



# Reducing the risk of surface water flooding

NATIONAL  
INFRASTRUCTURE  
COMMISSION

Better infrastructure for all

November 2022

## Our remit

The Commission provides government with impartial, expert advice on major long term infrastructure challenges.

The Commission's objectives are to:

- support sustainable economic growth across all regions of the UK
- improve competitiveness
- improve quality of life
- support climate resilience and the transition to net zero carbon emissions by 2050.

In fulfilling our purpose and objectives, we:

- **set a long term agenda** – identifying the UK's major economic infrastructure needs, and the pathways to address them
- **develop fresh approaches and ideas** – basing our independent policy recommendations on rigorous analysis
- **focus on driving change** – building consensus on our policy recommendations, and monitoring government progress on their delivery.

A fuller description of the Commission's remit can be found on page 62 and on our website at [nic.org.uk/about/what-we-do/](https://www.nic.org.uk/about/what-we-do/). This includes a table of devolved administration responsibilities by infrastructure sector.

## The members of the Commission



Sir John Armitt  
(Chair)



Professor Sir Tim  
Besley CBE



Neale Coleman  
CBE



Andy Green CBE



Professor Jim  
Hall FEng



Professor Sadie  
Morgan OBE



Julia Prescott



Bridget Rosewell  
CBE



Kate Willard OBE



Nick Winser CBE

Full biographies can be found on page 64 and on our website at [nic.org.uk/about/the-commission/](https://www.nic.org.uk/about/the-commission/)

# Contents

Foreword .....	4
Executive summary .....	5
1. Surface water flooding .....	14
2. Surface water management .....	26
3. Identifying the places most at risk and setting targets for improvement .....	35
4. Joint plans and devolved funding .....	41
Acknowledgements .....	56
Glossary .....	58
Remit and structure of the Commission.....	62
References.....	66

# Foreword

The challenges of tackling river pollution and addressing water supply shortages have dominated public discussion about the water sector in recent months – but we risk ignoring a problem that can literally drop out of the sky at any moment.

As the climate changes, heavy rainstorms are happening more often. Sudden deluges can overwhelm drainage, leading to ‘surface water flooding’. Londoners will recall the scenes in July 2021, when parts of the city received more than twice the average monthly rainfall in just two hours; more recently, parts of Leicestershire and the Isle of Wight were hit by similar incidents.

Surface water flooding is a potential risk to many homes and businesses in England. Currently around 325,000 properties are in areas at the highest risk – meaning there is a more than 60 per cent chance they will flood in the next 30 years. Without action, up to 295,000 more properties could be put at risk.

Whatever the figures, such modelling masks the human cost of floods. The impact of a sudden flooding incident on health, livelihoods and wellbeing for affected residents and businesses can be profound. And if you’re in that situation, you don’t really care where the water has come from – you just want it to stop.

Surface water flooding is the flood risk we know the least about. It is highly localised, and hard to predict. A highly local problem needs local solutions.

This report sets out how we can better identify the places most at risk and reduce the number of properties at risk there. This will mean devolving funding to local areas at the highest risk, and supporting them to make long term strategies to meet local targets for risk reduction.

At a national level, there is a need for the Environment Agency to expand its strategic oversight role in relation to surface water flooding. It will also be vital that Ofwat enables water and sewerage companies – who own and operate underground drainage on which we will rely – to invest in solutions to address surface water flooding, including nature based drainage systems. This will require them to work closely with local authorities to protect the people in the areas they serve.

Such an approach also depends on reducing the amount of water that enters drains in the first place, as well as building new infrastructure to increase future drainage capacity. Our report sets out recommendations in each of these areas.

We should not let surface water flooding continue as a stealth threat. We have the means to address it – what’s largely required is impetus for a range of bodies to act, and better coordination between them. Our hope is this report helps provide such an impetus, and a long term framework to help the country weather the coming storms.

**Jim Hall**  
Commissioner

**Sadie Morgan**  
Commissioner

**Julia Prescott**  
Commissioner

# Executive summary

Around 325,000 English properties are currently at high risk of flooding caused by heavy rainfall. Known as ‘surface water flooding’, this type of flooding can cause major disruption to people’s lives and livelihoods. Without action, climate change and urbanisation could put an additional 230,000 properties at high risk by 2055. Action is needed to both increase the capacity of pipes and sewers and capture more rainwater before it enters them.

Surface water flooding is highly localised and requires local knowledge and solutions. But local areas currently have to bid for funding for schemes to address it, and do not have local targets, or plans formed jointly across all the relevant organisations, including water and sewerage companies.

There need to be long term targets for surface water flood risk reduction, devolved funding to the areas at highest risk, and costed joint plans at a local level. It is not affordable to eliminate surface water flood risk everywhere, but a more focussed and coordinated approach can significantly reduce the numbers of properties that would otherwise be at risk.

The Commission recommends that:

- government acts to mitigate the impact of urban development on surface water flooding
- the Environment Agency should improve identification of the highest risk areas, drawing on local maps and models
- government should set a long term target for a reduction in the number of properties at high and medium risk of surface water flooding
- government should clarify in its strategic priorities that Ofwat should enable water and sewerage companies to invest in solutions to manage surface water flooding, including nature based solutions where appropriate
- in high risk areas, local authorities, water and sewerage companies and, where relevant, internal drainage boards, should be required to develop costed, long term, joint plans to manage surface water flooding, including local targets for risk reduction, assured by the Environment Agency with input from Ofwat
- government should devolve public funding to upper tier local authorities in the new flood risk areas based on their level of risk
- for properties remaining at high risk of flooding, government should explore options for funding property level measures.

Some of these recommendations will require changes to current flood risk management arrangements. It is for government to decide how best to make these changes.

## Around 325,000 English properties are already in areas at high risk of surface water flooding

While surface water floods tend to lead to lower water levels and result in lower damages than river and coastal flooding, they can cause major disruption to people's lives and livelihoods. In July 2021, widespread flooding in London affected over 1,500 properties, as well as health infrastructure and transport networks.

Around 325,000 properties in England are in areas that currently have a more than 60 per cent chance of being affected by surface water flooding in the next 30 years ('high' risk), and a further 500,000 are in areas that have a similar chance of being affected in the next 100 years, not considering the impacts of climate change or new development. Over 85 per cent of these properties in high risk areas are in cities and towns. Flood risk management is devolved to the governments of Scotland, Wales and Northern Ireland.

## Climate change and urbanisation are set to put more properties at risk

The number of properties in areas at high risk is set to increase by 2055, including:

- an increase of around 20,000-135,000 properties in areas at high risk due to the impacts of **climate change**, which will increase the intensity and frequency of heavy rainfall
- an increase of around 35,000-95,000 properties due to **new development** putting more pressure on drainage systems.

A further 50,000-65,000 properties may be put in areas at high risk due to **unplanned increases in impermeable surfaces** (e.g. front gardens being paved over), which, alongside new development, is part of 'urbanisation' – the conversion of natural (often permeable) environments to urban ones where rainwater cannot enter natural drainage systems.

## Government should act to mitigate the impact of urbanisation

New developments have a legal right to connect to existing drainage infrastructure for surface water, which can increase the volume of rainwater that flows into drainage. Current processes do not do enough to encourage new developments to properly mitigate this impact.

In response to the 2007 Pitt Review, the government enacted, but did not implement, legislation in 2010 to improve the planning and delivery of surface water drainage in new development. The proposed changes in Schedule 3 to the Flood and Water Management Act 2010 included making sustainable drainage systems a legal requirement for most new developments and amending the right to connect to public sewers. However, government decided not to implement Schedule 3 in England, in favour of strengthening planning policy in 2014. In 2022, the government reviewed whether to implement Schedule 3 in England. A decision is still pending.

**Recommendation 1: By the end of 2023, government should implement Schedule 3 of the Flood and Water Management Act 2010 and update its technical standards for sustainable drainage systems.**

Government should also consider whether and how to control unplanned increases in impermeable surfaces. Government has three main options: controls, incentives, and public education. Alternatively, government could accept that it will continue to increase the risk of surface water flooding, and factor its impacts into targets, plans and funding. Government should carry out a comprehensive review and decide on the best course of action by the end of 2024.

**Recommendation 2: Government should undertake a comprehensive review of the effectiveness of all available options to manage unplanned increases in impermeable (or hard) surfaces, and their costs and benefits. By the end of 2024, government should decide whether policy changes are required to reduce the impacts on surface water flooding or adjust investment levels for flood risk reduction accordingly.**

## **Drainage systems must be improved to protect properties in the coming decades**

The recommendations above will help reduce the amount of rainwater that would otherwise enter drainage systems. However, drainage systems will still need to be effectively maintained and enhanced to reduce the number of properties already at risk, and help prevent further properties being put at risk, for example as a result of climate change.

‘Drainage systems’ usually include a mix of interventions above and below the ground. Conventionally engineered drainage systems incorporate above ground gullies, channels and drains that convey water to piped underground systems and storage tanks. In England, storm water is mostly drained in the same underground sewers (‘combined’ sewers) that convey wastewater to treatment works. Some above ground solutions – such as green roofs, ponds and rain gardens – provide additional environmental and social benefits.

Interventions should be considered following the ‘solutions hierarchy’. This prioritises maintenance and optimisation, followed by above ground interventions, with below ground interventions (pipes and sewers) considered last. This ensures lowest cost options are considered first and maximises the opportunity to deliver wider benefits such as biodiversity.

The recommendations below set out changes in governance and funding to improve the capacity of drainage systems, and to protect properties when flooding does inevitably occur.

## **Processes to identify the places most at risk should be improved**

The Environment Agency supports upper tier local authorities to identify areas where there is a ‘significant’ risk of surface water flooding – known as ‘Flood Risk Areas’. These are reviewed every six years, with the next review planned for 2023.

One of the sources of data the Environment Agency uses to identify Flood Risk Areas is the National Flood Risk Assessment. The first National Flood Risk Assessment took place in 2004. The second is due to be published at the end of 2024 and will provide an updated national flood risk map based on better modelling and data.

Government should consider delaying the next review of flood risk areas to 2025, to allow the Environment Agency to use the results of the second National Flood Risk Assessment when identifying new flood risk areas. This would provide a better basis for identifying those areas at highest risk and for directing future interventions and investment.

The Environment Agency also produces a nationwide map of surface water flooding risk, the 'Risk of Flooding from Surface Water Map'. It is broadly accurate at a high level, but more granular local data would improve the reliability of risk mapping at the street or property level, giving government and the public a better understanding of risk.

Currently only 35 out of 95 local authorities in Flood Risk Areas have modelling integrated into the national map. There is also no requirement to make local modelling interoperable with Environment Agency maps and models. Government should support local authorities to develop interoperable flood risk maps and models to appraise potential interventions and review the case for commencing provisions in the Flood and Water Management Act 2010 that would provide powers to sanction authorities that do not share data, so that the Environment Agency can include it in the national mapping.

### **Recommendation 3: Government should:**

- **require the Environment Agency to use the results of the second National Flood Risk Assessment in 2024 to identify new flood risk areas**
- **from 2025, require upper tier local authorities, water and sewerage companies, and other relevant authorities in the new flood risk areas to, where necessary, develop detailed local risk maps that can be integrated into the Environment Agency's national map, and models that can be used to plan future management of surface water flooding.**

## **Government should set national risk reduction targets to drive and monitor progress**

While the government has set goals for overall flood risk reduction and property protection by 2027, there is no quantifiable long term target for reducing the risk of surface water flooding. The lack of common goal limits progress and prevents effective monitoring.

Government should set a national target for risk reduction. Identifying such a target – which would be measured by the number of properties remaining at different risk levels – requires consideration of what is achievable, cost beneficial, and affordable. Modelling carried out on behalf of the Commission indicates that investing about £12 billion over 30 years in cost effective drainage infrastructure measures could reduce the number of properties that would otherwise be at high risk of surface water flooding in 2055 by around 60 per cent.



The investment would come largely from public sources and water and sewerage companies based on who is best placed to intervene and who benefits. However, this amount is only indicative, and government should assess the appropriate level itself based on improved Environment Agency mapping and modelling, and considering the potential risk reduction that can be achieved by all types of flood risk protection, including individual property protection.

To drive and monitor progress at the local level, upper tier local authorities, water and sewerage companies, and, where relevant, internal drainage boards in the new flood risk areas should identify quantifiable local targets for reductions in surface water flooding – and the flood damage avoided – as part of their single joint plans (see below).

**Recommendation 4: By early 2025, government should set a long term target for a percentage reduction in the number of properties at high and medium risk of surface water flooding.**

**Recommendation 5: The government should require risk management authorities in the new flood risk areas to agree appropriate local targets by mid 2025.**



## Water and sewerage companies should play a key role in reducing risk

Water and sewerage companies will play a key role in reducing surface water flood risk, by improving drainage. Water and sewerage companies have a duty to provide, improve and extend public sewers, and to cleanse and maintain those sewers to ensure that their areas is, and continues to be, effectually drained. However, this duty has tended to be interpreted as meeting the entitlement for property owners and developers to connect to public sewers to discharge surface water, and addressing sewer flooding. Government should clarify in its strategic priorities for Ofwat that it should enable water and sewerage companies to invest in solutions to manage surface water flooding.

The focus of investment will also need to change. Private investment from water and sewerage companies' customer bills has largely funded below ground drainage, such as pipes and sewers, although this is starting to change. Water and sewerage companies should continue to be encouraged to deliver both above and below ground solutions, and Ofwat should ensure its methodology for the next Price Review period in 2024 creates a level playing field for below and above ground interventions, including sustainable drainage systems.

### **Recommendation 6: Government should:**

- **clarify in its strategic priorities for Ofwat that it should enable water and sewerage companies to invest in solutions to manage surface water flooding including sustainable drainage.**

## Single, costed, joint plans

Upper tier local authorities are the main organisations responsible for managing the risks of surface water flooding.

Upper tier local authorities, water and sewerage companies and, where relevant, internal drainage boards in the new flood risk areas should develop and deliver long term, costed, joint plans, setting out local targets for flood risk reduction. They should replace Local Flood Risk Management Strategies and inform water and sewerage companies' business plans.

The plans should set out a common vision, identify quantifiable local targets, assign clear roles and responsibilities, and contain a costed programme of public and private investment for the next five years. The Environment Agency should review and assure the joint plans, with input from Ofwat and support from Regional Flood and Coastal Committees, by 2026.

To develop and deliver joint plans effectively, it will be critical that all authorities involved, including the Environment Agency and local authorities, have the right funding and capacity to fulfil their roles.

## Recommendation 7: Government should require:

- **upper tier local authorities, water and sewerage companies, and, where relevant, internal drainage boards in the new flood risk areas to produce and deliver costed, joint investment plans for managing surface water that achieve the agreed local objectives and follow the ‘solutions hierarchy’**
- **the Environment Agency to review and assure the final plans with input from Ofwat and support from Regional Flood and Coastal Committees, and publish data on progress against local and national targets**
- **joint plans to be completed by 2026 and revised every five years following the review of flood risk areas the year before, and to inform the following Ofwat Price Review.**

## Devolved local funding for local flood risks

Local authorities making long term plans for reducing flood risk in their areas require greater certainty on funding. To support long term planning, government should devolve funding to upper tier local authorities in or containing new flood risk areas, for the purposes of managing surface water flooding along with other local flood risks. This will help to provide the confidence to invest resources in planning, building capacity and identifying partnership funding to deliver programmes of interventions. It will also remove the need to bid to the Environment Agency for grant funding for surface water flooding interventions in the new flood risk areas.

The devolved budgets should initially be set for the five years from 2026-2031 and communicated prior to the development of the joint plans. Allocations could be calculated based on the Environment Agency’s assessment of the level of risk in each new flood risk area. While the additional public investment is not a significant increase on current levels, devolving this funding to local areas should ensure it is spent more effectively, as local bodies are best placed to understand local risks and solutions.

**Recommendation 8: By the end of 2025, government should devolve public funding to upper tier local authorities in or containing new flood risk areas, based on the Environment Agency’s assessment of the levels of risk in each new flood risk area. The funding allocation should be reviewed every five years, in line with single joint plan cycles.**

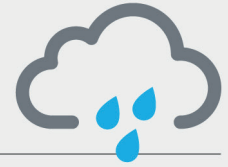
## There should be support for properties remaining at risk

It is not possible to protect all properties at high risk of flooding by delivering cost beneficial investments. The Commission’s modelling estimates that 170,000 – 200,000 properties are in areas that will remain at high risk in 2055. More properties will be protected in cities, both as a total, and as a proportion of properties at high risk.

However, other interventions, such as individual flood barriers or flood insurance, may still be cost beneficial for properties where infrastructure interventions may be less beneficial. This is because flood infrastructure interventions are most cost effective where properties at high risk are densely clustered. However, the costs of surface water flood protection should not automatically fall to individual property owners or occupants simply because of where they live.

**Recommendation 9: By the end of 2024, government should explore options for funding property level measures for those properties that remain at high risk of surface water flooding because improving drainage infrastructure is not cost effective.**

# Surface water flooding happens when heavy rainfall overwhelms drainage



**Around 325,000 properties across England are at high risk of surface water flooding**

Currently



**risk mapping is not good enough**



**there are no clear targets**



**responsibility and funding are fragmented**

And by 2055 the number of properties at high risk could increase by:

**20,000 – 135,000**



due to **climate change**

**35,000 – 95,000**



due to **new development**

**50,000 – 65,000**



due to increases in **impermeable surfaces**

Investing c. **£12 billion** in cost effective improvements to **2055** could **reduce** properties at high **risk** by **60%**.



## The Commission recommends...

**Government and the Environment Agency should:**



Stop unmanaged development making the problem worse



Improve risk mapping



Set national targets



Devolve funding to high risk areas



Explore options to protect individual properties

**Ofwat should enable water companies to:**



tackle surface water flooding



build and maintain sustainable drainage

**Risk management authorities in local areas should:**



Deliver long term joint plans to meet local targets.

Sources: Environment Agency, Mott MacDonald, Drainage and Wastewater Management Plans, Commission modelling

# 1. Surface water flooding

Around 325,000 properties across England are in areas at high risk of surface water flooding, particularly in towns and cities. As climate change increases the intensity of rainstorms, and a growing population increases urbanisation, the risk of surface water flooding will increase. While surface water flooding tends to have a slightly lower impact than river and coastal flooding, it is still disruptive, and can be dangerous.

High risk properties are in areas that have at least a 1 in 30 chance of flooding every year. A further 500,000 properties are in areas that have at least a 1 in 100 chance of flooding every year.

In the coming decades the number of properties in areas at high risk could increase by:

- 20,000-135,000 due to increases in intensity of rainfall due to climate change of two to four degrees above pre-industrial levels
- 35,000-95,000 due to new development.

An additional 50,000-65,000 more properties may also be put at risk due to increases in impermeable surfaces in urban and suburban areas (e.g. if front gardens are paved over). There may be overlaps between properties in these risk categories.

## 1.1 Surface water flooding

Surface water flooding – also referred to as pluvial or flash flooding – happens when there is so much rain that it cannot drain away quickly enough, either because drainage networks reach capacity and overflow, or because they are not operating at full capacity due to blockages in pipes and sewers, or in above ground drainage like gullies. Instead of draining away, the rainwater collects at low levels and causes flooding.<sup>1</sup> Surface water flooding can occur in rural and urban settings.

Surface water flooding is caused by a combination of factors including rainfall, soil permeability, drainage system capacity and maintenance, physical barriers and topography.<sup>2</sup> It is usually localised, hard to predict,<sup>3</sup> disruptive to homes and business and can pick up pollutants that drain into rivers and coastal waters (especially if it causes sewers to flood).<sup>4</sup> Surface water flooding can have serious impacts, including on lives, livelihoods, environmental quality, and public health.

More detail on the properties and areas surface water flooding affects is set out in Chapter 2.

## 1.2 Around 325,000 properties are at high risk

Around 325,000 properties – 1.1 per cent of properties in England – are in areas at high risk of surface water flooding. Areas at high risk currently have at least a 1 in 30 chance of flooding every year, equating to a more than 60 per cent chance of flooding at some point in the next 30 years. More properties are in areas at high risk of surface water flooding than of river and coastal flooding combined, which the Environment Agency estimates at around 200,000 properties.<sup>5</sup>

A further 500,000 properties in England are in areas at ‘medium’ risk (less than a 1 in 30 chance but greater than a 1 in 100 annual chance of flooding), meaning they have a more than 60 per cent chance of flooding in the next 100 years under current circumstances, not considering the impacts of climate change or new development.

### Figure 1.1: Around 325,000 properties are at high risk of surface water flooding

*Properties (residential and business) at ‘high’ or ‘high or medium’ risk of surface water flooding*

Risk level	Annual chance of flooding	Total properties in areas at this risk level	As a percentage of properties in England
High	1 in 30 or more	325,000	1.1 %
High or medium	1 in 100 or more	825,000	2.5 %

Source: Commission interpretation of Environment Agency Flood risk maps for surface water: how to use the map; Commission calculations based on Sayers et al.

There is no comprehensive record of surface water flooding incidents across England. Where this has been attempted, the estimates tend to rely on media reporting or similar.<sup>6,7</sup> Since the Floods and Water Management Act 2010, councils undertake more comprehensive investigations into flood incidents. These investigations provide more detail on causes and impact, including assessing whether individual floods were due to very intense rainfall, or poor maintenance or a combination of factors. However, these investigations are inconsistent in quality and are not collected centrally.<sup>8</sup>

Surface water flooding tends to be concentrated in specific places, for example in natural basins, or areas that are largely paved over so water can’t drain away into the soil. The causes of surface water flooding are often similar in rural and urban areas. However, the impact of runoff from fields onto roads is often an important factor in more rural areas.<sup>9</sup>

## Roles and responsibilities

The key organisations involved are:

- **Upper tier local authorities** (unitary authorities or council councils) are the main organisations responsible for managing surface water flood risk. They are designated as Lead Local Flood Authorities and required to develop, maintain, apply and monitor a strategy for local flood risk management in their area
- **Highway authorities**, which include local highway departments in unitary and county councils and National Highways, and are responsible for draining highways or adjoining land
- **District councils** (including borough councils) in areas with no unitary authority, which are the local planning authority and are required to consider flood risks when developing local plans and assessing planning applications from developers
- **Water and sewerage companies** deliver and maintain clean water and sewerage services and have a duty to provide, improve and maintain a public sewer system to effectually drain their areas. They are distinct from ‘water only’ companies, who are only responsible for supplying water to properties and not for drainage.
- **Internal drainage boards** are independent public authorities that manage water levels in low lying, mostly rural areas, to protect agriculture and the environment.
- **The Environment Agency** is the non-departmental public body with strategic oversight of all flood sources and is directly responsible for managing flood risks from main rivers, the sea and reservoirs.
- **The Department for Environment, Food and Rural Affairs** is the government department responsible for flood risk management policy in England.
- **Ofwat** is the economic regulator for the water sector in England and in Wales. Ofwat scrutinises water companies’ business plans and sets performance commitments for water companies to reduce sewer flooding.
- **Regional Flood and Coastal Committees** provide a forum for local and regional authorities to coordinate regional activities. They approve Environment Agency requests to raise local levies or implement regional programmes of investment.<sup>10</sup>

All of these (except Defra, Ofwat and Regional Flood and Coastal Committees) have legal responsibilities for surface water flooding as ‘Risk Management Authorities’ and are required to cooperate.<sup>11</sup>

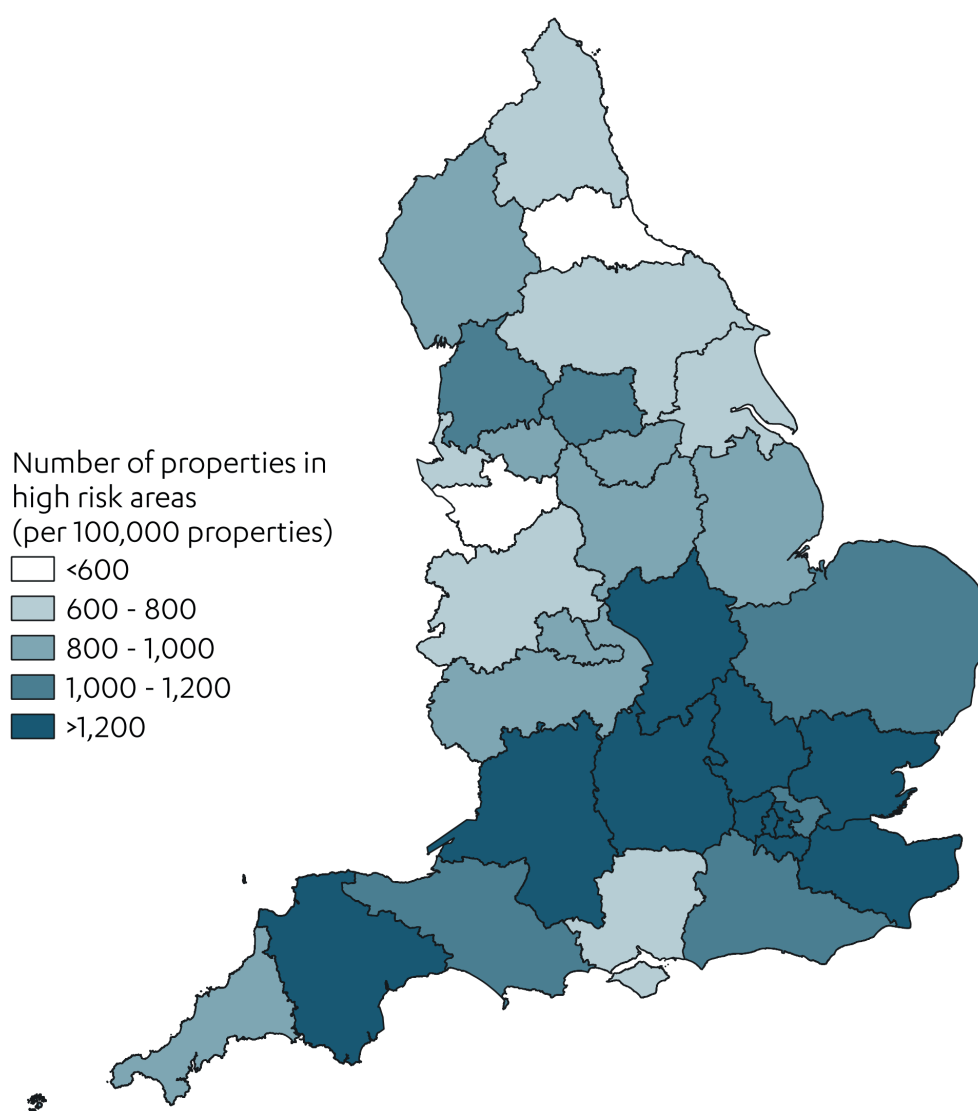
Flood risk management is devolved to the governments of Scotland, Wales and Northern Ireland. Arrangements in the devolved nations are set out in the Commission’s Second National Infrastructure Assessment: Baseline Report.<sup>12</sup> This study only considers England.



Figure 1.2 shows the number of properties in areas at high risk per 100,000 properties, by region. This shows that there are high risk areas across England. The proportion of properties at high risk does not appear to be entirely correlated either to the most densely populated areas, or to the areas with the highest rainfall (usually in the west). This is because the risk of surface water flooding is related to multiple factors, including the intensity of rainfall, the permeability of the surface on which it falls, and the capacity of the surrounding drainage system.

### Figure 1.2: There are high risk areas across England

*Number of properties in areas at high risk of flooding per 100,000 properties, by the Office for National Statistics' 'International Territorial Level 2' regions*

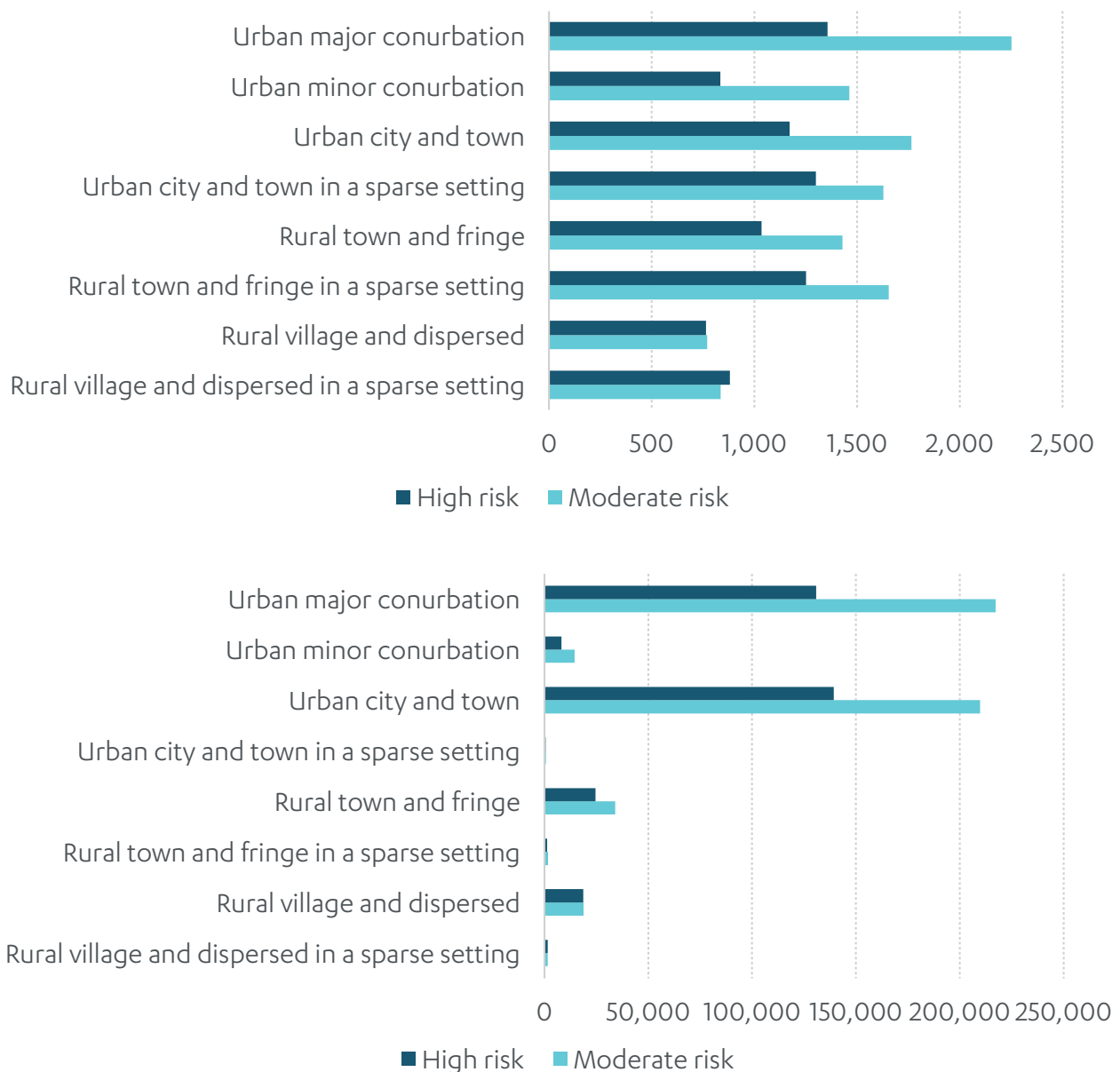


Source: Commission calculations based on Sayers et al.

Over 85 per cent of the number of properties in areas at high risk of surface water flooding are in towns and cities. While the proportion of properties in areas at high risk of surface water flooding per 100,000 properties is roughly the same in villages, towns and cities, more properties are in towns and cities overall, and properties in towns and cities are more likely to be in areas at medium risk of flooding than those in smaller villages or rural areas. Therefore, the biggest challenge is in towns and cities, and interventions there are likely to protect the most properties.<sup>13</sup>

**Figure 1.3: High and medium risk properties tend to be concentrated in cities and towns**

*Properties at risk per 100,000 (top) and in total (bottom), by settlement type and risk level*



Source: Commission calculations based on Sayers et al.

## Public awareness of surface water flooding is low

The Commission asked BMG to carry out social research on surface water flooding to inform this report. The social research consisted of an online survey of a nationally representative sample of over 2,000 adults in England, and three online focus groups to explore the topic further.

The survey found that:

- **Surface water flooding is not well understood:** Only 20 per cent of survey respondents were confident they knew what surface water flooding meant and it was very commonly confused with river and coastal flooding.
- **Flooding is not a concern for most households:** Flooding (from any cause) came ninth on a list of 11 concerns about damages to the home and disruptions to life, below fire, burglary, and burst pipes, and was picked in the top three concerns by only 14 per cent of participants. Even amongst those participants with experience of flooding, only a third ranked flooding in their top three concerns.
- **Everyone should pay some of the cost of reducing surface water flood risk:** Forty-two per cent of survey participants thought people should all pay the same amounts to protect properties at risk of flooding (irrespective of individual risk), while 25 per cent believed people living in properties at greater risk of flooding should pay more than those less at risk. Participants thought people living in higher risk properties should make some additional contribution to their flood protection.
- **Few people think they might need property level protection:** A majority of participants were unwilling to install flood resilience measures in their home. The most common reason for this was that participants thought they did not need it.

The [full social research report](#) is published alongside this report.<sup>14</sup>

## 1.3 Surface water flooding can be extremely disruptive

Surface water floods tend to lead to lower water levels and result in lower damages than river and coastal flooding.<sup>15</sup> But even flooding with low water levels can cause major disruption to people's lives, damaging homes and businesses and affecting people's wellbeing.

In extreme cases, surface water flooding can even lead to loss of life. This was seen in September 2021, when Hurricane Ida led to flooding in New York City, killing 13 people, 11 of whom were in basements.<sup>16</sup> Recent events in England have been less extreme, but have still caused major disruption, see box below.

Surface water flooding also often takes people by surprise – where it happens depends on where rainfall is heaviest, and where that rainfall collects when it cannot drain away. People living near rivers or coasts tend to be more aware of the potential risk.

Surface water flooding is also hard to predict, and advance warnings are almost impossible because it can happen very quickly after sudden intense rainfall (hence the term ‘flash flood’) and tends to be localised.<sup>17</sup> This can mean people have less time to prepare.

Surface water flooding has been recognised by the government as a key risk and was added to the national risk register in 2016.<sup>18</sup>

### Surface water flooding in England

Examples of surface water flooding incidents throughout the last decade include:

- **London, July 2021:** Widespread flooding affected 24 of London’s 32 boroughs,<sup>19</sup> with over 1,500 properties flooded.<sup>20</sup> This affected homes, businesses, health infrastructure and transport networks.<sup>21</sup> Further flooding hit London this year, but it is still too early for full reports.
- **Rochdale and Greater Manchester, February 2020:** There have been repeated events in Rochdale and wider Greater Manchester. Flooding caused by Storms Ciara and Dennis affected numerous properties and local businesses.<sup>22</sup>
- **England, September 2019:** Heavy rain caused flash flooding and travel problems, disrupting road and rail travel.<sup>23</sup>
- **The Midlands, May 2018:** Storms hit parts of the West Midlands,<sup>24</sup> Worcestershire<sup>25</sup> and Milton Keynes.<sup>26</sup> Collectively this resulted in over 750 properties being flooded across multiple locations.<sup>27</sup>
- **Kent and Cornwall, July 2017:** Over 50 properties flooded in at least four areas of Kent,<sup>28</sup> and a further 50 properties flooded and roads were damaged in at least two places in Cornwall.<sup>29</sup> Some of the areas in Kent were also impacted by flooding in 2015.
- **Woking, May 2016:** Forty-five properties were flooded, and three schools and one road were closed.<sup>30</sup>
- **Canvey Island, July 2014:** Surface water flooding impacted over 200 properties.<sup>31</sup>
- **Newcastle, June 2012:** Flooding resulted in over 500 properties being flooded, including shops and schools. Transport networks including roads and trams were also impacted.<sup>32</sup>

## 1.4 The number of properties at risk is set to grow

The number of properties at risk from surface water flooding is set to increase in coming decades. The three main drivers of this are:

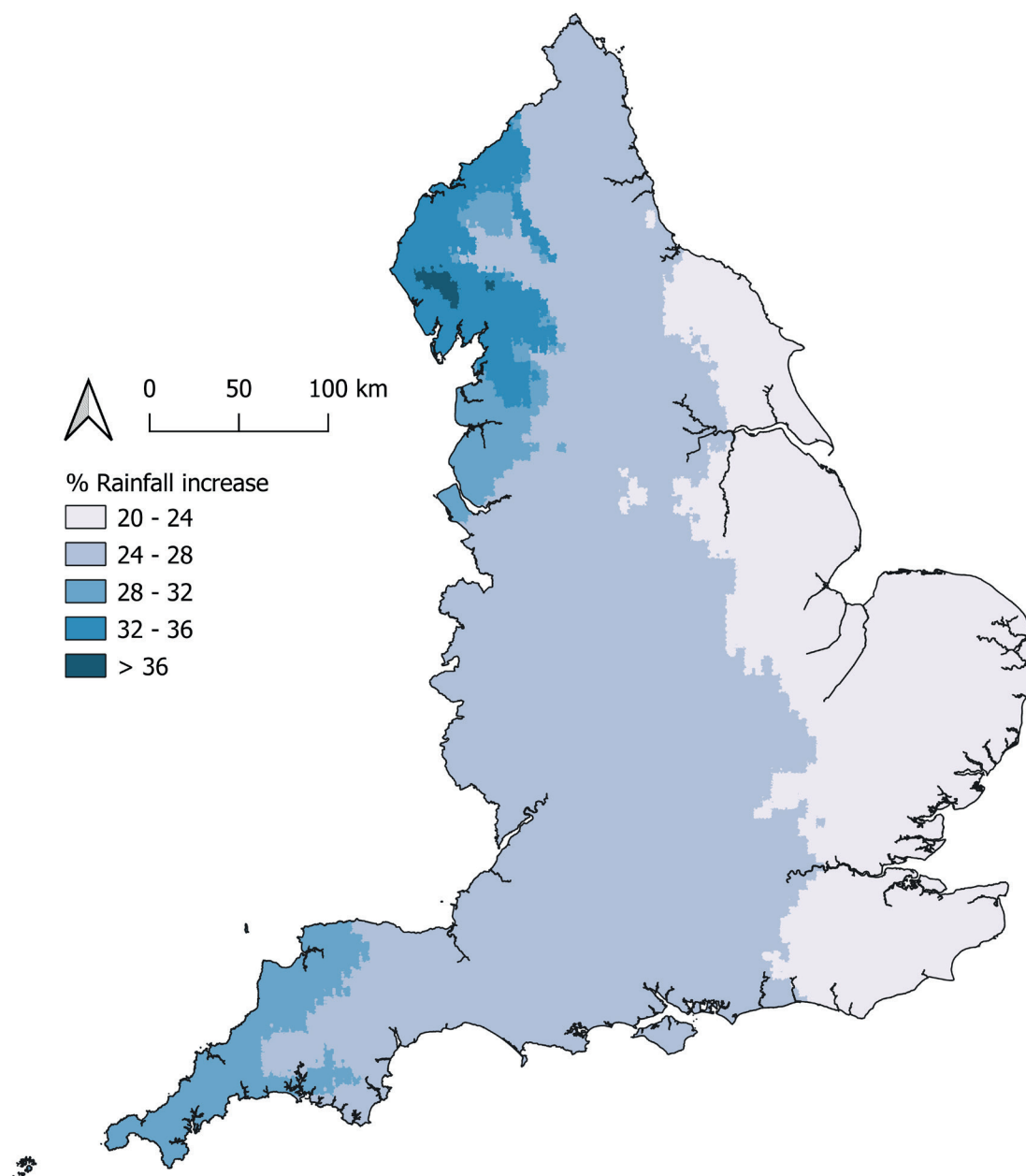
- **Climate change**, which will increase the intensity and frequency of heavy rainfall
- **New development**, which will increase pressure on drainage systems, and may increase the number of properties in areas at risk of surface water flooding
- **Unplanned increases in impermeable surfaces**, for example property extensions, or paving over front gardens, which increase the volume of water entering drainage systems.

## Climate change will increase the intensity and frequency of heavy rainfall

The atmospheric conditions that bring about intense rainfall, while possible at any time of year, tend to occur most often in the summer.<sup>33</sup> Although, overall, climate change is likely to mean the UK has hotter, drier summers in future, there is also likely to be an increase in the intensity of summer storms, meaning there will be storms where more rain falls in a shorter period of time. The season for these intense summer storms is also likely to extend into the autumn.<sup>34</sup>

### Figure 1.4: Climate change means heavy rainfall is more likely across England

*Percentage increase in intense (1 in 30) rainfall by the 2080s, in the four degree climate scenario (compared to 1981-2000 average baseline)*



Source: Sayers et al.

- i Represents the future rainfall scenario for the UK corresponding to a global mean temperature increase by 2100 of 4 degrees

The Commission has used two scenarios for climate change: one of a two degree increase in global temperatures by 2100 compared to preindustrial levels, and one of a four degree increase, using the Met Office's UKCP18 climate projections convection permitting model. Both scenarios imply an increase in intensity and frequency of heavy rainfall, which is greater in the four degree scenario. However, while these projections are widely used, the actual future increase in rainfall is uncertain.<sup>35</sup> It will be important to be resilient to a range of scenarios.

Increased volumes of rainfall will mean drainage systems need to drain away water at a much faster rate and are more likely to be overwhelmed and flood. Severn Trent plc (the water and sewerage company) forecast that a 2 degree climate change scenario could increase the number of properties at risk of internal flooding from sewers by 49 per cent by 2050.<sup>36</sup>

The relative importance of each of these three factors will vary between areas. Changes in precipitation patterns will vary across the country,<sup>37</sup> as will rates of new development and increases in impermeable surfaces.<sup>38</sup>

## All three factors will put additional properties at high risk

The Commission modelled the potential increase in properties at risk of surface water flooding without intervention due to climate change and new development. The possible increase varies widely – from 20,000 to 230,000 additional properties in areas at high risk by 2055 – depending on the scenario. Figure 1.5 shows four scenarios based on the Met Office's convection permitting model as set out above:

- two degree climate change, with no additional risk from new development (representing a scenario where new developments are responsible for their own drainage, and so do not add to total risk)
- two degree climate change with some additional risk from new development
- four degree climate change with no additional risk from new development
- four degree climate change with high additional risk from new development.

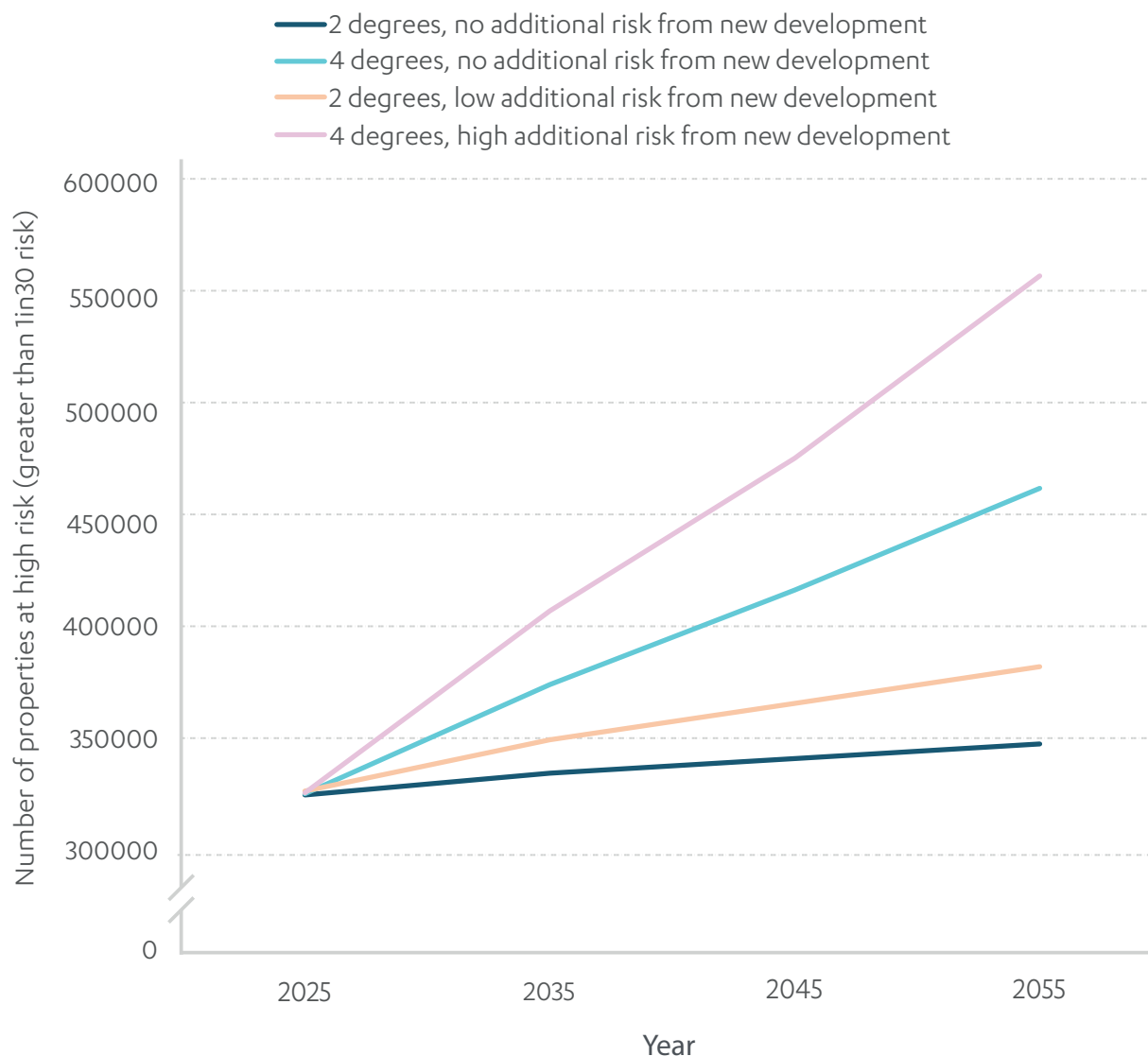
Figure 1.5 shows that climate change that exceeds a two degree increase on preindustrial global averages is the key risk factor in increasing the numbers of properties at risk.

The modelling showed that the number of properties at high risk is set to increase by between 20,000 and 230,000 by 2055, including:

- an increase of around 20,000-135,000 properties in areas at high risk due to the impacts of climate change, which will increase the intensity and frequency of heavy rainfall
- an increase of around 35,000-95,000 properties due to new development putting more pressure on drainage systems.

## Figure 1.5: Climate change and new development will increase properties at high risk

Number of properties at high risk over time in different scenarios<sup>ii</sup>



Source: Commission calculations based on Sayers et al.

The third risk factor is unplanned increases in impermeable surfaces (e.g. front gardens being paved over). This may put a further 50,000-65,000 properties in areas at high risk.<sup>39</sup> Research suggests that increases in impermeable surfaces have previously occurred in towns and cities at a rate of between 0.4 and 1.1 square metres per house per year.<sup>40</sup>

Calculations of properties in areas at risk are based on Environment Agency figures which assume drainage is operating at full capacity.<sup>41</sup> Blockages or lack of maintenance could put even more properties at risk.

ii Represents the future rainfall scenario for the UK corresponding to a global mean temperature increase by 2100 of 2 or 4 degrees

The Commission has not considered the additional risk from new development in its cost modelling in Chapter 4 due to recommendations in the next chapter, which should ensure new developments are responsible for their own surface water drainage.

## 1.5 The Commission's surface water flooding study

In November 2021, the government asked the Commission to assess how the relevant authorities in England can better manage and mitigate surface water flooding, with a focus on the role of infrastructure. The government has specifically asked that the study include:

- analysis of the risks of surface water flooding and the opportunities that exist to address these in the short and long term
- determining improvements needed to drainage systems to manage and prevent surface water flooding in urban and rural areas, including through nature based solutions
- considering the optimum cost benefit analysis of infrastructure options and how these can be combined to provide greater resilience and value for money, including through improving current governance arrangements.

The full terms of reference for the study can be found on [gov.uk](https://www.gov.uk).<sup>42</sup>

### Stakeholder engagement

Over the course of the study the Commission sought input from a wide range of stakeholders including authorities responsible for flood risk management and the public:

- **Call for evidence** – The Commission published a call for evidence which closed in December 2021. This received 49 responses from water companies, local government, professional bodies, regulators and others.<sup>43</sup>
- **Social research** – The Commission carried out an online survey of a nationally representative sample of 2,002 adults in England, plus three focus groups exploring the public's understanding of risks and priorities.<sup>44</sup>
- **Regional sounding boards** – The Commission convened three multistakeholder groups in London, Manchester and the West of England, with two meetings of each.
- **Detailed policy discussions** – The Commission had bilateral discussions including with government departments, the Environment Agency, Ofwat, water companies, local authorities, internal drainage boards, insurance providers and professional bodies.
- **Site visits** – The Commission visited drainage systems in Sheffield and Mansfield.
- **Expert panel meetings** – The Commission had regular meetings with its [Climate Resilience Expert Panel](#), [Design Group](#) and [Young Professionals Panel](#).



## 1.6 Recent and ongoing developments

The Commission's study interacts with a number of recent and ongoing developments in the governance of surface water flooding. These include:

- The Environment Agency and Lead Local Flood Authorities are updating Flood Risk Management Plans, due by the end of 2022<sup>45</sup>
- Water and sewerage companies are finalising Drainage and Wastewater Management Plans, published in draft in June 2022, and to be published in full in 2023<sup>46</sup>
- Ofwat is finalising its methodology for the next Price Review (PR24), which is due to be published in December 2022, prior to evaluating water company business plans for 2025-30
- The Environment Agency is updating guidance to upper tier local authorities and supporting capacity building
- The government published a Storm Overflows Discharge Reduction Plan at the end of August, including a 25 year £56 billion programme of water and sewerage company investment to address untreated sewage discharges into rivers, lakes and seas<sup>47</sup>
- The government also published revisions to the flood risk and coastal change planning guidance in August 2022, and is developing indicators to monitor long term changes in flood and coastal resilience, and monitoring the impact of changes to grant funding policy.<sup>48</sup>

The Commission has taken these into account when developing its recommendations.



# 2. Surface water management

Surface water can be managed by reducing volumes of water entering existing drainage, managing, and improving drainage systems, and planning for when drainage systems are overwhelmed. Changes are needed to carry out all of these more effectively in future.

The Commission recommends that government:

- **implement reforms to put more responsibility on developers to drain their own developments, to mitigate their impact on the volumes of water entering systems**
- **review the effectiveness of available options for managing unplanned increases in impermeable surfaces, which increase the volumes of water entering drainage, and decide whether policy changes are required to prevent it adding to the problem**
- **require local authorities and others to follow the ‘solutions hierarchy’ when improving drainage systems, optimising existing drainage first, then adding above ground solutions before considering new pipes or sewers.**

Recommendations to enhance drainage systems and protect properties when floods do happen, in line with the principles set out in this chapter, are covered in Chapters 3 and 4.

## 2.1 Reducing volumes of water entering existing drainage

### New developments should be responsible for their own drainage

New developments can increase surface water flood risk. They have a legal right to connect to existing drainage infrastructure for surface water.<sup>49</sup> This can undermine policy requirements for developers to first consider more sustainable ways to manage surface water, and increase the volume of rainwater that flows into drainage.

Planning legislation and policy requires:

- local planning authorities to prepare strategic policies that manage flood risks from all sources, including by steering development to areas with the lowest risk of flooding, and by using the opportunities provided by new development to reduce the causes and impacts of flooding
- new developments of ten or more units and all developments in areas at risk of flooding (from any source, now or in the future) to incorporate sustainable drainage systems, in line with the government’s technical standards
- local planning authorities to seek advice from their corresponding local flood authorities for major developments with surface water drainage.<sup>50</sup>

National planning policy does set out processes to help reduce the impact of new development on surface water flooding, but these may not do enough to encourage new developments to properly mitigate their impacts on existing drainage. This is because:

- sustainable drainage systems are only required by planning policy, not law, and are not required for minor developments outside areas at risk of flooding, although these make up the majority of planning applications
- policy and standards do not provide a strong incentive to consider sustainable drainage systems early in the design process, which can lead them to be underused by developers
- local planning authorities are not required to seek and receive advice from the lead local flood authority on minor development, even that proposed in areas at risk of surface water flooding
- sustainable drainage systems are approved on a case by case basis by local planning authorities, which can make it hard to plan them over a wider area
- planning applications often lack clear maintenance agreements for sustainable drainage systems, and local authorities can lack the resources to monitor and enforce compliance.<sup>51</sup>

Local planning authorities have reported surface water flooding in developments under ten years old.<sup>52</sup>

## **Government should implement reforms to put more responsibility on developers**

In response to the 2007 Pitt Review, the government enacted, but did not implement, legislation in 2010 to improve the planning and delivery of surface water drainage in new development. The changes in Schedule 3 to the Flood and Water Management Act 2010 would have:

- made sustainable drainage systems a legal requirement for new development with more than one dwelling, or a construction area of at least 100 square metres
- established a local level approving body for sustainable drainage systems, which would:
  - approve proposed drainage systems in new developments and redevelopments, consulting with water companies where necessary
  - adopt and maintain sustainable drainage systems that serve multiple properties
- amended Section 106 of the Water Industry Act to make the right to connect a new development to the public sewer conditional on the body approving its drainage.<sup>53</sup>

However, government later decided not to implement Schedule 3 in England, in favour of delivering sustainable drainage by strengthening planning policy in 2014.<sup>54</sup> In the intervening years, this approach has been criticised. In Wales, Schedule 3 legislation has been implemented since January 2019. Evidence suggests that it has improved the delivery of sustainable drainage systems, although there remain issues with funding for long term maintenance.<sup>55</sup> In 2022, the government reviewed whether to implement Schedule 3 in England. A decision is still pending.

Government should implement Schedule 3 and update its technical standards for sustainable drainage systems to align with the hierarchy described in section 2.3. Once these changes are made, they should be reflected in relevant national policy and guidance, such as the National Model Design Code and Manual for Streets. This will complement other actions by government and Ofwat to improve processes for the adoption of sustainable drainage systems by water companies.<sup>56</sup>

**Recommendation 1: By the end of 2023, government should implement Schedule 3 of the Flood and Water Management Act 2010 and update its technical standards for sustainable drainage systems.**

## Unplanned increases in impermeable surfaces impact drainage systems

Unplanned increases in impermeable surfaces add to the volume of water entering drainage systems rather than filtering into the soil.<sup>57</sup> According to water and sewerage company Drainage and Wastewater Management Plans, unplanned increases in impermeable surfaces (e.g. front gardens being paved over) could be responsible for about 15-20 per cent of the increase in future flood risk to 2055, equating to around 50,000-65,000 more properties in areas at high risk.<sup>58</sup>

Current planning rules require households to gain planning permission for hard surfacing of domestic front gardens by more than five square metres unless the surface is rendered permeable.<sup>59</sup> Installing smaller areas of hard surfacing in front gardens, and the construction of home extensions, outbuildings and decking on up to 50 per cent of the property area, are classed as 'permitted development', and do not require planning permission.<sup>60</sup>

Local authorities can put in place stronger planning policies for development in areas with limited drainage capacity, and withdraw permitted development rights for specific areas on the grounds of its contribution to flood risk by issuing an 'Article 4 Direction'.<sup>61</sup> However, government has increasingly sought to limit the use of Article 4 Directions and sets a high bar for justification and evidence.<sup>62</sup> Some local planning authorities have reported uncertainty on how to provide this evidence in Strategic Flood Risk Assessments.<sup>63</sup>

Water companies can incentivise customers to reduce impermeable areas by adopting 'Area Based Charging'. This is where drainage charges are made proportionate to the site area that drains into sewers, excluding areas with natural drainage. Some, but not all, water companies have adopted this approach.<sup>64</sup> Ofwat is encouraging water companies to trial approaches for extending Area Based Charging to residential customers.<sup>65</sup>

## Government should review options to address increases in impermeable surfaces

Government could control unplanned increases in impermeable surfaces by, for example:

- reducing the extent of permitted development rights for hard surfaces
- via Building Regulations, for example by requiring the use of permeable materials for surfaces in back gardens, or green roofs for home extensions
- encouraging wider adoption of Area Based Charging, or other incentives
- supporting information campaigns run by local authorities and/or water companies to improve public awareness of the impacts of unplanned increases in impermeable surfaces and encourage behaviour change.

Further restrictions would require sufficient local resources for monitoring and enforcement to be effective, and there are already concerns around local authority capacity.<sup>66</sup> Building regulations can be rigid and lead to excessive caution from builders.<sup>67</sup> And restrictions should not prevent households from creating spaces for electric vehicle charging (although new driveways would not be an issue if they are permeable).

Alternatively, government could accept that unplanned increases in impermeable surfaces will continue to increase the risk of surface water flooding, and factor this impact into its targets, plans and funding, see Chapters 3 and 4. Taking this approach would increase the cost of achieving flood risk reduction targets.

There is a trade off between taking further measures to reduce unplanned increases in impermeable surfaces and allowing them to continue, increasing flood risk. This study could not consider this topic in depth as some of the policy options have implications that go beyond flood risk management. Government should carry out a comprehensive review and decide on the best course of action by the end of 2024.

**Recommendation 2: Government should undertake a comprehensive review of the effectiveness of all available options to manage unplanned increases in impermeable (or hard) surfaces, and their costs and benefits. By the end of 2024, government should decide whether policy changes are required to reduce the impacts on surface water flooding or adjust investment levels for flood risk reduction accordingly.**

## 2.2 Managing and improving drainage systems

### Drainage systems

Rainwater can drain away into the ground or into rivers and eventually the sea, either through natural drainage channels, or manmade drainage infrastructure, see figure 2.1.

Fig 2.1: How surface water is managed



## Combined sewers

‘Combined sewers’, owned by water and sewerage companies, which carry both rainwater and wastewater to treatment works, form a large part of the drainage system. Rainwater from around 62 per cent of properties drains into combined sewers.<sup>68</sup>

The government recently committed to a 25 year, £56 billion programme of water and sewerage company investment to address untreated sewage discharges into rivers, lakes and seas that occur when combined sewer storm overflows spill excess wastewater and rainwater, often during heavy rainfall, potentially causing harm to the environment and public health.<sup>69</sup> Sewer flooding tends to be caused by blockages and sewer collapses, but is sometimes, like surface water flooding, caused by heavy rain.<sup>70</sup> Some combined sewer overflow investment could also help to manage surface water flood risk.<sup>71</sup> However, for the around 40 per cent of properties where surface water is drained separately to wastewater, combined sewer overflow investment will not help manage the risk of surface water flooding.

The main types of drainage are as follows:

- **Infiltration drainage systems** manage rainfall to ensure it soaks and filters into the soil, before returning it to the groundwater. They include permeable surfaces, rain gardens, and depressions or pits where water can drain to (‘infiltration basins’ or ‘soakaways’). They tend to be on private property or owned by public bodies, and can also help improve water quality and support biodiversity.
- **Storage drainage systems** capture rainfall in small storage areas, typically on private property or roads. They are owned by property owners, water companies or public bodies. They can include playing fields, ponds and wetlands, and can improve water quality and biodiversity, as well as storing extra water.
- **Above ground pathways** transfer surface water to other drainage systems. They include ‘swales’ (shallow grassy channels), ‘filter strips’ (gently sloping land, particularly at the side of roads), and raised kerbs. These tend to be owned by public bodies, and can provide additional benefits including biodiversity.
- **Public sewers**, which can drain only surface water or be combined (see box).
- **Pipes** transport water below ground between locations in the drainage system. These include pipes on private property and those draining roads. These are owned by property owners, water companies, and highways authorities.
- **Below ground storage** such as storage tanks, oversized pipes or other storage containers store a fixed volume of water. These are owned by water companies. They have limited benefit beyond managing flows in sewers.

The costs of different types of drainage interventions vary widely depending on type and local conditions. Work to support the modelling carried out on behalf of the Commission provides indicative costs for these interventions, including for sewers and sustainable drainage, but they are not directly comparable.

This indicates improving sewers to increase capacity can cost between £900,000 and £1,300,000 per kilometre, while typical sustainable drainage systems cost between £5,000 and £7,000 per property (all in 2021 prices). The government's existing drive to increase the use of sustainable drainage is likely to improve the ability to make comparisons.<sup>72</sup>

Drainage assets are built to specific standards, which vary depending on their purpose but are usually characterised by the amount of rainfall (measured in terms of intensity and duration) they can cope with, e.g. highway drainage is usually built to manage rainfall with a 1 in 5 or above chance of happening annually, while modern sewers are required to be built to manage rainfall with a 1 in 30 annual probability.<sup>73</sup> The way drainage systems are operated and maintained can mean their day to day capacity is, in reality, less than the designed capacity due to blockages.<sup>74</sup>

## Improving drainage systems: the 'solutions hierarchy'

The recommendations set out in section 2.1 will help reduce the amount of rainwater that would otherwise enter drainage systems. However, drainage systems will still need to be effectively maintained and enhanced to reduce the number of properties already at risk, and help prevent further properties being put at risk, for example as a result of climate change. The appropriate set of interventions to improve drainage systems will be informed by both the physical environment and the drainage infrastructure already in place.

The '**solutions hierarchy**' sets out the order in which drainage interventions should be considered to maximise the range of benefits and reduce costs. It prioritises maintenance and optimisation, followed by above ground interventions, with below ground interventions (pipes and sewers) considered last.

The first option should be **optimising existing drainage infrastructure, through** targeted maintenance and cleaning of existing assets including sewers and gullies, or technological optimisation, including real time control of rainwater in the drainage system during a storm. Starting with optimising existing assets ensures consideration of the lowest cost interventions and can address network blockages that can cause sewer flooding even in relatively low intensity rainfall events. The Commission will consider the maintenance of drainage infrastructure as part of its work on asset management in the second National Infrastructure Assessment.

If existing drainage is not sufficient, **above ground interventions**, such as rain gardens, ponds and kerbs should be considered next, to manage flows of rainwater, and reduce the volumes of water entering below ground drainage. This will reduce the risk of pipes and sewers flooding, and potentially reduce the cost of wastewater treatment. Considering above ground measures before underground pipes and storage also maximises the opportunity to deliver wider benefits, such as improving biodiversity,<sup>75</sup> as well as tending to be cheaper.<sup>76</sup> **Below ground interventions** – additional pipes and sewers – should be the final option considered.

The Commission expects this approach to be followed when single joint plans are developed (see Recommendation 6), and has used the hierarchy to inform its analysis, see Chapter 4. While above ground solutions will not resolve flood risk in many locations, their feasibility should be considered first because of the additional benefits they provide.



## Building the evidence base for above ground solutions at scale

As part of this study, the Commission carried out modelling to identify an indicative level of cost beneficial investment (see Chapter 4). The modelling followed the solutions hierarchy set out above.

The level of above ground solutions indicated by the modelling would represent a significant increase compared to current levels. It is broadly equivalent to around 16.5 times the investment in large scale above ground solutions set out in the green recovery fund, which Ofwat described as ‘a step change in the management of surface water’.<sup>77</sup> This involves a large scale scheme led by Severn Trent Water to deliver the equivalent of up to 60 per cent of the anticipated future network storage required in Mansfield by 2050 through nature based infrastructure. The scheme will include delivery of assets such as street planters, raingardens, detention basins and permeable paving, and will provide improvements to flooding pathways, as well as delivery of wider environmental and social benefits. However, the modelling indicated that the majority of the indicative investment would likely go towards below ground solutions, building or replacing 1,100 kilometres of sewer pipe, around 0.4 per cent of current network length.<sup>78</sup> In the two degree scenario, investment is slightly less skewed towards below ground solutions.

The skew towards below ground solutions is because there is currently more certainty on the drainage capacity (and therefore flood risk reduction) provided by pipes and sewers, and these form part of water and sewerage companies’ regulated asset bases. More pipes and sewers are needed because they can more reliably drain larger volumes of rainwater. In comparison, there is less data around above ground interventions when delivered at scale, in part because they are not yet widely used in the UK. Where there is uncertainty around the capacity needed, pipes look like a better option.

However, it should be noted that the modelling was designed to maximise flood risk reduction. Above ground solutions can also provide additional environmental and social benefits when they include natural elements like plants and ponds. They should be considered before below ground solutions in order to maximise these benefits.

In practice, there is likely to be scope for even more above ground solutions than the modelling indicates. The exact balance of investment between above and below ground solutions will depend on local circumstances and should be decided in local areas. And as sustainable drainage schemes are implemented more and the evidence base becomes stronger, they may become more attractive.

Government and Ofwat has indicated that they want to facilitate a greater use of nature based solutions. It is important that the regulatory framework for water companies explicitly permits investment at scale in sustainable drainage systems and provides companies with additional surety of funding for these types of solutions where cost effective (see Chapter 4). This will enable the sector to move beyond important pilots such as Mansfield to scaling up nature based solutions where appropriate.

## 2.3 Planning for when drainage systems are overwhelmed

It is not always feasible or cost effective to build a drainage system that can cope with even the most extreme rainfall events throughout the country, so there will always be instances when they are overwhelmed. Therefore, there need to be plans in place to manage surface water flows when there are extreme rainfall events, to avoid damage to buildings and infrastructure. This can be addressed through landscape resilience measures and property level resilience measures.

Landscape resilience measures divert flooding away from buildings and infrastructure when drainage systems are overwhelmed. Guidance on how to approach design for such events broadly involves changing specific elements of the urban environment to safely route and store surface water flows when the capacity of the drainage system is exceeded.<sup>79</sup> Options include using roads to channel water, raising or dropping kerbs to redirect water, and using areas like car parks and open green space for temporary storage. These approaches often require coordination between organisations, and have been used in parts of Cornwall, Oxfordshire and the West Midlands.<sup>80</sup> Improved modelling can improve understanding of the places at risk in exceedance events, see Chapter 3. These measures should be considered in the single joint plans, see Chapter 4.

Property level resilience measures include physical measures like flood barriers, sealed air bricks, and small pump units that can help to prevent water from entering buildings or enable quicker recovery after flooding. Flood insurance can also support a quicker recovery. The measures are often recommended when properties suffer from frequent flooding or where other flood management measures are not cost effective. This is covered in more detail in Chapter 4.



# 3. Identifying the places most at risk and setting targets for improvement

National government, regulators, local government and water companies must work together to identify the places most at risk of surface water flooding and set targets for risk reduction to help track progress. As climate change increases the risk of surface water flooding, this will become even more important.

National and local flood risk maps and models do not align. The Environment Agency does not set a national target for reducing surface water flood risk, and the areas most at risk of surface water flooding do not typically identify quantifiable local targets for risk reduction.

The Commission recommends:

- the Environment Agency should use the results of the second National Flood Risk Assessment in 2024 to improve the identification of flood risk areas
- improving local risk mapping in the new flood risk areas and integrate local maps into the Environment Agency's national model
- government should set a long term target for a percentage reduction in the number of properties at high and medium risk of surface water flooding
- authorities responsible for the new flood risk areas should agree appropriate local targets.

## 3.1 Identifying the areas at highest risk of flooding

As the risk of surface water flooding increases, it will be vital to have a consistent and rigorous process for identifying the areas at highest risk, based on the best possible data. This will help direct funding and efforts to the places that need them most.

### **'Flood Risk Areas' are not always identified precisely and consistently**

The Environment Agency supports upper tier local authorities to identify areas where there is a 'significant' risk of surface water flooding – known as 'Flood Risk Areas'. These are reviewed every six years, in accordance with the Flood Risk Regulations 2009. The next review is planned for 2023.<sup>81</sup>

The Environment Agency uses its national data to identify indicative flood risk areas based on thresholds for the number of people, services, or properties at risk from surface water flooding per square kilometre. Upper tier local authorities then use their local knowledge to review and refine the proposed areas. The Environment Agency has a last review to ensure its guidance has been applied appropriately and consistently and confirms the final Flood Risk Areas.<sup>82</sup>

However, the process does not appear to result in consistent outcomes. In one case, a Flood Risk Area has simply been defined using a local authority's administrative boundaries. In other cases, Flood Risk Areas have square boundaries which do not fully align with the topography of those places.<sup>83</sup> These results are counterintuitive, and likely reduce effective coordination across local authority boundaries.

Risk mapping needs to be sufficiently accurate to best deliver protection to areas truly at high risk and encourage joined up working across organisational and administrative boundaries. Government and the Environment Agency should review the criteria used to identify flood risk areas and provide greater clarity and consistency in how those areas are defined.

## **Future processes should take advantage of better data**

One of the sources of data the Environment Agency uses to identify flood risk areas is the National Flood Risk Assessment. The first National Flood Risk Assessment took place in 2004.<sup>84</sup> The second is due to be published at the end of 2024,<sup>85</sup> which falls after the next planned review of flood risk areas in 2023.

The second National Flood Risk Assessment will provide the Environment Agency with an updated national flood risk map, based on better modelling of terrain, and urban and rural drainage rates. It will also reflect better data on flood defences and other assets which alter the flow of water, such as channels and bridges.

Government should consider delaying the next review of flood risk areas to 2025, to allow the Environment Agency to use the results of the second National Flood Risk Assessment when identifying new flood risk areas. This would provide a better basis for identifying those areas at highest risk and for directing future interventions and investment.

## **Upper tier local authorities do not typically produce high quality risk mapping**

The Environment Agency produces a nationwide map of surface water flooding risk, the 'Risk of Flooding from Surface Water Map'. It is broadly accurate at a high level, but it does have major limitations.<sup>86</sup> The 2024 National Flood Risk Assessment process will help improve this map. But more granular local data – that aligns with the Environment Agency's own modelling – would enable flood risk mapping to account for local drainage systems and small topographical changes, such as channels, dropped kerbs, and raised pavements, which can significantly affect where water flows. This data would improve the reliability of risk mapping at the street or property level.<sup>87</sup>

## Variations in the quality and comprehensiveness of surface water flood risk data

A lack of high quality, comprehensive data is an obstacle to effective surface water management:

- **There is variation in the quality and quantity of data on drainage assets:** Across the sector, some organisations – whether local authorities or water and sewerage companies – have detailed data on their assets and their performance,<sup>88</sup> while data on some assets, such as culverts, may be very limited.<sup>89</sup> Where data exists, often it is not shared freely due to commercial, privacy or reputational concerns,<sup>90</sup> or is not interoperable.<sup>91</sup>
- **There are inconsistencies in how upper tier local authorities maintain asset registers:** Upper tier local authorities are required to maintain registers of assets (theirs and those of third parties) and their condition.<sup>92</sup> However the quality and comprehensiveness of these registers vary.<sup>93</sup>
- **There are differing approaches to how upper tier local authorities investigate floods:** Upper tier local authorities are usually required to investigate local floods.<sup>94</sup> However, there can be inconsistencies between the data collected and the modelling carried out.<sup>95</sup>

These have been addressed by recommendations in previous reviews, including the 2020 Jenkins Review, which recommended that government and the Environment Agency develop and issue national guidance on asset registers and flood investigations.<sup>96</sup> Government has accepted those recommendations, but not yet implemented them.<sup>97</sup> The 2022 London Independent Flood Review also recommended that authorities review critical assets and identify ways of monitoring data to inform decision making and prioritisation.<sup>98</sup>

There are 63 designated Flood Risk Areas in England, spanning an area covered by 95 local authorities. However, not all upper tier local authorities in these Flood Risk Areas produce high quality risk mapping that can be integrated into the model – currently only 35 out of 95 have modelling integrated into the national map. Some upper tier local authorities have been given grants to develop local mapping on a risk basis,<sup>99</sup> but otherwise progress has been piecemeal.

Where upper tier local authorities develop their own risk maps and share them with the Environment Agency, they supersede the Agency's own modelling results.<sup>100</sup> However, local authorities do not typically work with other relevant authorities to produce them, and water and sewerage companies and others do not routinely share their asset data, models and maps with upper tier local authorities.<sup>101</sup> There is also no requirement to make local modelling interoperable with Environment Agency maps and models.<sup>102</sup>

The government's 2018 Surface Water Flooding action plan said that the Environment Agency would "work with Lead Local Flood Authorities, insurance companies and water and sewerage companies about accessing and sharing the data they hold and the modelling they have completed, with the objective of making this information more accessible to the public and using it to improve the surface water maps."<sup>103</sup> The Environment Agency should continue to do this.

## **The new flood risk areas should be supported to deliver interoperable risk maps**

In the new flood risk areas, the relevant upper tier local authorities should be required to work with water and sewerage companies, insurance companies, and, where relevant, internal drainage boards, to develop their flood risk maps and to develop models to appraise potential interventions. Government should support this by providing funding, support and coordination where necessary, and the Environment Agency should work with local authorities to make sure the maps and models align with its own.

These maps and models should then be integrated into the national risk map. This will provide consistency between national and local level maps, improve the process of identifying priority areas of flood risk and enable easier monitoring of progress. In turn this will provide benefits to insurers and lenders, who can more accurately price their products, and to current and prospective property owners who use the national level map. Government should review the case for commencing provisions in the Flood and Water Management Act 2010 that would provide powers to sanction authorities that do not share data so that the Environment Agency can include it in the national mapping. The surface water flood models that are used to create these improved maps will be essential tools for prioritising flood risk reduction measures and developing shared plans (see Chapter 4).

### **Recommendation 3: Government should:**

- **require the Environment Agency to use the results of the second National Flood Risk Assessment in 2024 to identify new flood risk areas**
- **from 2025, require upper tier local authorities, water and sewerage companies, and other relevant authorities in the new flood risk areas to, where necessary, develop detailed local risk maps that can be integrated into the Environment Agency's national map, and models that can be used to plan future management of surface water flooding.**

## 3.2 New targets to reduce properties at risk

### The lack of a common goal slows progress and prevents effective monitoring

While the government has set goals for overall flood risk reduction and property protection by 2027,<sup>104</sup> there is currently no quantifiable long term target for reducing the risk of surface water flooding, nor a framework to agree one locally.<sup>105</sup> The Environment Agency's 2020 Flood and Coastal Erosion Risk Management strategy does not define clear policy goals for surface water flooding. By contrast, other policy objectives in the government's 25 Year Environment Plan (although not river and coastal flooding) have clear outcome targets which are being legislated under the 2021 Environment Act.<sup>106</sup>

The lack of a common goal limits progress. Risk management authorities have no shared commitment to deliver an outcome within a set timeframe, and national policy and strategy does not provide sufficient detail to drive local action and encourage coordination. The various components of a drainage system are designed to achieve different levels of performance, based upon sector specific codes of practice and standards, rather than to achieve a common outcome in terms of risk reduction.<sup>107</sup>

The lack of targets also prevents effective monitoring. Without them, there is no robust way for government to determine whether local action adds up to sufficient progress at a national level.<sup>108</sup> The Environment Agency currently only reports on the number of properties in areas at different levels of surface water flooding risk as part of a wider target to 'better protect' properties from all types of flooding by 2027. The National Audit Office and Efra Select Committee have both stated the need for quantifiable targets to monitor progress and allocate funding efficiently.<sup>109</sup>

### Government should set a national target to reduce properties at risk

Government should set a national target for risk reduction to drive and monitor progress. Identifying such a target – which would be measured by the number of properties remaining at different risk levels – requires consideration of what is achievable, what is cost beneficial, and what is affordable.

Modelling carried out on behalf of the Commission indicates that investing in drainage infrastructure measures where the benefits outweigh the costs could reduce the number of properties that would otherwise be at high risk of surface water flooding by 2055 by around 60 per cent. This level of investment would also reduce the number of properties that would otherwise be at either high or medium risk – a much larger group – by around 30 per cent. However, this amount is only indicative, and government should assess the appropriate level itself based on improved Environment Agency mapping and modelling. Government's target will need to consider the potential risk reduction that can be achieved by all types of flood risk protection (including individual property protection), not just improvements to drainage infrastructure.

Upper tier local authorities, water and sewerage companies, and, where relevant, internal drainage boards in the new flood risk areas should identify quantifiable local targets for reductions in surface water flooding – and the flood damage avoided – as part of their single joint plans, see Chapter 4. As part of the assurance process for joint plans, the Environment Agency should consider if local targets will deliver the progress needed to meet the national target.

The Environment Agency should publish rigorous, comparable data on local authorities' progress in reducing local flood risk, and overall progress against the national target to maximise transparency and accountability, including enabling local citizens to hold local leaders to account, and Ofwat to assess water and sewerage company progress. Local authorities should also be expected to publish information enabling them to be held to account by local people.

Progress in delivering against the targets should be reported on annually. The targets themselves should be reviewed every five years to ensure they remain ambitious, affordable and deliverable.

**Recommendation 4: By early 2025, government should set a long term target for a percentage reduction in the number of properties at high and medium risk of surface water flooding**

**Recommendation 5: The government should require risk management authorities in the new flood risk areas to agree appropriate local targets by mid 2025.**





# 4. Joint plans and devolved funding

A more focussed approach to surface water flooding is required, with clear plans and responsibilities. Water and sewerage companies should have a key role in draining local areas and reducing surface water flood risk. They should work with local authorities to develop single joint plans to address local flood risks. And government should devolve public funding to local authorities in or containing new flood risk areas, to address local flood risks.

The Commission recommends that:

- government should clarify in its strategic priorities that Ofwat should enable water and sewerage companies to invest in solutions to manage surface water flooding
- Ofwat should provide companies with additional surety of funding for sustainable drainage solutions where appropriate
- in the new flood risk areas, local authorities and water and sewerage companies and, where relevant, internal drainage boards should be required to deliver costed, long term, joint plans to address surface water flood risk
- the joint plans should be assured by the Environment Agency, with input from Ofwat
- for properties remaining at high risk of flooding, government should explore options for supporting property level measures.

The Commission's analysis suggests total public and private investment of around £12 billion up to 2055 would deliver cost effective reductions in surface water flood risk. Of this, £3.6 billion would be above current baseline expenditure by government and water companies.<sup>110</sup>

## 4.1 Water and sewerage companies' role

Water and sewerage company assets will have a key role to play in reducing the risk of surface water flooding in future, through both improvements to below ground drainage systems, and delivering further above ground interventions that can relieve pressure on pipes and sewers. However, water and sewerage companies are currently not encouraged to address surface water flooding, and water and sewerage company investment has typically focussed on pipes and sewers, rather than above ground interventions.

The analysis for this study shows that there will need to be significant enhancements to the capacity of below and above ground drainage infrastructure to reduce the risk of surface water flooding over the next 30 years. A large part of this investment will need to come from water and sewerage companies to ensure their infrastructure keeps pace with external pressures.

Water and sewerage companies have a legal duty to provide, improve and extend public sewers, and to cleanse and maintain those sewers to ensure that their areas is, and continues to be, effectually drained.<sup>111</sup> However, this duty has tended to be interpreted as meeting the entitlement for property owners and developers to connect to public sewers to discharge surface water, and addressing sewer flooding. Ofwat's outcome delivery incentives, including those planned for the next Price Review, encourage water and sewerage companies to focus their efforts on preventing internal and external sewer flooding, rather than sewer flooding caused by heavy rainfall.<sup>112</sup>

Water and sewerage companies' Drainage and Wastewater Management Plans reflect this. The plans are intended to identify risks to their drainage assets and solutions to mitigate these risks up to 2050, and inform water and sewerage company business plans.<sup>113</sup> Draft first round Drainage and Wastewater Management Plans for Price Review 2024 did not all address surface water management, and those that did only identified risks to properties from their own drainage assets.

Water and sewerage companies will play a key role in reducing surface water flood risk, by improving drainage. Government should clarify in its strategic priorities for Ofwat that it should enable water and sewerage companies to invest in solutions to manage surface water flooding.

The focus of investment will also need to change. Private investment from water and sewerage companies' customer bills has largely funded below ground drainage, such as pipes and sewers. This is because both Ofwat and water and sewerage companies have greater confidence in the ability of pipes and sewers to reduce sewer flooding than above ground solutions, and because companies are concerned the operational maintenance cost of above ground solutions won't be sufficiently accounted for in their allowances.<sup>114</sup> However, this is starting to change. For example, Severn Trent's programme in Mansfield includes substantial above ground drainage investment.<sup>115</sup> This should increase the confidence of Ofwat and water and sewerage companies in deploying above ground drainage solutions at scale.

Water and sewerage companies should be encouraged to deliver both above and below ground solutions. Ofwat has already made changes to allow water companies to adopt a wider range of assets, including some sustainable drainage systems,<sup>116</sup> and government plans to strengthen these processes by implementing Section 42 of the Flood and Water Management Act.<sup>117</sup>

As emphasised in the government's strategic priorities for Ofwat,<sup>118</sup> Ofwat should ensure its methodology for the next Price Review period (2024) creates a level playing field for below and above ground interventions, including sustainable drainage systems. It could do this by explicitly permitting water companies to recover the costs of strategic investment in sustainable drainage from water bills (including maintenance costs) and creating a mechanism for them to do so. Ofwat has proposed to address this in their draft methodology for the next Price Review in 2024.<sup>119</sup>

## **Recommendation 6: Government should:**

- **clarify in its strategic priorities for Ofwat that it should enable water and sewerage companies to invest in solutions to manage surface water flooding including sustainable drainage**

To best address the risks of surface water flooding, water and sewerage companies will need to work closely with the other authorities responsible for addressing this risk, including upper tier local authorities and, where relevant, internal drainage boards.

## **4.2 Single joint plans for shared risks**

As set out in Chapter 3, understanding local flood risks and solutions requires local knowledge. In the majority of the country, lead local flood authorities in upper tier local authorities are the main organisations responsible for managing the risks of surface water flooding. Currently, upper tier local authorities and water and sewerage companies have disconnected processes for planning, funding and delivery.<sup>120</sup>

Upper tier local authorities develop, maintain, apply, and monitor Local Flood Risk Management Strategies for managing flood risks from surface water, groundwater and some rivers. These reflect county council and unitary authority boundaries and are published to various cycles, depending on local authority priorities. They are required to be consistent with the national Flood and Coastal Erosion Risk Management Strategy for England, cover all local flood risks, and describe what the upper tier local authority and others are doing to meet their objectives.<sup>121</sup>

Drainage and Wastewater Management Plans are expected to demonstrate links with other plans, including upper tier local authorities' Local Flood Risk Management Strategies, but there is no legal requirement for them to be consistent.<sup>122</sup>

In the first National Infrastructure Assessment, the Commission recommended that water and sewerage companies and local authorities should work together to publish joint plans to manage surface water flood risk.<sup>123</sup> Government responded that Drainage and Wastewater Management Plans would help achieve this.<sup>124</sup> However, Ofwat has expressed concerns about the quality of water and sewerage companies' engagement with local authorities, particularly to address surface water management.<sup>125</sup>

Good practice does exist. Partnerships have emerged to improve coordination in different parts of the country, such as Severn Trent's Mansfield project, Manchester's IGNITION project, Sheffield's Grey to Green project and the collaboration between Northumbrian Water, the Environment Agency and North Tyneside Council.<sup>126</sup> However, the majority are pilot projects and reliant on one-off funding.

Since surface water flood risk can extend beyond administrative boundaries, particularly in larger urban areas, where upper tier local authorities and water and sewerage companies should also partner with neighbouring councils, and, where relevant, internal drainage boards. This can be challenging,<sup>127</sup> but in London, a new partnership is being established to develop a strategic plan for managing surface water across the city.<sup>128</sup>

Stronger partnerships between water and sewerage companies and upper tier local authorities, coordinating planning, funding and delivery on set timescales, should become the norm for managing surface water flooding in future.

## Single, costed, joint plans

Upper tier local authorities, water and sewerage companies and, where relevant, internal drainage boards in the new flood risk areas should develop and deliver long term, costed, joint plans, setting out local targets for flood risk reduction. The plans should be mandatory. In large urban areas with complex drainage catchments, it may be appropriate to have a single joint plan that covers multiple upper tier local authorities.

For upper tier local authorities in or containing new flood risk areas, joint plans should replace Local Flood Risk Management Strategies, and be based on their own local knowledge and accountability. For water and sewerage companies', the joint plans should inform, not replace Drainage and Wastewater Management Plans as agreed by Ofwat, which necessarily relate to wider geographic areas and also address issues beyond surface water flooding.

The joint plans should:

- set out a common vision for managing surface water flooding
- identify quantifiable local targets for the reduction in surface water flooding that will be achieved by the investment programme, and the flood damage avoided
- assign clear roles and responsibilities
- be based on the joint flood risk models described in Chapter 3
- contain a costed programme of public and private investment for the next five years, plus indicative plans for the next 20 years, which is consistent with the public funding available or expected, and reasonable expectations for regulatory settlements
- follow the 'solutions hierarchy' set out in Chapter 2
- be stress tested for a range of more extreme events, and where necessary set out plans for property level measures or additional exceedance management approaches such as landscape level surface water management
- include a framework for reporting progress and adapting the plans, allowing them to expand their drainage solutions if circumstances change
- design drainage systems based on the Environment Agency's chosen climate scenarios, taking an adaptive approach where possible, but designing pipes and sewers for more extreme scenarios if replacing them later would be more expensive
- set out how other local flood risks (previously covered in Local Flood Risk Management Strategies) will be managed

- consider how they can address related challenges, including water pollution (from combined sewer overflows and other pollutants), urban regeneration and nature recovery
- have regard to the Commission’s Design Principles for National Infrastructure.<sup>129</sup>

The Environment Agency should review and assure the joint plans, with input from Ofwat and support from Regional Flood and Coastal Committees, by 2026. As part of this assurance process, the Environment Agency should consider if local targets will deliver the progress needed to meet the national target. The plans should be revised and assured every five years, to inform the following Ofwat Price Review.

The requirement for mandatory joint plans will improve the effectiveness of the duty for risk management authorities to cooperate in managing local flood risk. As part of its reform of local flood risk planning, government should consider how best to introduce the requirement for costed, joint plans to reduce surface water flooding in a way that simplifies and streamlines the existing flood risk planning landscape and ensures alignment, where necessary, with other flooding plans and environmental policies. It should be for the local bodies themselves to choose the best operating and governance model to oversee the development and delivery of the joint, costed plans.

As set out in Chapter 3, the Environment Agency should publish rigorous, comparable data on local authorities’ progress in reducing local flood risk, and overall progress against the national target to maximise transparency and accountability, including enabling citizens to hold local leaders to account and helping Ofwat to assess water and sewerage company progress. Reporting should focus on the surface water flood risk to specific numbers of properties, and the cost effectiveness of the measures that have been implemented to reduce risk.

To develop and deliver joint plans effectively, it will be critical that all authorities involved, including the Environment Agency and local authorities, have the right funding and capacity to fulfil their roles. The Chartered Institution of Water and Environmental Management is currently running a survey on risk management authority capacity,<sup>130</sup> which government should use to help identify and address any gaps.

### **Recommendation 7: Government should require:**

- **upper tier local authorities, water and sewerage companies, and, where relevant, internal drainage boards in the new flood risk areas to produce and deliver costed, joint investment plans for managing surface water that achieve the agreed local objectives and follow the ‘solutions hierarchy’**
- **the Environment Agency to review and assure the final plans with input from Ofwat and support from Regional Flood and Coastal Committees, and publish data on progress against local and national targets**
- **joint plans to be completed by 2026 and revised every five years following the review of flood risk areas the year before, and to inform the following Ofwat Price Review.**

A lack of long term funding has meant that some authorities have not developed high quality, long term, costed programmes of investment to address surface water flooding. Existing local strategies have varied widely in quality and ambition, and, while they are required to include costs, in practice this has varied from some limited data on costs to more rigorous cost estimates.<sup>131</sup> Upper tier local authorities will not develop effective joint plans if there is uncertainty about their ability to secure the funding needed to implement them.

### 4.3 Devolved local funding for local flood risks

Local authorities making long terms plans for reducing flood risk in their areas require greater certainty on funding. This will help to provide the confidence to invest resources in planning, building capacity and identifying partnership funding to deliver programmes of interventions. The current process of competitive bidding for individual flood risk management schemes makes this difficult.

The Commission's analysis, based on published information, suggests the main source of funding for drainage interventions – around 60 per cent of current investment in new drainage infrastructure (c. £160 million a year) – is from water and sewerage companies, paid for via bills, and determined by Ofwat.<sup>132</sup> It is not possible to establish a precise figure for current spending on maintenance related to surface water flooding, because maintenance spend delivers multiple other benefits.

The remaining 40 per cent largely comes from public funding, including:

- Grant in Aid, a competitive pot administered by the Environment Agency in accordance with Defra's partnership funding policy, which covers all forms of flooding, typically requires applicants to secure partnership funding from other sources, and makes up around 45 per cent of current public funding for surface water flood schemes
- local authority expenditure, funded through government grants, revenue from local levies, and council tax, which makes up around 37 per cent of current public funding
- investment in drainage from National Highways' road investment strategy, which makes up around 10 per cent of current public funding
- other central government funding through the Environment Agency's Flood and Coastal Resilience Innovation Programme and Defra's core retained budget, which together make up around nine per cent of current public funding.<sup>133</sup>

Upper tier local authorities report that bidding for Grant in Aid can be resource intensive, time consuming and uncertain, particularly for smaller schemes.<sup>134</sup> Government does not assess whether local authority funding is sufficient to address the flood risk they experience, which makes it difficult to tell if funding is being directed to the places with the highest level of risk.<sup>135</sup>

To support long term planning, government should devolve funding to upper tier local authorities in or containing new flood risk areas, for the purposes of managing surface water flooding along with other local flood risks (although surface water will likely be the main flood risk in these areas). The devolved budgets should initially be set for the five years from 2026-2031 and communicated prior to the development of the first joint plans, and calculated based on the Environment Agency's assessment of the level of risk in each new flood risk area.

Further indicative budget allocations should be given for future five year cycles over a 20 year period. Government should adjust budget allocations depending on upper tier local authorities' progress against their local targets.

This should remove the need for local authorities to bid to the Environment Agency for grant funding for surface water flooding interventions in the new flood risk areas.

While the additional public investment suggested by the modelling carried out on behalf of the Commission is not a significant increase on current levels, devolving this funding to local areas should ensure it is spent more effectively, as local bodies are best placed to understand local risks and solutions. Local authorities should also be expected to spend this money on the most cost beneficial interventions, make evidence based decisions, evaluate the performance of their investments, and publish information enabling them to be held to account by local people on how they have invested in infrastructure.

A suggested process, and estimates of total funding needed, are set out below.

## **Estimating total public sector investment required**

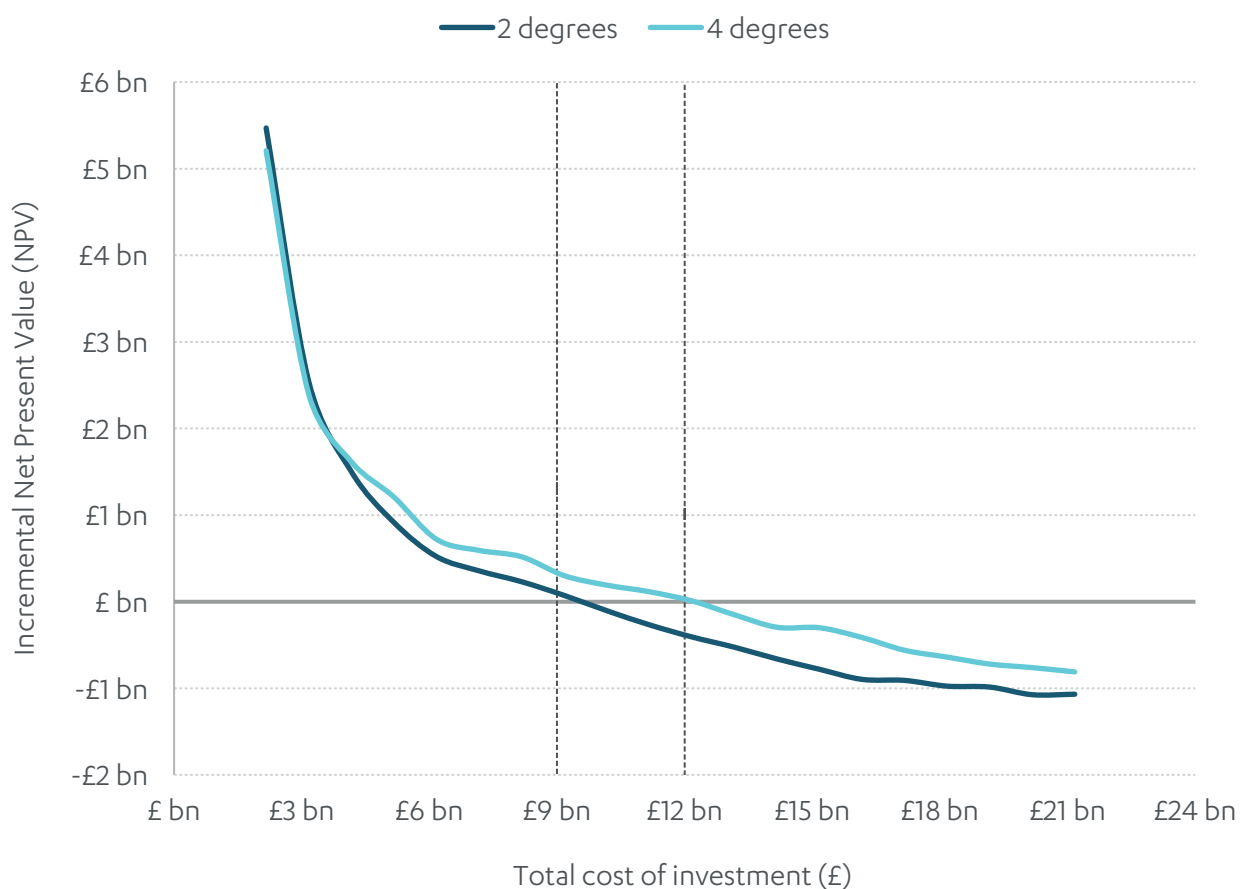
To estimate the public funding needed, the Environment Agency could use its improved maps and models to provide an estimate of the total investment needed to deliver cost beneficial interventions in new flood risk areas (which would also inform the national and local targets), and then assess the proportion of these to be delivered via public sector funding.

Modelling carried out on behalf of the Commission indicated that delivering cost beneficial investments would require total combined public and private investment of around £12 billion between 2025 and 2055 (within a range of £10.5 – 14.5 billion),<sup>136</sup> about £3.6 billion above current indicative baseline expenditure.<sup>137</sup>

This baseline includes an around 40 per cent increase in funding since 2020, including a doubling of funding through the Environment Agency's Flood and Coastal Erosion Risk Management grant in aid programme, and one off funds including the Environment Agency's Flood and Coastal Resilience Innovation Fund and Ofwat's Green Recovery Fund. The Commission's proposals require sustaining and increasing this higher level of investment.

### Figure 4.1: £12 billion will deliver cost beneficial measures, even in a four degree climate change scenario

Incremental costs and benefits at different levels of investment, by scenario<sup>iii</sup>



Source: Commission calculations based on Sayers et al.

Using the current public and private funding split as an indicator, the Commission estimates that around 40 per cent of additional expenditure (£1.4 billion) would add £37 million per year in capital expenditure to public investment to 2055, plus additional operational expenditure. The exact public/private split will be determined by government.

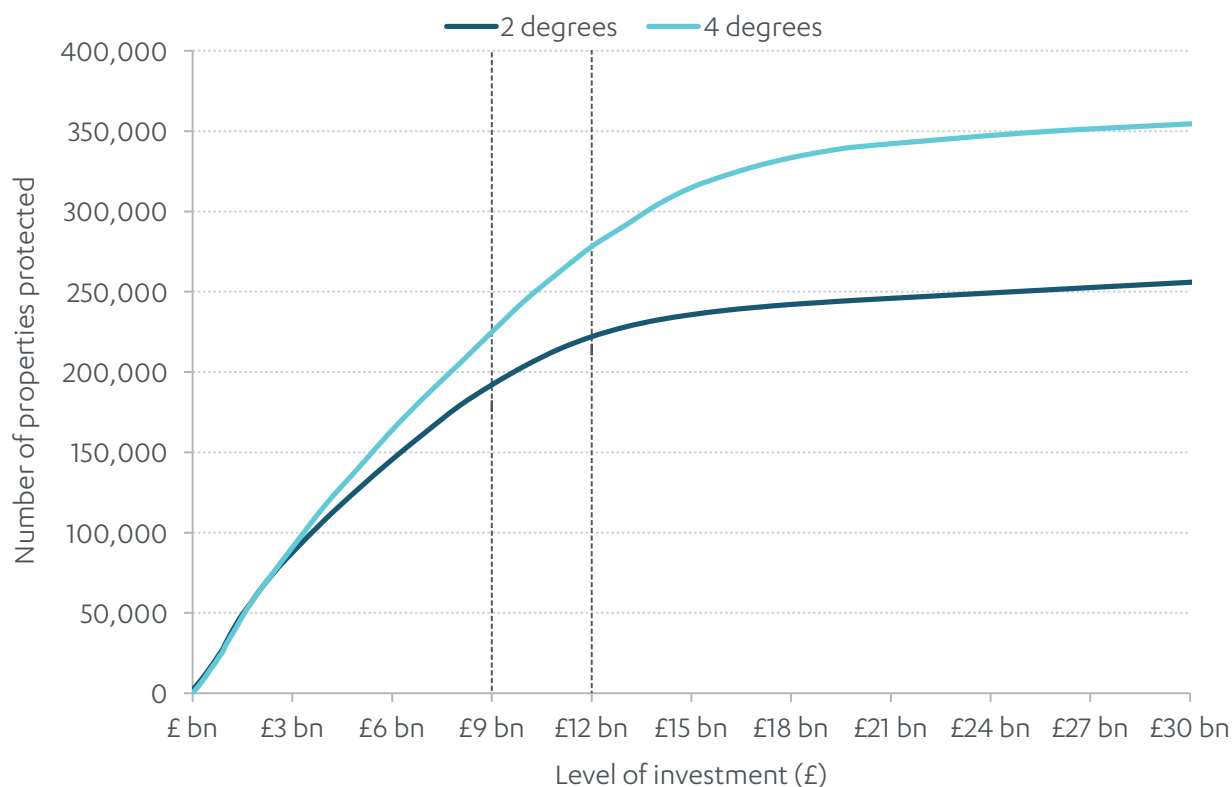
Investing more than this would mean investing in schemes that cost more than they deliver in benefits and, according to the model, would not protect many more properties, see figure 4.2. The model suggests that the combined public and private spending proposed could reduce the number of properties that would otherwise be at high risk of surface water flooding by 2055 by around 60 per cent.

<sup>iii</sup> Represents the future rainfall scenario for the UK corresponding to a global mean temperature increase by 2100 of four degrees



**Figure 4.2: Investment beyond £12 billion would not protect significantly more properties**

*Levels of investment vs number of properties removed from 'high risk' level<sup>iv</sup>*



Source: Commission calculations based on Sayers et al.

## Managing uncertainty

The Commission's calculation of total investment is for a four degree climate change scenario. This is not because the Commission thinks this is the most likely, but because it is the lowest risk approach. The actual future increase in rainfall in different climate scenarios is uncertain (see Chapter 1),<sup>138</sup> and so it will be important to be resilient to a range of scenarios. This could include taking an adaptive approach, whereby the investment strategy could be changed as more information about future rainfall patterns becomes available, meaning £12 billion would be the upper end of the potential spend.

Although investing for a four degree scenario risks spending £3 billion more than is economically optimal if warming only occurs to two degrees above preindustrial levels, the extra spend would still deliver around £2.2 billion of benefits including protection for 62 per cent of properties instead of 51 per cent.

The required spend may be reduced due to the overlap with government's planned investment in combined sewer overflows. As set out in Chapter 1, the government has committed to allowing water companies to invest £56 billion across 25 years to reduce combined sewer overflow spills.<sup>139</sup> Reducing rainwater flows in sewers will contribute to reducing the risk of combined sewer overflow spills. This means some combined sewer overflow investment could

iv Represents the future rainfall scenario for the UK corresponding to a global mean temperature increase by 2100 of two or four degrees

be designed to also address surface water flooding, reducing the total investment needed. A few successful schemes have been designed to address both goals, demonstrating what is potentially possible.<sup>140</sup>

The Environment Agency will need to take the potential reductions into account when estimating the public funding requirement. Water and sewerage companies and local authorities should explore the scope for synergies between spending on combined sewer overflows and surface water flooding in their joint plans. However, the scope for overlap will be limited: around 40 per cent of the country is not served by a combined sewer network.<sup>141</sup>

### **Assessing investment need for drainage interventions**

The Commission asked Sayers and Partners LLP to carry out modelling to assess the indicative investment needed to deliver drainage improvements for which the benefits outweigh the costs. The model allowed the implementation of interventions, and their associated costs and benefits, to vary according to the geographical and other characteristics of each area, to mimic the fact that each individual area will require a tailored solution. This broadly followed the approach set out in Chapter 2, implementing above ground before below ground measures.

The modelling used two scenarios for climate change: a two degree increase in global mean temperatures compared to preindustrial levels, and a four degree increase, using the Met Office's UKCP18 climate projections convection permitting model.

For each of the portfolios, a wide range of benefits were accounted for. The benefits fall into three broad categories:

- damage avoided to properties, business and infrastructure, including statistical risk to life and the negative mental health effects of flooding
- savings from merging investment in combined sewer overflows with surface water flood risk reduction investment
- wider benefits, including health benefits from the provision of new green space.

Since little is known about current asset condition and the extent of its impact, the model assumes drainage is working at full capacity, and so does not account for investment in maintenance. This means all estimates included in this report do not include investment for maintenance of existing drainage.

The model operates at a national scale and makes assumptions about local conditions and future efficiencies in infrastructure solutions. Real conditions will not always align with the model's assumptions and, as discussed in Chapter 3, the model is based on the Environment Agency's current assumptions about properties at risk, which may change following the National Flood Risk Assessment process in 2024. This means it is unlikely that it will identify the optimal portfolio in every location – the more detailed modelling recommended in Chapter 3 should do this more effectively, providing the basis for the quantified plans that are recommended in the Chapter. More detail is set out in the **Flood Model Technical Annex**.<sup>142</sup>

## Allocating devolved, local funding to address local flood risks

Once the total budget for public sector investment has been identified, the Environment Agency could use a formula to calculate the budget for individual new flood risk areas, taking into account:

- the level of risk in each flood risk area, to ensure that places with more properties at high risk will get the most public funding
- how much it expects to be delivered by water and sewerage company investment, overseen by Ofwat – the Commission’s baseline estimates this at 60 per cent, but it will be for the government to ultimately determine how much should be met by taxpayers
- how much it expects local authorities to secure from other sources of partnership funding, such as highway investment or developer investment in drainage assets – again this could be initially based on current levels.

Government will then devolve the funding to the appropriate level of local government, based on its calculations of the total investment required, and how to allocate it based on local levels of risk.

## Water and sewerage company investment

Public investment, with the exception of highways drainage, has tended to focus on above ground interventions, including sustainable drainage systems. Private funding to deliver the joint plans will continue to come primarily from water and sewerage companies’ customer bills.

As set out in section 4.1, government’s clarified strategic priorities for Ofwat should enable water and sewerage companies to make investments to tackle surface water flooding, and methodology changes should mean they are more able to invest in above ground solutions. Draft Drainage and Wastewater Management Plans from some companies (such as Thames Water) already include ambitious proposals on surface water flooding.

Water and sewerage companies would put forward investment proposals that contribute to the single joint plans in Price Reviews from 2029 onwards once joint plans have been developed and reviewed. To maintain progress in the meantime, Ofwat should consider identifying some areas where it will prioritise investment in reducing surface water flood risk ahead of the Price Review in 2029.

The total water and sewerage company investment that Ofwat deems best value to deliver local targets may be less than expected by the Environment Agency (or estimated by the Commission, see above). However, this should not be an issue as long as water and sewerage company investment delivers against the joint plan, and local surface water flood risk targets are achieved.

Using the current public and private funding split as an indicative average figure, modelling carried out on behalf of the Commission estimates that water and sewerage companies delivering cost beneficial investments to address surface water flooding would add £2 per year to average annual water bills between now and 2055. The impact on bills will vary significantly from region to region due to the uneven spread of surface water flood risk.

The Commission's calculations assume that at least 60 per cent of future expenditure on enhanced drainage will be from water and sewerage company investment, based on its analysis of current expenditure and likely future requirements, but it will be for government to consider the precise split.

**Recommendation 8: By the end of 2025, government should devolve public funding to upper tier local authorities in or containing new flood risk areas, based on the Environment Agency's assessment of the levels of risk in each new flood risk area. The funding allocation should be reviewed every five years, in line with single joint plan cycles.**

## 4.4 Property flood protection measures

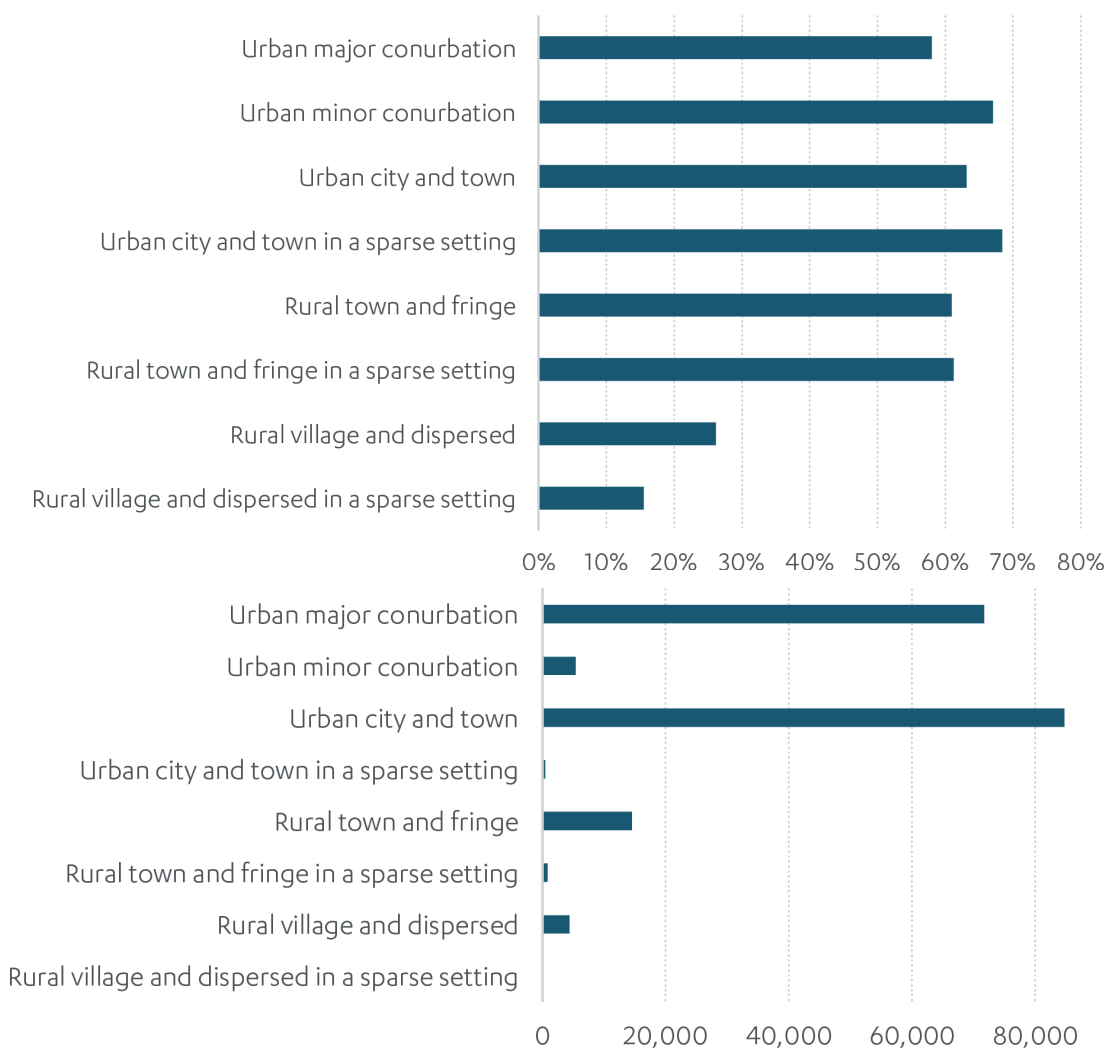
It is not possible to protect all properties in areas at high risk of flooding by delivering cost beneficial investments. The Commission's modelling estimates that 170,000 – 200,000 properties are in areas that will remain at high risk in 2055.

Figure 4.3 shows that cost beneficial investment is primarily in urban areas, protecting between 50-70 per cent of high risk properties in cities and towns compared to 15-25 per cent in rural villages. (Figure 4.3 shows the two degree climate scenario, but the pattern in the four degree scenario is the same).



### Figure 4.3: The proposed investment would protect cities and towns most

Change in the number of properties in areas at high risk between now and 2055 as a percentage of properties in areas at high risk (top) and in total (bottom), with £11 bn investment in flood defence under a two degree climate scenario<sup>v</sup>



Source: Commission calculations based on Sayers et al.

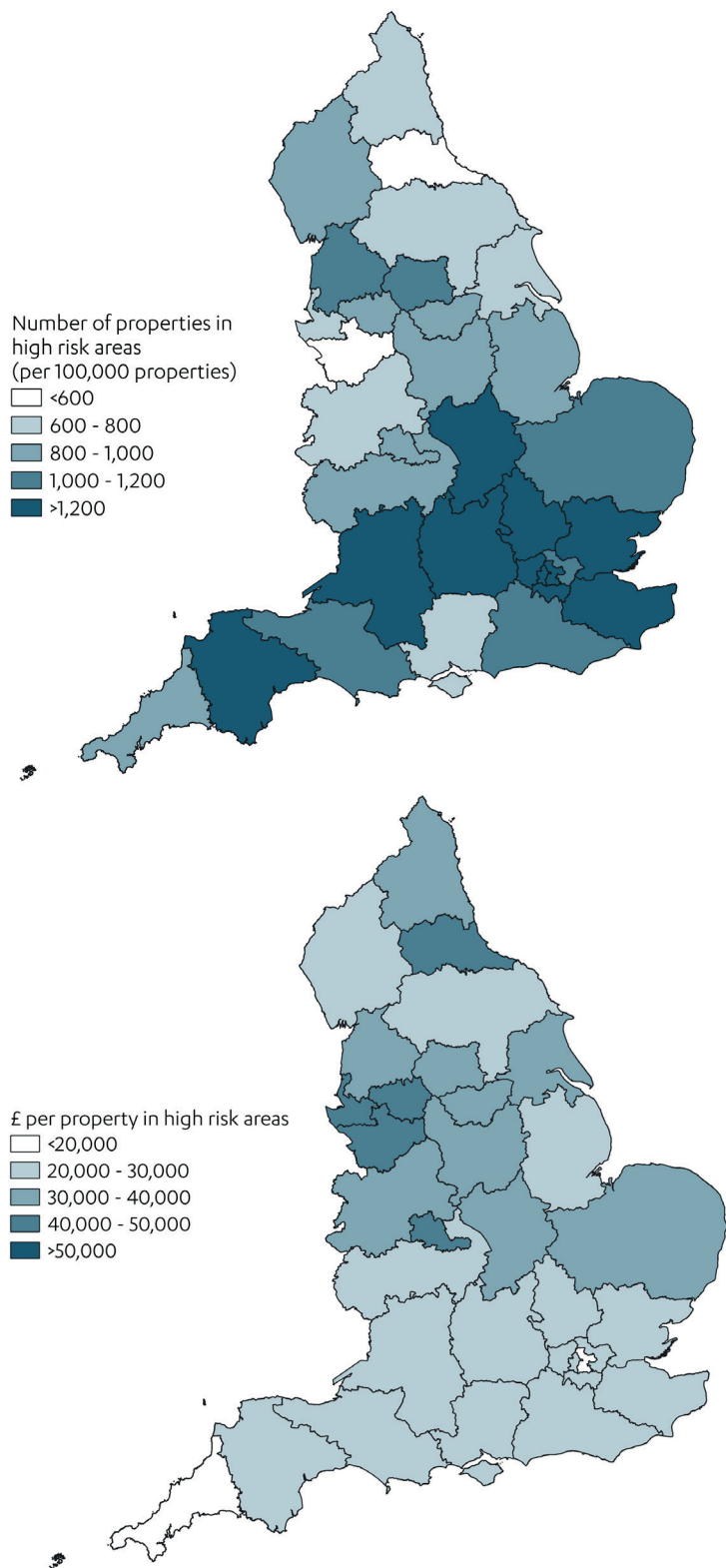
This is because, as shown in figure 4.5, the investment needed per property tends to be lower in areas with a higher proportion of properties at risk. In places with many properties at high risk, the cost of an intervention will be spread between more properties, and so the cost per property will be lower.

However, other interventions may still be cost beneficial for properties where infrastructure interventions may be less beneficial. Property level flood protection measures, including flood barriers, sealed air bricks, and small pump units, can help to protect water from entering buildings or enable quicker recovery after flooding. Flood insurance can also support a quicker recovery. A greater take up of property level resistance measures could help to significantly reduce flood risk for individual property owners.<sup>143</sup>

<sup>v</sup> Represents the future rainfall scenario for the UK corresponding to a global mean temperature increase by 2100 of two degrees

### Figure 4.4: Investment tends to be lowest where high risk properties are concentrated

Number of properties currently at high risk of flooding per 100,000 properties (top) and investment levels by 2055 per property at high risk (bottom), by the Office for National Statistics' 'International Territorial Level 2' regions



Source: Commission calculations based on Sayers et al.

Additional pipe based interventions in more rural settings can be expected to cost over £500,000 per property, and in some cases over £1 million per property, while property level measures might cost £2,500 to £17,900.<sup>144</sup>

The costs of surface water flood protection should not automatically fall to individual property owners or occupants simply because of where they live, particularly if properties in areas with similar levels of risk are being protected by investment funded by taxpayers or billpayers.

Government should explore options for funding property level flood protection measures for those properties in areas that remain at risk that are less likely to benefit from drainage improvements. This could potentially be provided in the form of government grants (which could be means tested), or via water and sewerage company schemes (similar to, for example, the Energy Company Obligation scheme, which requires energy suppliers to invest in energy efficiency for low income, fuel poor and vulnerable households).<sup>145</sup>

**Recommendation 9: By the end of 2024, government should explore options for funding property level flood protection measures for those properties that remain at high risk of surface water flooding because improving drainage infrastructure is not cost effective.**

## Acknowledgements

The Commission is grateful to everyone who engaged with the development of this study. The list below sets out organisations that have engaged with the Commission in delivering this report, including by responding to the Commission’s Call for Evidence.

The Commission would like to acknowledge the contribution of the consultants that have been engaged during the development of this study and would like to thank the Greater Manchester Combined Authority for providing a secondee to support this work.

The Commission would also like to thank the members of its climate resilience expert advisory panel for their contributions, as well as David Balmforth, David Butler and David Jenkins for their support.

The Commission is grateful to officials from across government, members of the public who took part in social research workshops and polling, and others who have engaged with the assessment in an individual capacity, including members of the Commission’s Young Professionals Panel and Design Group.

The Commission would like to acknowledge the members of the Secretariat who worked on the report: Ed Beard, Jon Chappell, Alex Goodwin, James Harris, David Hodcroft, Catherine Jones, Ryan McGowan, David Menzies, Jack Parker, Giles Stevens, Monika Szczyrba.

Association of Directors of Environment, Economy, Planning and Transport	Chartered Institution of Water and Environmental Management	Environment Agency
Amey	Cheshire Mid-Mersey Flood Risk Management Partnership	Environmental Policy Consulting
Anglian Water	Civic Engineers	Flood Re
Arcadis	Construction Industry Council	Flusher Ltd
Arup	Construction Industry Research and Information Association	Frontier Economics
Association of Drainage Authorities	Consumer Council for Water	Geospatial Commission
Association of SuDS Authorities	Department for Environment, Food & Rural Affairs	Greater London Authority
Bath and North East Somerset Council	Department for Levelling Up, Housing and Communities	Greater Manchester Combined Authority
British Geological Survey	Dorset Council	Hampshire County Council
Broadway Initiative		Horritt Consulting
		HM Treasury
		HR Wallingford



Jacobs	Newcastle University	Trafford Council
JBA Consulting	North Somerset Council	Transport for Greater Manchester
Kent County Council	North Tyneside Council	Transport for London
London Borough of Enfield	Northumbrian Water	UK Centre for Ecology and Hydrology
London Borough of Hammersmith and Fulham	Office for Environmental Protection	United Utilities
London Borough of Hillingdon	Ofwat	University of Exeter
London Councils	Parrett Internal Drainage Board	VAPAR
London Drainage Engineers Group	Sayers and Partners	Wakefield Council
London Flood Review	Severn Trent	Warwickshire County Council
Manchester City Council	Somerset Council	Water Management Alliance
Marsh	Somerset Drainage Boards Consortium	Water UK
Met Office	Somerset Rivers Authority	Wessex Regional Flood and Coastal Committee
Metis Consultants	South Gloucestershire Council	Wessex Water
National Farmers' Union	Southern Water	Westcountry Rivers Trust
National Flood Forum	Stantec	Woking Borough Council
National Highways	Thames Water	WSP
Nationwide	Three Dragons	Yorkshire Water
Network Rail		

## Glossary

<b>Biodiversity</b>	The variety of plant and animal life.
<b>Combined sewer overflows</b>	Some places have ‘combined sewers’ which collect both rainwater and wastewater. During heavy rainfall, combined sewers can become full as their content cannot be treated fast enough at sewage treatment works. When this happens, they are designed to discharge (overflow) excess sewage into nearby rivers, lakes, and the sea. This avoids sewage backing up into property or roads. Combined sewer overflows are also known as storm overflows.
<b>Drainage and Wastewater Management Plans</b>	25-year plans developed by water and sewerage companies, setting out how each company intends to improve drainage and wastewater management in its area.
<b>Flood Risk Areas</b>	Areas which have been identified by lead local flood authorities and the Environment Agency as having a ‘significant’ risk of flooding. The exact criteria for identifying Flood Risk Areas is set out in government guidance.
<b>Flood Risk Management Plans</b>	The Environment Agency develops a Flood Risk Management Plan for each of England’s seven river basin districts. These plans explain the risk of flooding from the sea, surface water, groundwater and reservoirs – and how the risk management authorities in each region will manage those risks. These plans must be reviewed every six years.
<b>Grant in Aid</b>	Money paid by a government department to an arm’s length body (such as the Environment Agency) to cover operating costs and allow it to carry out government policy.
<b>Gullies</b>	Drains which collect water from the surface and take it down into sewers.

<p><b>High risk / medium risk / low risk</b></p>	<p>The Environment Agency defines three risk bands for surface water flooding:</p> <p><b>High risk:</b> 1 in 30 (or greater) chance of flooding in any given year</p> <p><b>Medium risk:</b> less than a 1 in 30 chance but greater than a 1 in 100 chance of flooding in any given year</p> <p><b>Low risk:</b> less than 1 in 100 chance of flooding in any given year</p>
<p><b>Internal Drainage Boards</b></p>	<p>Independent public authorities that manage water levels in low lying, mostly rural areas, to protect agriculture and the environment.</p>
<p><b>Lead Local Flood Authorities</b></p>	<p>The public body with lead responsibility for managing the risk of surface water flooding in a local authority area. This is typically a team within an upper tier local authority (i.e., unitary authority or county council).</p>
<p><b>Local Flood Risk Management Strategies</b></p>	<p>Lead local flood authorities are required to develop strategies for flood and coastal erosion risk management in their local area. The Commission proposes replacing these with single joint plans in priority flood risk areas.</p>
<p><b>Local highways authorities</b></p>	<p>The public body legally responsible for managing and maintaining the local road network in a local authority area. This is located in the upper tier local authority.</p>
<p><b>Local planning authorities</b></p>	<p>The public body legally responsible for managing town planning in a local authority area, including consideration and determination of planning and development applications. This is located at the unitary, district or borough level.</p>
<p><b>Nature based solutions</b></p>	<p>Natural ways of slowing or reducing the flow of water through an area, ultimately reducing the risk of surface water flooding. These may include planting trees, improving soil, and restoring marshes.</p>
<p><b>Permeable / impermeable</b></p>	<p>‘Permeability’ refers to whether water can pass through a surface. This is an important risk factor in surface water flooding. ‘Impermeable’ surfaces, such as paved driveways and garden patios, prevent rainwater from soaking down into the earth.</p>

<b>Price Review</b>	Ofwat (the water regulator) controls the prices that water and sewerage companies are allowed to charge their customers. Ofwat reviews these prices every five years, known as a 'price review period'. The next price review is due to take place in 2024 and will apply from 2025 to 2030.
<b>Property level measures</b>	'Property level measures' (also known as property level 'resilience' or 'protection') are ways of protecting individual properties from flooding, separate from area wide flood defence schemes. Sealed barriers on doors and windows are examples of property level measures.
<b>Regional Flood and Coastal Committees</b>	A forum for local and regional authorities to coordinate regional activities. They approve Environment Agency requests to raise local levies or implement regional programmes of investment.
<b>Schedule 3</b>	Schedule 3 is a currently inactive part of the Flood and Water Management Act 2010. If brought into force, it would give local authorities powers to mandate the inclusion of sustainable drainage systems in new developments. The government is currently considering whether to implement Schedule 3.
<b>Solutions hierarchy</b>	Sets out the order in which drainage interventions should be considered to maximise the benefits and reduce costs. It prioritises maintenance and optimisation, followed by above ground interventions, with below ground interventions (pipes and sewers) considered last.
<b>Storm Overflows Discharge Reduction Plan</b>	The government's plan, published in August 2022, to reduce the amount of untreated wastewater discharged into rivers, lakes, and the sea.
<b>Sustainable drainage systems</b>	Sustainable drainage systems (sometimes abbreviated as 'SuDS') use natural processes to catch, drain or store water above ground – reducing the amount of water that enters underground sewers. Permeable paving, ponds and rain gardens are examples of sustainable drainage systems.
<b>Upper tier local authority</b>	In areas with two tiers of local government (district and county councils), this means the county council. In areas with one tier of local government, it means the unitary authority.

## Urbanisation

The conversion of natural (often permeable) environments to urban (often impermeable) environments. Urbanisation may include the construction of buildings on previously green land and making previously permeable surfaces (i.e. soil) impermeable (e.g. through paving over front gardens to make driveways).



## Remit and structure of the Commission

The National Infrastructure Commission was established as an executive agency of the Treasury to provide impartial, expert advice and make independent recommendations to the government on economic infrastructure. The Commission operates independently, at arm's length from government.

The Commission's purpose, and its principal outputs, accountabilities and duties are set out in its Charter and accompanying Framework Document.

The inaugural Framework Document published in 2016 committed government to reviewing the Commission's performance of its core objectives and responsibilities within five years. This review was conducted during 2021 and is reflected in a revised and enhanced set of objectives and fiscal remit for the Commission, set out below. The date of the next such review will be no later than 2026.

The Commission's remit covers all sectors of economic infrastructure: energy, transport, water and wastewater (drainage and sewerage), waste, flood risk management and digital communications. The Commission also considers potential interactions between its infrastructure recommendations and housing supply; and between its recommendations and the government's legal target to halt biodiversity loss by 2030. This explicit biodiversity consideration was added in 2021. Housing supply itself, other social infrastructure such as schools, hospitals or prisons, and agriculture and land use are all outside the remit of the Commission.

The Commission's objectives are to: 1) support sustainable economic growth across all regions of the UK, 2) improve competitiveness, 3) improve quality of life, and 4) support climate resilience and the transition to net zero carbon emissions by 2050. The latter objective was added in 2021.

In fulfilling its purpose and objectives, the Commission seeks to:

- set a long term agenda – identifying the UK's major economic infrastructure needs, and the pathways to address them
- develop fresh approaches and ideas – basing our independent policy recommendations on rigorous analysis, and
- focus on driving change – building consensus on our policy recommendations, and monitoring government progress on their delivery.

The Commission delivers the following products and services:

- a National Infrastructure Assessment once in every Parliament, setting out the Commission's assessment of long term infrastructure needs with recommendations to the Government
- specific studies on pressing infrastructure challenges as set by the government, taking into account the views of the Commission and stakeholders; these studies will include recommendations to government

- an Annual Monitoring Report (styled as an Infrastructure Progress Review), taking stock of the government’s progress in areas where it has committed to taking forward recommendations of the Commission.

The Commission’s binding fiscal remit requires it to demonstrate that all its recommendations for economic infrastructure are consistent with, and set out how they can be accommodated within, gross public investment in economic infrastructure of between 1.1 per cent and 1.3 per cent of GDP each year between 2025 and 2055. The fiscal remit was previously between 1.0 per cent and 1.2 per cent of GDP. The Commission’s reports must also include a transparent assessment of the impact on costs to businesses, consumers, government, public bodies and other end users of infrastructure that would arise from implementing its recommendations.

When making its recommendations, the Commission is required to take account of both the role of the economic regulators in regulating infrastructure providers and the government’s legal obligations, such as carbon reduction targets. The Commission’s remit letter also requires the Commission to ensure that its recommendations do not reopen decision making processes where programmes and work have been decided by the government or will be decided in the immediate future.

The Infrastructure and Projects Authority (IPA), a separate body, is responsible for ensuring the long term planning carried out by the Commission is translated into successful project delivery, once the plans have been endorsed by government.

The Commission’s remit extends to economic infrastructure within the UK government’s competence. Across much of the Commission’s remit there is currently substantial devolution to Northern Ireland, Scotland and Wales. The Commission’s role is to advise the UK government, but the Commission works with both the UK government and the devolved administrations where responsibilities interact.

**Table: Devolved administration responsibilities, by infrastructure sector**

Sector	Devolved administration responsibility		
	Northern Ireland	Scotland	Wales
Digital	Reserved	Reserved	Reserved
Energy	Devolved, except nuclear	Reserved, except energy efficiency	Reserved, except energy efficiency
Flood risk	Devolved	Devolved	Devolved
Transport	Devolved	Largely devolved	Devolved, except rail
Waste	Devolved	Devolved	Devolved
Water and sewerage	Devolved	Devolved	Devolved

## The Commission's members

The National Infrastructure Commission comprises a Chair and between four and 12 additional non-executive Commissioners.

The current members of the Commission are:



**Sir John Armitt CBE (Chair)** published an independent review on long term infrastructure planning in the UK in September 2013, which resulted in the National Infrastructure Commission. Previously Chief Executive of Railtrack (later Network Rail), Sir John sits on the boards of the Berkeley Group and Expo 2020.



**Professor Sir Tim Besley CBE** is School Professor of Economics and Political Science and W. Arthur Lewis Professor of Development Economics at the LSE. From September 2006 to August 2009, he served as an external member of the Bank of England Monetary Policy Committee.



**Neale Coleman CBE** is a co-founder of Blackstock Partnership. He worked at the Greater London Authority from 2000-2015 leading the Mayor's work on London's Olympic bid, the delivery of the games, and their regeneration legacy. Neale has also served as Policy Director for the Labour Party.



**Andy Green CBE** holds several Chairman, Non-Executive Director and advisory roles, linked by his passion for how technology transforms business and our daily lives. He chairs Lowell, a major European credit management company and has served as Chair for the Digital Catapult, an initiative to help grow the UK digital economy.



**Professor Jim Hall FrEng** is Professor of Climate and Environmental Risks in the University of Oxford and Director of the University's Environmental Change Institute. He is internationally recognised for his research on risk analysis and decision making under uncertainty for water resource systems, flood and coastal risk management, infrastructure systems and adaptation to climate change.



**Professor Sadie Morgan OBE** is a founding director of the Stirling Prize winning architectural practice dRMM. She is also Chair of the Independent Panel for High Speed Two and is a Mayor's design advocate for the Greater London Authority. She sits on the boards of the Major Projects Association and Homes England.





**Julia Prescott** holds several board and advisory roles. She is a co-founder and Chief Strategy Officer of Meridiam and sits on the Executive Committee of Meridiam SAS. She has been involved in long term infrastructure development and investment in the UK, Europe, North America and Africa. She is an Honorary Professor at the Bartlett School of Construction and Project Management, University College London. Since 2019 she has sat on the board of the Port of Tyne.



**Bridget Rosewell CBE** is a director, policy maker and economist. She served as Chief Economic Adviser to the Greater London Authority from 2002 to 2012 and worked extensively on infrastructure business cases. She has served as a Non-executive Director of Network Rail and Non-executive Chair of the Driver and Vehicle Standards Agency. She is currently Chair of the Atom Bank and the M6 Toll Road.



**Kate Willard OBE** is the is the Thames Estuary Envoy and chairs the Thames Estuary Growth Board. Since 2017 she has served as Chair for the Arts Council England's Area Council North. In addition, she is an independent consultant working on a diverse portfolio of infrastructure and growth projects. In March 2022 she was appointed Chair of Teesside International Airport.



**Nick Winser CBE** has had a 30-year career in the energy sector, including serving as UK and European CEO of the Board of National Grid and President of the European Network of Transmission System Operators for Electricity. He currently serves as Chair of the Energy Systems Catapult.

## References

- 1 Department for Environment, Food & Rural Affairs (2018), [Surface Water Management An Action Plan](#)
- 2 The Flood Hub (2021), [What Causes Surface Water Flooding?](#)
- 3 Department for Environment, Food & Rural Affairs (2021), [Surface water management: a government update](#)
- 4 National Oceanic and Atmospheric Administration (2019), [Watersheds, flooding and pollution](#)
- 5 Environment Agency (2022), [Flood and coastal erosion risk management report: 1 April 2020 to 31 March 2021](#)
- 6 ClimateNode (2021), [UK Flood Impact Map](#)
- 7 JBA Trust (2019), [British Chronology of Flash Floods](#)
- 8 Department for Environment, Food & Rural Affairs (2020), [Report of a review of the arrangements for determining responsibility for surface water and drainage assets](#)
- 9 Department for Environment, Food and Rural Affairs (2015), [Evidence review of factors contributing to surface water flooding from Section 19 LLFA reports](#)
- 10 Department for Environment, Food & Rural Affairs, Environment Agency (2020), [National Flood and Coastal Erosion Risk Management Strategy for England: Annex A](#); HM Government (2010), [Flood and Water Management Act 2010](#); Local Government Association (2022), [Managing flood risk: roles and responsibilities](#); National Audit Office (2020), [Managing flood risk](#); Ofwat and the Environment Agency (2022), [A joint approach for how water companies should consider flood and coastal resilience in the context of their statutory roles and duties](#)
- 11 Department for Environment, Food & Rural Affairs, Environment Agency (2020), [National Flood and Coastal Erosion Risk Management Strategy for England: Annex A](#); HM Government (2010), [Flood and Water Management Act 2010](#)
- 12 National Infrastructure Commission (2021), [Baseline Report Annex C: Flood resilience](#)
- 13 This has also been highlighted by Department for Environment, Food & Rural Affairs (2018), [Surface Water Management: An Action Plan](#), p.5
- 14 BMG (2022), [Surface Water Flooding Social Research](#)
- 15 Current LTIS scenarios assume surface water floods on average cause around 80 per cent of the damage of coastal and river flooding, Environment Agency (2019), Long Term Investment Scenarios: Additional Analysis Topic 13 technical report – Progress in Knowledge since LTIS 2014 – Surface Water, p.6
- 16 Deputy Mayor for Administration (New York City) (2021), [The New Normal: combating storm-related extreme weather in New York City](#)
- 17 Department for Environment, Food & Rural Affairs (2021), [Surface water management a government update](#)
- 18 HM Government (2020), [National Risk Register: 2020 edition](#)
- 19 London Councils (2022), [Surface Water Flood Risk Management in London](#)
- 20 London Flood Review: Independent Expert Group (2022), [London Flooding Review-Stage 4 - Recommendations](#)
- 21 Thames Water (2021), [Internal Review into the 12 and 25 July 2021 storms in London](#)
- 22 The Flood Hub (2022), [The River Roch, Rochdale and Littleborough Flood Risk Management Scheme](#); Greater Manchester Combined Authority (2020), [Greater Manchester Flood Event Report](#)
- 23 FloodList (2019), [UK - Flash Flooding in England Leaves Drivers Stranded, Travel Disrupted](#)
- 24 Birmingham City Council (2019), [May 2018 Flooding](#)
- 25 Worcestershire County Council (2019), [Hollywood flooding event 2018](#)
- 26 Milton Keynes Borough Council (2018), [Flood Event: May 2018](#)
- 27 Birmingham City Council (2019), [May 2018 Flooding](#)

- 28 Kent County Council (2019), [Flood Investigation Report](#)
- 29 Cornwall Council (2020), [Flood Investigation Reports 2017](#)
- 30 Surrey County Council (2016), [Section 19 Flood Investigation Report Woking](#)
- 31 Environment Agency (2021), [Flood risks on Canvey Island](#)
- 32 Newcastle City Council (2013), [The Newburn Culvert Collapse and Citywide Flooding: A review of Extreme Events in Newcastle 2012](#)
- 33 Met Office (2022), [Summer showers - Met Office](#)
- 34 Met Office (2022), [UK Climate Projections: Headline Findings](#)
- 35 Met Office (2019), [UKCP Convection-permitting model projections: Science Report](#), p.12.
- 36 Severn Trent Water (2022), [Drainage and Wastewater Management Plans: Level 1 Non-Technical Report](#), p.31
- 37 Met Office (2022), [UK Climate Projections: Headline Findings](#)
- 38 This has been borne out by Commission interrogation of draft Drainage and Wastewater Management Plans
- 39 Commission calculations of an approximate average 15-20 per cent increase from baseline risk. The impact is based on data from Wessex Water (2022), [The Wessex Area Drainage and Wastewater Management Plan](#), p.113 and South West Water (2022), [Our Draft Drainage and Wastewater Management Plan: Company Level Technical Summary](#), p.30, and unpublished correspondence with Severn Trent Water.
- 40 UK Water Industry Research (2010), Impact of Urban Creep on Sewerage Systems. Referenced in Ofwat (2011), [Future Impacts on Sewer Systems in England and Wales](#)
- 41 Environment Agency (2019), [What is the Risk of Flooding from Surface Water map?](#), p.15
- 42 HM Government (2021), [Reducing the Risks of Surface Water Flooding: Terms of Reference](#)
- 43 Available on request
- 44 BMG (2022), [Surface Water Flooding Social Research](#)
- 45 Environment Agency (2021), [Draft Flood Risk Management Plans \(FRMPs\): 2021 to 2027](#)
- 46 Water UK (2022), [Drainage and Wastewater Management Plans](#)
- 47 Department for Environment, Food & Rural Affairs (2022), [Storm Overflows Discharge Reduction Plan](#)
- 48 Department for Levelling Up, Homes and Communities (2022), [Guidance: Flood risk and coastal change](#); Environment Agency (2021), [Measuring Resilience to Flooding and Coastal Change](#)
- 49 HM Government (1991), [Water Industry Act 1991: Section 106](#)
- 50 Department for Levelling Up, Housing and Communities (2022), [Guidance: Flood risk and coastal change](#); Ministry of Housing, Communities, and Local Government (2021), [National Planning Policy Framework](#), p.48; HM Government (2014), [The Town and Country Planning \(Development Management Procedure and Section 62A Applications\) Order 2014](#), Schedule 4
- 51 Ministry of Housing, Communities & Local Government (2018), [A review of the application and effectiveness of planning policy for Sustainable Drainage Systems \(SuDS\)](#); Department for Environment, Food & Rural Affairs (2018), [Review of local approaches to surface water flood risk management](#); Department for Environment, Food & Rural Affairs, Ministry of Housing, Communities & Local Government, Environment Agency (2021), [Review of policy for development in areas at flood risk](#); Department for Environment, Food & Rural Affairs (2020), [Report of a review of the arrangements for determining responsibility for surface water and drainage assets](#); Chartered Institution of Water and Environmental Management (2017), [A Place for SuDS?](#)
- 52 Department for Environment, Food & Rural Affairs, Ministry of Housing, Communities & Local Government, Environment Agency (2021), [Review of policy for development in areas at flood risk](#), p.14
- 53 HM Government (2010), [Flood and Water Management Act 2010: Schedule 3](#)
- 54 Department for Environment, Food & Rural Affairs and Department for Communities and Local Government (2014), [Consultation on delivering Sustainable Drainage Systems](#); Department for Communities and Local Government (2014), [Written Statement made by: The Secretary of State for Communities and Local Government \(Mr Eric Pickles\) on 18 Dec 2014](#)

- 55 Arup (2021), Draft report for the Welsh Local Government Association: Measuring the effects of the Sustainable Drainage legislation on SABs in Wales: Issues & Recommendations (unpublished)
- 56 Ofwat (2018), **Sewers for Adoption: A Design and Construction Guide for Developers**
- 57 UK Water Industry Research (2010), Impact of Urban Creep on Sewerage Systems. Referenced in Ofwat (2011), **Future Impacts on Sewer Systems in England and Wales**
- 58 Commission calculations assuming a 15-20% increase in risk from the baseline, based on data from Wessex Water (2022), **The Wessex Area Drainage and Wastewater Management Plan**, p.113 and South West Water (2022), **Our Draft Drainage and Wastewater Management Plan: Company Level Technical Summary**, p.30, and unpublished correspondence with Severn Trent Water
- 59 Ministry of Housing, Communities & Local Government (2009), **Guidance on the permeable surfacing of front gardens**
- 60 HM Government (2015), **The Town and Country Planning (General Permitted Development) (England) Order 2015: Schedule 2**
- 61 Department for Levelling Up, Housing and Communities (2022), **Guidance: Flood risk and coastal change**
- 62 Ministry of Housing, Communities & Local Government (2021), **National Planning Policy Framework**, p.15
- 63 Environment Agency (2021), **Research on using flood risk information in spatial planning**, p.44
- 64 Chartered Institution of Water and Environmental Management (2022), **River water quality and storm overflows: A systems approach to maximising improvement - technical report**, p.53
- 65 Ofwat (2022), **Consultation on charging innovation to support affordability**, p.22
- 66 Water UK (2022), Summary of recommendations from legislative options review for the Storm Overflow Taskforce (unpublished); House of Commons Environment, Food and Rural Affairs Committee (2021), **Flooding**, p.50; and Royal Institute of Chartered Surveyors (2018), **Assessing the impacts of extending permitted development rights to office-to-residential change of use in England**, p.75
- 67 Construction Industry Research and Information Association (2012), **Using SuDS close to buildings**
- 68 Sayers and Partners (2022), **Surface Water Future Risk and Investment Needs**, p.25
- 69 Department for Environment, Food & Rural Affairs (2022), **Storm Overflows Discharge Reduction Plan**
- 70 Southern Water (2022), **Drainage and Wastewater Management Plan**, p.41; Wessex Water (2022), **Drainage and Wastewater Management Plan**, p.44; and United Utilities Water (2022), **DRAFT Drainage and Wastewater Management Plan 2023**, p.60
- 71 Christopher Ellis et al. (2016), **Transforming Water Management in Llanelli**, UK, p.26
- 72 Sayers and Partners (2022), **Surface Water Future Risk and Investment Needs**, Appendix E Cost Functions
- 73 Construction Industry Research and Information Association (2006), **Designing for exceedance in urban drainage – good practice**, p.34
- 74 Department for Environment, Food and Rural Affairs (2015), **Evidence review of factors contributing to surface water flooding from Section 19 LLFA reports**
- 75 Susdrain (2022), **Benefits of SuDS**
- 76 Environmental Policy Consulting (for the Welsh Government) (2017), **Sustainable Drainage Systems on new developments**
- 77 Ofwat (2020), **Green Economic Recovery: Final Decisions**, p.30
- 78 For the current length of network see NIC (2021), **Annex D: Water and Wastewater, The Second National Infrastructure Assessment: Baseline Report**, p.3
- 79 Construction Industry Research and Information Association (2022), **Background to drainage exceedance**
- 80 Construction Industry Research and Information Association and the Environment Agency (2014), **Managing urban flooding from heavy rainfall - encouraging the uptake of designing for exceedance: Lessons and success factors**
- 81 Environment Agency (2017), **Review of preliminary flood risk assessments (Flood Risk Regulations 2009): guidance for lead local flood authorities in England**; the last six yearly review took place in 2017 – see Cheshire East Council (2022), **Preliminary Flood Risk Assessment**

- 82 Environment Agency (2017), [Review of preliminary flood risk assessments \(Flood Risk Regulations 2009\): guidance for lead local flood authorities in England](#)
- 83 Environment Agency (2019), [Flood Risk Maps for Surface Water in England – December 2019](#); Hampshire County Council (2017), [Preliminary flood risk assessment review: self-assessment form](#); East Riding of Yorkshire Council (2011), [Preliminary Flood Risk Assessment 2011](#)
- 84 Environment Agency (2009), [Flooding in England: A National Assessment of Flood Risk](#)
- 85 Department for Environment, Food & Rural Affairs (2021), [Flood and coastal erosion risk management: An investment plan for 2021 to 2027](#)
- 86 Environment Agency (2019), [What is the Risk of Flooding from Surface Water map?](#)
- 87 Environment Agency (2019), [What is the Risk of Flooding from Surface Water map?](#)
- 88 Mott MacDonald (2022), [London Flooding Review Stage 4 - Recommendations](#)
- 89 Department for Environment, Food & Rural Affairs (2020), [Report of a review of the arrangements for determining responsibility for surface water and drainage assets](#)
- 90 Jacobs (2022), [Understanding the challenges of data sharing between risk management authorities](#)
- 91 Mott MacDonald (2022), [London Flooding Review Stage 4 - Recommendations](#)
- 92 HM Government (2010), [Flood and Water Management Act 2010](#)
- 93 Department for Environment, Food & Rural Affairs (2020), [Report of a review of the arrangements for determining responsibility for surface water and drainage assets](#)
- 94 HM Government (2010), [Flood and Water Management Act 2010](#)
- 95 Department for Environment, Food & Rural Affairs (2018), [Review of local approaches to surface water flood risk management: Final report](#)
- 96 Department for Environment, Food & Rural Affairs (2020), [Report of a review of the arrangements for determining responsibility for surface water and drainage assets](#)
- 97 Department for Environment, Food & Rural Affairs (2021), [Surface water management: a government update](#)
- 98 Mott MacDonald (2022), [London Flooding Review Stage 4 - Recommendations](#)
- 99 Department for Environment, Food & Rural Affairs (2021), [Surface water management: a government update](#)
- 100 Environment Agency (2019), [What is the Risk of Flooding from Surface Water map?](#)
- 101 Department for Environment, Food and Rural Affairs (2018), [Surface Water Management: An Action Plan](#)
- 102 Environment Agency (2019), [What is the Risk of Flooding from Surface Water map?](#); National Audit Office (2020), [Managing flood risk](#); Department for Environment, Food and Rural Affairs (2018), [Surface Water Management: An Action Plan](#)
- 103 Department for Environment, Food & Rural Affairs (2018), [Surface Water Management: An Action Plan](#)
- 104 HM Government (2020), [Flood and coastal erosion risk management: Policy Statement](#)
- 105 National Audit Office (2020), [Managing flood risk](#)
- 106 Department for Environment, Food & Rural Affairs (2022), [Consultation on environmental targets](#)
- 107 Department for Environment, Food & Rural Affairs (2018), [Review of local approaches to surface water flood risk management](#); CIRIA (2006), [Designing for exceedance in urban drainage – good practice](#), p.34.
- 108 Committee on Climate Change (2019), [Progress in preparing for climate change](#)
- 109 National Audit Office (2020), [Managing flood risk](#); House of Commons Environment, Food and Rural Affairs Committee (2021), [Flooding](#)
- 110 2021 prices
- 111 HM Government (1991), [Water Industry Act 1991: Section 94](#)
- 112 Ofwat (2017), [Outcome definitions – PR19](#), Ofwat (2022), [Delivering UK Government priorities for the English water sector through our 2024 price review draft methodology](#)

- 113 Department for Environment, Food & Rural Affairs, Welsh Government, Environment Agency, Ofwat, and Natural Resources Wales (2022), [Drainage and wastewater management plans: guiding principles for the water industry](#)
- 114 Water UK (2021), [Ensuring the Water Industry National Environment Programme \(WINEP\) and Water Industry Strategic Environmental Requirements \(WISER\) set the right framework for the future](#), Water UK (2022), [Water 2050: A White Paper](#), United Utilities (2020), [Evolving the Water Industry National Environment Programme to deliver greater value](#)
- 115 Ofwat (2021), [Green economic recovery: Final decisions](#)
- 116 Ofwat (2018), [Code for Adoption Agreements](#); Water UK (2018), [Sewers for Adoption: Eighth edition](#)
- 117 UK Parliament (2020), [Water Industry \(Schemes for Adoption of Private Sewers\) Regulations 2011: Question for Department for Environment, Food and Rural Affairs](#)
- 118 Department for Environment, Food & Rural Affairs (2022), [The government's strategic priorities for Ofwat](#)
- 119 Ofwat (2022), [Delivering UK Government priorities for the English water sector through our 2024 price review draft methodology](#)
- 120 Department for Environment, Food & Rural Affairs (2018), [Review of local approaches to surface water flood risk management](#); Defra (2020), [Report of a review of the arrangements for determining responsibility for surface water and drainage assets](#); National Audit Office (2020), [Flooding](#); Mott MacDonald (2022), [London Flooding Review: Stage 4 - Recommendations](#); Chartered Institution of Water and Environmental Management (2022), [River water quality and storm overflows: A systems approach to maximising improvement - technical report](#)
- 121 HM Government (2010), [Flood and Water Management Act 2010](#), Section 9; Environment Agency (2020), [National Flood and Coastal Erosion Risk Management Strategy for England](#)
- 122 Department for Environment, Food & Rural Affairs, Welsh Government, Environment Agency, Ofwat, and Natural Resources Wales (2022), [Drainage and wastewater management plans: guiding principles for the water industry & Guiding principles for drainage and wastewater management plans](#); HM Government (2010), [Flood and Water Management Act 2010: Section 11](#); HM Government (2021), [Environment Act](#), Section 79
- 123 National Infrastructure Commission (2018), [National Infrastructure Assessment](#)
- 124 HM Treasury (2020), [Response to the National Infrastructure Assessment](#)
- 125 Ofwat (2022), [Ofwat's industry overview of draft drainage and wastewater management plans 2022](#)
- 126 Ofwat (2021), [Green economic recovery: Final decisions](#), Greater Manchester Combined Authority (2022), [The IGNITION Project](#); Sheffield City Council, [Grey to Green](#); North Tyneside Council (2020), [Clean sweep of awards for North Tyneside improvement project](#)
- 127 Mott MacDonald (2022), [London Flooding Review: Stage 4 - Recommendations](#); Defra (2018), [Review of local approaches to surface water flood risk management](#); House of Commons Environment, Food and Rural Affairs Committee (2021), [Flooding](#)
- 128 London Councils (2022), [Surface Water Flood Risk Management in London](#)
- 129 National Infrastructure Commission (2020), [Design Principles for National Infrastructure](#)
- 130 Chartered Institute of Water and Environmental Management (2022), [Survey on Surface Water Management for Risk Management Authorities](#)
- 131 Department for Environment, Food & Rural Affairs (2018), [Review of local approaches to surface water flood risk management](#)
- 132 Sayers and Partners (2022), [Surface Water Future Risk and Investment Needs](#), pp.61-3
- 133 Department for Environment, Food & Rural Affairs (2022), [Central Government Funding for Flood and Coastal Erosion Risk Management in England](#); National Audit Office (2020), [Managing Flood Risk](#), Highways England (2020), [Designated funds plan: 2020-2025](#)

- 134 Department for Environment, Food & Rural Affairs (2017), **Evaluation of the arrangements for managing local flood risk in England**; Department for Environment, Food & Rural Affairs, Environment Agency, Natural Resources Wales and Welsh Government (2018), **Further evaluation of partnership funding**; Department for Environment, Food & Rural Affairs and Environment Agency (2021), **Evaluating the effectiveness of flood and coastal erosion risk governance in England and Wales**
- 135 National Audit Office (2020), **Managing Flood Risk**
- 136 Real prices, HM Treasury discount rate
- 137 Sayers and Partners (2022), **Surface Water Future Risk and Investment Needs**, p.62
- 138 Met Office (2019), **UKCP Convection-permitting model projections: Science Report**, p.12
- 139 Department for Environment, Food & Rural Affairs (2022), **Storm Overflows Discharge Reduction Plan: Impact Assessment**, p.36
- 140 Luca Locatelli et al. (2020), **Socio-Economic Assessment of Green Infrastructure for Climate Change Adaptation in the Context of Urban Drainage Planning**; Christopher Ellis et al. (2016), **Transforming Water Management in Llanelli, UK**
- 141 Sayers and Partners (2022), **Surface Water Future Risk and Investment Needs**, p.22
- 142 National Infrastructure Commission (2022), **Surface Water Flooding technical annex: flood modelling** (forthcoming)
- 143 Environment Agency (2020), **National Flood and Coastal Erosion Risk Management Strategy for England**
- 144 Department for Environment, Food, and Rural Affairs (2015), **Delivering Benefits Through Evidence: Cost Estimation for Household Flood Resistance and Resilience Measures – Summary of Evidence**, p.12, £2,000 lower estimate to £14,000 higher estimate adjusted to 2022 prices using HM Treasury’s GDP deflator. Pipe cost assumes pipes are designed to a 1 in 30 rainfall standard.
- 145 Ofgem (2022), **Energy Company Obligation**.

**NATIONAL  
INFRASTRUCTURE  
COMMISSION**

---

Better infrastructure for all

Finlaison House  
15-17 Furnival Street  
London EC4A 1AB



[nic.org.uk](https://www.nic.org.uk)



[@NatInfraCom](https://twitter.com/NatInfraCom)

**November 2022**