Environment Agency

Evidence

Delivering sustainable river basin management: plausible future scenarios for the water environment to 2030 and 2050

Report A: Overview

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

Acting to reduce the impacts of a changing climate on people and wildlife is at the heart of everything we do.

We reduce the risks to people, properties and businesses from flooding and coastal erosion.

We protect and improve the quality of water, making sure there is enough for people, businesses, agriculture and the environment. Our work helps to ensure people can enjoy the water environment through angling and navigation.

We look after land quality, promote sustainable land management and help protect and enhance wildlife habitats. And we work closely with businesses to help them comply with environmental regulations.

We can't do this alone. We work with government, local councils, businesses, civil society groups and communities to make our environment a better place for people and wildlife.

This report is the result of research commissioned and funded by the Defra Futures Partnership[1].

Published by:
Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH

http://www.gov.uk/government/organisations/environment-agency

ISBN: 978-1-84911-400-4

Further copies of this report are available from our publications catalogue:
http://www.gov.uk/government/publications

or our National Customer Contact Centre:
T: 03708 506506

Email: enquiries@environment-agency.gov.uk

Authors: Centre for Environmental Risks and Futures (CERF) Kenisha Garnett, Catarina Henriques, João Delgado, Fiona Lickorish, David Forrow, Anna Rathé, Hayley Shaw, George Prpich, Jason Weeks and Simon Pollard.

Dissemination status:
Publicly available

Keywords:
Alternatives scenarios, futures, river basin management, water.

Research contractor:
Cranfield Institute for Resilient Futures (CIRF), Institute for Environment, Health, Risks and Futures, Cranfield University, MK43 0AL

Environment Agency's Project Manager:
Dr David Forrow

Collaborators:
[1]The work was carried out through a Defra led partnership by the Centre for Environmental Risks and Futures (CERF) (now Cranfield Institute of Resilient Futures) at the University of Cranfield. The partnership included the Environment Agency, Defra, Natural England, Forestry Commission England, Marine Management Organisation, CAMERAS, Natural Environment Research Council, Scottish Government and Welsh Government.

Evidence at the Environment Agency

Scientific research and analysis underpins everything the Environment Agency does. It helps us to understand and manage the environment effectively. Our own experts work with leading scientific organisations, universities and other parts of the Defra group to bring the best knowledge to bear on the environmental problems that we face now and in the future. Our scientific work is published as summaries and reports, freely available to all.

You can find out more about our current science programmes at https://www.gov.uk/government/organisations/environment-agency/about/research

If you have any comments or questions about this report or the Environment Agency's other scientific work, please contact research@environmentagency.gov.uk .

Professor Doug Wilson
Director, Research, Analysis and Evaluation

Executive summary

What might the world look like in 2050? How can we ensure we deliver environmental outcomes for the water environment over the long term? How do we make sure we do not set off on a course of action that may fail due to factors that are not viewed as important now but that become important in the future? We cannot predict the future. Failed attempts to do so are numerous. We also know that the past is not necessarily a good predictor of the future.

We can, however, make assumptions about the future and develop an envelope of plausible futures in which the likely future will exist. This allows us to test current, developing and future actions to ensure they are effective across the range of futures and that we deliver our intended aims.

This project elaborated existing socioeconomic scenarios developed by the Environment Agency and Defra for application to river basin management. Five scenarios are presented:

- uncontrolled demand
- innovation
- sustainable behaviour
- local resilience
- reference

The intention was to use the scenarios to explore implications for managing water and the water environment in terms of pressures nationally and in different catchment types (for example, phosphorus concentrations in rivers) and to different sectors including the general public, manufacturing industries, leisure industries, utility companies (water and energy), and farming and fisheries.

The scenarios are considered a useful starting point to frame discussions among water managers, policymakers and other stakeholders. They may be further updated to maximise their utility in the review of policies, strategies or management practice.

Using the outputs of this futures research initiative will help the Environment Agency and its partners better understand the inherent uncertainties about the future of water and the water environment and, in turn, help to reveal more innovative and successful management strategies for adapting to change.

This report provides an overview of the scenarios. It is one of 3 reports produced by the project. The other 2 describe the scenarios in detail and discuss the implications of each scenario for the water environment and water users, respectively.

Note that the scenarios and the environmental consequences described in these reports reflect the collective views of a set of stakeholders at the time the work was undertaken (2012 to 2014). The work was completed before a number of significant political changes occurred, not least the outcome of the referendum on the UK exit from the EU. Although this affects some of the specifics in the scenarios (notably the reference scenario), the generalities of the scenarios are still valid.

The project was led by the Environment Agency and delivered through joint working with Defra and its arm's length bodies (Environment Agency, Natural England, Forestry Commission England) and the Scottish Environment Protection Agency and Natural Resources Wales through the Defra Futures Partnership initiative, led by Cranfield University.

About the Defra Futures Partnership

Cranfield University was contracted by Defra and 9 partners to deliver a package of pan-government futures research activities including:

- regular horizon scanning
- risk prioritisation/analysis
- medium- to large-scale foresight studies
- end-user capacity building

This futures research programme is designed to enable Defra and its partners to look ahead, to analyse what is seen, react to it and use that insight to strengthen strategic, policy and operational goals and approaches.

As part of the futures research programme at Cranfield University, medium- and large-scale futures research projects are undertaken to assess the implications of future change to high priority areas of policy, strategy and/or delivery. This research takes a long-term strategic approach to investigating plausible changes, developments, challenges and opportunities within complex, interconnected, socio-technical systems such as the water environment. It aims to identify what opportunities and challenges exist, which these systems might face in the future.

The research, developed in close collaboration with the project's partners, provides organisations with the tools needed to assess the skills, resources, institutions and policies required to deal with a range of plausible futures. Research outputs establish a context for dialogue and encourage foresight in decision-making by providing a framework for assessing the robustness of strategies and policy approaches in different situations.

Contents

List of tables and figures

1 Introduction

Water and the water environment are critical to human health, well-being and prosperity. Water integrates across spatial scales and sectors that use and influence the quality and availability of water and have an impact on the water environment. In recognition of this, a number of recent policy documents and regulations stress the need to achieve more sustainable management of water and the water environment.

- The Water White Paper, 'Water for Life', stipulates that damage to the water ecosystem should be remediated to maintain essential services to the human and natural environment (HM Government 2011a).
- The Natural Environment White Paper, 'The Natural Choice', states that by 2050 water bodies in England should be resilient to future pressures and support a wide range of future uses. It also states that catchments will be effectively managed to deliver multiple benefits and coherent and resilient ecological networks (HM Government 2011b).
- 'Biodiversity 2020', the biodiversity strategy for England's wildlife and ecosystem services, suggests that by 2050 'biodiversity will be valued, conserved, restored, managed sustainably and be more resilient, and able to adapt to change, providing essential services and delivering benefits for everyone' (Defra 2011).
- The Water Framework Directive states there will be no further deterioration of water bodies and 'good status' will be achieved in all water bodies by 2027 and beyond.

The challenge for government, its arm's length bodies and stakeholders is delivering these environmental outcomes over the long term. The water environment is subject to a wide range of external political, social, technological, environmental and economic influences. How these play out in combination and the consequences for the water environment, looking into the future, is highly uncertain. Investigating the likely consequences of future changes in water and the water environment, and the risks and uncertainties associated with climatic, socioeconomic and management conditions is important in making good decisions that will enable environmental outcomes to be delivered over the long term in a cost-effective way.

Delivering cost-effective and sustainable water management will be important to protect not only the environment, but also those who depend on and benefit from water uses and services. This understanding comes about by making reasonable assumptions about the development of the most important key 'drivers or factors' that may affect environmental outcomes (positively or negatively). These can be used to inform and construct a range of scenarios that cover a likely range of futures.

The water and water environment scenarios, presented in the 3 reports in this series detailed in Table 1.1, provide a framework for analysing a complexity of issues and envisioning solutions to the problems revealed. The questions underpinning this research project were:

- How robust are current and planned management approaches for river basin districts and catchments for the future under a set of plausible scenarios for the natural environment at 2030 and 2050?
- What are the implications for the aims and objectives of river basin management?

In response, a number of coherent, internally consistent and plausible scenarios have been developed. The purpose of these scenarios, which cover a range of possible futures, is to better understand uncertainties and, in turn, help reveal more innovative and successful management strategies for adapting to change. The scenarios provide decision-makers, water managers and planners with a tool to:

- analyse insights about the future
- consider how different management actions might perform across a range of futures

While it is understood that some management strategies may be effective and economical despite the futures depicted in these scenarios, the consensus is that more robust actions are those taken in response to conditions highlighted in multiple scenarios (Alcamo 2008, Pillkahn 2008). This allows for better understanding of the underlying drivers of change in broader policies, strategies, programmes and actions (Alcamo 2008), thus mitigating the occurrence of unexpected consequences and ensuring there are more resilient responses to the uncertainties of the future (Maack 2001, Bradfield et al. 2005, Wright et al. 2008).

Exploring alternative development paths towards the future, looking at the short-to-medium and long-term issues, is an important step in developing a context for future strategies in the management of water and the water environment in England and Wales. It was to achieve this objective that Cranfield University, contracted by Defra and 9 partner organisations to deliver a futures research programme, worked in partnership with the Environment Agency and its stakeholders to elaborate existing Environment Agency's socioeconomic scenarios, making them more relevant to the wider context of water and the water environment and river basin management in England and Wales.

The project's journey began with an environmental scanning exercise that took stock of existing information and knowledge related to the water environment. The intention was to assess the long-term challenges, identifying the most important trends and drivers of change for water and the water environment. Involving experts from a range of disciplines, such as catchment, risk and environmental management, provided a basis for elaborating the scenarios, varying assumptions about water and other resource conditions to reveal areas of uncertainty. Future projections of key drivers deemed plausible and consistent, formed the basis of the scenarios, supplemented by 'explicit storylines' that illustrate alternative futures. The description of the scenarios and analysis of their implications are presented in 3 reports (Table 1.1).

Table 1.1 Outline of the reports produced for this project

Report	Description
Report A: Overview **THIS REPORT**	This report presents an overview of the scenarios and key outputs of the analysis, looking at the consequences for the water and the water environment and its management. It is not intended as a summary of the scenarios and the overall analysis.
Report B: Full scenarios	This report explains the scenarios in detail. It describes the process of their development, documents the progression from current day to 2030 and from 2030 to 2050, and illustrates how the main drivers develop.
Report C: Consequences for water and the water environment	This report examines the implications of each scenario for the water environment, and for water users. It describes the implications of the scenarios for different generic types of catchments representing contrasting parts of England and Wales and across a range of sectors

Report	Description
	including the general public, manufacturing industries, leisure industries, utility companies (water and energy), and farming and fisheries.

1.1 Interpreting the report

This report draws on evidence from the academic literature, published reports and the knowledge of experts to build on the Environment Agency's existing socioeconomic scenarios, making them more relevant to the wider context of the water environment and water management in England and Wales. The scenarios include an analysis of source pressures, exposure pressures and the impacts and consequences to water users and the water environment. This reflects the approach advocated for understanding significant water management issues in the Water Framework Directive and the Natural Environment White Paper (HM Government 2011b).

When reading the report, it is important to note that plausible futures were developed through the design of qualitative scenarios. These include explicit storytelling pieces that illustrate a progression from the current state of affairs to the future. The scenarios are not intended to predict the future but provide plausible 'views' based on:

- past trends and knowledge
- assumptions about the future
- insights gathered from a wide range of experts and the pervasive literature

The 'real' future is unlikely to be identical to any of these futures, but it may be contained somewhere within this 'envelope' of future scenarios.

1.2 Using the scenarios

The water and the water environment scenarios are 'think pieces', designed to fuel discussion and debate. The aim is to consolidate reflections about future developments into coherent depictions of potential courses of events leading up to 2030 and 2050. Seen from this perspective, the scenarios aim to provide a basis for reflecting on the long-term impact and significance of the management of water and the water environment (Report C). They are a useful starting point to frame a discussion among water managers, policymakers and other stakeholders, and may be further updated to maximise their utility in the review of policies, strategies or management practice. They aim to provide a strategic tool from which objectives and action plans can be developed to 'future-proof' current and emerging policies and strategies.

The scenarios and the environmental consequences described in these reports reflect the collective views of a set of stakeholders at the time the work was undertaken. The process of embellishing the scenarios involved a range of experts from government and government agencies, each with unique views, insights or priorities related to the evolution and interpretation of the scenarios. While the analysis of the scenarios reflects the collective views of multiple experts, it is also constrained by their collective experience. As such, not all the implications associated with the water and water environment were analysed and additional work is required to assess those not mentioned in the reports.

2 Building on the Environment Agency's scenarios

In its efforts to understand the scale of impact on water availability now and in the future, the Environment Agency has previously produced a number of scenarios looking towards 2050. Recognising that factors such as climate change, population growth, water demand changes, and quality and environmental requirements induce pressures that vary in time, the Environment Agency has regularly updated its scenarios to take stock of existing information and knowledge related to water and the water environment. These scenarios use the best available evidence to look at possible impacts of future pressures to develop an understanding of the scale of the challenge.

2.1 Environment Agency's socioeconomic and water scenarios

In 2006, the Environment Agency and Defra together with the Henley Centre for Headlight Vision (now The Futures Company) produced a set of core socioeconomic scenarios that explored possible changes for the UK environment towards 2030 (Environment Agency 2006a). These scenarios were revised in 2008 and extended to 2050 with a focus on the implications for water demand. They were used to produce an estimate of future water demand under a number of key sectors. The projections informed the development of the Environment Agency's Water Resources Strategy and were subsequently used to test it (Environment Agency 2009).

In 2009, the Environment Agency, in collaboration with The Futures Company and other external stakeholders, revisited the core socioeconomic scenarios to consider the implications to water quality towards 2050 (Environment Agency 2010a). Using the core scenarios as a basis, the Environment Agency then, with guidance from The Futures Company, considered what the UK would look like in 2100 (Environment Agency 2010b).

In 2011, the water demand scenarios were used within the Environment Agency to support a 'Case for Change' analysis (Environment Agency 2013, Environment Agency and Natural Resources Wales 2013). This informed the development by the Department for Environment, Food and Rural Affairs (Defra) of the Water White Paper (HM Government 2011a), which articulated a vision for future water management in England and Wales.

In 2012, the Environment Agency 'refreshed' the core generic socioeconomic scenarios (The Futures Company 2012). These refreshed scenarios were, in turn, used to 'refresh and extend' the 2008 water demand scenarios, considering changes to the household, leakage, agriculture, industry and commerce sectors. These scenarios have recently been used to develop new water demand projections for the electricity generation sector, and the figures have been used to revise the 'Case for Change'.

The Environment Agency's core socioeconomic scenarios were intended to provide a generic overview of future water resource challenges. The expectation was to further develop and deepen these scenarios (and the revised versions) 'tailoring them to specific policy areas or issues' of interest to the Environment Agency (Environment Agency 2006b).

2.2 Water and the water environment scenarios

For the sake of tailoring the scenarios to an area of interest, the information presented in this report reflects wider implications for water and the water environment towards 2050. The work involved elaborating the Environment Agency's existing socioeconomic scenarios, that is:

- uncontrolled demand
- innovation
- sustainable behaviour
- local resilience

The elaborated scenarios illustrate a broader, systemic and integrated picture of developments spanning a range of drivers and activities for river basin management. A fifth 'reference scenario' was developed to consider a future based on a policy and governance context similar to today, but in the absence of additional environmental and water-related policy intervention. The process for developing and elaborating the Environment Agency's socioeconomic scenarios is summarised in Figure 2.1.

The 5 scenario narratives describe consistent relationships between the most important drivers and activities of change associated with managing water and the water environment in England and Wales. Each narrative presents an alternative future that reflects various states of political, economic, social, technological and environmental development. A detailed description of the methodology and the general assumptions underpinning the scenarios is provided in Appendix A of Report B.

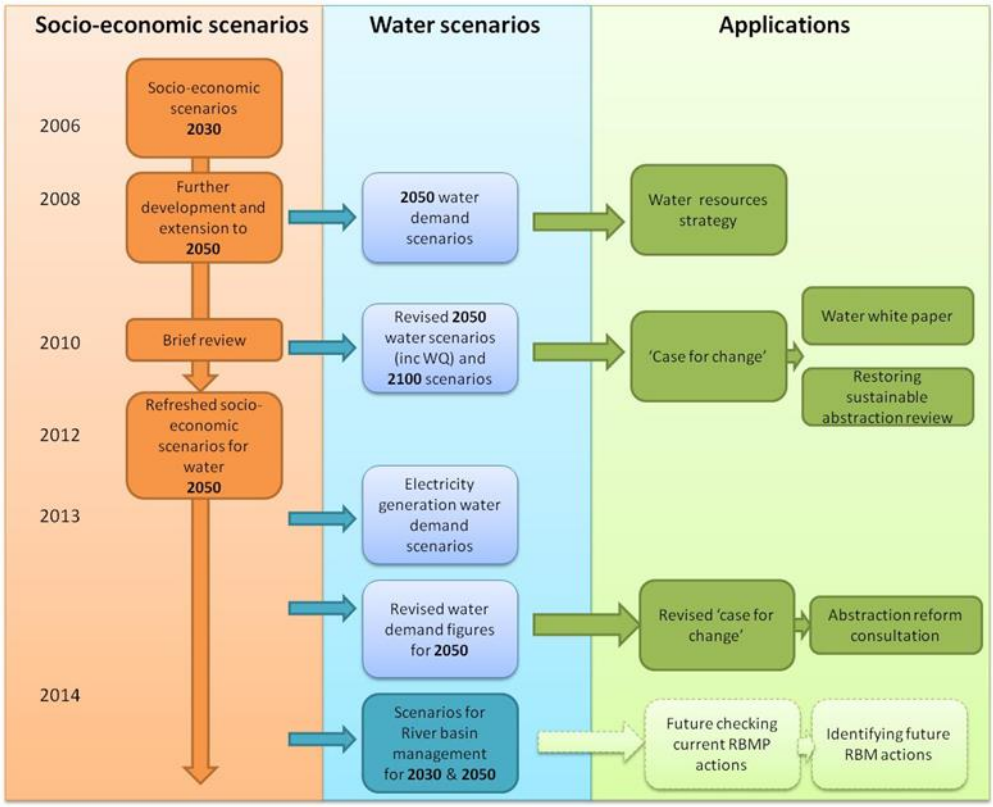

Figure 2.1 Development and elaboration of the Environment Agency's scenarios

Notes: RBM = river basin management; RBMP = river basin management plan; WQ = water quality

3 Scenarios for water and the water environment

Five scenario narratives were developed to describe consistent relationships between the most important drivers and activities of change associated with managing water and the water environment in England and Wales (Figure 3.1). Each narrative presents an alternative future that reflects various states of political, economic, social, technological and environmental development. The Environment Agency's existing socioeconomic scenarios (uncontrolled demand, innovation, sustainable behaviour and local resilience) form the core set of scenarios, elaborated to illustrate an integrated picture of developments spanning a range of drivers and activities.

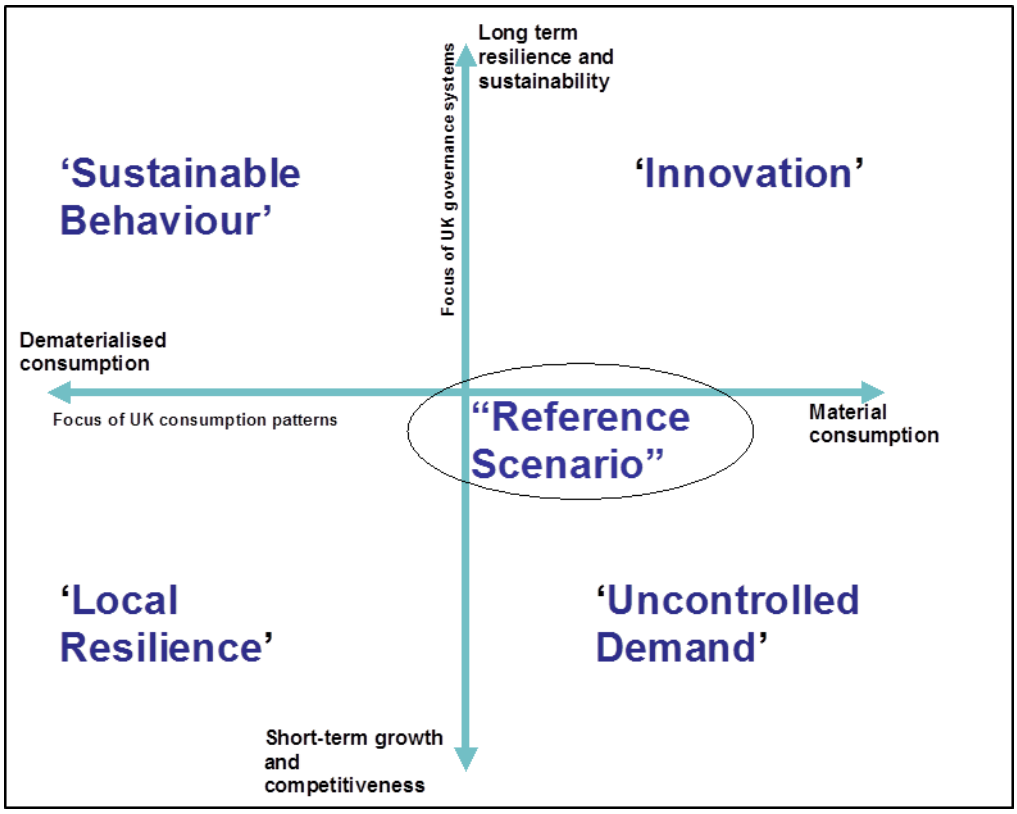

Figure 3.1 Axis of uncertainty representing the dominant drivers defining the scenarios

Notes: Based on scenarios developed for the Environment Agency by The Futures Company
Source: The Futures Company (2012)

The scenarios are based on a 2 × 2 matrix developed around 2 key drivers of change:

- consumption patterns
- governance systems

The horizontal axis of the matrix explores different assumptions about the change in 'societal attitudes and behaviour around consumption', moving from one extreme where 'consumption patterns is constrained with a focus on well-being and sustainability' to the other extreme where 'individuals exist in an intensified materialistic "desire economy" in which the possession of goods and experiences outweighs any concerns around wider or longer term impact or sustainability concerns'.

The vertical axis explores different assumptions about the change in 'governance systems', moving from one extreme where 'governance systems and decision-making focus on longer term sustainability' to the opposite extreme where 'governance is directed towards shorter term socioeconomic concerns' (Environment Agency 2006a).

In addition, a reference scenario was developed that:

- illustrates a progression of current trends
- considers a future in the absence of additional environmental and water-related policy intervention

The following sections provide an overview of the 5 scenarios.

3.1 Uncontrolled demand

Uncontrolled demand is indicative of a self-interested society where social and economic disparities prevail as economic growth is pursued with little regard for the environment and social equity.

3.1.1 Drivers and activities

Political attitudes are strongly influenced by ambitious economic growth at both national and individual scales over the short term. Lobbyism and personal interest dominate the political agenda. The country prospers economically and policies support growth. The EU plays a small role in the implementation and enforcement of policies and there is a relaxation of environmental regulation, as environmental protection is perceived to hinder economic growth, except where it ensures resource availability. England and Wales successfully market internationally specialised products such as exporting British 'heritage' in the form of luxury goods and services to the wealthy in emerging economies including Brazil, Russia, India and China (BRIC). Investment decisions are in favour of technologies that promote growth over those with diminished opportunities for growth due to the need to mitigate environmental impacts. Green technologies are, however, pursued or adopted if economic gains are accrued in the short term.

High economic growth is associated with high levels of immigration and high fertility rates that increase the population in England and Wales to over 78 million. Personal and national attitudes are generally focused on self-interest and income. There is a wide divide between the rich and the poor. Those on low incomes struggle to cover their basic needs and often resort to parallel economies (the 'black market') as the price of water, energy, land and food increases, while the affluent consume without restriction. Much of society lacks awareness and interest in the environment. The environment is considered a commodity for the very rich who can afford to pay to access and maintain areas of high environmental quality.

3.1.2 Picture of the scenario in 2050

A growth (42% increase) in the size of the English and Welsh population, combined with an export-led economy, resulted in an expansion of land being brought into production for agriculture and allocated for industrial development and urbanisation, often reducing the availability of green space. The price of land is directly associated with the quality of the water environment. A spin-off is that the wealthiest tend to live, or have second homes, in gated communities in tributary sub-catchments or upland areas with greater access to a high quality natural environment. The leisure industry is based

in these areas providing cultural ecosystem services for those that can afford to pay. In contrast, those with less income live in deprived housing areas built in urban floodplains that suffer from regular flooding and are exposed to a poor quality local environment. Surface water management schemes in urban areas are generally non-existent and new developments have largely failed to incorporate sustainable drainage systems (SUDS), resulting in an increase of urban run-off directly entering sewerage systems and water bodies. Heavily engineered flood defences are built around high income and economically productive areas.

A highly competitive water industry is unrestrained in its pursuit of profit, resulting in serious environmental consequences. For instance, reduced investment in wastewater infrastructure, combined with population growth, result in increased sewage overflow incidents. There is investment in large-scale supply augmentation measures, as consumption is restricted only by the amount of income available. Leakage losses increase significantly to similar levels as the 1980s due to weak regulation along with the attitude that leakage is 'someone else's problem', resulting in minimal reporting and little appetite for public expenditure on maintenance. In rural areas where there is affordable housing, water abstraction is not registered regardless of the volumes abstracted and there is extensive installation of poor quality wastewater drainage and inadvertent connections into the surface water system.

Industry moves to regions where cheap land is available, such as urban areas of 'sacrificial' catchments, where water quality has degraded substantially. These areas are typically a primary target for the discharge of effluents from industry and urban areas, subject to less stringent discharge consents, in order to protect other areas. There is a significant increase in the quantity of chemicals imported for manufacturing and nanotechnology is a particular concern, often causing heavy metal pollution. The most advanced manufacturers reuse materials where it provides short-term economic advantages.

A growing population leads to the intensification of food production systems. This is achieved through land management practices and increased use of chemicals (for example, fertilisers and pesticides) and water for irrigation. All available productive land is used for intensive arable practices, while less productive and non-productive land is used for intensive livestock production. Available land close to urban areas is used for subsistence agriculture, practised out of necessity by the poorest of society. There is an increase in diffuse pollution from farmed rural catchments as agricultural practices reflect relaxed environmental regulations, which permit increased production and are not associated with technological developments. Examples include pollution incidents due to deteriorating silage storage facilities and increased usage of riparian areas for livestock grazing, and increased rates of run-off due to excessive tillage and deep ploughing and continuous removal of 'unproductive' hedgerows to increase field size.

There is a marked increase in water demand across all sectors and the profit maximisation goals of the highly competitive water industry are poorly restrained due to a combination of poorly enforced environmental regulations and deteriorating hydrological and hydrogeological monitoring systems due to insufficient investment. The water supply and wastewater services provided are associated with large environmental impacts, which is of little concern to society as a whole. Moreover, leakage losses increase and any limit to consumption is restricted only by the amount of income available.

Life in the uncontrolled demand scenario is described by the character, Ibrahim, in the vignette below (Figure 3.2).

Ibrahim wakes up in his flat where he resides alone, surrounded by all sorts of technological gadgets. He feels more comfortable in urban spaces and rarely ever ventures into the natural environment, as typical outdoor activities are provided in simulators (swimming pools, artificial beaches, indoor climbing walls and indoor skydiving).

Ibrahim is very attached to his car and uses it for his daily commute. Although he works in a neighbouring city, it is difficult to distinguish land boundaries or distinct landscape features that marks a division between the 2 cities. The drive along the motorway crosses the city water infrastructure, an impressive canal that transfers water from the upland catchments. Smaller streams have either dried out or are being redirected to surface water drainage systems. Ibrahim drives across the bridge and looks across at the city's river. In summer the water levels are low and the river is green from the huge amount of algae, but after a heavy rainfall episode, it flows really fast with brownish and murky water.

Ibrahim struggles to remember the last time he drove through the rural environment, but he recalls the endless cultivated fields and the heavy machinery used for ploughing and harvest. These fields are beyond city limits, after the industrial zone where the river is frothy and changes colour daily. Ibrahim is saddened at the thought that lots of people live in slums near the river and struggle daily to make ends meet.

He works hard to achieve his dream of moving to one of the upland catchments he heard about, where the rich folk live. Properties there are expensive, but appealing because they are surrounded by woods and wildlife and have rivers and lakes that you can actually bathe in, which are rare qualities these days.

Figure 3.2 Life under the uncontrolled demand scenario

3.2 Innovation

Innovation is the mantra in major economic sectors aided by investment in advanced technologies that contribute to sustaining 'good quality' lifestyles, while protecting the environment as a source of resources.

3.2.1 Drivers and activities

Government strategy focuses on efficient use of resources. There is significant investment in infrastructure, technology and research and development (R&D) to combat water security issues and other problems posed by climate change, as well as securing long-term protection of the environmental resources that provide economic benefits. There are tight environmental regulations established in support of closed loop systems that are associated with high compliance. Industry and farmers are being supported to use resources efficiently (for example, reduce, reuse and recycle) and to procure win-win solutions (for example, industrial partnerships closing the cycle and using waste as resources).

Investment in technology and high-end manufacturing provides the basis for strong economic growth. High economic growth drives an influx of skilled immigrants, which alongside an aging population, increased the English and Welsh population to 73 million. Technology eases pressure on energy, land and water resources, and economies of scale permit affordable prices. There is greater equity between the rich and poor factions of society. The majority of the population has a higher level of educational attainment and are part of a skilled workforce. Society is aware of the value of the environment, but is unwilling to change their lifestyles to preserve it. Instead, the government has the ability to deal with issues such as resource shortfall and environmental impacts, as well as to develop innovative solutions that do not inconvenience consumers or require behavioural change.

3.2.2 Picture of the scenario in 2050

An increasing population (that is, 32% increase) in England and Wales is associated with an expansion in urbanised land and increased demand for food. This is exacerbated by improved national food security, which has driven sustainable intensification of agriculture. Urban areas are densely populated with intensive high-tech urban agriculture such as vertical farms, hydroponics and the production of synthetic meat. Improved infrastructure and materials that enhance urban water quality are widely implemented by multidisciplinary teams of land use planners and qualified developers; examples include SUDS, permeable paving and porous road surfaces. With technology at the heart of innovation, flood protection is based on engineered river modification.

Water and wastewater services remain privatised and are provided by several competing multinational companies which exploit different elements of the business (for example, water distribution and business retail). Customer choices drive innovation across the industry. An enhanced and expanded water infrastructure is based on a national network of large-scale reservoirs, artificial groundwater recharge and water transfers. The areas where water supplies are scarce benefit from technological advancement in weather forecasting, cloud seeding technologies and desalination with lower energy consumption. A twin track approach is used and demand is reduced without people changing their daily routines. Levels of leakage, which are strongly regulated, are reduced. Governmental support is instrumental in retrofitting water-saving household appliances in most dwellings including smart meters, greywater reuse and toilet flushing devices.

Customers demand good quality water and more ‘green’ water utility companies. Water and wastewater treatment processes are more sophisticated and compliant to tightened discharge consents. Wastewater treatment and recycling plants exist in many areas producing potable water compliant to stricter drinking water standards. Water utilities also invest in monitoring systems and comply with water abstraction regulations, allocating sufficient water to the environment.

There is an expansion of industrial areas dominated by high technology manufacturing, which benefits from fiscal incentives to use resources efficiently. Industry develops closed loop systems, resulting in investment in manufacturing processes for recovering waste and byproducts into raw materials. Despite this, an expanding industrial and manufacturing sector increased water demand, but with a reduced impact on the water environment. New types of pollution such as synthetic chemicals for textiles and pharmaceuticals are a concern. However, regulations are gradually updated to control new pollutants.

Agricultural practices have been revolutionised to optimise resources and increase yields of food and energy crops. Innovation brings efficient use of land, fertiliser and water (for example, the introduction of genetically modified crops and the production of

synthetic meat). Regulations are tight and strict enforcement reduces the impacts of industry and agriculture on the environment. High levels of compliance are mirrored in healthy aquatic environments. More land is available for improved biodiversity, wildlife corridors and for leisure, or arable cropping in the future. Carbon sequestration projects cause expansion of woodlands in wetter and upland areas, where water-intensive tree species grow. Water used for agriculture increases significantly, despite increased efficiencies, to ensure high quality and increased yields.

Closed loop systems are widely implemented. Recovering phosphorus reduces the cost of fertilisers; nevertheless, farmers follow fertiliser application guidelines strictly, consistently meeting the targets. There has been a move away from grass-fed livestock farming to factory type intensive production. Manure and slurry are used in anaerobic digestion plants, providing energy to run livestock installations and farm vehicles, while digestate is used on fields closing the loop. Second generation biofuels are also manufactured from residues of food crops. The agricultural sector also benefits from other technological advancements that permit protection of the environment. Farming machinery is replaced by smaller and lighter autonomous units, allowing for reduced soil compaction and greater fuel efficiency. While innovation results in novel chemicals with reduced environmental impacts and innovative technology stops these entering the environment, operators accept unexpected environmental impacts as they take a 'calculated risk' to ensure quick adoption of new innovations.

Life in the innovation scenario is described by the character, Daria, in the vignette below (Figure 3.3).

Daria lives in the city, surrounded by a wide range of technological gadgets. She marvels at the self-regulating energy efficient building where she lives, as it uses the latest technology. She works at a technological development company, which is one of the country's most prominent companies in the industry. She, like her co-workers, has a long daily commute to work but this is made easier by an efficient public transport system.

When Daria visits her Mum, she drives her 'zero emission car' across the countryside. It dawns on her how much it has changed in the last 30 years. You don't see cows and sheep grazing anymore and most of the food produced is done indoors and artificially. A number of extensive infrastructural complexes built for water and energy supply split the landscape, but it is gradually growing on her. Daria notices that the large dams in Wales and in the Lake District, where she spent most of her summer holidays, have become part of the landscape. Rivers and lakes are different from what they used to be; they now appear to be oversized canals diverted at the will of urban development planners. The water is clear and looks like you could drink it, and often there is a fish or a frog lurking in its depths.

Daria works hard to afford the big apartment she lives in just opposite the river. This spacious apartment with its riverside view is her most valued asset. She appreciates the great engineering works alongside the riverbank; these are beautiful structures that display the technological competence humanity has achieved.

Figure 3.3 Life under the innovation scenario

3.3 Sustainable behaviour

Sustainable behaviour is evident in personal and national attitudes that are aligned to long-term environmental sustainability and greater social and financial equity. Plans for social and economic development embrace a 'green' but cautious mindset, whereby solutions of proven reliability are adopted to reduce risks posed to the environment.

3.3.1 Drivers and activities

The political agenda is driven by a desire to achieve and maintain economic stability and social equity. Moreover, the political powers and personal attitudes align to deliver long-term environmental sustainability. The population in England and Wales increases by 19% and 'green actions' are seen as a symbol of status, which takes precedence over behaviours that demonstrate economic wealth. The public is altruistic, sharing both the benefits and dis-benefits resulting from sustainable governance and business strategies. Ecosystem services are high on the government's agenda, where effective regulation, environmental policies and tools such as whole life costs and personal credits drive sustainability.

Regulation is successful leading to generally higher environmental standards (for example, a strict carbon agenda). Under national co-ordination, centralised initiatives allow regions to choose their own systems and processes to meet these standards. Society recognises its responsibility to the environment and for its problems, and acts as a watchdog to help ensure compliance with environmental regulation. The government introduces whole life costs by taking account of environmental and social costs in lifecycle analyses, thereby allowing a 'true' comparison of the options available to the public. Goods are more expensive as the price of externalities, such as virtual water, are passed on to the consumer. Products with higher total costs are heavily taxed, while others remain affordable. This promotes investment in green technology but only where reliability, cost-efficiency and low risk are proven. This is complemented by product legislation that bans substances responsible for environmental impacts and health hazards (for example, general chemicals and pharmaceuticals).

3.3.2 Picture of the scenario in 2050

The rate at which land is allocated for urbanisation and industrial development increases, but remains below the population growth rate. Urbanised areas are managed to provide access to a high quality natural environment and 'blue–green' infrastructure projects are widely implemented, effectively complementing urban surface water management schemes. River restoration projects are common, particularly in wealthier regions, and reduce flood risk creating opportunities for improving biodiversity and recreation. Agricultural land expands and rural communities grow as there is a boost in the agricultural sector, which creates new jobs and promotes healthy farmland and rural environments. Across the country there is a marked difference in the level of environmental sustainability achieved to meet targets set nationally and internationally. Actions to meet these targets are decided locally, ensuring all activities comply with minimal environmental standards. This is a result of differing legal frameworks together with marked distinctions in pressures (for example, water resources, environment and wealth) at a regional level.

Wastewater treatment is less efficient, although sewer blockages and overflow incidents are less common. Ambitious carbon emission targets led to the use of low energy wastewater treatment processes (for example, tertiary treatment in reed beds), which are usually less efficient even with reduced flow to wastewater systems. Locally led regulation therefore relaxes discharge consents, particularly for discharge to

coastal water environments, ensuring high compliance with the less stringent water quality standards. Investment in water quality monitoring has been locally led to protect catchment sensitive areas and avoid public health scares. In wealthier regions, however, low energy technology is available to perform wastewater treatment processes at higher standards albeit at a higher cost.

A focus on pollution prevention as opposed to end-of-pipe solutions means that the goal of industry is to produce goods with small environmental footprints. A slow but strong shift in the economy occurred with carbon- and water-intensive products almost entirely priced out of the market. Investment in robust technology was made to use resources efficiently and minimise the impacts on the environment. Older technology is often retrofitted or maintained if this is more economical and/or sustainable than replacing it. This is complemented by product legislation that has banned substances responsible for environmental impacts and health hazards (for example, general chemicals and pharmaceuticals).

Extensive sustainable agriculture that integrates environmental sustainability into production systems becomes the norm with subsequent expansion in irrigated land. There is less pressure on farmers to produce 'aesthetically pleasing' produce, so they focus irrigation on yield maximisation rather than quality. Livestock production decreases as a result of an increased vegetarian diet and a rise in the price of ruminant based meat due to externalities such as methane emissions. The application of chemicals is reduced and soil is nurtured. Water used for irrigation increases despite the implementation of more efficient agricultural practices. This increase results from higher temperatures associated with climate change and a greater proportion of vegetable crops that require irrigation.

Life in the sustainable behaviour scenario is described by the character, Rose, in the vignette below (Figure 3.4).

Rose lives in a small city and owns her house, which has been fitted with the latest green technology. Her most recent addition is a water recovery system, the best in the neighbourhood. Rose takes equal pride in her allotment, where she produces the tastiest vegetables without any pesticides or fertilisers. The city has a mixed landscape, where industry operates close to urban areas – though the factories are so tightly regulated that it is barely noticeable. Rose's house is close to a river, which provides leisure opportunities in the summer when it is pleasant. This is a bonus, as some urban centres have found it difficult to improve the quality of local water bodies to keep their carbon footprint low, something everyone is talking about.

Rose's work frequently takes her across the country. In agricultural areas where the rural communities have grown, there is more work in sustainable agriculture. The countryside has benefited from environmental planning and management practice that responds to a more environmentally conscious and literate society. Rose frequently spots farm birds that she did not know about when she was younger. The rivers are in good condition and contain many life forms as they are valued for their biodiversity.

Rose likes to make the most of the natural environment so spends most of her holidays exploring the many different landscapes the

Figure 3.4 Life under the sustainable behaviour scenario

3.4 Local resilience

Local resilience is underpinned by the notion of localism, where political agendas promote self-sufficient communities in a poor economic climate. Subsistence type lifestyles and a 'make do and mend' culture, along with the short-term management and protection of environmental resources are seen as the best means of achieving security for communities.

3.4.1 Drivers and activities

Local priorities drive political agendas. The state of the economy is poor with little international interaction, prompting the government to base policies and plans on long-term subsistence. However, there is limited funding available for agricultural subsidies, environmental initiatives, and investment in R&D and infrastructure. Water, wastewater and energy infrastructure is degraded. International and EU agreements and directives have limited influence on legislation in England and Wales. The environmental legislation adopted is flexible and allows regions to set their own standards. Thus, policies implemented and enforced are not coherent across the country. Short-term goals often take precedence over long-term thinking and lead to a relaxation in regulations to ensure compliance (for example, land planning, discharge consents and water abstraction). In practice, public health is protected at a local level, disregarding long-term environmental interests and potential impacts on communities downstream.

The population in England and Wales increases by 18% with a shift to a more aging populace. Poor economic conditions mean the majority struggle to meet their basic needs and individuals reduce consumption of food, water and energy. People adopt a subsistence type lifestyle and a 'make do and mend' culture, where close relationships within communities provide security. Communities operate as a unit and are more concerned with their own well-being than that of neighbouring communities. Economic and resource challenges are often dealt through co-operation in the community; for example, with on-farm reservoirs for irrigation and raised earth embankments that protect against floods.

3.4.2 Picture of the scenario in 2050

Regionalisation leads to diversification within catchments. Subsistence agriculture based on small-scale family farms becomes widespread, satisfying local food demands. Wood is a cheap source of energy and construction materials, leading to an expansion in woodland areas where it does not compete directly with food production. In urban areas, there is increased household occupancy due to economic pressures with multiple generations living under the same roof. This results in little growth in urbanised land, with increases occurring mainly in the margins of large urban areas. The affluent of society move to areas with abundant resources. Surface water management schemes are installed in new developments where financially beneficial. Local jobs reduce commuting which in turn diminishes urban pollution. Small industrial developments also occur as a means of alleviating local economic pressures. There is little co-ordination across communities regarding flood policies and practice, resulting in a mismatch of engineering and natural flood defences, with different levels of sophistication, along the lengths of rivers. While wealthier communities are better protected, a greater number of poorer areas are vulnerable to flooding with farmlands particularly at risk.

Nationally led legislation is weak and non-prescriptive. Close control is maintained by the surrounding community and responsible local authorities to ensure accountability for environmental impacts in the local area. Given the lack of monitoring, only

observable impacts are of concern. Industry invests in greywater reuse systems, but maintains the existing wastewater treatment technologies, even if dated and inefficient, as long as there are no penalties or risk of being shut down. The magnitude of environmental impacts considered acceptable by the local community depends on the services and products in question. A greater environmental footprint is accepted for producing goods and services that are core to the community's subsistence. Environmental regulations are adjusted to fit the requirements of the local population disregarding the impacts on the environment and on downstream local government areas. Local authorities facilitate developments to augment supplies locally and permit abstraction beyond sustainable limits, easing the burden off their communities during periods of water stress. Local authorities also set less stringent discharge consents on effluents, particularly where discharges occur downstream of that community. However, exceptions are made for public health reasons, particularly where discharges are from upstream fisheries or abstraction points for the same community.

The water and wastewater services are often provided by local companies at a catchment scale. Per capita consumption reduces as individuals make use of their DIY skills and retrofit their own homes with simple and cheap appliances to use rainwater and greywater. Increased household occupancy also means higher resource efficiency. Lack of funding and leadership by most companies to upgrade and maintain infrastructure implies leakage losses, unreliable supplies and frequent combined sewer overflows and overload of sewage treatment works to which communities are increasingly resilient as more dwellings are adapted to minimise impacts. Companies protect the water environment in order to protect public health and avoid visible pollution events that typically invoke public outcry.

There is an increase in food produced locally, especially in the regions struggling most to meet the demands of their population. Subsistence agriculture becomes more widespread across rural and urban areas. Family food is produced in allotments and gardens, although intensive farms still exist. There has been a transition to mixed farming, which allows for using slurry/manure alternatives as the price of fertiliser increases. Farmers choose suitable crops based on the availability of water in the area to minimise the need for irrigation. Farmers' groups are established to collectively tackle challenges (for example, building on-farm water storage). Reduced investment in R&D means that technology is essentially unchanged from the 2010s and 2020s. Thus, agricultural practices have increased negative environmental impacts associated with the deterioration of farm equipment and facilities. Moreover, agricultural production is more vulnerable to changing environmental conditions (for example, pests and drought), which means farmers have to accept and adapt to frequent production losses. Some of the measures used to cope with these pressures include applying higher quantities of pesticides, to which pests are resistant, or utilising substances previously banned. Moreover, the expansion of agriculture, practised by first generation unskilled farmers, leads to diffuse pollution.

Life in the local resilience scenario is described by the character, Sergei, in the vignette below (Figure 3.5).

Sergei is actively involved in community life as he is part of the neighbourhood watchdog group responsible for monitoring local industry. He lives in a town that aspires to be self-sufficient, which is evident in the landscape characterised by mixed spaces for industry, urban and agricultural use. His role as part of the neighbourhood watchdog group is to ensure industries that are vital for the community do not over-exploit local resources.

Sergei lives with his entire family in a modest house. He works in a local factory but takes on odd jobs to help make ends meet. Like most of his neighbours, he grows his own food and develops and repairs homemade gadgets to save money and reduce his energy and water bills. In periods of intense rainfall, Sergei helps his neighbours build basic temporary flood defences to protect their properties and agricultural fields. Sergei is so busy building small water storage reservoirs that he does not have the time to enjoy the natural environment.

The community depends on its local river and groundwater for water supplies, and with inadequate monitoring equipment, these resources are deteriorating. The river is off limit as the water quality is poor, occasionally generating bad odours during warmer summer periods. Sergei blames the towns located upstream as these seem to pollute the river at will with no regard for the well-being of his community.

Sergei's dream is to move upstream with his family. This is difficult as land prices increase as you move upstream, but he has heard of areas far upstream where water quality is so good you can actually bathe in the stream.

Figure 3.5 Life under the local resilience scenario

3.5 Reference

The reference scenario depicts a society that is environmentally conscious, but one where personal interests often dictate behaviour. EU legislation and codes of good practice establish the standards by which the environment is managed, but short political cycles cause most long-term initiatives to fall short of these standards. Goals related to environmental sustainability are reflected in plans for economic growth, but these are often reneged when growth falls below what is expected.

3.5.1 Drivers and activities

The reference scenario describes England and Wales with similar levels of progression in political and economic conditions and dynamics in international trade as the 2010s. The political agenda is driven by the desire for economic growth and the aspiration for sustainable development, supported by EU regulations (for example, carbon agenda and Water Framework Directive). Economic growth is slow, prompting the government to prioritise short-term economic goals, while advances in environmental protection are pursued only to appease the public. Nevertheless, environmental protection is enforced where there is direct relevance to the economy. This is often during growth periods, being relaxed during less favourable economic conditions. Limited funding is allocated

to develop technologies that permit carbon, energy and water savings. New technology is embraced if it is reliable and provides short- to medium-term economic gains.

The population in England and Wales rises to over 70 million as a result of mass immigration and an aging population. Society, dominated by the middle class, is concerned about the environment, but attitudes and behaviours are focused mainly on personal income and self-interest. Nevertheless, progress towards environmental protection is backed by strong interest groups, where individuals are willing to make minor lifestyle changes in order to minimise consumption of water and energy that are expensive commodities.

3.5.2 Picture of the scenario in 2050

The population rises by 25%, prompting an expansion of irrigated land used for agricultural production and a proliferation of new industrial and housing developments. In older urban areas where infrastructure is outdated, pressures from urbanisation lead to an increase in sewage incidents, but this is avoided in new urban areas where SUDS are implemented and managed efficiently. There is significant media attention given to flood events and their impacts. Flood defences are built in vulnerable areas, including those areas with high population density or premium agricultural land. Typical flood and erosion control measures include raised banks and shoreline reinforcements, which increase the flood risk in other areas that are gradually abandoned by farmers and householders. These abandoned areas become important for their flood attenuation properties.

Prescriptive regulation, coupled with an efficient hydrological and hydrogeological monitoring system, protects water resources and the water environment. This is most efficient in wealthy areas over poor areas, urban areas over agricultural areas, and during favourable economic periods. Nevertheless, water companies are permitted to over-abstract during periods of drought as the security of public water supplies has a higher priority than the protection of the aquatic environment.

Brand reputation is important for the consumer with many producers investing in certification procedures with benefits for the environment. Reputation combined with higher water prices lead to investment in R&D and implementation of water-saving technologies, which provide medium- and short-term economic benefits. The most advanced manufacturers reuse materials, but industrial treatment technologies are slow to advance due to financial constraints. Industry is subject to strong environmental regulation, where for instance the EU precautionary approach makes it difficult to approve the use of chemical substances.

On agricultural land, there is increased competition for production of food and biofuel crops and increased yields associated with intensification practices – albeit at a cost to the environment. Nevertheless, agricultural production is specialised and dependent on local factors such as soil type, the availability of water resources and the sensitivity of the receiving water bodies. Some areas traditionally associated with agriculture (for example, East Anglia) find management of water resources very challenging due to warmer summers and less reliable rain patterns to replenish groundwater sources. Reduced security of abstraction (for example, more frequent abstraction cessation orders) has associated impacts on yields and profits. The EU, supported by its Member States, has removed agricultural subsidies forcing farmers to optimise their practices to reduce inefficiencies and maximise profit margin.

Life in the reference scenario is described by the character, Aaron, in the vignette below (Figure 3.6).

Aaron lives in a flat in the city and commutes to work daily using public transport. On the way to work he crosses the river that runs through the city. During this economic recession the river is dirty, despite claims that water quality has improved with the investment from the water companies in the previous price review. People can no longer walk along the riverbanks as they have been populated by bank reinforcements for flood protection. These structures are not pretty but do protect the city from flood events, unlike the 'ghost town' nearby that gets flooded frequently.

Aaron enjoys visiting the countryside once in a while. He purposely avoids those 'non-ending' farmlands that have lost their aesthetic value. Farms have expanded all the way to the riverbanks, where livestock is often seen drinking water directly from the river. Unsustainable agricultural practices have had an impact on wildlife, making his preferred outdoor activity (sport fishing) less fulfilling. Aaron prefers going to the uplands as these still maintain most of their natural characteristics due to lower population density and an unsuitable topography for intensive agriculture.

Aaron aims to move to a suburban area. He would prefer a place on the outskirts of the city, one of the few locations with a view of the river and the municipal park. His dream however, is to progress in his career and for the country to avoid yet another recession.

Figure 3.6 Life under the reference scenario

4 Implications of the water and water environment scenarios

4.1 Impacts of scenarios on indicators of significant water management issues

The scenarios build a perspective of the long-term challenges to water management. Indicators of significant water management issues are used to evaluate the consequences of the scenarios for water and the water environment. The indicators used are taken from the Environment's Agency's 'Challenges and Choices' consultation document (Environment Agency 2013). They include:

- nutrients (phosphorous and nitrate)
- sanitary pollutants
- chemicals and metals
- faecal indicator organisms
- abstraction and flow regulation
- physical modification
- sediments
- invasive non-native species

The source and exposure pressures for each indicator were analysed under each scenario (scenario (

Table 4.1).

In summary, there is significant deterioration of all the indicators under the uncontrolled demand and local resilience scenarios. Conversely, there are substantial improvements in most, but not all, of the indicators under the innovation and sustainable behaviour scenarios. Improvements are limited by heavy engineering solutions under the innovation scenario and reduced efficiency in wastewater treatment processes due to a strict carbon agenda under the sustainable behaviour scenario. There are minor changes from the present status associated with indicators under the reference scenario.

Table 4.1 Summary of change in environmental risk under each scenario

	Uncontrolled demand	Innovation	Sustainable behaviour	Local resilience	Reference scenario
Phosphorus	↓↓↓	↑↑	↓	↓↓↓	↑
Nitrate	↓↓↓	↑↑	↑	↓↓↓	↓
Sanitary pollutants	↓↓↓	↑↑↑	↓	↓↓↓	No change
Chemicals and metals	↓↓↓	↑↑	↑↑	↓↓	↑
Faecal indicator organisms	↓↓↓	↑↑↑	↓	↓↓	No change
Abstraction and flow	↓↓↓	↑↑	↑↑↑	↓↓	↓
Physical modification	↓↓↓	↓↓	↑↑	↓↓	↓
Sediments	↓↓↓	↓	↑↑	↓↓	No change
Invasive non-native species	↓↓↓	↓	↑	↓↓	↓

Notes: Change is characterised as an improvement (green arrow up) or degradation (red arrow down). The extent of change is characterised as weak (one arrow), moderate (2 arrows) or strong (3 arrows).

4.2 Environmental outlook

The implications of the scenarios on the water environment vary significantly across the 5 scenarios (5 scenarios (

Table 4.2).

- Under the uncontrolled demand and local resilience scenarios, there is a general deterioration of the water environment.
- Under the innovation and sustainable behaviour scenarios, there is an overall improvement.
- Small changes are seen with the reference scenario.

The picture in each scenario is described in turn below.

Table 4.2 Major water management challenges under the scenarios

Water management challenge	Uncontrolled demand	Innovation	Sustainable behaviour	Local resilience	Reference
Eutrophication	■	■	□	■	□
Acid and nitrogen deposition	■	■	■	■	□
Un-ionised ammonia	■	■	□	■	□
Nitrate in drinking water	■	□	□	■	□
Microbiological contamination	■	■	□	■	□
Sediments	■	□	■	■	□
Chemical pollution	■	■	■	■	□
Hydro-morphological alterations	■	■	■	■	□
Water quantity	■	■	■	■	□
Invasive non-native species	■	□	□	■	□

Notes: Significance indicated by positive (green), negative (red), no (white) direction of change.

4.2.1 Uncontrolled demand scenario

Overall, the aquatic environment in rivers, coastal and transitional waters, and groundwaters has degraded substantially under the uncontrolled demand scenario. There are frequent incidents of eutrophication and pollution. Sediments, invasive non-native species, hydromorphological alterations, affected low flows and flow variability all have an impact on the aquatic environment.

Nutrient pollution from both agricultural fields and effluent discharges cause eutrophication and toxic algal blooms, leading to loss of wildlife and a negative impact on the aesthetics of the environment. Environmental problems are exacerbated by climate change, as intensive rainfall periods generate higher run-off and more frequent and longer drought periods are associated with increased temperatures and lower dilution capacity. In the most severely affected areas, water bodies are blocked with excessive weed growth causing obstructions to navigation and increasing flood risk. During wet periods, run-off from poorly managed urban and agricultural land increases the loads of nutrients, sediments, chemicals and microorganisms into the water bodies.

Scarcity of land for development mean there is an increasing number of properties built on floodplain areas. Increasing impact of floods may, to some extent, be mitigated by engineered defences that are constructed to protect high value and high income areas.

This hydromorphological alteration impacts the water ecosystems. There is an over-exploitation of water resources that are already poor in quality. The impacts on reduced low flows and the water ecosystems lead to interrupted water supplies. The situation is worst where water is illegally abstracted and discharged by the poorest of society in sub-urban areas.

Upland catchments are a source of clean water and are subject to heavily engineered infrastructure based on large-scale water reservoir storage and water transfers. Despite this, pleasant environments remain in these areas for the affluent. In general, lowland systems, estuaries and coastal waters are heavily polluted, developed and modified. Invasive non-native species are generally widespread, imposing a further impact on the water environment.

4.2.2 Innovation scenario

Innovation and technology achieve significantly improved environmental conditions. However, environmental management is invasive and hard engineering solutions are sought. Although hydromorphological alterations have a significant impact on aquatic ecosystems, water management challenges regarding water quality and water quantity are being dealt with efficiently. A consistent approach to water management is used at a national level. In order to balance the water supply and demand balance, large-scale infrastructure is adopted across the landscape, connecting catchments with high water availability (for example, north-west England and Wales) with water scarce areas (for example, south-east England and London). Equally, flood management policies focus on shoreline reinforcement and raised flood banks.

Pollution from both diffuse agricultural sources and effluent discharges has been dramatically reduced. Sustainable water abstractions, largely supported by less sustainable large-scale water transfers at times of low flows, help to achieve desired water flows in terms of flow velocities, depth and variability. All these factors are reflected in improved conditions for fish, macroinvertebrates and aquatic plants. This is ultimately for the benefit of society, which takes advantage of these improved environmental services. The environment in itself is significantly managed and altered. For instance, the landscape changes with ‘vertical’ agriculture being practised mainly indoors and invasive non-native species are introduced when it is economically beneficial.

4.2.3 Sustainable behaviour scenario

Sustainable behaviour drives an overall improvement of the water environment. Working with nature to solve challenges and creating opportunities for habitats within the urban and farm environments has created conditions for wildlife to flourish and improved aesthetics.

Sustainable water management practices are adopted. Local water is supplied to the local population, when possible, and water trading within the region becomes the norm. Sustainable abstraction protects low flows and flow variability. In water-stressed areas, interruptions of supply are common and accepted by the population. Moreover, there is a trend towards working with nature. For instance, wetlands are used to regulate peak floods, and integrated farming systems significantly reduce chemical inputs (for example, toxicity and quantity of pesticides) and the risk of land and water pollution.

Improvements to environmental quality, specifically to habitats of native flora and fauna, contributed to the restoration of the natural environment in line with traditional 20th century rural English and Welsh landscapes. This had a positive impact on biodiversity and made native species more resilient to colonisation by invasive non-

native species. Nevertheless, there is a deterioration of water quality downstream of urban areas due to limitations posed on the carbon footprint associated with the wastewater treatment processes. This affects river reaches and estuaries near towns and cities that could not yet afford the new low energy treatment technologies.

4.2.4 Local resilience scenario

Under the local resilience scenario there is an overall degradation of the water environment with visible destruction of habitats, loss of native species and colonisation by more resistant invasive non-native species. This is not as severe as under the uncontrolled demand scenario and not as homogeneous across England and Wales. Eutrophication of water bodies is observed in rural farmed areas, causing loss of sensitive species. Unsustainable agricultural practices also lead to problems of erosion, and pollution by chemicals, nutrients and microorganisms. For instance, agricultural production is more vulnerable to pests and farmers apply higher quantities of pesticides, to which the pests are already resistant, or substances previously banned.

In urban areas, water quality has not deteriorated substantially except in areas located downstream of the area administered by the local council in question. Water demand is met mainly locally by an increasing number of small-scale reservoirs, particularly in more water-stressed catchments. Farmers co-operate and build on-storage farm reservoirs to cope with periods of drought.

There is little co-ordination across communities with regard to flood policies and practice. This has resulted in a patchwork along river lengths composed of a mixture of engineering solutions, with different levels of sophistication, and areas where natural flood management approaches are used. While wealthier communities are better protected, a greater number of areas are more vulnerable to flooding with farmlands particularly at risk. Significant hydromorphological alterations are associated with flood protection.

4.2.5 Reference scenario

Environmental protection measures are insufficient to offset the impacts of demographic growth, climate change and changed consumption patterns on the water environment. Environmental degradation of water bodies is more noticeable in agricultural areas where incidents of eutrophication and toxic algal blooms are not uncommon. In urban areas, there is a noticeable improvement in the quality of water bodies.

Both hard and soft engineering approaches are used to deal with flooding. Hard protection is prioritised for existing densely populated areas and high value land. Low value developments built on floodplain areas in urban fringe areas have been gradually abandoned due to high insurance premiums and provide an area for natural attenuation of flood peaks.

Water resources are managed using a combination of water augmentation measures and demand control, minimising the impacts on low flows and flow variability. Issues with invasive non-native species remain largely unchanged.

5 Impacts of the scenarios on catchments and key sectors

Further analysis, through case studies, revealed emerging water and environmental management implications for different generic catchment types and key sectors. The case studies are illustrative, with the aim of stimulating further discussion and analysis.

5.1 Impacts of the scenarios on catchment types

Four catchment types were selected to illustrate the contrasting diversity of topography, climate, land-uses and water resources across England and Wales:

- uplands
- lowland grassland
- lowland arable
- lowland urban

These contrasting catchment types are vulnerable to different pressures under each scenario. Climate change plays an important role across all the scenarios, often exacerbating the impacts of socioeconomic changes.

5.1.1 Upland catchments

These catchments represent a vital water reserve under all scenarios.

Where these catchments are of national significance (uncontrolled demand and innovation scenarios), heavy engineering infrastructure to augment supplies is widely adopted.

Under the sustainable behaviour and local resilience scenarios, these reserves provide local supplies with occasional transfers across neighbouring catchments.

Abstraction levels are sustainable under the innovation and sustainable behaviour scenarios.

Land use change significantly affects upland catchments, primarily livestock production under the uncontrolled demand and local resilience scenarios, and woodland and forest development for timber and/or carbon sequestration under all the scenarios.

Under the innovation and sustainable behaviour scenarios, there is sustainable management of peat lands to preserve their value, particularly for carbon storage.

The amenity value of the uplands is preserved under all scenarios except local resilience, where there is lack of demand for leisure opportunities.

5.1.2 Lowland grasslands

Lowland grasslands in an urban catchment suffer from an expansion in urban areas under all scenarios. This has an impact on the water environment where there is:

- a proliferation of poor housing under the uncontrolled demand scenario

- overloaded and aging water and wastewater infrastructure under the local resilience
- less efficient effluent treatment under the sustainable behaviour scenario

It is only possible to minimise the negative impacts of expanding urban areas under the innovation scenario through technological improvements.

5.1.3 Lowland grasslands

Lowland grasslands in rural catchments are converted for intensive agriculture with unsustainable practices and negative impacts on water resources and the environment under the uncontrolled demand and local resilience scenarios. However, healthy grasslands are protected under scenarios driven by long-term sustainability (that is, the innovation and sustainable behaviour scenarios).

5.1.4 Lowland arable

These catchments are of national importance under the uncontrolled demand and innovation scenarios as they are a source of food production for an increasing population.

Under the uncontrolled demand scenario, these catchments suffer pressure from expanding agricultural land, but that is not the case under the innovation scenario, as technologies permit an optimisation of existing agricultural land.

Lowland arable catchments contain important groundwater reserves (for example, Chalk aquifers). The expansion and/or intensification of agricultural practices under the uncontrolled demand and local resilience scenarios cause a deterioration of the water quality, namely increasing the concentration of nitrates in groundwater.

Where agricultural practices are sustainable (innovation and sustainable behaviour scenarios), human health risks arise solely as a result of past nitrate pollution.

5.2 Impacts of the scenarios on key sectors

The sectors selected have a dependence on water and the water environment, a role in its management and/or are general users. They are:

- general public
- manufacturing industries
- leisure industries
- utility companies (water and energy)
- farming and fisheries

The implications for these key sectors under each scenario are summarised in Table 5.1.

Table 5.1 Summary of findings for key sectors

	Uncontrolled demand	Innovation	Sustainable behaviour	Local resilience	Reference
General public	Social achievement and financial stability epitomise the goals of individuals in society.	Society meets its needs, achieving environmental protection without change in consumer behaviour.	Individual and community behaviours ensure environmental protection.	Society struggles to meet its basic needs, relying on local community support for subsistence.	Individuals aspire to relocate to the countryside to elevate their social status in society.
Manufacturing industries	Industry flourishes as profit margins are maximised, unhindered by environmental regulation.	Investment in R&D provides a good business model and opportunity for technology to improve environmental performance.	Environmental legislation and social pressure prompt green manufacturing.	Environmental standards are traded off against economic growth.	Minimal compliance with environmental standards is pursued to reduce financial pressures.
Leisure industries	A dichotomy of services exists where the 'natural water environment' is offered on an exclusive basis, while the 'artificial water environment' is mainstream.	The leisure industry capitalises on changing notions of aesthetics, providing new leisure services.	The leisure industry provides opportunities to maximise the outdoor experience.	Leisure industries decline and are restricted to services provided at a local community scale.	Growing confidence in water quality increases demand for leisure services.
Utility companies (water and energy)	Profit is prioritised in a society where water resources are scarce.	Investment in infrastructure and technology improves services with reduced environmental impact.	The drive for sustainability reforms the water industry.	Companies provide services locally and struggle to operate.	Periodic reviews support improved water resource management.
Farming and fisheries	Production systems are defined by the quality of environmental resources.	Efficient production systems rely on technology to maintain competitiveness and to comply with environmental standards.	There is high demand for locally grown and seasonal produce grown sustainably.	There is increased local food production for self-subsistence.	Market-driven intensive agriculture is dominated by big corporations.

References

ALCAMO, J., 2008. *Environmental futures: The practice of environmental scenario analysis*. Amsterdam: Elsevier.

BRADFIELD, R., WRIGHT, G., BURT, G., CAIRNS, G. AND VAN DER HEIJDEN, K., 2005. The origins and evolution of scenario techniques in long range business planning. *Futures*, 37 (8), 795-812.

DEFRA, 2011. *Biodiversity 2020: A strategy for England's wildlife and ecosystem services*. London: Department for Environment, Food and Rural Affairs.

ENVIRONMENT AGENCY, 2006a. *Environment Agency scenarios 2030*. Science Report SC050002/SR1. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2006b*. Exploring the future: guidance toolkit for using Environment Agency scenarios 2030*. Science Report SC050002/SR12. Bristol: Environment Agency. Available from: http://webarchive.nationalarchives.gov.uk/20140328084648/https://publications.environment-agency.gov.uk/skeleton/publications/viewpublication.aspx?id=94ef9cc2-115c-4405-ba44-22c266a7baa8 [Accessed 10 May 2017].

ENVIRONMENT AGENCY, 2009. *Water resources strategy for England and Wales*. Bristol: Environment Agency. Available from: http://webarchive.nationalarchives.gov.uk/20140328084622/http:/www.environment-agency.gov.uk/research/library/publications/40731.aspx [Accessed 10 May 2017].

ENVIRONMENT AGENCY, 2010a. *Water: planning ahead for an uncertain future - Water in the 2050s*. Bristol: Environment Agency. Available from: http://webarchive.nationalarchives.gov.uk/20140328084648/https://publications.environment-agency.gov.uk/skeleton/publications/viewpublication.aspx?id=8a2bf3dc-4a07-4c8e-9192-573d5af234d7

ENVIRONMENT AGENCY, 2010b. *Water: Planning ahead for an uncertain future. Water in the 2100s*. Briefing note. Bristol: Environment Agency. Available from: https://data.gov.uk/data/contracts-finder-archive/download/815282/b5bb574c-3fae-4942-ba2e-a169200af3b6 [Accessed 10 May 2017].

ENVIRONMENT AGENCY, 2013. *England's waters: Challenges and choices*. *Summary of significant water management issues.* Consultation paper. Bristol: Environment Agency.

ENVIRONMENT AGENCY AND NATURAL RESOURCES WALES, 2013. *Current and future water availability – addendum. A refresh of the Case for Change analysis*. Briefing note. Bristol: Environment Agency.

HM GOVERNMENT, 2011a. *Water for life*. White Paper CM8230. London: TSO.

HM GOVERNMENT, 2011b. *The Natural Choice: Securing the value of nature*. White Paper CM8082. London: TSO.

MAACK, J., 2001. Scenario analysis: a tool for task managers. In *Social Analysis: Selected Tools and Techniques*, Social Development Papers No. 36, pp. 62-87. Washington DC: The World Bank. Available from: http://siteresources.worldbank.org/INTCDD/Resources/SAtools.pdf [Accessed 10 May 2017].

PILLKAHN, U., 2008. *Using Trends and Scenarios as Tools for Strategy Development.* Erlangen, Germany: Publicis Corporate Publishing.

THE FUTURES COMPANY, 2012. *Socio-economic scenarios for water to 2050*. Unpublished report prepared for the Environment Agency.

WRIGHT, G., VAN DER HEIJDEN, K., BURT, G., BRADFIELD, R. AND CAIRNS, G., 2008. Scenario planning interventions in organizations: an analysis of the causes of success and failure. *Futures*, 40 (3), 218-236.

Would you like to find out more about us or about your environment?

Then call us on
03708 506 506 (Monday to Friday, 8am to 6pm)

email
enquiries@environment-agency.gov.uk

or visit our website
www.gov.uk/environment-agency

incident hotline 0800 807060 (24 hours)
floodline 0345 988 1188 / 0845 988 1188 (24 hours)

Find out about call charges: www.gov.uk/call-charges

Environment first: Are you viewing this on screen? Please consider the environment and only print if absolutely necessary. If you are reading a paper copy, please don't forget to reuse and recycle if possible.