everyone interested in the water environment.

Dr Kerry Sims | Monitoring Manager

# Harnessing the benefits from the natural environment with nature-based solutions

#### "Our economies, livelihoods and wellbeing all depend on our most precious asset: nature." – Dasgupta 2021

Healthy ecosystems – our natural capital – underpin our lives, livelihoods and the economy, providing food, clean water, protection against flooding, and places to enjoy for our physical health and mental wellbeing. But the services and benefits we get from natural assets are at risk. As pressures increase and nature is degraded, there is less resilience in food and water security, increased flood hazards and greater environmental inequity.

Harnessing the wider benefits from nature is becoming increasingly important to achieve government priorities for economic growth through a cleaner environment, nature recovery, flood risk management, resilience and climate adaptation.



Slowing the flow with leaky dams within the Surrey Hills area. Credit: Andrew Turton, Defra Communications

# What are nature-based solutions and why do they matter?

Nature-based solutions (NbS) are actions that protect, restore and support sustainable management of natural assets, or natural capital. By harnessing the power of nature, NbS can provide multiple benefits. For example, planting trees and restoring wetlands such as peatlands increases the amount of carbon stored in the natural environment and reduces the risk of flooding. NbS are not generally intended as substitutes for conventional, engineered solutions to flooding and pollution control. However, when NbS are used in combination with other actions, wider benefits can be achieved that improve the overall cost effectiveness of the interventions.

Natural flood management refers to NbS used for flood and coastal erosion risk management. Solutions involve slowing water flowing from upland catchments or off bare soil, reconnecting rivers with their natural floodplain and making space for water.

In towns and cities, green infrastructure and sustainable drainage systems can reduce surface water flooding. At the same time, they enhance biodiversity and access to green spaces, which promotes wellbeing.

#### What evidence is there?

In 2017, Environment Agency scientists published the 'Working with natural processes (WwNP) evidence directory', setting out for the first time the scientific evidence to support flood risk management practitioners. This clearly explained what is known, and not yet known, about how effective NbS are for reducing flood risks and providing wider benefits. In early 2024, the <u>directory was updated</u> to cover 17 measures, with the addition of new sections for beaver reintroduction, reefs and submerged aquatic vegetation. The update draws on a detailed review of over 700 new pieces of evidence, highlighting how the growing evidence base gives confidence in the flood risk reduction and wider benefits NbS can bring.

In a separate study, the Environment Agency brought together a synthesis of <u>135 studies of</u> <u>the effects of NbS</u>. It evaluates the benefits of NbS for high and low flow management, water quality, biodiversity and habitat. The findings are presented by catchment types (for example, upland or lowland), with case studies and 2-page summaries of the different interventions available. It includes assessments of confidence in the realisation of, rather than hypothesised outcomes for, the different NbS based on the quantity and quality of the evidence.

The synthesis found generally positive evidence for NbS, but it matters that we do the right thing in the right place. There is relatively less quantification of benefits beyond flood risk management, and it is also clear that extreme events and a changing climate may affect the outcomes that can be achieved from NbS.

## How is the evidence used to inform decision-making?

The WwNP directory supported a £15 million natural flood management pilot programme between 2017 and 2021. The 60 pilot projects found that natural flood management measures used in combination across a large area could provide flood risk benefits by reducing runoff and increasing water storage. Information from the pilots was used in 2024 to design the Environment Agency's £25 million fund for natural flood management. The fund supports schemes across England and includes monitoring to generate new knowledge about the effectiveness of NbS in different settings. The WwNP has also been used outside the Environment Agency. The United States Army Corps of Engineers referenced it to produce and publish <u>international guidelines on natural and</u> <u>nature-based features for flood risk management</u>. 'Slow the Flow', a natural flood management charity, used evidence from the WwNP directory to install over 800 leaky barriers, which are dams made of natural woody material laid in streams. It demonstrated that the leaky barriers delayed flood waters arriving downstream.

#### What's next?

The growing evidence base is providing increasing confidence that NbS provide important benefits, particularly for flood risk management. However, there are still gaps in knowledge about the effectiveness of some measures, how much benefit can be achieved in different settings, and how different combinations of measures and actions might be most effective. Other challenges include how best we can achieve water quality targets by combining engineered and NbS solutions, as well as understanding the limits to NbS.

The Environment Agency has ongoing research focused on how to quantify the flood risk reduction benefits of NbS. We are working with the Natural Flood Management programme to test quantification tools in development.

We're continuing to build greater quantification of benefits of NbS and understanding of what works and where. Doing so will help the Environment Agency manage risks from flooding and pollution, while maximising wider benefits and protecting and enhancing our natural capital for generations to come.



A series of connected ponds designed to help mitigate diffuse agricultural pollution by capturing and filtering sediment and nutrients from the surrounding farmland. Credit: David Gasca-Tucker

Contact: <u>Dr Harriet Orr</u> and <u>Ruth Jones</u> Chief Scientist's Group <u>Hayley Bowman</u> Flood Research team, part of the Risk Assessment and Research team in the Flood and Coastal Risk Management directorate

# Changing the way we think about the value and benefits of clean and plentiful water

Improving the water environment is a complex task. It challenges us as scientists, it inspires us to innovate, and it provides a test bed for our commitment to nature recovery, with improvements to water providing benefits to people and wildlife.

Much of our scientific work has a silver thread of water running through it. But this year we have seen the different strands of our water-related work start to come together to support real positive transformation. We are changing the way we think about water, using systems understanding, learning from the past, and informing strategy for the future.

We are seeing data from the first of our new unbiased and nationally representative monitoring networks, the River Surveillance Network, start to mature. The newer data sets collected under the Natural Capital and Ecosystem Assessment programme are adding new insights in different parts of the water system. This increasingly enables us to look at the effectiveness of what we are doing now and engage others in what we want the future to hold for us. It unlocks new understanding, supports the development of new tools, and will result in new approaches, making a positive difference to our many and diverse waters.

#### Where are we now?

There have been marked improvements in water quality <u>since 1990</u>, but the use of the English landscape for food security, water security, energy generation, flood mitigation, the disposal of waste and space for urban development is still putting significant pressures on wildlife within catchments and coastal waters. Balancing the needs of people, businesses and nature in the context of supporting resilient growth alongside a changing climate requires continued improvements in evidence to support individual and large-scale decisions. Detecting emerging and changing threats will also enable timely and tailored responses to maintain the improvements we seek.

Society creates demands on the environment and society depends on it. We all benefit from well-functioning catchments. As well as food and water, natural environments also provide aesthetic value, recreation opportunities, mental health benefits, space for wildlife and other essential services such as water quality regulation and carbon sequestration. This drives the need for greater scientific understanding to underpin good decision-making.

Climate change, population growth, unsustainable land management practices, depletion of nonrenewable resources, industrial output and pollution all have significant implications for maintaining and improving the availability and quality of water and ecosystem function in the future. Conversely, proactive, thoughtful management of our highly modified water systems, in the knowledge of the way they operate and the benefits they can bring, offers positive outcomes for both people and nature. Generating science that is directly usable by many across society is going to be important to enable effective decisions to be made by all concerned.

#### New understanding

Grasping the opportunities to manage the water environment in a better way requires unbiased and representative data. The Natural Capital Ecosystem Assessment programme is one major programme making a step change in the way we monitor and understand the environment. Its new nationally representative networks are designed to work alongside local pressure-specific targeted monitoring. It considers the environment as a system, building a picture of the extent, condition and location of natural assets and the environmental, social and economic benefits they provide to society. It should enable us to discern much more clearly the changes we are seeing in the state of the environment, meaning we can put nature at the heart of decision-making, driving improvement in the water environment.



Monitoring environmental systems.

We are deepening our understanding of cause and effect by embedding formal evaluation in more of our intervention activities, such as those in Catchment Sensitive Farming, the Water Environment Improvement Fund, Local Nature Recovery Strategies and the Water Industry Natural Environment Programme.

Water work, research, understanding and innovation is intrinsically linked to other themes in this review, and we will continue to apply our learning across subject areas to make the most of our knowledge capital.

#### New tools

The Chief Scientist's Group continually look for better ways to present environmental data, and to increase understanding of the pressures, interventions and benefits present.

We have created an 'Analysis Ready Water Network' that will bring together a standardised set of data, tools and techniques to provide consistent information about the environment, wider river network and catchments of all stretches of rivers in England.

We are also improving our understanding of how the condition of natural assets influences their ability to support sustainable functioning ecosystems and, therefore, the physical flows of ecosystem services that people benefit from.

Last year, we developed prototype condition indicators to reflect 10 ecosystem services provided by rivers and mapped them in pilot catchments as a proof of concept. This year, we have refined the indicator and mapping methods and are scaling up some of these ecosystem services nationally to enable further user testing and refinement before fully scaling up next year.

#### New approaches

The environment can take a long time to change and for nature to recover, so it is imperative that we act swiftly and think about the future now. The Chief Scientist's Group is helping to drive progress in both the short and long term.

Elsewhere in this report, you will see how our work is addressing the changing quantity of water available to nature and society – too much and too little at different times of the year and in different places. We are researching the effects of the transition to net zero and the changing farming landscape on the water system. We continue to look at the movement and effects of chemicals in our surface and ground waters. And we are looking into the opportunities to work more closely with different parts of society and with nature-based solutions to maximise the co-benefits of improving water around the country.

In the longer term, we are supporting the need to change the way we use the land in the next few decades to rebalance where the current demands on the environment, and the services it can provide, are outstripping supply. But the water environment is a complex system, characterised by multiple interconnections between components, processes, functions, uses and stakeholders. These interactions determine its behaviour, function and outcomes, and they need to be considered together. Our interventions won't work to secure overall gains unless we work that way; that means water, land and biodiversity.

But, further than that, when thinking about the future, a rule of thumb is that to look, for example, 75 years into the future, you need to look backwards twice as far to appreciate the scale of change that is possible. If we look ahead 75 years, we should consider what things were like 150 years ago, and that the UK didn't have any environmental regulation then. So, there is scope for profound future change, but we can't say what those changes will be, especially in complex systems. The future environment will depend partly on how we all contribute to the design of the politics, technology, society, culture and the economy of the future. Enabling people to consider this now will help us to take decisions that have a greater chance of taking us towards a resilient, positive future.

Working towards transformation of the water environment for people, nature and wildlife is incredibly challenging, incredibly worthwhile, and incredibly necessary.

#### Contact:

Dr Susan Casper and Jennifer Taylor Chief Scientist's Group



### Cleaner, healthier environments for people to enjoy

Two-thirds of adults in England regularly visit a green space, such as a park, field, woodland or riverside path. Spending time outdoors is essential for our physical, mental and overall wellbeing. And spending time in higher quality environments outside is now known to deliver even greater benefits to people from a range of backgrounds. Protecting and improving the environment, therefore, clearly has knock on benefits for people's health.

Through its many different roles in maintaining and improving the quality of the environment, the Environment Agency creates a better place for both people and wildlife. We achieve this through environmental monitoring, regulation, research and incident response activities, many of which reduce health risks caused by contact with environmental hazards. Environmental hazards can affect people through many routes, such as air pollutants that we inhale, water pollution that we ingest, soil or other surfaces that we touch, and extreme weather events like flooding that impact our lives. The Environment Agency's work to minimise hazards in the environment creates clean and safe outdoor space for everyone to enjoy.

#### Researching better ways to monitor and regulate air emissions

One example of this is the work the Environment Agency does to reduce harmful pollutants in the air. Air quality is one of the biggest ways that the environment affects human health. Poor air can cause respiratory illnesses, lung and heart diseases, and other chronic conditions that reduce life spans. It is essential that sources of poor air quality, like emissions of pollutants from industrial sites, are monitored and regulated. The Environment Agency's work has greatly reduced harmful air pollution since the 1990s, but there is still work to be done to make our air healthier. Air pollution in the UK is still 2 times higher than the level recommended by the World Health Organisation. To help tackle this, the Environment Agency has been researching improved ways to manage and regulate emissions. This includes identifying levels above which particular chemicals released into the air can cause harm (environmental assessment levels) so that they can be regulated to safer levels. Other research is understanding how temperature differences can change the movement of air masses over regulated sites such as landfills so that health risks associated with that air movement can be managed.

#### Building the benefits of blue spaces

The Environment Agency also helps keep swimmers and other water users like surfers and kayakers safe at popular sites called 'designated bathing waters'. The Environment Agency monitors these sites for certain bacteria as an indication of health risk to water users. The Environment Agency's bathing waters monitoring website, Swimfo, shows the general cleanliness of swimming sites across the country, and we produce pollution risk forecasts to give potential water users further information about possible shorter term reductions in water quality.

Like green spaces, spending time in or around water can help people feel great and keep fit. These so called 'blue spaces' are gaining popularity across the UK, with 27 new designated bathing water sites added just this year. Building on the Environment Agency's past research on the social benefits of blue space, the Blue Space Forum project published in 2024 used a collaborative approach to understand how communities are benefiting from and using blue spaces. Further research is looking at novel sources of data on when, where and for how long people are visiting blue spaces. This research helps the Environment Agency and the local authorities we work with ensure everyone can safely access and benefit from the UK's beautiful seasides, rivers and lakes.

# Scanning for future links between our environment and health

Although the overall link between health and the environment is clear, there is still much scientists don't understand, particularly about new risks to health that might arise in the environment due to changing human activities. Researchers in the Environment Agency are working to better understand some of these risks to ensure that we are ready for environmental health concerns that may need to be managed and monitored in the future.

For example, the Environment Agency has been investigating the tendency of infectious microbes like bacteria and fungi to become invulnerable to anti-microbial medicines. This phenomenon is called 'antimicrobial resistance' or AMR. While the problem has grown due to the wide use of antimicrobial drugs in modern medical and veterinary practice, the sources and possible risks of AMR in the environment have not yet been well researched.

Together with the UK Health Security Agency and the Food Standards Agency under the research programme PATH-SAFE, the Environment Agency has been leading on some comprehensive research to better understand AMR in the environment. This work has produced an impressive collection of reports and has confirmed that AMR in the environment poses a risk to human health. It has also sparked additional research into fungal AMR and other illness-causing microbes that we may be exposed to through the environment now and in the future. The next phase of research in the Environment Agency will build on this to consider which microbes in the environment may need to be tracked in future to lower the chances that people are exposed to these emerging microbial risks.

# Demonstrating the wider value of investing in a better environment

The Environment Agency's work doesn't stop with minimising environmental hazards to health through monitoring, regulation and research. Our scientists are also working with the UK Health Security Agency and others to better understand more broadly how society benefits most from the environment, so it can provide the best outcomes for people and nature.

One way to do this is with a natural capital approach, which brings together environmental, economic and social evidence to create an understanding of the wider value of ecosystems to society and the trade-offs from decisions.

The Environment Agency is using this approach to estimate the economic and health benefits of our work. This evidence demonstrates the value of a clean and safe environment, and shows how a society that regularly enjoys the great outdoors can help save health care costs – a win-win for the NHS, people and the environment.

Contact: Research and Natural Capital

# **Forward look**

Environmental science remains at the core of the Environment Agency's work and continues to attract significant public attention. Our scientists will continue to support the Environment Agency's understanding of the state and pressures on the environment and will work to find solutions to some of the pressing environmental problems we face. Our planned highlights include the following:

#### 1. Developing our people

We will continue to develop the Environment Agency's science profession, helping our scientists with their professional and technical development, and doing more to bring our scientific community together to build greater organisational resilience and leadership. We will expand our successful scientific seminar series, provide guidance on career paths for our scientists and introduce new scientific disciplines to develop wider technical leadership in the many areas of science covered by our work.

#### 2. Building our monitoring capability

In 2025 to 2026, we aim to build over 20 new air quality monitoring stations that will provide real time data on airborne pollutants at a range of locations across the country. These sites will be added to an expanding network of sites that will bring together air quality information from rural and urban locations to give government and the public a reliable source of air quality information.

## 3. Gaining new insights into the water environment

The Chief Scientist's Group is leading a wide variety of programmes that will bring us more comprehensive assessments of the state of rivers, streams, lakes, coastlines, estuaries and groundwaters and the impacts of the environmental pressures that humans put on them. We will produce guidance and training for water companies to use natural capital evidence to determine 'best value' options in their investment planning, and provide more support to citizen scientists, with guidance on how to bring publicly sourced data together with Environment Agency data to build a more complete picture of the environment and the pressures acting on it. We will continue to publish a series of statutory reports, including urban wastewater treatment compliance, shellfish and bathing waters. An important outcome will be assessing and reporting on a comprehensive assessment of England's waters, including identifying reasons for poor quality and what needs to be done.

#### 4. Novel science for now and the future

We will publish new research that explores how estuaries may respond to sea level rise and changes from the land. We will continue our work on understanding river ecosystem function by examining microbial eDNA. We will report on how thermal winds drive airborne pollutant transport. We will continue to look at antimicrobial resistance in rivers and coastal waters. We will start new work on cumulative chemical exposure from all environmental sources. Our net zero research programme will consider the impact on water quality in industrial clusters, and we will work with the Royal Society to convene a workshop on further environmental research needs resulting from the net zero transition. We will publish research into new methods to assess bioaccumulation and chemical mobility. Our flood and coastal erosion risk management research programme will continue to focus on the areas of research interest published in 2024. New research will be targeted at supporting the recently announced £2.65 billion government investment to build and maintain flood defences. This includes research into new ways to monitor and inspect existing defences, and

research that will enable investment into a wider range of ways to mitigate flooding and coastal change, beyond traditional defences, such as the activities trialled in our <u>flood and coastal resilience</u> <u>innovation programme</u>. We will also continue to look longer term to understand, and plan for, the potential effects of climate change on rivers, the sea and coastlines.

#### 5. Evaluation, analysis and reporting

We will publish the Catchment Sensitive Farming (CSF) Evaluation Report, including assessment of progress against environmental objectives, driving continuous improvement of CSF delivery, informing decisions on reinvestment in CSF and supporting stakeholder communications and engagement. We will gather and analyse evidence to underpin delivery of leading Environment Agency publications such as the Chief Regulator's report, state of the environment assessments and responses to government review. We will also finalise a restriction proposal for per- and polyfluoroalkyl substances (PFAS) in firefighting foam.

# Publications and peer-reviewed papers

Research publications from the Chief Scientist's Group and Flood and Coastal Erosion Risk Management Research teams in 2024.

#### **DNA** monitoring

<u>Understanding ecosystem dynamics using</u> <u>ecological network analysis</u> explores whether ecological network science could help the Environment Agency understand the role microbial communities play in English river ecosystems.

Molecular data generation and preliminary analysis of river microbial biofilm communities generated a DNA-based data set that captures genetic information from microbial biofilm communities in English rivers.

Operationalisation of eDNA methods for crayfish monitoring. A new species-specific monitoring method that analyses genetic material in the environment to detect crayfish species in English waterbodies.

#### Drought

Understanding catchment responses to drought in current and future climates explores new approaches for examining the impact of droughts on English catchments and water supply systems.

#### Antimicrobial resistance

Pilot surveillance of antimicrobial resistance in river catchments in England. A pilot approach to detecting, identifying and quantifying antimicrobial resistance in 3 selected river catchments in England.

Development of experimental approaches for determining concentrations of antifungals that select for resistance looks at methods for determining the lowest concentration of antifungals that can lead to a selective advantage for resistant organisms. Determining selective concentrations for antibiotics and antifungals in natural environments determined the concentrations of specified antimicrobials at which selection for resistance may occur.

Determining concentrations of substances that influence development of antimicrobial resistance reviews the available data on concentrations at which selection for antimicrobial resistance has been reported for different antimicrobials and the approaches used to determine these concentrations.

Potential impact of disinfectants on antimicrobial resistance development identifies the range of disinfectants currently used in the UK and reviews available information on their potential role in the development of antimicrobial resistance.

Overview of potential human pathogens in the environment reviews pathogens to which people can be exposed through water, land and air, now and in the future.

<u>Risk screening and prioritisation tool for</u> <u>antimicrobial resistance in the environment</u>. A risk screening and prioritisation tool to assess antimicrobial resistance in the environment.

#### Net zero

Environmental impacts of temperature changes from ground source heating and cooling systems examines the potential for ground source heating and cooling systems to change the temperature in the ground and identifies receptors that could be affected.

Net zero technologies: environment impact

<u>summaries</u> provides an overview of the potential environmental impacts of different net zero technologies and how the Environment Agency may need to regulate such impacts.

#### **Climate change**

Investigating variability in landfill methane emissions using air quality monitoring data. This project took existing measurements of methane concentrations around a landfill and used these data in computer models to estimate methane emission rates.

Improving river habitats to support wildlife during high and low flows examines which river restoration measures can improve river habitats during high and low flows in different river types.

Exploring the use of resilience concepts in catchment management explores what is meant by resilience, and how it is currently understood and

used in the Environment Agency.

Use of research in climate change adaptation: participatory research identifies different approaches to knowledge exchange and explores how they could be used to aid and inform climate change adaptation measures.

#### Chemicals

Polyvinyl Chloride (PVC) additives: a scoping review identifies which polyvinyl chloride additives are likely to be relevant to the UK market and prioritises them based on readily available information.

#### **Chief Scientist's Group reports**

Chief Scientist's Annual Review 2023. The Environment Agency's Chief Scientist's annual review for 2023.

#### Flood and coastal erosion risk management

Flood and coastal erosion risk management areas of research interest. The Flood and Coastal Erosion Risk Management (FCERM) research and development programme published areas of research interest to set the direction on flood and coastal erosion research for England and Wales to 2028. Working with natural processes to reduce flood risk 2024: evidence directory update reviews

the latest research on natural flood management. The report builds on the evidence directory published in 2017, allowing practitioners to access recent information.

Shore and cliff sensitivity to accelerating sea level

rise develops a new method to better understand future cliff recession around the coastline of England and Wales. It uses improved modelling tested at different case study sites. The National Coastal Erosion Risk Map (NCERM), published in January 2025, uses this improved methodology.

Communicating climate change information for flooding and coastal erosion examines how to effectively communicate climate change information related to flooding and coastal erosion risks. These insights can help risk management authorities and others.

#### Evidence on the costs of floods in England

and Wales provides estimates on the cost of floods between January 2016 and November 2019 in England and Wales. This research helps inform flood risk management funding and investment decisions.

Removing or repurposing redundant reservoirs

summarises what to consider when removing or repurposing redundant reservoirs. The report and tool are intended for reservoir owners, reservoir managers, undertakers and panel engineers.

<u>Eel passes – improving design and performance</u> reviews how different designs of eel passes in England are working. The report helps to identify problems with installed eel passes and considerations to improve the design and performance of existing and future passes.

Review of methodology for estimating flood peaks and hydrographs for small catchments examines how we estimate peak flood and river flows. This will help reduce uncertainty when we design assets to manage floods.

#### Academic journal articles by the Chief Scientist's Group and Flood and Coastal Erosion Risk Management Research teams in 2024

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