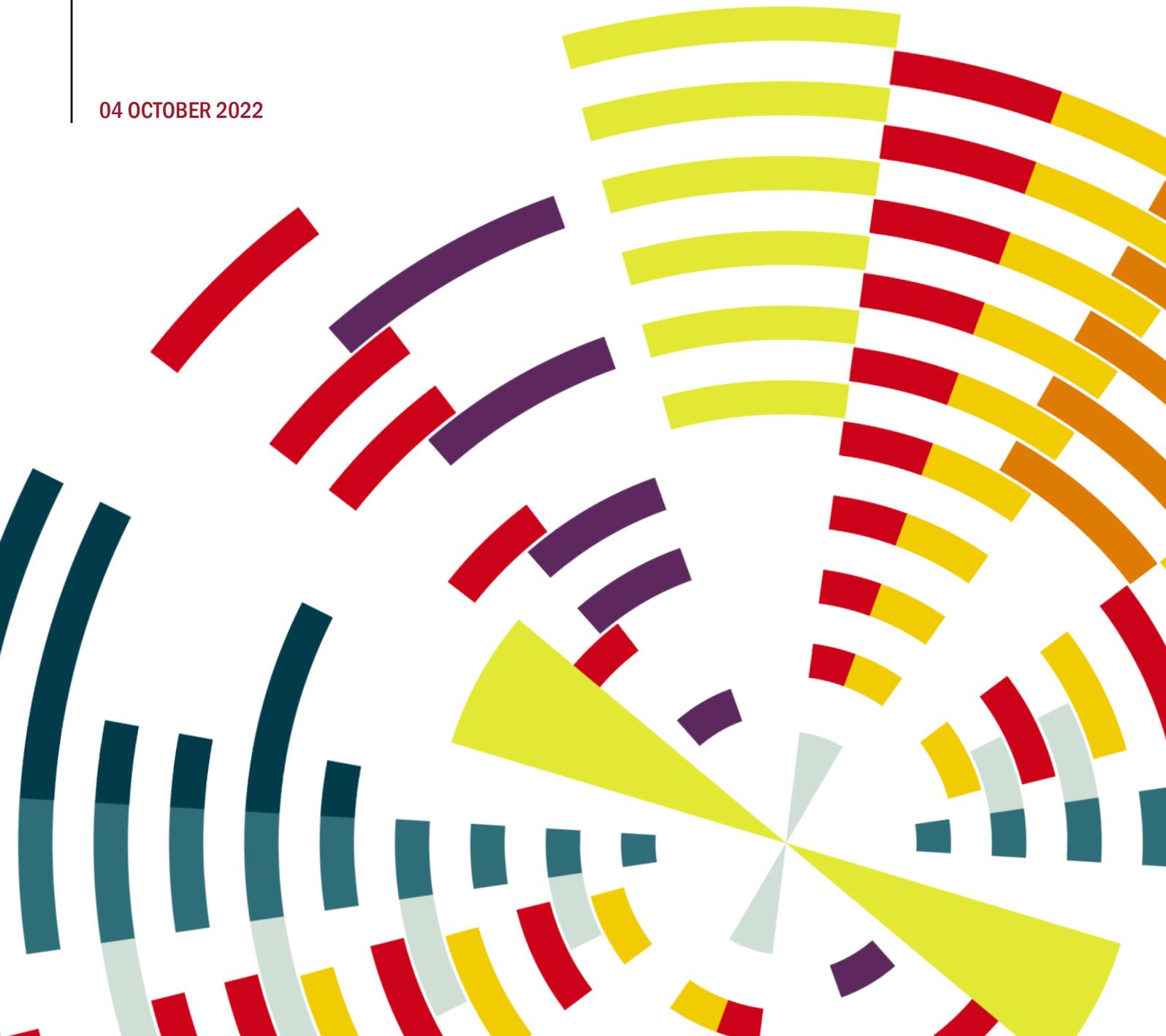


MANAGING EXTREME WEATHER EVENT RISK IN THE REGULATORY FRAMEWORK

04 OCTOBER 2022



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1 Executive summary

- 1.1 England has a relatively mild climate but the weather is highly variable. It has potential for a wide range of extreme events including wind storms, heavy rainfall, floods, droughts, cold snaps, freeze-thaw events and heatwaves. With climate change, the risks of extreme heat and heavy rainfall has already increased and will continue to rise in the longer term. Extreme weather events have substantial impacts on water and wastewater customers and companies when they do arise. For example, Storm Arwen resulted in approximately 8,000 properties experiencing a supply interruption.¹ Clearly, water and wastewater companies cannot control the weather but they can influence the impacts of extreme weather events on customers through how they plan for, and respond to those extreme weather events.
- 1.2 There are a number of legislative and regulatory requirements on water and wastewater companies to manage their operations and networks to be resilient to a particular level of weather event. The companies are funded for this level of resilience through the price control process. For some types of extreme weather, this level of resilience is clear: for example managing wastewater networks to be resilient to a 1-in-50 year storm. However, for other types of extreme weather this level is less clear and is implicit in, for example, the standards of buildings owned and used by water and wastewater companies.
- 1.3 In its PR24 Draft Methodology², Ofwat proposed that water and wastewater companies take the risk associated with extreme weather events subject to aggregate risk-sharing mechanisms such as totex sharing. This increases water and wastewater companies' exposure to the risk associated with extreme weather events compared to the current (PR19) situation, where companies can make an application to Ofwat to suspend aspects of the regulatory regime (i.e. ODI penalties) following civil emergencies such as an extreme weather event. Other proposed reforms to the regulatory framework at PR24, particularly the removal of collars on ODI payments, would serve to further increase water and wastewater companies' exposure to the risk of extreme weather events.
- 1.4 Frontier Economics and Atkins were commissioned by Northumbrian Water, Yorkshire Water and South East Water to review options for the allocation of the risk associated with extreme weather events and to assess how those options would benefit customers.
- 1.5 Extreme weather events affect all infrastructure networks, and are not limited to the UK. Therefore, we conducted a rapid review of regulatory precedent across a range of regulated infrastructure in the UK and the water sector in Australia to inform the development of options on how the risk of extreme weather events could be allocated in England. This rapid review of regulatory precedent is summarised in Table 1.

¹ Northumbrian Water, June 2022, "Northumbrian Water Storm Arwen representation", Para. 53.

² Ofwat, July 2022, "Consulting on our methodology for PR24", p. 55. Available at: <https://www.ofwat.gov.uk/wp-content/uploads/2022/07/Draft-methodology-main-document-3.pdf>

Table 1 Summary of rapid review of regulatory precedent

SECTOR	RISK SHARING MECHANISM FOR EXTREME WEATHER	SUMMARY
Energy - ED2	Yes	The “severe weather 1-in-20 year” funding mechanism provides ex-post funding for efficient costs incurred during extreme weather events and the “exceptional events” exclusions for planned interruptions target excludes performance under the interruption incentive scheme during the event. The trigger for these events is a material deterioration in the performance of the network.
Aviation - economic regulation of Heathrow	Yes	The Asymmetric Risk Mechanism provides ex-ante funding for lost revenue in future asymmetric events (such as pandemics or extreme weather). The Aerodrome Congestion Term exceptions means that Heathrow Airport Limited is not liable to pay rebates to airlines for disruption during bad weather.
Rail - Schedule 8 agreement between Network Rail and the Train Operating Companies (TOCs)	No	While extreme weather is recognised as a reason for delay, Network Rail is liable for disruption caused by weather, and there are no exemptions for extreme weather.
Telecommunications - Openreach	Yes	The Matters Beyond Our Reasonable Control (MBORC) allowance means that Quality of Service standards no longer apply for eight weeks once the MBORC is declared. In addition, Service Level Guarantees (SLGs) payment to communications providers are also suspended in the event of extreme weather.
Water sector in Australia	Yes	Companies do not have to pay rebates to customers under the Guaranteed Service Level (GSL) scheme in the event of extreme weather. The Sydney Desalination Plant (SDP) incentive scheme is also suspended in the event of an uninsurable force majeure event such as extreme weather.

Source: Ofgem, CAA, ORR, Ofcom, Sydney Water, IPART. See Table 4 - Table 8 for more detail.

- 1.6 As can be seen from the table above, regulatory mechanisms which share the risk of extreme weather are common across other regulated infrastructure sectors. This rapid review highlights that there are a number of ways in which the risk associated with extreme weather can be allocated; and the following dimensions should be considered:
- Whether there is an explicit risk sharing mechanism, or whether the risk of extreme weather is dealt with under an aggregate risk sharing mechanism (the second appears to be Ofwat’s position at PR24 in the Draft Methodology);

- If there is an explicit risk sharing mechanism for extreme weather, whether this deals with costs (either ex-ante³ or ex-post⁴) and/or whether the incentive regime is suspended during and in the immediate aftermath of the extreme weather event.⁵

1.7 We developed a number of options which combined these characteristics and assessed those options against the criteria outlined below. In developing these criteria, we have been mindful of Ofwat’s duties as an economic regulator includes protecting the interests of consumers, ensuring companies can carry out and finance their statutory functions and further the long-term resilience of water and wastewater systems.⁶ The criteria below focus on the needs and preferences of customers before, during and after an extreme weather event so as to identify the option which works in the best interests of consumers.

■ **A: Incentives for appropriate preparation and response**

- i) Does the option give water and wastewater companies an incentive to: prepare for extreme weather events; invest in appropriate resilience of water and wastewater networks so that those networks continue delivering services to customers during extreme weather events; and – in the event of an extreme weather event – act in a way which is in the best interests of consumers.
- ii) Does the option give customers an incentive to take reasonable and proportionate actions to reduce the impact of extreme weather events on themselves.

■ **B: Impact on incentive package**

- To what extent does the option interact with the overall package of incentives contained within PR24. In particular, does the option ensure that companies have incentives to focus on achieving their committed levels of service throughout PR24: whether there is, or is not, an extreme weather event. As Performance Commitments (PCs) are set to focus on the outcomes which customers want to experience, it is important that companies are focussed on delivering those to the extent possible throughout PR24.
- A second element of this criteria is the extent to which an incentive regime which is put into place for “normal” times could become a constraining factor on companies acting in the best interests of customers in the event of an extreme weather event. For example, whether there are actions that a water or wastewater company may not identify as beneficial if there is an extreme weather event because they are encouraged to focus on the incentive regime designed for “normal” times.

³ For example, Heathrow Airport Limited’s Asymmetric Risk Allowance provided by the CAA. This is aimed at compensating Heathrow Airport Limited for a loss of revenue in the event of further pandemic-type events and so is focussed on revenue rather than costs but the principle is directly applicable to costs.

⁴ For example, Ofgem’s “Severe weather 1 in 20 mechanism”.

⁵ There are examples of this type of suspension of the broader incentive regimes in the regulatory regimes of Heathrow, Openreach, Sydney Desalination Plant, and ED2.

⁶ Other duties are that licenced activities are properly carried out, promote economy and efficiency, no undue discrimination, protect customers’ interests in land sales and unregulated activities and contribute to sustainable development. See Ofwat’s duties [here](#).

■ **C: Ability to absorb risk**

- The extent to which a company is able to absorb the risk if it arises, and what action/behaviour the allocation of that risk might drive such that the company is able to absorb the risk if it arises, particularly if those actions/behaviours are not beneficial to customers. There are two particular aspects to this criteria:
 - i) Are companies able to absorb the risk and what changes in company behaviour might arise from this risk allocation such that they are able to absorb it.
 - ii) To what extent are customers protected from the financial impacts of an extreme weather event; both before the event occurs (i.e. the level of bills before the event) and after it (i.e. the level of bills after the event).

■ **D: Consistency with regulatory best practice**

- The extent to which the option is consistent with regulatory best practice of being simple, predictable and transparent. A mechanism which meets these best practice aspects will allow companies to plan their business efficiently which will lead to lower costs for customers (for example, by avoiding over-investment in the networks or an inefficient capital structure); and to enable stakeholders to understand the regulatory regime.

1.8 Based on our assessment of various options against these criteria, we find that an option which combines an ex-post pass through of efficiently incurred costs with a temporary and limited suspension of the ODI regime in the event of an extreme weather event would be likely to provide the best outcomes for customers. This would apply to extreme weather events which are outside of the range of weather conditions that water and wastewater companies are funded for: within that range, water and wastewater companies are funded to prepare for and respond to those events and so no further mechanism beyond the aggregate sharing mechanisms already in place would apply.

1.9 We suggest that the core set of ODIs that are temporarily suspended during and immediately after the event are the common PCs which can be materially affected by extreme weather events: supply interruptions, leakage, mains repairs (bursts), internal and external sewer flooding, per capita consumption, pollution incidences, discharge permit compliance, bathing water quality, river water quality, storm overflows, unplanned outage and sewer collapses. We are not proposing a specific mapping between types of extreme weather events and ODIs as this would introduce significant complexity, in particular to deal with compound and cumulative events.

1.10 We suggest that ODIs are suspended for an initial period of two weeks after the event occurs, and that this could be extended at Ofwat's discretion following submissions from the companies that the effects of the extreme weather remain of sufficient magnitude to warrant a continued exclusion.

1.11 We base this conclusion on the following factors:

- Extreme weather events are relatively unlikely in any given year or over the whole of PR24. Therefore dealing with the (efficient) costs incurred in responding to an extreme weather event

after it happens avoids customers paying potentially substantial sums in the more likely scenario of no extreme weather event (which would be the case if there was an ex-ante allowance).

- The existence and severity of extreme weather events are outside of the control of the water and wastewater companies; and when those events arise there are— by the nature of the event — substantial impacts on customers. Therefore when that event does happen, customers will want their water company to focus on what is needed during and in the immediate aftermath of that event. However, the ODI regime is not calibrated for during and immediately after an extreme weather event. For example, if there is an extreme weather event which results in widespread supply interruptions then the costs of reinstating supplies may be higher than usual (for example because extensive damage needs to be repaired, or substantial overtime is required). Therefore by allowing the recovery of efficient costs and temporarily suspending elements of the ODI framework, this enables those companies to focus on delivering for customers at all times.
 - This approach reduces the exposure of water and wastewater companies to risks that they cannot control. However, by ensuring that only efficiently incurred costs can be recovered, water and wastewater companies will be incentivised to take appropriate action before and during an extreme weather event to mitigate the impacts of those events on customers. This is consistent with Ofwat’s duties to further long-term resilience while protecting the interests of customers and ensuring companies are financeable.
- 1.12 We have considered a number of more detailed factors on how to implement such a mechanism and believe that such a mechanism is practical and could be implemented for PR24.
- 1.13 Inevitably, given extreme weather events are relatively rare, the details of this mechanism will change over time. For example, as the range of events that water and wastewater companies are funded for changes; or as knowledge of best practice in preparing for and responding to these extreme weather events improves, it is logical that this mechanism should evolve to reflect those. However, we believe that having an explicit risk-sharing mechanism in place for these events will work in the best interests of customers and serve to focus on gathering information on these events over time.

2 Introduction

- 2.1 England has a relatively mild climate but the weather is highly variable, with potential for severe windstorms, floods, droughts, cold snaps and heatwave conditions. With climate change, the risks of extreme heat and heavy rainfall has already increased and will continue to rise in the longer term. For example, summers above 40 °C somewhere in the UK have a return frequency of 1-in-100 / 300 years at present, but, without mitigating greenhouse gas emissions, this return frequency may increase to as high as 1-in-3.5 years by 2100⁷. Similarly heavy rainfall events, like those that occurred during Storm Desmond, are seen as at least 40% more likely than without climate change⁸. By Ofwat's own analysis "It is further estimated that there is a 25% chance of the worst drought in recorded history within the next 30 years."⁹ Extreme weather can be very destructive when it happens, and can have substantial impacts on consumers. For example, Storm Arwen resulted in approximately 8,000 properties experiencing a supply interruption with over 5000 experiencing an interruption of greater than 12 hours.¹⁰
- 2.2 When extreme weather occurs, water and wastewater companies incur substantial additional costs in responding to the extreme weather event. For example, Northumbrian Water incurred costs of c.£1.9 million in responding to Storm Arwen, and a series of storms in February 2022 cost South East Water £2 million in damaged equipment, emergency response and replacement generators.¹¹,¹² In addition to these direct costs of responding to the extreme weather events, water and wastewater companies can also incur substantial penalties through the incentives in place under the regulatory framework (penalties under the Outcome Delivery Incentive (ODI) regime) and compensation for customers directly affected. For example , the increase in supply interruptions as a result of Storm Arwen increased the ODI penalty for Yorkshire Water by £1.06 million as well as leading to £70,000 of GSS payments to customers.¹³ The risk associated with extreme weather events is therefore an important factor in the regulatory framework.
- 2.3 In its Draft Methodology for PR24, Ofwat has proposed that water and wastewater companies take the risk associated with extreme weather events, subject to the other risk sharing mechanisms included in the Draft Methodology (such as cost sharing):

⁷ Christidis, N., McCarthy, M. & Stott, P.A. The increasing likelihood of temperatures above 30 to 40 °C in the United Kingdom. *Nat Commun* 11, 3093 (2020). <https://doi.org/10.1038/s41467-020-16834-0> and [Zachariah et al., 2022. Without human-caused climate change temperatures of 40°C in the UK would have been extremely unlikely.](#)

⁸ Otto, F.E.L. et al., 2018. Climate change increases the probability of heavy rains in Northern England/Southern Scotland like those of storm Desmond—a real-time event attribution revisited. *Friederike E L Otto et al 2018 Environ. Res. Lett.* 13 024006 and <https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2021/future-extreme-rainfall-more-extreme-than-first-thought>

⁹ Ofwat, February 2022. 'Ofwat's 3rd Climate Change Adaptation Report'. Available at <https://www.ofwat.gov.uk/wp-content/uploads/2022/01/Ofwats-3rd-Climate-Change-Adaptation-Report.pdf>

¹⁰ Northumbrian Water, June 2022, "Northumbrian Water Storm Arwen representation".

¹¹ Northumbrian Water, 2022, "Northumbrian Water Storm Arwen Representation".

¹² South East Water, July 2022, "Case for excluding supply interruptions minutes resulting from civil emergency in February 2022".

¹³ Yorkshire Water, July 2022, "Yorkshire Water In-period ODI Report 2021/2022".

“We consider that a performance commitment does not need to be fully in a company's control for it to be worth incentivising company action to deliver its functions in the interests of customers. In many cases, companies can mitigate the impact of external factors such as weather events, on customers. We do not think exclusions for such factors are appropriate.”¹⁴

- 2.4 This is a material change from the position in PR19, where companies could (and did – for example after Storm Arwen) apply for exemptions on particular ODIs after extreme weather events.
- 2.5 Ofwat’s approach to price control regulation for the monopoly parts of the water and wastewater businesses is an important of its functions and how it aims to deliver against its statutory duties. Ofwat’s duties as an economic regulator include protecting the interests of consumers, ensuring companies can carry out and finance their statutory functions and further the long-term resilience of water and wastewater systems¹⁵. Frontier Economics and Atkins have been commissioned by three companies: Northumbrian Water, Yorkshire Water and South East Water to examine the characteristics of extreme weather events and options for how those events could be incorporated within the regulatory regime to best support Ofwat’s duties. The focus of this assessment has been on what is practical and implementable in PR24, rather than a perfect or ideal option.
- 2.6 This report identifies a number of options with different costs and benefits; which option is ultimately preferred requires an assessment of trade-offs in a number of dimensions. We present an option which is – in our view – pragmatic and could be implemented at PR24.
- 2.7 The remainder of this report is structured as follows:
- Section 3 gives more detail on the characteristics of extreme weather events;
 - Section 4 provides a brief introduction to the economics of extreme weather events;
 - Section 5 outlines a range of options for allocating the risk of extreme weather events;
 - Section 6 develops criteria for assessing different options for the allocation of the risk of extreme weather events and provides an assessment of options against those criteria;
 - Section 7 gives more details on the shortlisted option; and
 - Section 8 offers conclusions and recommendations.

¹⁴ Ofwat, July 2022, “Consulting on our methodology for PR24”, p. 55. Available at: <https://www.ofwat.gov.uk/wp-content/uploads/2022/07/Draft-methodology-main-document-3.pdf>

¹⁵ Other duties are that licenced activities are properly carried out, promote economy and efficiency, no undue discrimination, protect customers’ interests in land sales and unregulated activities and contribute to sustainable development. See Ofwat’s duties [here](#).

3 Characterising extreme weather events

Types of extreme weather

3.1 Over the last year, the UK has experienced:

- six named storms (Arwen in November 2021 to Franklin in February 2022) with some exceptionally high wind gusts;¹⁶
- a ‘cold snap’ and freeze-thaw conditions in January;
- the highest observed temperature of 40.3°C recorded on 19th July 2022 at Coningsby (Lincolnshire)¹⁷ with above 35°C observed across large areas of England; and
- exceptionally low seasonal rainfall leading to a drought declaration in eight Environment Agency areas in August¹⁸.

3.2 An extreme weather event can be defined in different ways and it is not straightforward to separate extreme weather from other types of weather: weather events are a continuum. Extreme weather events are often described as “unusual, severe or unseasonal changes in weather patterns”¹⁹. Identifying extreme weather events requires good data on weather patterns and meteorological data to assess the magnitude and likelihood of events based on climate, hazard or “system response” characteristics e.g. rainfall depths, peak river levels or low reservoir levels respectively.

3.3 The Met Office is responsible for issuing severe weather warnings, which aim to give advance warning of extreme weather to the public, businesses, emergency services and Government. Warnings are provided as part of ‘nowcasts’ (0-6 hours ahead), short-range forecasts (1-3 days) and medium range forecasts (3-10 days), which all provide information on severe weather. Weather warnings are ‘impact based’ providing information on likelihood and impact. Longer ranged forecasts will indicate the possibility of unusual weather without providing specific severe weather warnings. The joint Met Office-Environment Agency Flood Forecasting Centre provides flood forecasting services for rivers and coastal surges. Warnings and outlooks are a source of information for both anticipatory action and post-event analysis of the extreme weather events.

3.4 The Met Office is also responsible for maintaining historical climate data, which provides information to estimate the likelihood of events and specific post event analysis. The Met Office ‘WOW’ initiative provides instant access to recent climate data, although this is not fully quality

¹⁶ [UK storm season 2021/22 - Met Office](#)

¹⁷ [UK climate extremes - Met Office](#)

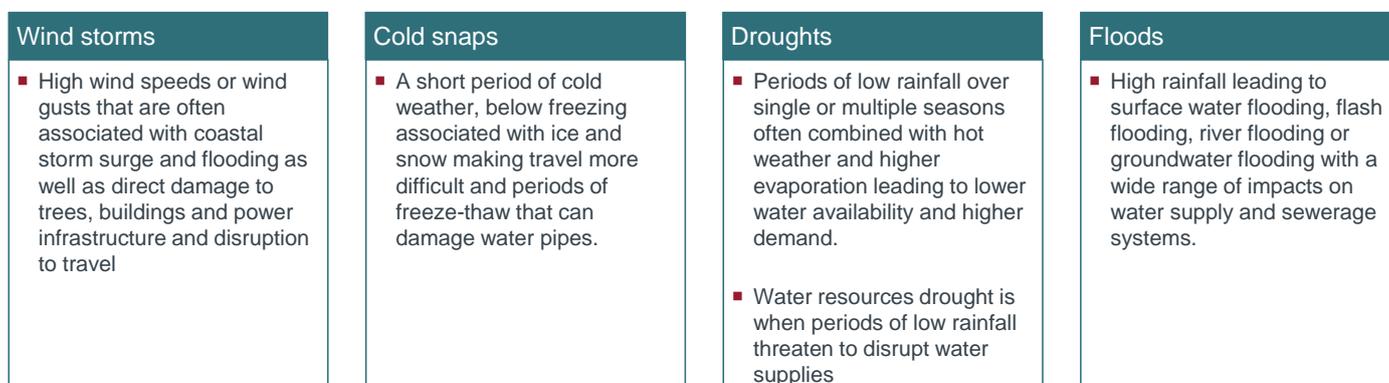
¹⁸ Devon and Cornwall, Solent and South Downs, Kent and south London, Herts and north London, East Anglia, Thames, Lincolnshire and Northamptonshire, and the east Midlands

¹⁹ Department for the Environment, Food and Rural Affairs, June 2013. “Climate change and extreme weather events, establishing a methodology for estimating economic impacts on agriculture – SCF0101”. Available at: <http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18670>

assured.²⁰ Similarly, the Environment Agency and Natural Resources Wales are custodians of hydrological data for hydrological analysis of floods and droughts. The Centre of Ecology and Hydrology provides a hydrological outlook and occasional post-event analysis. Water companies also collect their own data on some hazard variables (e.g. with weather stations at water treatment works) and their systems' performance. These data sets provide information for post-event analysis to quantify the magnitude and likelihood of events.

3.5 For this report we have identified four main types of extreme weather events which we consider are relevant to the water and wastewater sector: wind storms, cold snaps, droughts and floods. These were identified through reviewing Met Office information on types of extreme weather and industry reports and submissions on extreme weather events.²¹ Examples of extreme weather events are in Table 3, and the descriptions of the four types are in the following Figure 1.

Figure 1 Descriptions of types of extreme weather



Source: Frontier Economics and Atkins

Note: From sources including the Environmental Agency, Met Office and Flood Guidance UK

Defining what “extreme” means

3.6 Each type of hazard needs a definition for when it is extreme as not all hazard events should be considered as extreme weather. In the rest of this section we discuss options for characterising what these extreme weather events are and what triggers can therefore be used for a definition of extreme weather events in the regulatory framework. We also consider the issues around compound and cumulative events.

²⁰ The Met Office WOW is a database and mapping tool that collects real time weather data from a range of third party operators. The data are not quality assured in real time by the Met Office however this is still a useful tool to help understand severe wet or hot conditions in real-time or immediately after an event.

²¹ We note that the Met Office issues warnings for other types of weather events such as fog, but have focussed on the types of event that are likely to impact the water and wastewater sector

3.7 The following table sets out options for characterising different extreme weather events that can be used as triggers for extreme event clauses, including the thresholds set in industry frameworks. We have assessed these based their simplicity and predictability (how clear the definitions are).²²

²² We note that setting triggers by using a defined set of rules/ thresholds for the weather event to meet is consistent with a parametric insurance approach to risk allocation. Parametric insurance is based around indemnifying a certain amount when a predefined event occurs, rather than the actual loss occurs. It requires a trigger, or index of triggers, which is often around a Natural Catastrophe, including extreme weather events. Best practice for parametric insurance has triggers which are easily measurable and reported quickly. See for instance Swiss Re, August 2018, "What is parametric insurance". Available at https://corporatesolutions.swissre.com/insights/knowledge/what_is_parametric_insurance.html

Table 2 Options for extreme weather definitions and triggers

WEATHER EVENT TYPE	OPTION	SIMPLICITY	PREDICTABILITY	OTHER NOTES
Windstorm	1-in-50 year wind velocities (Defined through periodically updated national assessments using Met Office data sets)	Medium Varies geographically according to location and terrain	Medium Wind gusts are part of the weather forecast	Based on British Engineering Standards e.g. BS50125 50 year gust speeds were exceeded in some places by Storm Arwen. In line with industry frameworks.
Windstorm	Amber or Red Weather Warning for windstorm	High	Medium (forecast classifies possibility of event from unlikely to very likely)	See Weather warnings guide - Met Office
Cold snap	Met Office Cold Weather Alert level 3 or higher (a mean temperature of 2C or less and widespread ice and snow. Level 4 is a major incident declared by Central Government where sectors other than health are affected)	High	Medium	See Weather warnings guide - Met Office
Drought	EA National Drought Group Drought Status	Medium	Medium	Based on a range of hydrological, ecological and water resources triggers according to regional EA drought plans. Note that the recent drought, which triggered 14 areas into drought status, was reported as ca. 1:50 year event

WEATHER EVENT TYPE	OPTION	SIMPLICITY	PREDICTABILITY	OTHER NOTES
Drought	Exceedance of 1-in-200 year drought	Low	Medium	In line with industry frameworks; threshold is a related to water resources system response and potential use of Emergency Drought Orders. Very dry soils, with high Soil Moisture Deficits, have high potential impacts on pipe network in clay soils.
Flooding	EA severe flood warning (provided by the EA in conjunction with other services)	High	High	Issued for all forms of flooding; alerts, warnings and severe warnings issued
Surface water flooding	Rainfall depths greater than 1-in-50 year event	Medium (varies geographically)	Medium	System response affected by antecedent conditions, storage and other factors. Rainfall depths available from Radar and other sources.
Flooding	Flood depths or extents greater than modelled 1-in-50 year depths	Medium	Medium	Most at risk urban areas protected by flood defences of other measures The EA Risk of Flooding from Rivers and the Sea (RoFRS) data provides information on flood extents considering existing flood defences.
River/ coastal flooding	River flooding exceeding 1-in-100 year and coastal flooding exceeding 1-in-200 year annual probabilities			Most companies have completed work to ensure critical infrastructure is resilient to 100-200 year events, e.g. see Adaptation Reporting Power reports. The National Infrastructure Commission has argue for greater levels of resilience ²³ .

Source: Atkins and Frontier Economics

Note: The Met Office during the forecasting process will release warnings, which will be upgraded or downgraded up to the event. Short-term forecasts are quite accurate. The companies should log warnings affecting their area as part of their emergency planning processes and create a detailed history of warnings.

²³ [Second National Infrastructure Assessment: Baseline Report - NIC](#)

- 3.8 Planning, statutory and regulatory frameworks for water/wastewater companies provide thresholds for what levels of weather companies are expected to be resilient to, and therefore what constitutes extreme weather. We propose to use these in characterising extreme weather events for PR24 to be consistent with industry frameworks as companies are funded through the price control process to develop and manage their networks against these events²⁴. However, this is only for droughts and storms which cause flooding.
- Water Resource Management Plans (WRMPs) require companies to manage their systems to be resilient to 1-in-200 year droughts (avoiding the need for emergency drought orders)²⁵.
 - Drainage and Wastewater Management Plans (DWMPs) are becoming statutory with considerations for companies to manage their networks for 1-in-50 year storms that can cause sewer flooding²⁶.
- 3.9 Windstorms, other types of flooding and cold snaps are not explicitly included in the planning/statutory/regulatory frameworks (in the water sector) and in this case we recommend aligning with other external standards where possible. In the absence of any explicit standard with existing industry frameworks, a judgement will need to be made on what constitutes a sufficiently extreme weather event to be outside the range of weather that companies should reasonably develop their networks to.
- 3.10 We do not consider it appropriate for either companies or Ofwat to declare when an extreme event has happened unilaterally, without any other rules. This could lead to perverse incentives for investing in resilience, a lack of objectivity and a lack of predictability.
- 3.11 In our view, the most appropriate definitions and thresholds are those set out in industry frameworks for storms causing sewer flooding and for low rainfall conditions that lead to water resources droughts. For other weather events types we think external standards that are linked to good practice, standard severe weather thresholds and potential impacts and performance of inter-dependent systems are the most appropriate. These are set out in Figure 2. Water company systems performance is often modelled against these events, which provides opportunities to test system resilience and evaluate expected versus actual performance using a range of evidence and performance data. This strikes the right balance between having clear-cut rules that are predictable while being sufficiently comprehensive and robust. The declaration of an extreme event is made by an independent third party (e.g. Met Office, Defra/EA, National Drought Group, Cabinet Office) and/or with post event analysis providing further details on magnitude, severity,

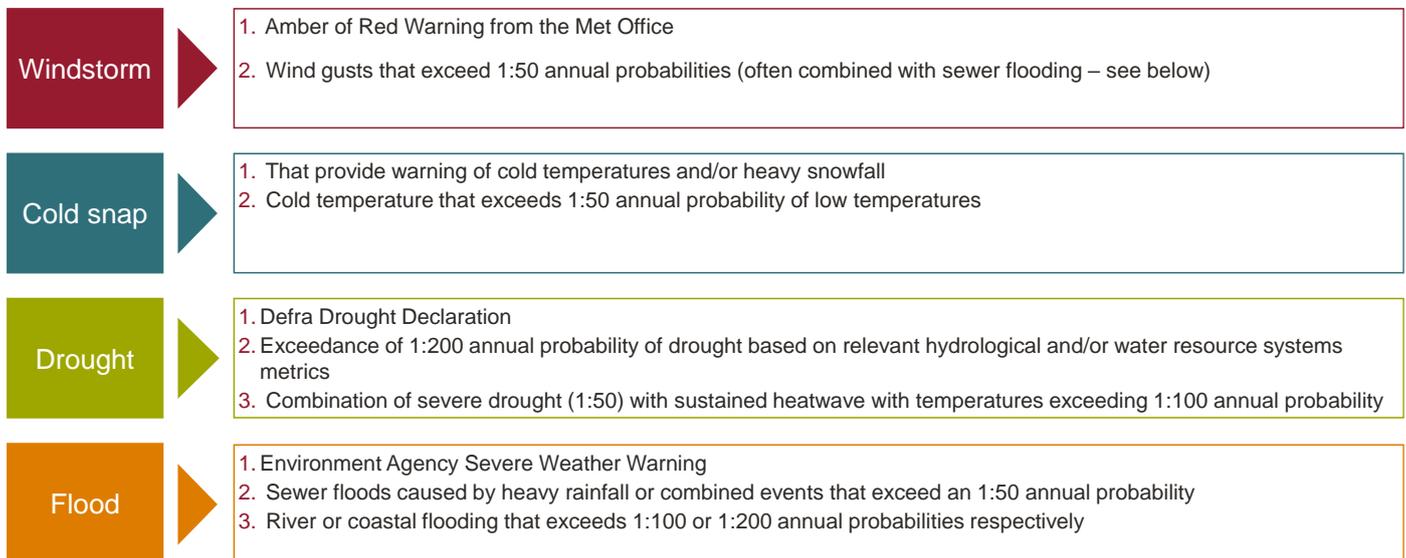
²⁴ Defra's Storm Overflows Discharge Reduction Plan does not affect PR24. It will require improvements in storm overflows with exceptions for unusually heavy rainfall but will not allow any adverse ecological harm by 2050 and will limit discharges to no more than 10 rainfall events per year. A rainfall event is classified as up to 12 hours of rainfall but what constitutes heavy or exceptional rainfall is not defined. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1101686/Storm_Overflows_Discharge_Reduction_Plan.pdf

²⁵ Moving to a 1 in 500 year period after 2039. <https://www.gov.uk/government/publications/water-resources-planning-guideline/water-resources-planning-guideline>

²⁶ See for instance: Water UK, September 2018. "A framework for the production of Drainage and Wastewater Management Plans". Available at <https://www.water.org.uk/wp-content/uploads/2018/12/Water-UK-DWMP-Framework-Report-Main-Document.pdf>

extent and other relevant characteristics. The post event analysis would be done by water companies making submissions to Ofwat.

Figure 2 Recommended framework by extreme weather type for triggers and post event analysis



Source: *Frontier Economics and Atkins*

3.12 The use of forecasting services promotes anticipatory action and real-time observations and modelling studies can be used to set triggers related to the specific actions. These can be based on weather data or system response data, e.g. when flows or storages are exceeded due to a combination of antecedent wetness and high event rainfall, in the case of sewerage systems. There is a consistency benefit in using the same measures that are used in anticipatory action, particularly where ex-post analysis of company actions is needed. The geographical scale of any frequency or extreme event analysis will be based on appropriate units, such as drainage areas for sewer flooding, river basins or water resources zones. These could be agreed with Ofwat as part of the framework for extreme weather events, with the post event analysis demonstrating the extreme event conducted by companies.

3.13 Consideration of triggers for what should be considered extreme weather may also consider spatial extent, which is particularly important in specific circumstances. For example, it may be reasonable to be prepared for local flooding in a single location but widespread flooding across whole company areas presents a much greater challenge. In the context of drought, zones with low water availability would typically benefit from imports of water from neighbouring zones but this becomes impossible if the whole region is suffering from drought. Any regulatory rules will need to include rules on the extent of the water company area that has been affected by the extreme weather. It is possible for only part of a company's area to be affected and local events should not trigger a change in rules for the whole company. This is especially true for companies with

disparate areas and/or areas with substantially different terrains and therefore risk profiles²⁷. This is a topic which is picked up again in section 7.

- 3.14 In the following subsections we discuss issues around compound and cumulative events, changes to weather patterns over time and provide examples of extreme weather events.

Compound and cumulative events

- 3.15 The types of weather events described in Table 2 were considered as separate, independent events. However, it is possible for these extreme events to occur concurrently and cumulatively, which may present additional challenges related to impacts and also challenges on how to characterise the likelihood of these events. Examples of more complex situations include multi-hazards, where two hazards occur at the same time (windstorm and coastal flooding impacting on operational performance), compound risks where weather hazards may be combined with other factors increasing overall risk (heatwave and Covid-19 impacts on peak demand), sequential or cumulative risks where a series of events increases risk (high antecedent rainfall followed by heavy rainfall and surface flooding) and so on. As such, definitions of extreme weather should be extended to include the most relevant combined events (where these outside the standard design parameters set out in best practice).
- 3.16 An additional issue is the role of interdependencies where water system performance is linked to the performance of third party systems, which may themselves fail due to extreme weather or other factors. Energy company performance is linked to the frequency of faults caused by extreme weather rather than any direct weather triggers, which makes it more difficult to align water and energy regulatory approaches. Many flood events are due to a combination of surface water flooding, river flooding and sewer flooding and these may be triggered by failures in flood defence systems or catastrophic failures, such as canal, flood defence or dam breaches. Unravelling the attribution of risk to different parties is complex. Water companies need to set expectations/boundary conditions on the levels of service and performance provided by others and plan for a reasonable range of contingencies. As such, definitions of weather risks should focus on weather events and performance of water company systems, with reasonable assumptions on interdependencies and how their systems may perform if other systems fail.

Weather changes over time

- 3.17 Assessment of likelihoods of events using historical data is challenging in the context of climate change because the climate is 'non-stationary' and the likelihood of certain types of events, such as heavy rainfall or short summer droughts, is higher than revealed by historical analysis alone. Climate models have been used for long term water resources planning since the late 1990s and have also informed studies that provide standard uplifts for heavy rainfall for sewerage design. Climate models can be used to assess the current and changing likelihood of severe weather events over future planning periods. As such water companies may anticipate and plan for a greater magnitude or frequency of extreme weather events than experienced in the past. This is

²⁷ For instance, coastal flooding from extreme weather will affect coastal areas but not inland areas.

achieved by following existing industry guidelines, which set out how you should consider future climate change.

3.18 What constitutes extreme weather, and in particular the likelihood of extreme events, can change over time. There is substantial and growing literature on the impact of climate change on weather and extreme weather events:

- “A small shift in the average climate can lead to major changes in extreme events: A small change in the average climate can drive unprecedented weather events, because it shifts the distribution. For example, what used to be a 1-in-100-year flood event can become a 1-in-10-year event.”²⁸
- “It is further estimated that there is a 25% chance of the worst drought in recorded history within the next 30 years.”²⁹
- The common reference scenarios for companies to use at PR24 include ‘high’ climate change scenarios from UKCP18 RCP8.5 (from the Climate Change Committee). This includes changes to precipitation, temperatures, sea levels etc. companies also have to consider improved technology and changes to demand and environmental ambitions.³⁰

3.19 There are different levels of uncertainty around the direction and magnitude of climate change impacts on extreme weather. This uncertainty is high for windstorms, medium for drought, medium for river and surface water flooding and relatively low for sea level rise and coastal flooding, heatwaves and heavy rainfall. However, for all hazards informative climate impacts studies are available from the water industry (Environment Agency, UKWIR, Ofwat and water company studies), relevant research organisations (e.g. CEH, BGS, Met Office) and the national Climate Change Risk Assessments and National Infrastructure Commission that can be used to characterise hazards under the past and future climates. Ofwat has promoted the use of scenarios and an “adaptive pathways” approach for incorporating future uncertainties into long term planning.

3.20 These definitions for characterising extreme weather and reasonable expectations and uncertainties for future planning periods could be agreed and set for each Price Control to reflect these changes.

Impacts and examples of extreme weather

3.21 Extreme weather events can have impacts on water³¹ companies, customers and society. There are also actions that companies, customers and society that can take to mitigate these.

²⁸ HM Government, January 2022, “UK Climate Change Risk Assessment 2022”. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1047003/climate-change-risk-assessment-2022.pdf

²⁹ Ofwat, February 2022. ‘Ofwat’s 3rd Climate Change Adaptation Report’. Available at <https://www.ofwat.gov.uk/wp-content/uploads/2022/01/Ofwats-3rd-Climate-Change-Adaptation-Report.pdf>

³⁰ Ofwat, November 2021, “PR24 and beyond: Long-term delivery strategies and common reference scenarios”. Available at: <https://www.ofwat.gov.uk/wp-content/uploads/2021/11/PR24-and-beyond-Long-term-delivery-strategies-and-common-reference-scenarios.pdf>

³¹ And wastewater companies

- Wind storms can cause damage to infrastructure, power outages and reduce access. Where wind storms are combined with coastal storm surges and heavy rain there can also be flooding. Actions to mitigate these include following design guidelines and standards to ensure that buildings can withstand high wind gusts, ensuring adequate back up power generators to deal with power outages and increasing flood resilience of works.
- Cold snaps can cause supply interruptions (including from burst pipes from the thaw after freezing), difficulties for customers to access alternative water supplies, frozen groundwater supplies and slower sludge processes. The freeze/thaw event caused by the “Beast from the East” in 2018 caused leakage to increase by 40-45 million litres per day for Yorkshire Water customers. Actions to mitigate these include implementation of cold weather plans, asset monitoring and leak detection, increase in operational teams to maintain the supply network and fix leaks.
- Drought can lead to hosepipe bans, restrictions on water usage, supply interruptions; algae blooms, pumping inefficiency, reductions in biodiversity, low flows causing sewerage blocks, wildfire, reduction in surface water and groundwater, increased demand for potable and raw waters, low pressure, leaks and bursts from soil moisture deficit and subsidence accelerating asset deterioration. Actions to mitigate these include implementation of water company drought plans including demand and supply-side measures, use of operational drought forecasting and in extreme cases bringing mothballed supplies back on-line, importing water and asking industrial users to decrease their demand for water.
- Flooding can lead restricted access to assets, assets closures from flooding, sewerage overflows with environmental consequences, scour of pipe crossings, water quality problems and dam safety problems and extreme sea levels can prevent free drainage from stormwater systems contribute to coastal erosion and saline intrusion to groundwater. Floods in 2007, 2015, and 2019 cost Yorkshire Water a combined £145 million.³² Actions to mitigate these include increasing the level of flood resilience of water company assets, contributing to joint flood risk management projects and making using of flood forecasting and warning and real-time control of sewerage assets.

3.22 In the following table we set out examples of historic material events with their impacts, mitigations and whether these would be considered extreme events within our framework, as set out in Figure 2. This is not an exhaustive list of extreme weather events: it demonstrates how selected events are treated by our framework and provides high level information on impacts and mitigations.

³² Yorkshire Water, 2022, “Climate change and carbon”. Available at: <https://www.yorkshirewater.com/environment/climate-change-and-carbon/>

Table 3 **Examples of historic events and whether they are classified as extreme weather events**

EVENT	DATE AND LOCATION(S)	WEATHER TYPE	IMPACTS	MITIGATIONS	EXTREME EVENT?
Drought	Yorkshire, 1995	Drought	Severe water shortages Water quality impacts Environmental impacts	Implementation of emergency drought plan Water tankers Post event, it led to a large investment in more integrated water resources zone	Yes (based on drought hazard metrics ³³)
Drought	South East, 1998 (starting 1995)	Drought	Low river flows and groundwater levels following several dry seasons from 1995 onwards	Implementation of drought plans	Yes (based on long term rainfall, hydrological and groundwater metrics in parts of the region)
River Floods	Midlands and South East, Autumn 2000	River flooding	Extensive river flooding Economic damage Travel disruption	Risk management measures in many areas were overwhelmed by the sheer volume of flood water	Yes (unprecedented long duration heavy rainfall)
Surface Water Flooding	May to July 2007	Heavy summer rainfall Surface Water Flooding	Over 55,000 homes and businesses were flooded in the wettest May to July period for 250 years. Two-thirds of the properties were affected by surface water flooding. Over 140,000 homes in Gloucestershire lost water supplies due to river flooding	Household flood resilience measures; use of temporary defences to protect critical infrastructure	Yes (based on rainfall intensities and extents)

³³ For example see analysis here: [Water Resources \(ncl.ac.uk\)](http://www.ncl.ac.uk/WaterResources)

EVENT	DATE AND LOCATION(S)	WEATHER TYPE	IMPACTS	MITIGATIONS	EXTREME EVENT?
The “Flouht”	South East, 2010-2012	Long drought 2010-2012 with flooding in 2012/2013	Low river flows and groundwater levels Poor water quality Algal blooms Led to Water UK Long Droughts project and move towards setting the new 1:500 year drought resilience standard	Implementation of drought plan and emergency plans to protect water supplies for London Olympics	Yes (based on long term rainfall, hydrological and groundwater metrics across large areas of the UK)
Beast from the East / Winter Storm Emma	England and Wales (particularly south west), March 2018	Storm and cold snap with freeze thaw	Widespread supply interruptions with 200,000 customers with no water for more than four hours and tens of thousands were left off supply for days ³⁴ . Increase in pipe bursts and leakage (inc. customer pipes)	Post event it has led to Ofwat requiring companies to publish responses to concerns raised by Ofwat, and for poorly performing companies to have externally assured action plans. Ofwat consulted on changes to GSS.	No (the event was not extreme in many of the areas where the impacts were greatest)
Hot weather demand spike	England, late spring-summer 2020	Prolonged warm and dry weather	Increased water demand, particularly peak demands and changes in daily variations due to hybrid working	Proactive engagement with customers to try and reduce water consumption but limited by the increased need for water for hygiene during Covid-19.	No. The demand peaks were predominantly driven by Covid-19. Hot and dry weather exacerbated this but there was not a drought so it was not extreme weather.
Storm Arwen	Northumbria, November 2021	Storm and flooding	100,000 electricity customers without power and power outages affecting	Incident Management Teams mobilised, mobile power generators mobilised, distribution of bottled water and	Yes (in some areas based on combination of wind gusts, wind direction, freezing conditions and

³⁴ [Ofwat Out in the Cold: Water companies’ response to the “Beast from the East”](#)

EVENT	DATE AND LOCATION(S)	WEATHER TYPE	IMPACTS	MITIGATIONS	EXTREME EVENT?
			water supply and wastewater treatment Fortunate that storm Arwen coincided with neap tides and not spring tides.	liaison between water companies and electricity Distribution Network Operators (DNOs)	flooding, compounded by unprecedented energy outage) No (based on average wind gusts over regions)
Storm Eunice	South England, February 2022	Windstorm and cold snap	Snow impact in the north, high winds in the south and southwest. New record gusting windspeeds set (four fatalities). Gusts with a 200-year return period wind speed recorded at Charlwood near Gatwick Airport. More than 58 EA flood alerts and tens of flood warnings. Outage at water supply and wastewater works. Significant interruptions to power networks.	As above with additional work to protect water infrastructure from flooding	Yes (across most of England and Wales)
Drought	England and Wales, summer 2022	Drought - Highest daily max temperature of 40.3 Deg [hard to compare with previous droughts as unclear how long it will last ³⁵]	Low rivers flows and groundwater in August 2022 Severe agricultural drought Water quality impacts	Implementation of drought plans Environment Agency Drought Declaration in August 22	Drought No Heatwave Yes Combined drought and extreme heat July/Aug Yes

Source: Atkins and Frontier Economics

3.23 This section has developed a framework for considering whether a weather event can be considered extreme. The next section develops our analysis by considering the economics of extreme weather events.

³⁵ Met Office, August 2022, "Driest July in England since 1935". Available at: <https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/driest-july-in-england-since-1935>

4 The economics of extreme weather events

- 4.1 As previously described, extreme weather events are characterised by their rarity, unpredictability and severity. Water companies cannot control the weather or influence the likelihood or severity of extreme weather events. However, they can mitigate (to some extent) the impact of these extreme weather events through planning, preparation and investment.
- 4.2 These high impact, low probability events represent significant downside risks for customers and companies through impacts on operations and service delivery. For example, Storm Arwen's impact on customer outcomes was such that Northumbrian Water would have had to pay an ODI penalty of over £22 million if a reduction was not agreed³⁶. Therefore regulators need to consider the ramifications of how the risk associated with these events is allocated between customers and companies.
- 4.3 The impact of extreme weather events are unpredictable as the result of two linked, but discrete, forms of uncertainty:
- First, the uncertainty about whether an event may occur in a given asset management period; and
 - Second, if an extreme weather event does occur, uncertainty around what the impact of the extreme weather event will be on the water and wastewater system and therefore on customers and company's ultimate operational and service delivery exposure.

Example: Storm Arwen

Storm Arwen provides a recent example of these two considerations. The storm was estimated to have annual return periods of between 1-in-20 to 1-in-50 years and resulted in severe and rare northerly winds, as opposed to the usual west, south-west direction³⁷. The unusual winds knocked down power lines and the resulting loss of power disrupted water supply for Northumbrian Water and Yorkshire Water customers. This caused more than 5,500 Northumbrian Water customers to be without supply for more than 12 hours.³⁸ The particular circumstances of Storm Arwen resulted in a very substantial impact on water customers, which would have been difficult to predict before the storm because of the interactions between the water and electricity networks, and the unusual direction of the winds in Storm Arwen.

- 4.4 The risks associated with extreme weather events can be mitigated by increasing the resilience of the water and wastewater networks. However, the benefits of this approach (delivering reduced impacts on customers if such an event occurs) need to be balanced against the costs of such an approach (an increase in customer bills to fund the additional expenditure required to reinforce the networks as needed). For example, the impacts from 1-in-100 year events are likely to be significantly higher than impacts from 1-in-20 year events, but the costs of constructing the

³⁶ Northumbrian Water, 2022, "Northumbrian Water Storm Arwen Representation".

³⁷ Jacobs, April 2022, "Review of Northumbrian Water's response to Storm Arwen". The severity of the storm depends on the exact location in question. Some areas experience wind speeds above 1 in 50.

³⁸ Northumbrian Water, 2022, "Northumbrian Water Storm Arwen Representation".

network to a standard required to be resilient to this will also be substantially higher (and these costs will be reflected in customer bills). For example, Defra's Storm Overflow Discharge Reduction Plan is designed to reduce overflows which damage the environment against an increasing risk of severe storms due to climate change.³⁹ While not specifically about resilience due to extreme weather the magnitude of the costs for reducing overflows are pertinent. Defra is setting out a mandatory £56 billion in investment from water companies before 2050 to reduce the environmental impact of storm overflows, and this would require an average increase of £42 in bills per year over the 25 years to fund this.⁴⁰ The modelled bill increases would be £12 during PR24, with significant variation across companies.

4.5 However, regardless of the risk of extreme weather events, that risk will need to be allocated in a way which is consistent with Ofwat's duties to protecting the interests of consumers, ensuring companies can carry out and finance their statutory functions and further the long-term resilience of water and wastewater systems.⁴¹ There is a longstanding economic principle of allocating risk to the party which is best placed to manage it⁴². However, in practice, this principle is too high-level to be useful where there are a number of dimensions to consider, such as the impact of risk allocation on incentives⁴³. We therefore consider the different aspects of allocating risk in section 6 as we develop our criteria for assessing different options against.

4.6 There are a number of ways in which this risk can be allocated between companies, customers and other parties (notably insurance companies), as outlined briefly below. Any allocation will have a number of impacts to consider: particularly the incentives on customers and companies to undertake action to mitigate the risk and respond appropriately; it will interact with the wider regulatory regime (which is carefully designed to focus water and wastewater companies throughout the price control period on what matters for customers); and (potentially) the return which investors require to invest in water and wastewater companies.

4.7 Insurance is a traditional approach to hedging against risk and it is possible to purchase insurance against extreme weather event risk. However, the uncertainty highlighted above makes it difficult and costly for companies to protect themselves from every permutation of extreme weather. For example, parametric insurance such as Munich RE's "Weather Risk Transfer Solutions" product provides insurance against wind, precipitation and other variances in weather against agreed-upon ranges⁴⁴. However, due to the two-fold uncertainty described above, defining a complete range of all extreme weather events would be a difficult ex-ante exercise for water companies to perform

³⁹ Instances of storm overflows are also affected by non-extreme storms as well as population growth, sewer blockages and paving green spaces which limits drainage.

⁴⁰ DEFRA, August 2022, "Storm Overflow Discharge Reduction Plan". Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1101686/Storm_Overflows_Discharge_Reduction_Plan.pdf

⁴¹ Other duties are that licenced activities are properly carried out, promote economy and efficiency, no undue discrimination, protect customers' interests in land sales and unregulated activities and contribute to sustainable development. See Ofwat's duties [here](#).

⁴² See, for example, HM Treasury, 2022, "The Green Book: Central government guidance on appraisal and evaluation", p. 48. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063330/Green_Book_2022.pdf

⁴³ We note that CEPA's report for Ofwat on risk allocation has a similar perspective as illustrated by the following quote: "For the purposes of this report, we consider that the 'best placed to manage' decision rule is too high level a test in isolation on which to base risk allocation for the purpose of this report, which is inevitably more complex than a single characteristic." CEPA, June 2021, "Allocation of risk", p. 5. Available at: <https://www.ofwat.gov.uk/wp-content/uploads/2021/06/CEPA-report-Allocation-of-risk.pdf>

⁴⁴ Munich RE, Weather Risk Transfer solutions. See: <https://www.munichre.com/en/solutions/for-industry-clients/energy-weather.html>

and the resulting insurance costs would ultimately be paid by customers. Similar definitional issues exist with other insurance-like solutions for extreme events, as seen in the experience with pandemic catastrophe bonds after Covid-19⁴⁵.

- 4.8 One option is for the risk to be allocated to water and wastewater companies. From the perspective of a regulated company, extreme weather events present a material downside risk. South East Water faced £1.5 million in Supply Interruptions ODI penalty as a result of Storm Eunice and Franklin exceeding their ODI penalty collar as well as significant costs.⁴⁶ Without collars in the upcoming pricing period the downside risk would be even greater. Where a company takes this risk, it will result in a negatively skewed distribution of expected returns. This may have implications for the allowed return required to compensate investors for the cost of capital. In the face of asymmetric and downside risks the expected return would be below the allowed rate of return set by the regulator and therefore the allowed rate of return would need to be set above the cost of capital in order for the expected return to be equal to the cost of capital. Separately the exposure to the downside risk could, in itself, increase the cost of capital leading to a further impact on the allowed rate of return. Although a full discussion of that issue is outside the scope of this paper, we note that the CAA has recently in its recent H7 proposals for Heathrow, CAPM estimates (used to determine the allowed cost of capital for water and wastewater companies) assume that risks are symmetrically distributed⁴⁷:

“CAPM is a mean-variance model which assumes that all risks are symmetrically distributed. If risks during the H7 period are not in fact symmetrically distributed, the CAPM beta and the allowed cost of equity, by design, will not compensate shareholders for bearing asymmetric risks.”

- 4.9 To the extent that water and wastewater companies bearing the risk associated with extreme weather events results in the need for a higher allowed rate of return, this will increase customers' bills.
- 4.10 An alternative option for allocating the risk of extreme weather events between customers and companies is through uncertainty mechanisms in the regulatory framework. These mechanisms explicitly target uncertain events which are unlikely to occur during a given price control period but which will have significant consequences for customers and companies if they arise. Uncertainty mechanisms can relate to ex-ante or ex-post provisions, such as ex-ante allowances or ex-post cost passthrough, that reduce the risk of high upfront resilience costs while also ensuring investors are protected from extreme outcomes. As part of its RIIO methodology, Ofgem has described the rationale behind uncertainty mechanisms as follows⁴⁸:

“Uncertainty mechanisms can be used to reduce investors' exposure to the risk that a network company needs to spend more than envisaged at the price control review to deliver outputs... The use of uncertainty mechanisms should be limited to instances in which they will deliver value for money for existing and future consumers while also protecting the ability of networks to finance efficient delivery.”

⁴⁵ Calvert / Financial Times, “After COVID-19: The future of pandemic bonds. Available at: <https://www.ft.com/partnercontent/calvert/after-covid-19-the-future-of-pandemic-bonds.html>

⁴⁶ South East Water, June 2022, “SEW Approach to ODI Exclusions 2021/22- Storm Eunice and Franklin”.

⁴⁷ CAA, June 2022, “Economic regulation of Heathrow Airport Limited: H7 Final Proposals”. Available at: <https://publicapps.caa.co.uk/docs/33/CAP2365D%20H7%20Proposals%20Section%203-kb.pdf>

⁴⁸ Ofgem, October 2010, “Handbook for implementing the RIIO model”. Available at: https://www.ofgem.gov.uk/sites/default/files/docs/2010/10/riio_handbook_0.pdf

- 4.11 The way that Ofgem has approached the use of Uncertainty Mechanisms provides a good example for how Ofwat should approach extreme weather risk in the light of its own statutory duties.
- 4.12 Having introduced some of the core economic issues associated with considering the allocation of the risk of extreme weather events, the next section examines regulatory precedent on how the risk associated with extreme weather events is treated in other sectors.

5 Options for allocating risk of extreme weather events

A framework for understanding the allocation of risk of extreme weather events

Risk allocation

- 5.1 Extreme weather also impacts other regulated sectors and countries. In many of those, regulators have developed specific mechanisms for extreme weather events. We have summarised some of the key aspects of these mechanisms from other regulated sectors in UK and the water sector in Australia in following Table 4 - Table 8. The purpose of this review is not to provide a comprehensive review of all approaches, but to review a sufficiently wide selection of infrastructure sectors to inform the design of options which could be adopted in PR24.
- 5.2 The review shows that most other sectors have at least one mechanism to share the risk of extreme weather between infrastructure companies and other parties (users of that infrastructure and/or consumers). Ofgem (Table 4) and the CAA (Table 5) include mechanisms that target both the costs or the lost revenue as a result of an extreme weather event as well as the impact that it has on the incentive regimes. Ofcom's regulation of Openreach (Table 7) and the water sector in Australia (Table 8) both have mechanisms that deal with the impact of extreme weather events on the existing incentive regimes. Out of the sectors reviewed, only Schedule 8 agreements between Network Rail and the Train Operating Companies (Table 6) leaves the effect of extreme weather to existing risk mechanisms.

Table 4 Energy - Ofgem proposed risk mechanisms for ED2

	Severe weather 1-in-20 year funding mechanism⁴⁹	Exceptional Events exclusions for planned interruptions target⁵⁰
1. What performance area is being monitored? (e.g. service performance, cost over/underspend, volume risk)	Totex cost performance	Planned interruptions service performance and associated financial incentives (“Interruptions Incentive Scheme”)
2. Which risk is linked to the performance area? (e.g. wind storms, cold snaps, other extreme events)	Severe weather events	Severe weather events and other exceptional events
3. How the “extreme event” is defined: (e.g. based on a declaration by someone (e.g. the Met Office), triggered by a particular metric (e.g. recorded wind speeds))	A severe weather 1-in-20 year event is classified as an event where a DNO experiences 42 times its mean daily faults within a 24-hour period.	Severe weather is defined as eight times the daily average number of faults at High voltage networks and above. Other exceptional events are defined as risks that are genuinely unusual or rare occurrences that are not a function of day-to-day network operations and which Ofgem would not expect networks to be fully resilient to
4. How is the risk shared? (e.g. partial or full sharing with customers, exclusions or suspension of performance monitoring, partial or full re-opener, allowance for cost pass-through)	In the event of a 1-in-20 year storm, efficient costs associated with the event are reported and trued-up in the next charging period.	Performance under the Interruptions Incentive Scheme in these circumstances is excluded to recognise the impact of these events
5. Why are the risks shared? (e.g. what are the regulator’s stated principles for sharing this risk, what are the impacts on incentives)	Providing DNOs with a fixed allowance for 1-in-20 year storms does not take into account the uncertain nature of these events. Ex-post funding avoids uncertain spend in baseline allowances, and instead addresses additional costs if they eventuate.	The exceptions to the targets ensure that the incentive is consistent with expectations about the level of reliability that is funded under the price control

Source: Ofgem, June 2022, “RIIO-ED2 Draft Determinations – Core Methodology Document”. Available at: <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Core%20Methodology.pdf>

⁴⁹ Ofgem, June 2022, “RIIO-ED2 Draft Determinations – Core Methodology Document”, p. 203-206. Available at: <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Core%20Methodology.pdf>

⁵⁰ Ofgem, June 2022, “RIIO-ED2 Draft Determinations – Core Methodology Document”, p. 176-182. Available at: <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Core%20Methodology.pdf>

Table 5 Aviation - e Heathrow

	Asymmetric risk mechanism	Aerodrome congestion term exceptions
1. What performance area is being monitored? (e.g. service performance, cost over/underspend, volume risk)	Revenue performance, based on forecast vs outturn passenger volumes	Service performance and financial incentives, in terms of actual versus estimated air traffic movements
2. Which risk is linked to the performance area? (e.g. wind storms, cold snaps, other extreme events)	Low frequency, high impact shocks that only result in downside risk to passenger volumes (e.g. pandemics, terrorism)	Bad weather
3. How the “extreme event” is defined: (e.g. based on a declaration by someone (e.g. the Met Office), triggered by a particular metric (e.g. recorded wind speeds))	“Pandemic-magnitude events” - likelihood that sits between a 1-in-20 year and 1-in-50 year occurrence, or the equivalent of a 3.5% probability that a new pandemic-magnitude event might begin in any given year	Low visibility, ice and snow – but only when bad weather cannot be mitigated through Heathrow’s “Relevant Bad Weather Equipment”
4. How is the risk shared? (e.g. partial or full sharing with customers, exclusions or suspension of performance monitoring, partial or full re-opener, allowance for cost pass-through)	Up-front revenue allowance is provided to compensate HAL for the expected loss of profit arising from a future pandemic-magnitude event. This is done by modelling the loss of profit HAL would suffer if price control revenues were to fall due to a downside event and applying a 3.5% annual probability. Heathrow then carries any outturn risk from any future pandemic-level events	Normally, Heathrow pays a rebate to airlines where a material event has occurred which was caused primarily by a failure on the part of the Heathrow or its agents / contractors. Heathrow is not liable to pay rebates for disruption due to bad weather, unless it also occurs alongside a failure on Heathrow’s part (e.g. runway assets are not operational, bad weather equipment is not available etc)
5. Why are the risks shared? (e.g. what are the regulator’s stated principles for sharing this risk, what are the impacts on incentives)	“In the case of passenger forecasts, historical experience suggests that the risks that HAL could encounter sudden downside shocks to traffic, such as those experienced during the pandemic, are not likely to be accompanied by an equal and offsetting set of possible upside events. To address this, it is appropriate to consider adjustments for these asymmetric risks”	None explicitly stated, but rebates are suspended if weather impacts cause disruption beyond Heathrow’s best efforts in providing runway resilience (e.g. bad weather equipment, runway lighting etc.)

Source for HAL example: CAA, June 2022, “Economic regulation of Heathrow Airport Limited: H7 Final Proposals”, p. 110-120. Available at: <https://publicapps.caa.co.uk/docs/33/CAP2365D%20H7%20Proposals%20Section%203-kb.pdf> ; CAA, October 2013, “Economic regulation at Heathrow from April 2014: final proposals”, p. 293. Available at: <https://publicapps.caa.co.uk/docs/33/CAP%201103.pdf>

Table 6 Rail - Schedule 8 agreement between Network Rail and the Train Operating Companies (TOCs)

Schedule 8	
<p>1. What performance area is being monitored? (e.g. service performance, cost over/underspend, volume risk)</p>	<p>Service Performance and financial incentives, measured in minutes of delay (weighted by the number of passengers)</p>
<p>2. Which risk is linked to the performance area? (e.g. wind storms, cold snaps, other extreme events)</p>	<p>Any extreme weather event causing delays including; Wind, Flooding, Heat, Snow/Ice/Frost</p>
<p>3. How the “extreme event” is defined: (e.g. based on a declaration by someone (e.g. the Met Office), triggered by a particular metric (e.g. recorded wind speeds))</p>	<p>At least 2 of the following criteria needs to be met:</p> <ul style="list-style-type: none"> • the relevant authorities are advising the public not to travel due to the adverse weather being experienced on that day. • a severe weather warning has been issued to the industry that is relevant to the cause of delay and in the vicinity in which the delays are occurring • other modes of transport in the vicinity are being affected by the severe weather; • Route Controls declaring a RED alert in accordance with National Control Instructions and Extreme Weather Action Team (EWAT) being initiated. • a railway asset is operating outside of the design parameters due to the conditions being experienced.
<p>4. How is the risk shared? (e.g. partial or full sharing with customers, exclusions or suspension of performance monitoring, partial or full re-opener, allowance for cost pass-through)</p>	<p>There is no change in the risk sharing as a result of the weather being defined as severe. The definition above is used to classify the reason for delay.</p> <p>Payments are made by Network Rail to the TOC or vice versa depending on who is responsible for the delay. Delays due to severe weather are generally attributed to Network Rail and are attributed to the TOC only when the delay is specific to their equipment (e.g. rolling stock)</p> <p>Payments are made when a party causes more delay than its benchmarked amount. This allows a level of expected delay that is reasonable and will include a forecast for the delay expected due to extreme weather. If both parties agree, there is also scope for re-opening Schedule 8 to recalibrate the benchmarks.</p>
<p>5. Why are the risks shared? (e.g. what are the regulator’s stated principles for sharing this risk, what are the impacts on incentives)</p>	<p>The original intention of Schedule 8 was that, for franchised passenger operators, this ultimately reduced the cost to taxpayers by reducing the risk premia that firms include in their franchise bids.</p>

Source: ORR, June 2021, “Schedule 8 performance regime - ORR factsheet”. Available at: <https://www.orr.gov.uk/sites/default/files/2021-06/schedule-8-orr-factsheet-june-2021.pdf> ; Delay Attribution Board, April 2022, “Delay Attribution Principles and Rules”. Available at: [https://sacuksprodnrdigital0001.blob.core.windows.net/delay-attribution-board/Delay%20Attribution%20Board/Delay%20Attribution%20Principles%20and%20Rules%20\(DAPR\)/April%202022%20DAPR.pdf](https://sacuksprodnrdigital0001.blob.core.windows.net/delay-attribution-board/Delay%20Attribution%20Board/Delay%20Attribution%20Principles%20and%20Rules%20(DAPR)/April%202022%20DAPR.pdf)

Table 7 Telecommunications - Openreach

	<i>High-level MBORC allowance</i>	<i>SLG Payments</i>
<i>1. What performance area is being monitored? (e.g. service performance, cost over/underspend, volume risk)</i>	<i>Quality of Service standards such as repair time, first available date for installation and installations completed by the committed date</i>	<i>SLG (Service Level Guarantee) refers to the fixed compensation that Openreach might be liable to pay to the communications provider in the event of any delays in providing a service or fixing a fault.</i>
<i>2. Which risk is linked to the performance area? (e.g. wind storms, cold snaps, other extreme events)</i>	<i>For matters beyond our reasonable control (MBORC) such as Force Majeure events which affect the ability to provide the service. Extreme weather (of any type) is an example.</i>	<i>Any event beyond Openreach's reasonable control</i>
<i>3. How the "extreme event" is defined: (e.g. based on a declaration by someone (e.g. the Met Office), triggered by a particular metric (e.g. recorded wind speeds))</i>	<i>No definition of a Force Majeure event is provided. However, the High-Level MBORC allowance is intended to take account of events affecting over 2,000 lines; incidents which are/are likely to become the subject of regional or national media interest; and anything likely to impact on the BT and/or Openreach brand.</i>	<i>No definition is provided but "river flooded and cannot access end customer premises on the day." is used as an example⁵¹</i>
<i>4. How is the risk shared? (e.g. partial or full sharing with customers, exclusions or suspension of performance monitoring, partial or full re-opener, allowance for cost pass-through)</i>	<i>Ofcom allowed High Level MBORC exemptions in up to two regions per year, for up to eight weeks per event. This means that the standards no longer apply so there will be no impact on Openreach. Customers are impacted by the lower quality of service in these periods</i>	<i>Openreach will not have to pay SLG (Service Level Guarantee) payments to communications providers in the event of MBORC. There does not appear to be a limit to how often a MBORC is declared in this context.</i>
<i>5. Why are the risks shared? (e.g. what are the regulator's stated principles for sharing this risk, what are the impacts on incentives)</i>	<i>This allowance "allow[s] Openreach the flexibility to deal with severe weather or other unforeseen events"⁵²</i>	<i>No reason given, but likely also to allow Openreach flexibility to deal with these events</i>

Source: Ofcom, March 2021, "Promoting competition and investment in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26 Volume 5: Quality of Service". Available at: https://www.ofcom.org.uk/_data/assets/pdf_file/0026/216089/wftmr-statement-volume-5-quality-of-service.pdf; BT, September 2018, "SLA/SLG Policy Business Rules Overview"

⁵¹ BT, September 2018, "SLA/SLG Policy Business Rules Overview", p. 61

⁵² Ofcom, March 2021, "Promoting competition and investment in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26 Volume 5: Quality of Service", p. 20. Available at: https://www.ofcom.org.uk/_data/assets/pdf_file/0026/216089/wftmr-statement-volume-5-quality-of-service.pdf

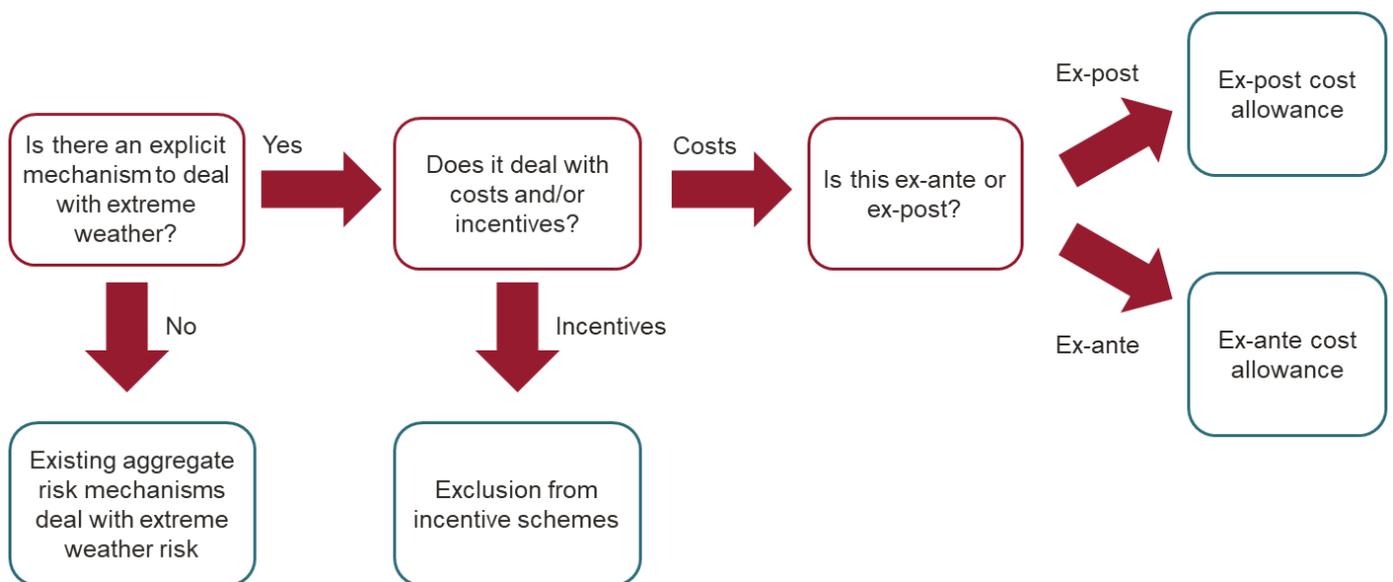
Table 8 Water - Australia

	Guaranteed service level (GSL) schemes in Customer Contracts	Sydney Desalination Plant (SDP) incentive scheme
1. What performance area is being monitored? (e.g. service performance, cost over/underspend, volume risk)	Service levels including unplanned interruption to water supply services, wastewater overflow on customer properties due to a failure in wastewater system, low water pressure, and dirty water	Whether the plant failed to maintain full production during a drought period or at other times when requested to provide water
2. Which risk is linked to the performance area? (e.g. wind storms, cold snaps, other extreme events)	Disaster events	Force majeure events
3. How the “extreme event” is defined: (e.g. based on a declaration by someone (e.g. the Met Office), triggered by a particular metric (e.g. recorded wind speeds))	Disaster events are defined as a major event affecting a significant portion of the water system or wastewater system that was caused by events outside of control such as a natural disaster (e.g. tsunami or earthquake) or a terror event, the risks of which the company could not reasonably have mitigated. Designated as disaster events by government.	The mechanism applies in the case of an ‘uninsurable force majeure event’. The purpose of the plant is to supply water during drought so this type of extreme weather does not apply.
4. How is the risk shared? (e.g. partial or full sharing with customers, exclusions or suspension of performance monitoring, partial or full re-opener, allowance for cost pass-through)	Customers are usually entitled to rebates if the water company fails to meet the expected service level. However, this no longer applies in the case of a disaster event.	Usually, SDP is subject to a financial incentive scheme to incentivise maintenance of the assets during periods of non-operation. This scheme no longer applies in the case of an ‘uninsurable force majeure event’.
5. Why are the risks shared? (e.g. what are the regulator’s stated principles for sharing this risk, what are the impacts on incentives)	No reason given	For events that are outside of the plant’s control, value for SDP’s customers must be balanced with SDP’s exposure to risk

Source: Sydney Water, “Customer Contract (Operating Licence 2019-23)”. Available at: <https://www.sydneywater.com.au/content/dam/sydneywater/documents/customer-contract-2019-2023.pdf>; IPART, June 2017, “Information Paper - Sydney Desalination Plant 2017 Price Review”. Available at: <https://www.ipart.nsw.gov.au/sites/default/files/documents/information-paper-sydney-desalination-plant-2017-price-review-june-2017.pdf>

5.3 This review of some of the regulatory precedent gives several different mechanisms for dealing with extreme weather events. The following figure outlines our framework for categorising these mechanisms into four main types.

Figure 3 Framework for categorising risk mechanisms



Source: Frontier Economics.

Note: boxes with blue borders are the main types of risk mechanisms.

- 5.4 One mechanism is to allow **existing aggregate risk mechanisms** to deal with extreme weather risk. For example, the Schedule 8 agreement between Network Rail and the Train Operating Companies (TOCs) still applies in the event of extreme weather (Table 6). Therefore, Network Rail must still make payments to the TOC's which reduces the financial risk of extreme weather for the TOCs. In the context of PR24, this would involve aggregate risk mechanisms such as cost sharing rates being used to allocate the extreme weather risk between the companies and customers.
- 5.5 If there is a specific mechanism to deal with extreme weather risk then this can deal with either costs or incentives, or both. If it targets incentives, then this usually means an exclusion from incentive schemes during and in the immediate aftermath of an extreme weather event. There are several examples such as Ofgem's Exceptional Events exclusions for planned interruptions targets for ED2 (Table 4), Ofcom's High-level MBORC allowance for Openreach (Table 7), and the exceptions from the Guaranteed Service Level (GSL) schemes in customer contracts for water companies in Australia (Table 8). This means that companies do not incur penalties for missing targets due to matters beyond their control such as extreme weather. This reduces the downside risk for companies since extreme weather can have a significant negative impact on customer outcome targets. This could be applied to the ODI incentive scheme in PR24 to reduce the risk that extreme weather leads to companies missing their targets and being subject to large penalties.
- 5.6 If the mechanism instead focuses on the cost aspect of dealing with extreme weather events, then this can take different forms. One mechanism used is an ex-post cost pass-through for costs to deal with an extreme weather event. An example of an ex-post cost pass-through is Ofgem's Severe weather 1-in-20 funding mechanism (as shown in Table 4). This allows the DNOs to recover efficient costs that arise from dealing with an extreme weather event. Alternatively, an ex-

ante allowance can be used to deal with costs due to extreme weather events⁵³. An example of an ex-ante allowance – albeit one focussed on revenue rather than costs - is the Asymmetric Risk Mechanism for Heathrow (as shown in Table 5). This provides an upfront allowance to compensate for the expected loss of profit as a result of future pandemic-magnitude events. The company then bears the risk of any overspend above this allowance.

5.7 Therefore, when considering options for dealing with extreme weather risk in PR24, regulatory precedent provides several mechanisms that could be used and combined. The risk could be included in existing aggregate risk mechanisms or, if Ofwat decide to include specific treatment of extreme weather risk, mechanisms can target either incentives or costs. We can use these mechanisms as a framework to provide several options that could be implemented.

Approaches to defining extreme weather events

5.8 All of these mechanisms rely on an extreme weather event being defined in some way. The precise way of defining an extreme weather event (or other extreme event) is varied;

- Under some approaches, operational triggers are mechanistically applied, such as in Ofgem’s 1-in-20 year severe weather funding mechanism which is triggered after a network operator experiences 42 times its mean daily faults within a 24-hour period.
- Other approaches use third-party mechanistic triggers, such as the EA National Drought Group defining a drought.
- Other triggers are more subjective and would need to be justified by companies’ submissions to regulators. This includes GSL payment suspension in Australia, which are triggered by disaster events which are out of companies’ control, or Ofgem’s categorisation of “Other Exceptional Events” which are events that are “*genuinely unusual or rare occurrences that are not a function of day-to-day network operations and which Ofgem would not expect them to build their networks to be fully resilient to*”.

Description of risk allocation options

5.9 Using the framework provided from our assessment of the regulatory precedent, we consider five options for how the risk associated with extreme weather in PR24. These are summarised in Table 9.

5.10 The options are defined in terms of treatment of both costs and incentives on the basis that if there is a mechanism in place to deal with one of these aspects then it is likely that the impacts of the event are sufficiently large that it would be beneficial to consider both.

⁵³ An ex-ante allowances can be implicit. I.e. if cost allowances are based on historical averages and the period is sufficiently long to capture some of these events then this approach will effectively include an ex-ante allowance. However if the allowances are based on industry frontier performers then the likelihood is that there will be no automatic ex-ante allowance as these performers are more likely to not have experienced adverse cost shocks, unless this is explicitly captured in determining which companies are considered to be performing at the efficient frontier.

Table 9 Description of Options for PR24

Option	Ex-post cost pass-through or ex-ante allowance?	Suspension of broader incentive regime?	Description
1 (No specific treatment of extreme weather risk)	None	No	Reflects Ofwat’s PR24 draft methodology – companies do not receive specific funding for extreme weather events and must deal with extreme weather risk under existing aggregate risk sharing mechanisms, such as totex sharing. Normal incentive regimes remain in place during and after the event.
2 (Ex-post cost pass-through and suspension of broader incentive regime)	Ex-Post	Yes	Companies receive ex-post reimbursement to recover efficient costs incurred in responding to an extreme weather event. Normal incentive regimes are suspended during the severe weather event and its immediate aftermath
3 (Ex-post cost pass-through and no suspension of broader incentive regime)	Ex-Post	No	Companies receive ex-post reimbursement to recover efficient costs incurred in responding to an extreme weather event. Normal incentive regimes remain in place during and after the event.
4 (Ex-ante allowance and suspension of broader incentive regime)	Ex-Ante	Yes	Companies are provided with an ex-ante allowance to respond to extreme weather events. Normal incentive regimes are suspended during the severe weather event and its immediate aftermath.
5 (Ex-ante allowance and no suspension of broader incentive regime)	Ex-Ante	No	Companies are provided with an ex-ante allowance to respond to extreme weather events. Normal incentive regimes remain in place during and after the event.

Source: Frontier Economics

Note: 1) Under all options, companies are also provided with funding through the price control review to spend on preparing for severe weather events, for example on asset resilience or assets dedicated to this risk. 2) Under all options, there remains a possibility of applying for an interim determination/reopening the price control.

5.11 Option 1 reflects Ofwat’s position in its draft methodology for PR24, where extreme weather risk is managed using existing aggregate risk mechanisms such as totex risk sharing. Options 2 to 5 are alternatives that include specific provisions for extreme weather risk. These options vary in whether they provide ex-ante or ex-post cost allowances, as well as whether they allow for the temporary exclusion of incentive schemes during the severe weather event and its immediate aftermath.

5.12 Having developed a range of options in this section, the next section of the report develops a set of criteria against which those options can be assessed to identify which option is likely to offer good value to customers.

6 Criteria for, and assessment of, options of allocating risk of extreme weather events

6.1 As outlined in section 4, extreme weather events are complicated and affect customers in a number of different ways. Therefore, in assessing the options set out in the previous section, we have used five criteria to assess the suitability of each option. These criteria are designed to identify the option which provides the best outcome for customers when there is, and when there is not, an extreme weather event.

Criteria for assessing options of allocating risk of extreme weather events

6.2 In developing these criteria, we have taken into account Ofwat's position on risk allocation which is that the risk should be allocated to the party that is best placed to manage that risk. CEPA, commissioned by Ofwat, uses a risk allocation framework that has elements which are broadly consistent to the criteria we propose above, although framed somewhat differently⁵⁴. We have also considered Ofwat's duties as an economic regulator, including protecting the interests of consumers, ensuring companies can carry out and finance their statutory functions and further the long-term resilience of water and wastewater systems.⁵⁵

6.3 These four criteria are set out below.

A: Incentives for appropriate preparation and response

- i) Does the option give water and wastewater companies an incentive to: prepare for extreme weather events; invest in appropriate resilience of water and wastewater networks so that those networks continue delivering services to customers during extreme weather events; and – in the event of an extreme weather event – act in a way which is in the best interests of consumers. . Resilience is important to mitigate the impacts of extreme weather events on customers. However, it is important that resilience is delivered to appropriate levels to avoid excessive costs being incurred which will be funded by customers. For example, if a given option provides limited protection from extreme event risk, companies may be incentivised to fund very high levels of resilience to mitigate the risk of a rare but very expensive event but at the cost of high customer bills before that event has occurred.
- ii) Does the option give customers an incentive to take actions to reduce the impact of extreme weather events on themselves.

B: Impact on incentive package

- To what extent does the option interact with the overall package of incentives contained within PR24. In particular, does the option ensure that companies have incentives to focus on achieving their committed levels of service throughout PR24: whether there is, or is not, an extreme weather event. As Performance Commitments (PCs) are set to focus on the outcomes which customers

⁵⁴ CEPA, June 2021, "Allocation of risk". Available at: <https://www.ofwat.gov.uk/wp-content/uploads/2021/06/CEPA-report-Allocation-of-risk.pdf>

⁵⁵ Other duties are that licenced activities are properly carried out, promote economy and efficiency, no undue discrimination, protect customers' interests in land sales and unregulated activities and contribute to sustainable development. See Ofwat's duties [here](#).

want to experience, it is important that companies are focussed on delivering those to the extent possible throughout PR24.

For example, consider the PC of water supply interruptions. There is good evidence that customers value having a continual supply of water. A large storm could affect incentive structures that combine elements that are largely within company control (e.g. supply interruptions in normal weather conditions) with elements that are largely not within company control (supply interruptions during extreme events) can lead to unintended consequences and poor incentive properties overall. Options that reduce incentives to achieve targets that impact consumer outcomes in periods before/after extreme weather are clearly less desirable.

One recent example of the impact on supply interruptions is from Storm Arwen in 2021. Looking at Northumbrian Water the ODI penalty is over 40 times bigger when the full impact is included.⁵⁶ Northumbrian Water estimated that without the majority of the impact of Storm Arwen it would have received a £0.57 million ODI penalty across its three interruption PCs in 2021/22. This includes a small proportion of the penalty from including the impacts as Northumbrian Water's review of the event found areas where its response could have been more robust. If no impacts of the storm were included the ODI would be a reward of £2.81 million. With all the impacts included the penalty is nearly £23 million.⁵⁷ Northumbrian's exemption proposal to Ofwat is based on the storm constituting a civil emergency and comparison to expected performance without Storm Arwen on recent years as baselines.

A second element of this criteria is the extent to which an incentive regime which is put into place for "normal" times could become a constraining factor on companies acting in the best interests of customers in the event of an extreme weather event. For example, whether there are actions that a water or wastewater company may not identify as beneficial if there is an extreme weather event because they are encouraged to focus on the incentive regime designed for "normal" times. For PR24, Ofwat is proposing to ensure all PCs have significant financial incentives, with no reputational-only PCs or lower value financial incentives.

C: Ability to absorb risk

- The extent to which a company is able to absorb the risk if it arises, and what action/behaviour the allocation of that risk might drive such that the company is able to absorb the risk if it arises, particularly if those actions/behaviours are not beneficial to customers. There are two particular aspects to this criteria:
 - i) Are companies able to absorb the risk and what changes in company behaviour might arise from this risk allocation such that they are able to absorb it. As outlined in section 4, extreme weather events are infrequent but significant in scale when they happen. For example, flooding due to Storm Sebastian cost Yorkshire Water £13.9 million in 2019.⁵⁸ Companies may respond to being required to absorb this risk by seeking to increase investments in the resilience of their networks to reduce their risk profile (which would benefit customers in the event of a severe weather event but needs paying for in all circumstances); or to change their capital structure to increase the level of

⁵⁶ This excludes where Northumbrian is accepting small amounts of the penalty due to its response to Storm Arwen. APR 2022 report.

⁵⁷ Northumbrian Water, 2022, "Northumbrian Water Storm Arwen Representation".

⁵⁸ Yorkshire Water, 2022

equity (which could reduce the benefits to customers resulting from a gearing level that would be appropriate in the absence of these risks). In addition, if water companies take this risk then this will add a substantial negative risk which the companies bear and therefore reduce expected returns.⁵⁹ This would require some offsetting adjustment (i.e. a reduction in risk allocation elsewhere in the regulatory framework) to ensure that companies can continue to earn their cost of capital (in expectation).

ii) To what extent are customers protected from the financial impacts of an extreme weather event; both before the event occurs (i.e. the level of bills before the event) and after it (i.e. the level of bills after the event).

D: Consistency with regulatory best practice

- The extent to which the option is consistent with regulatory best practice of being simple, predictable and transparent. A mechanism which meets these best practice requirements will allow companies to plan their business efficiently which will lead to lower costs for customers (for example, by avoiding over-investment in the networks or an inefficient capital structure); and to enable stakeholders to understand the regulatory regime.

Assessment of options for allocating risk of extreme weather events

- 6.4 Table 10 provides an assessment of each option outlined in section 5 against the preceding criteria, along with a simple red/amber/green rating for each option against each criteria to illustrate the extent of consistency of that option with the objectives of that criteria.
- 6.5 Based on our assessment against the criteria, we find that Option 2 (an ex-post cost pass-through and temporary, limited, suspension of the ODI regime) is preferred. This would ensure that companies focus on delivering for customers whether there is an extreme weather event or not. Water and wastewater companies would be incentivised to plan for extreme weather events and ensure resilience standards are met as they will know that only efficient costs can be recovered. However, they do not have an incentive to over-invest in resilience at the expense of higher customer bills (which could be the case for Options 1, 3, 4 and 5). By temporarily suspending a focussed set of ODIs, companies will be focussed during and after the extreme weather event on delivering for customers. In other options where companies carry outturn risk from extreme events (Options 1, 3, 4 and 5 – albeit to different extents), there is a risk that companies build additional (potentially inefficient) resilience into their networks to further reduce their exposure from extreme events. This inefficient resilience would likely be funded through companies focussing on increasing resilience to the detriment of other aspects of service provision (assuming that increased spending on resilience is not permitted by Ofwat). This may result in improved outcomes for customers if there is an extreme weather event but is likely to reduce the service provision when there is not the extreme weather event.
- 6.6 Under Option 2, parts of the ODI regime are temporarily suspended during the extreme weather event. This ensures that ODIs are not overwhelmed during the event (for example, if extreme weather leads to one aspect of the incentive regime being very difficult/expensive to achieve such

⁵⁹ It is also possible that absorbing such a risk may increase the required rate of return if this risk is not diversifiable. A full discussion of this issue is beyond the scope of this study.

as a storm leading to a large number of supply interruptions making it difficult or impossible to achieve the overall supply interruption PC unless the impact of the storm is excluded). The risk is that, if the ODI regime continues to apply during the extreme weather event (as in Options 1, 3 and 5) that the ODI regime – which is calibrated for “normal” times – is either overwhelmed by the extreme weather event and therefore loses its incentive properties; or that the ODI regime acts as a barrier to companies acting in the best interests of customers during the extreme weather event. This temporary, limited, suspension of the ODI regime should therefore ensure that companies remain focussed for the entire duration of the price control on delivering what customers want from their water and wastewater services, whether there is an extreme weather event in PR24 or not. Under Option 2, companies will still be incentivised to maintain service performance (based on doing what is right for customers during that event) during an extreme weather event, as efficient costs (and therefore how those costs are incurred) will be scrutinised by Ofwat following the event. In contrast, Option 4, where incentives are suspended but there is ex-ante funding, would create an incentive to minimise costs while the regime is suspended. As the purpose of the incentive regime is to focus companies on delivering what matters to customers, Option 2 would be conducive to ensure that the incentives to deliver for customers are retained throughout PR24 and not distorted by an extreme event.

- 6.7 A further benefit of Option 2 is that customers are only paying for costs which are incurred in responding to extreme weather events, rather than in anticipation of those (such as in the case of an ex-ante allowance for Options 4 and 5). Under Option 1, customers would be likely to only pay for a part of the costs incurred in responding to extreme weather events (because the totex sharing rate is less than 100%) but this is balanced by potential incentives for companies to focus on inefficient levels of preparation and resilience at the expense of other aspects of the service provision. Under Option 3, customers would only pay for costs incurred efficiently during an extreme weather event and would benefit from reduced ODI payments: however, this is balanced by the risk of companies focussing on inefficient levels of preparation and resilience to extreme weather events because of the potential costs of those events. Options 4 and 5 would require customers to pay for the ex-ante risk allowance whether or not an extreme weather event occurred. As extreme weather events are, by definition, relatively unlikely, this means that customers will most likely pay for an allowance which is not used during PR24.
- 6.8 Option 4 (an ex-ante allowance and a suspension of the broader incentive regime) would also provide benefits, primarily by giving ex-ante certainty to customers and companies about the funds available to mitigate risk from extreme weather events. However, due to the unpredictable nature of extreme weather, both in terms of its frequency and impact on water/wastewater company operations, downside risk would still remain in this option. This is because companies would take outturn cost risk beyond the ex-ante allowance and it is difficult to correctly estimate the costs and probability of extreme events when calculating the ex-ante allowance. To manage this uncertain risk exposure, companies may inefficiently invest in excessive network resilience; deleverage and increase financing costs; or purchase costly and imperfect insurance. On this basis, we conclude that Option 2 would provide a reasonable approach to allocating extreme weather risk at PR24. Option 2 provides companies with incentives to invest in resilience and planning for extreme weather events, while also ensuring that extreme events are managed efficiently if they occur and asymmetric risk faced by investors is minimised. In short, it incentivises companies to focus on managing the risks that they can manage (i.e. mitigating the risks to customers in the event that an extreme weather event occurs) while not exposing them to substantial risks that they cannot

manage. This is consistent with Ofwat's duties to protect customers and longer-term resilience, while ensuring companies can deliver and fund their statutory services.

6.9 A more detailed assessment of each option against each criteria is provided in the following table.

Table 10 Assessing risk allocation options

Option	A. i) Incentives for appropriate preparation and response (Companies)	A. ii) Incentives for appropriate preparation and response (Consumers)	B. Impact on broader incentive package	C. i) Ability to absorb risk (companies)	C. ii) Ability to absorb risk (customers)	D. Consistency with regulatory best practice
<p>1 (Ofwat option – no explicit treatment, rely on aggregate risk sharing mechanisms)</p>	<p>Some incentive for companies to invest in asset resilience and prepare/respond effectively as totex overspend sharing rates are <100%, so companies carry some risk from events.</p> <p>Some incentive for water companies to invest in inefficient resilience at the expense of other priority areas.</p>	<p>Limited incentive for consumers to invest in resilience as costs of extreme weather event pooled across all customers in an area.</p>	<p>Companies will be incentivised to deliver service performance during BAU times, but may over-focus on extreme event risk</p> <p>Following an extreme event, PCLs will likely be breached despite previous effort and companies may focus on other areas where they can meet or exceed targets.</p>	<p>Totex sharing reduces some overspend risk depending on the sharing rate, but companies may still have substantial risk beyond the sharing rate. Extent of company exposure is unclear.</p>	<p>Customers may pay higher bills during BAU times to fund resilience to extreme events (depending on allowance by Ofwat) and will face higher bills based on totex sharing following an extreme weather event, but to a lower extent than other options because of the cost sharing.</p>	<p>A single aggregate risk mechanism is simple and transparent, but total company exposure from extreme events is not predictable</p>
<p>2 (Ex-post funding and suspension of broader incentive regime)</p>	<p>Companies are incentivised to invest according to regulatory resilience standards and prepare/respond effectively as only efficiently-incurred extreme weather costs are recovered following an event.</p>	<p>Ex-post costs are passed onto customers but pooled across all customers in an area. Customers have some, but limited, incentive to invest in resilience to reduce these ex-post costs.</p>	<p>Companies' incentives to maintain service remain during an extreme event, as efficient costs and performance will be scrutinised ex-post.</p> <p>ODI exclusion also ensures companies' efforts against PCLs are not undone by a severe event, and companies still incentivised to perform against targets after the event.</p>	<p>BAU ability to absorb risk is not skewed by extreme event risk, due to ex-post funding covering efficient costs. This helps the companies understand the BAU magnitude of the risk they are taking and to manage that risk appropriately under efficient capital structures.</p>	<p>Lower customer bills during BAU times, but would face higher bills (up to efficient costs) after an extreme weather event.</p>	<p>With clear and simple principles defined for ex-post review, the process should require limited incremental resource and be transparent and predictable</p>
<p>3 (Ex-post funding and no suspension of incentive regime)</p>	<p>Similar incentives to invest as in option 2, but unlimited ODI risk could incentivise companies to invest in inefficient increases in resilience, diverting funds from other areas of operations to mitigate penalty payment risk.</p>	<p>Ex-post costs are passed onto customers but pooled across all customers in an area. Customers still have some, limited, incentive to invest in resilience to reduce these ex-post costs.</p>	<p>Following an extreme event, PCLs will likely be breached and companies could instead be incentivised to focus on other service areas where they are still able to meet or exceed the target.</p>	<p>As above, efficient costs are covered by ex-post funding but risk of substantial ODI penalties may influence companies towards more inefficient / costly capital structures to some extent.</p>	<p>Lower customer bills during BAU times, but would face higher bills (up to efficient costs) after an extreme weather event.</p> <p>Customers may also receive some bill reductions through ODI penalty payments.</p>	<p>With clear and simple principles defined for ex-post review, the process should require limited incremental resource and be transparent and predictable</p> <p>However, risk around ODI payments risk reduces predictability compared to options with ODI suspension.</p>

Option	A. i) Incentives for appropriate preparation and response (Companies)	A. ii) Incentives for appropriate preparation and response (Consumers)	B. Impact on broader incentive package	C. i) Ability to absorb risk (companies)	C. ii) Ability to absorb risk (customers)	D. Consistency with regulatory best practice
<p>4 (Ex-ante funding and suspension of broader incentive regime)</p>	<p>Companies are incentivised to build resilience to limit outturn cost risk in the event of extreme weather but have incentive to invest in inefficient levels of resilience.</p> <p>Suspension of ODI payments may limit incentives to invest in service during the event (to minimise costs against the ex-ante allowance)</p>	<p>Limited incentive for consumers to mitigate risks, as outturn risk falls on companies after ex-ante funding.</p> <p>Some incentive may be retained between price control periods as ex-ante allowances will be reviewed.</p>	<p>ODI exclusion ensures that companies' efforts against PCLs are not undone by a severe event, and they are still incentivised to perform against targets after the event.</p> <p>Given companies will want to manage outturn cost risk, their incentives to maintain service during the extreme event may be reduced given ODI suspension, compared with options where this is not suspended or efficiently incurred costs are permitted.</p>	<p>Potential for larger outturn costs than ex-ante allowance following a severe weather event. Companies may be able to insure against this risk in insurance markets, and/or opt for more inefficient / costly capital structures</p> <p>This is balanced to some extent by the suspension of ODI payments, which reduces risk</p>	<p>Customers protected from bill risk after a severe weather event, but pay higher bills under BAU to fund ex-ante payments.</p>	<p>Agreeing a "correct" view of expected costs and probability of extreme events ex-ante will be difficult and overall outturn impact on sector will be unpredictable. However, the ex-ante allocation of costs provides a clear funding allowance for the companies.</p>
<p>5 (Ex-ante funding and no suspension of incentive regime)</p>	<p>As above, companies are incentivised to build resilience to limit outturn cost risk in the event of extreme weather but have incentive to invest in inefficient levels of resilience</p> <p>ODI risk may lead to more incentive to fund resilience, but risk of overspend to minimise penalties.</p>	<p>Limited incentive for consumers to mitigate risks, as outturn risk falls on companies after ex-ante funding and companies need to manage ODI risk.</p> <p>Some incentive may be retained between price control periods as ex-ante allowances will be reviewed</p>	<p>Following an extreme event, PCLs will likely be breached and companies could instead be incentivised to focus on other service areas where they are still able to meet or exceed the target.</p>	<p>Potential for larger outturn costs than ex-ante allowance following a severe weather event as well as significant ODI penalties</p> <p>Companies may be able to insure against this risk in insurance markets, and/or opt for more inefficient / costly capital structures</p>	<p>Customers protected from bill risk after a severe weather event, but pay higher bills under BAU to fund ex-ante payments.</p> <p>Customers may also receive some bill reductions through ODI penalty payments, but long run impact on service unclear (see criteria B)</p>	<p>Agreeing a "correct" view of expected costs and probability of extreme events ex-ante will be difficult and overall outturn impact on sector will be unpredictable. However, the ex-ante allocation of costs provides a clear funding allowance for the companies.</p>

7 Shortlist option in more detail

- 7.1 The previous section suggested that Option 2 (an ex-post cost pass-through combined with a limited suspension of the ODI regime) is the option which is likely to provide good value for customers. We suggest that the core set of ODIs that are temporarily suspended during and immediately after the event are the common PCs which can be materially affected by extreme weather events: supply interruptions, leakage, mains repairs (bursts), internal and external sewer flooding, per capita consumption, pollution incidences, discharge permit compliance, bathing water quality, river water quality, storm overflows, unplanned outage and sewer collapses. We are not proposing a specific mapping between types of extreme weather events and ODIs as this would introduce significant complexity, in particular to deal with compound and cumulative events.
- 7.2 In this section, we explore some more detailed design issues on how that option could be implemented. Regulatory precedent provides us with some options when considering more detailed design questions for the options proposed in Section 5.
- 7.3 We can take some of the regulatory design decisions from Ofgem's risk mechanisms when thinking about the design of Option 2. The ex-post funding is similar to Ofgem's Severe weather 1-in-20 funding mechanism which involves an ex-post review of efficient costs. We would expect this to include Ofwat assessing companies' plans for responding to extreme weather events and, in the event of an extreme weather event, the companies making submissions to Ofwat on the level of incurred costs and what proportion of those were incurred efficiently. The mechanism would only apply to the areas affected by the extreme weather as other costs would not be deemed efficient. Mechanisms of this type are therefore well targeted to the areas that experienced negative outcomes as a result of extreme weather. This means that there is no need to include a geographic threshold for the area of the company affected above which an extreme weather event can be declared since funding can be targeted to specific areas in the case of more localised events. This ex-post review can also be used to determine how long after the event costs can be efficiently incurred.
- 7.4 In Option 2, there is also an exclusion from ODI incentives in the event of an extreme weather event. In the case of Ofgem's exceptional events exclusions for planned interruptions target, the mechanism is triggered when there is eight times the daily average number of faults at high voltage networks and above. An outcome based trigger based on averages across the network balances the severity of an event with the proportion of a company's area that it covers. For example, in order for a DNO to experience eight times its mean daily faults across its network, an event could either be very severe and cause a large amount of faults in a relatively localised area or be less severe but causing faults across a greater proportion of the DNO area.
- 7.5 However, given that there are reasons to choose a trigger that is exogenous to outcomes within the companies' control, as explained in Section 3, this creates a need for answers to questions such as the proportion of a company's area which needs to be covered to trigger the mechanism. This question is also related to the geography to which the mechanism would apply when an extreme weather event is declared. If the incentive exclusion only applies to the area affected, then there is no need to define a geographical threshold above which the mechanism should apply since the smaller the area affected, the smaller the impact of the incentive exclusion on the overall targets. If the incentive exclusion always applies to the entire area of the company however, then

there needs to be a geographic threshold specified within the trigger to avoid localised events impacting the incentives to achieve consumer outcome targets across the companies' networks. Setting this threshold is difficult when considered in combination with the threshold for severity of the weather since an event that comfortably exceeds one threshold but not the other is likely to have a greater impact than an event that only just meets both thresholds. However, this approach has the advantage that it is simple to implement since there is no need to impose geographic boundaries and it also takes into account that resources might be diverted to deal with the event which impacts the areas that are not directly affected by the extreme weather. Therefore we suggest that for some types of event, such as droughts or cold snaps, if either more than 50% of customers in a water or wastewater company's area or 50% of the total geographic area are affected by the extreme weather event then the incentive regime is suspended for the entire water company's area. For wind storms and flooding, where the impacts can be more localised and impacts on customers potentially more severe, a lower threshold may be more appropriate.

7.6 Further, an important question is how long the broader incentive regime would be suspended for after the extreme weather event is over. Either there will have to be a separate determination of how long the exclusion lasts for or there needs to be a separate rule/trigger for ending the exclusion. In the case of Ofcom's regulation of Openreach, the exemption for MBORC lasts for eight weeks once declared. However, this one size fits all approach is unlikely to be efficient in terms of incentives since some events can be dealt with in a shorter time frame. This means that incentives will still not be in place beyond the time frame that companies can reasonably be expected to be achieving their targets for consumer outcomes. Further, an event that has an impact that is likely to last longer than the period of incentive exclusion will increase penalties for the companies and reduce the effectiveness of the mechanism by placing additional risk on the companies. However, an ex-ante rule for incentive exclusions provides simplicity and reduces the need for an additional ex-post review in addition to the review of efficient costs for ex-post funding. Therefore, for Option 2, we propose an ex-ante rule of a shorter time frame such as two weeks (as opposed to Ofcom's eight week exclusion) to minimise the risk that incentives will still not be in place beyond the point that companies have dealt with the event. If needed, the companies could then apply to Ofwat for an extension of this exclusion.

7.7 Regulatory precedent is that any impact on customer bills from these measures are socialised across the individual network, such as funding from Ofgem's Severe weather 1-in-20 funding mechanism which would impact customers across the DNO. Therefore, for PR24, one option is to socialise costs incurred across the customers of a company. This prevents customers that live in areas that are more likely to experience extreme weather having large bill increases due to localised events. Further, given the likelihood of extreme weather having in a given year is low, it would be possible to spread the cost of this over a number of years by adding these costs, or a proportion of them, to the RCV. This prevents customers experiencing large increases in bills during the years where extreme weather occurs by increasing bills by a smaller amount over a number of years. In addition, we suggest that any cost pass-through is included as an in-period adjustment to reduce cash flow risks for the company.

7.8 For all of the detail design aspects, we note that the mechanism and the details of it are likely to evolve over time as more information becomes available. There is likely to be a key role for comparative analysis between companies, and evidence from companies, on the impacts of extreme weather on service standards to aid understanding across the industry of the impact of, and what works well in managing, these extreme weather events.

8 Conclusions and recommendations

- 8.1 Water and wastewater companies are funded to maintain and develop their network to a particular level of resilience to weather events. For some types of weather and types of infrastructure, these are clear – such as sewers being resilient to a 1-in-50 year storm through Drainage and Wastewater Management Plans (DWMPs); for other types of weather and infrastructure, these are less clear and the requirements are underpinned by a more general licence condition. There are also a range of other factors such as British Engineering Standards, industry best practice and construction industry codes of conduct which create a particular level of resilience to weather events: and which, to the extent that water and wastewater companies are purchasing these goods and services will also be reflected in the condition of assets owned/used by water and wastewater companies.
- 8.2 Within these expected levels of resilience, it would not be appropriate to have a further mechanism: water and wastewater companies are funded for the expenditure needed to achieve these levels of resilience through the price control process, which is raised from consumers through their water and wastewater bills.
- 8.3 The key question therefore is what happens if an extreme weather event arises which falls outside of these funded levels i.e. is more extreme than these levels: for example, a storm which is more severe than a 1-in-50 year event.
- 8.4 This question has been extensively considered in other regulated industries in the UK and abroad; and it is common for regulatory regimes to have explicit treatment of extreme weather events. Examining this precedent shows that there are two aspects to extreme weather events: 1) the costs incurred in responding to the event; and 2) whether incentive regimes are suspended during the extreme weather event, or not. These two aspects are separable i.e. it is possible to have a mechanism for costs but not the incentive regime; or vice versa. However, given the severity of extreme weather events there is a clear case for considering the treatment of both aspects.
- 8.5 One, fairly uncommon, approach to allocating the risk of extreme weather events is to use aggregate risk sharing mechanisms and continue to apply the incentive regime during and immediately after the extreme weather event. The key challenge with this approach is that actions which are desirable during “normal” times are not necessarily in the best interests of consumers during an extreme weather event; and incentive regimes which are calibrated for “normal” times may not work well when the water and wastewater networks are temporarily overwhelmed during an extreme weather event.
- 8.6 For these reasons, it is more common for extreme weather events to be treated as exceptional events in regulatory frameworks where additional costs are permitted and/or the incentive regime is suspended temporarily. This enables companies to focus on doing the right things for all consumers at all times and that the incentive regime has the correct incentive properties throughout the period of the price control.
- 8.7 On this basis, we recommend the introduction of a mechanism which permits the recovery of efficiently incurred costs after an event which falls outside of the range which water and wastewater companies are funded for; and that a core set of ODIs (common PCs which can be materially affected by extreme weather events: supply interruptions, leakage, mains repairs

(bursts), internal and external sewer flooding, per capita consumption, pollution incidences, discharge permit compliance, bathing water quality, river water quality, storm overflows, unplanned outage and sewer collapses) are temporarily suspended during and immediately after the event. We are not proposing a specific mapping between types of extreme weather events and ODIs as this would introduce significant complexity, in particular to deal with compound and cumulative events.

- 8.8 By ensuring that only efficiently incurred costs can be recovered after the event, this would ensure that consumers are protected from inefficient costs while also giving confidence to companies that they can act in the best interests of consumers during the event (knowing that they will need to justify any additional expenditure to Ofwat and demonstrate that this spending is in the best interests of consumers). The temporary, and limited, suspension of a set of materially affected ODIs should act to ensure that companies remain focussed on these ODIs during “normal” times as they will not have been overwhelmed by the extreme weather event. This is consistent with Ofwat’s duties as an economic regulator include protecting the interests of consumers, ensuring companies can carry out and finance their statutory functions and further the long-term resilience of water and wastewater systems.⁶⁰
- 8.9 There are a number of details which would be required to be resolved to implement such a risk sharing mechanism in PR24 but we consider that it should be possible to address those, and therefore that such a mechanism could be implemented for PR24. Given the characteristics of the risks, such a risk sharing mechanism for extreme weather events would be in the interests of customers by ensuring that water and wastewater companies are focussed at all times on delivering what is important to customers at that time (and this is likely to not be the same during and immediately after an extreme weather event as in normal times).

⁶⁰ Other duties are that licenced activities are properly carried out, promote economy and efficiency, no undue discrimination, protect customers’ interests in land sales and unregulated activities and contribute to sustainable development. See Ofwat’s duties [here](#).

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