Resilience Task
& Finish Group

Contents

About the Resilience Task and Finish Group

The Task and Finish Group was established by Ofwat in early 2015 as part of Ofwat's new strategy and following the introduction of a new primary duty on resilience. The group is chaired by Waterwise's managing director Jacob Tompkins and is an independent body reporting to Ofwat and seeking to influence the sector more widely.

The Task and Finish Group is made up of experienced professionals from across the water sector and beyond, including NGOs and academia. The group considered what resilience means for the wider water sector. The group aimed to answer the following questions:

- **What is resilience in relation to the provision of water and wastewater services?**

- **What do service providers need to consider as they think about how best to provide resilient water and wastewater services?**

- **What does Ofwat need to consider as it thinks about how best to regulate the water and wastewater service providers, having regard to its statutory duties, including its new duty on resilience?**

The group's work will feed into Ofwat's ongoing reform of the policy framework for PR19 and will help inform the wider resilience policy landscape. The analysis, conclusions and recommendations of this report are based on the findings and discussions of the group and are by no means comprehensive.

The group's remit is England and Wales, but it has consulted beyond this jurisdiction and beyond the water and wastewater sector.

Acknowledgements

Executive summary

Resilience is a priority issue for the water and wastewater sector. High-profile events such as the 1995 and 2011/12 droughts and the floods of 2007 and winter 2013/14 put pressure on companies' ability to provide water and sewerage services. This is coupled with a backdrop of climate change, population growth, cost pressures, stronger environmental standards and rising customer expectations. Together all these issues mean that water and sewerage service providers face more challenges than ever before to ensure services are delivered now and into the future.

In response to these challenges the UK and Welsh governments introduced a new primary duty on resilience for Ofwat in the 2014 Water Act (specifically to "further the resilience objective"). Ofwat are currently developing their policy response to their new duty and in July 2015 they consulted on resilience, to seek views on the broad areas in which Ofwat should be taking action in order to fulfil their duty, and on what should be for others to deliver. Ofwat are committed to publishing further thinking in December, including in response to this report.

In addition to their own policy development, in early 2015 Ofwat set up an independent Task and Finish Group to help inform and challenge the sector on resilience, and advise Ofwat on how they should respond to their new duty. The work of this group will be considered by Ofwat, although they are under no obligation to act on any of the recommendations made. This report presents the recommendations of the Task and Finish Group.

Through analysis of resilience guidance and key water sector documents, and consideration of a wide variety of resilience perspectives from carrying out extensive interviews across the sector, the main resilience challenges that need to be addressed have been identified. These broadly fall into three groups:

- **A step change in approach is needed to build resilience, with a greater need for partnership and softer infrastructure solutions where appropriate. This step change will, in particular, require far greater engagement with customers to understand their expectations on service levels and to enable a more active role for customers in building resilience.**

- **A clear overview of the resilience of the sector does not exist; this has come from a lack of an agreed definition of resilience, a dearth of consistent measures and no fixed resilience standards.**

- **It is unclear as to whether the current structure of the sector and the form of economic regulation encourage legitimate resilience investments to be made. It is also unclear if decisions are being made on the appropriate geographical scales to build resilience in an effective way.**

In general, whilst the aim of the group was not to answer the question 'is the UK water sector resilient?', it is clear that there has been a lot of work on resilience in the sector and that systems and plans are in place to ensure a degree of resilience. However, there needs to be better co-ordination of this work both within the sector and with other sectors and the wider public.

The group have reviewed the evidence and produced a set of 10 recommendations designed to help meet the challenges. These are summarised below:

1. Agree a shared definition of resilience for the sector.

2. Increase public engagement and education.

3. Ensure clear routes for funding legitimate resilience measures.

4. Ensure coherent planning for resilience at both a national and regional level.

5. Establish wastewater, sewerage and drainage plans.

6. Improve understanding of risk and failure.

7. Ensure services are resilient under different water sector structures.

8. Develop benchmarking, standards and metrics.

9. Ensure existing plans are stress-tested.

10. Establish a water and wastewater resilience action group.

The definition of resilience for the sector, the first recommendation, is a key outcome:

Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future.

The group recognise that developing a deeper understanding and awareness of resilience amongst the public is essential if they are to fully participate in setting resilience priorities for the sector. In addition, building resilience involves wider engagement outside of the water sector in order to understand and mitigate multi-sector cascade failures.

Although the recommendations will feed into Ofwat's policy development work, not all of them are directly for Ofwat – only through working together will resilience be systematically built in the water sector. It is clear that resilience will not be achieved through simply implementing a set of recommendations. The challenges are significant and it will take many years for the sector to build resilience.

Full list of recommendations

1. Agree a shared definition of resilience for the sector

When: *During 2016*
Lead: *Water and Wastewater Resilience Action Group (see Recommendation 10)*
Involved: *All bodies involved in planning and delivering water resilience*

There are numerous definitions of resilience in the water and wastewater sector. A coherent set of definitions (or definition) for resilience that is accepted by everyone is essential. Checking if companies are resilient when their definitions of resilience vary is difficult. Any board discussions of resilience or reporting should include which definition of resilience is being used. This includes the work of governments where definitions may vary between departments. The Water and Wastewater Resilience Action Group should act as a central body to collate and publicise the varying definitions of resilience (see Recommendation 10). For reference this is the definition we are currently using:

'Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future'.

This definition should be reviewed periodically by the Water and Wastewater Resilience Action Group.

2. Increase public engagement and education

When: *2015 - 2020*
Lead: *Water companies and governments*
Involved: *All sector and non sector partners, including stakeholders and third parties*

Using a common definition, or set of definitions, there is a need to engage the wider public, particularly in relation to risk, and to develop a common understanding of the acceptability of risk. This engagement should be twofold. Firstly it should involve the provision of pertinent information on a wide scale on an ongoing basis, with the aim of enhancing public understanding of water systems. Secondly it should aim to ensure this information is transformed into active engagement (which will lead to positive environmental behaviour) - the public should be given an active role in resilience, both in terms of adaptation and mitigation.

The action to deliver this recommendation sits with all bodies in the sector. But it sits primarily with water companies who must undertake much more active engagement and with governments who, whilst they are unlikely to do any public outreach in this area, must reinstate areas where they have removed information provision, like the reintroduction of the water cycle as a key element of the national curriculum. The water sector should, where possible, continue to increase access to data, subject to commercial confidentiality and security exemptions. The sector strategic dashboard currently being developed by water companies, regulators and other stakeholders could be a helpful contribution to facilitating that access. More open data would assist better public understanding and engagement and could promote innovation and understanding and increase resilience through crowd sourced solutions and oversight.

3. Ensure clear routes for funding legitimate resilience investment

When: *By 2017, in time to inform PR19*
Lead: *Ofwat and water companies*
Involved: *Water companies, investor community, customer bodies, wider water sector stakeholders*

There should be a clearer and smoother pathway for funding legitimate resilience-building measures. Ofwat should provide water companies with a clear framework; it is important that water companies retain ownership of their plans built using this framework. There needs to be clear guidance from Ofwat on its treatment of resilience investments when it considers business plans. There needs to be flexibility to fund innovation against a wide assessment of costs and benefits and future generational aspects should be factored into assessment of business plans. At the same time water companies and customer groups must develop improved methods to test customer acceptability of risks and costs - willingness to pay is a poor representation, as those who experience disruption are willing to pay more in the future and the water companies need to do more in-depth engagement and deliberative work with all their customers to build and maintain a real understanding.

There needs to be a better consideration of the most appropriate mix of hard infrastructure (e.g. below-ground networks and large physical assets) and soft infrastructure (e.g. community-led projects and sustainable urban drainage systems) for individual circumstances. This requires a clearer framework for developing, regulating, funding and evaluating soft infrastructure and community-based resilience.

Ofwat should specifically look at how and whether its framework could enable water companies or others to fund distributed assets and/or to manage assets at a community level. This would assist in promoting partnership working between water companies, NGOs and community groups. The water companies must do more of these projects and Ofwat should facilitate and encourage this.

4. Ensure coherent planning for resilience at both a regional and national level

When: *By 2020*
Who: *Water companies, Environment Agency, Natural Resources Wales*
Involved: *Water sector bodies and NGOs*

There is a question about how geographical planning scales and national versus local priorities affect resilience. There must be more inter-company discussion and co-ordination on water resources. There should be a revitalisation of supra-regional and national planning for water resources.

A newly-formed project group, under the auspices of Water UK and which includes water companies, Defra, Welsh Government, Ofwat, the Environment Agency, Natural England and Natural Resources Wales, is considering "What are England and Wales' long-term planning needs?" and "What are the practical steps required to meet these needs?". The project will allow for the development of a high-level strategy and framework for the long-term planning of water resources in England and Wales. It will aim to strengthen the overall resilience of water resources for all users, and to protect the environment. The project will enable the strengthening of future resource planning guidelines; a more integrated approach to water resource and drought plans; and consideration of minimum levels of service and risk levels. It will inform consideration of the need for a National Policy Statement.

There is also a need to ensure that large infrastructure projects, both hard and soft infrastructure, are progressed efficiently once a decision has been made, and that these projects are assessed, overseen and delivered in the context of national and regional plans.

5. Establish wastewater, sewerage and drainage plans

When: *2020 - 2025, with a Drainage Road Map produced during 2015 - 2020*
When: *Governments, water companies, local authorities*
Involved: *Regulators*

There must be national wastewater and sewerage strategies and each company should have a wastewater and sewerage plan. This should link to SuDS, wider drainage issues (highway and land drainage) and rainwater and greywater harvesting through the parallel development of drainage plans. Potentially these plans should be statutory, and there may be scope under the existing statutes.

There is good connectivity here with the work of the 'Delivering 21st Century Drainage Programme Board'. This programme is UK-wide and comprises representatives from governments, regulators, operators, environmental NGOs and stakeholders. It aims to gather evidence to enable governments and the sector to map out the future of drainage systems across the UK over the next two or three decades. It is intended that the evidence-based research will support the development of resilient drainage-systems, including highlighting options for changes to regulation, legislation and technology, and that this will enable the expectations of customers to be delivered. The programme also aims to enable the affordable and practicable control of discharges from drainage-collecting systems which remain compliant with EU requirements; and to set out how and at what cost the sector will begin to address the various longer-term pressures that drainage systems face, including those from climate change. This will form an important part of the evidence base on which long-term wastewater, sewerage and drainage plans should be based.

6. Improve the understanding of risk and failure

When: *2015 - 2020*
Lead: *Environment Agency, Natural Resources Wales, water companies*

There needs to be broad discussion, involving all parties including customers, leading to agreement on the level of service which should be planned for in each area. This would be based on better understanding and communication of the risks faced by the water sector, of the costs of failure, and of the costs and benefits of measures to avert, manage and recover from failure. Coping strategies for dealing with 'beyond resilience' emergencies (black swan events) also need to be agreed, in advance of their occurrence. Progress in these matters will enable water companies to focus on the risks to critical assets and services, and to plan for the effective delivery of services in critical conditions, with a mandate from their customers and society, and from their regulators and government.

Another requirement is an appreciation by all that some failures will occur, notwithstanding best plans being laid and large investment being made; for example, expecting zero leakage and never having supply interruptions is unhelpful thinking. Risk could also be better understood and dealt with through more open data, enabling wider scrutiny of water and wastewater management. This could link to the sector strategic dashboard that is currently under development.

7. Ensure services are resilient under different water sector structures

When: *By 2017*
Lead: *Governments and Ofwat*

The UK and Welsh governments should undertake work to analyse the impact of differing water sector structures on the delivery of resilience. Irrespective of any future model of delivery the common issue here is whether the water undertakers have structural capacity to deliver resilience. The key questions are who within each structure is responsible for resilience planning; is there structural capacity to deliver this; and will the regulatory regime enable resilience? Ofwat's approach and assessment of impacts needs to enable and incentivise resilience in a fragmented and/or evolving sector where not all the stakeholders are within the regulatory, licensed, regime. This does not just apply to the scale of the water and wastewater undertakers - it also applies to the skillset and objectives within the undertakers.

This means that where statutory, policy and regulatory changes are proposed that may impact on company structures there should be a requirement for impact assessments to explicitly consider the effect on resilience of services.

8. Develop benchmarking, standards and metrics

When: *By 2017*
Lead: *Ofwat, water companies and governments*
Involved: *Water companies and wider water sector stakeholders*

Ofwat and water companies need to work together to develop a method of comparing resilience, reflecting customer views, local context, the environment and company ownership of plans. Such metrics need to be at a level of detail appropriate to the scale of the risk (i.e. measurement of resilience to material risks); be practical to measure; measure impacts on customers and the environment; and establish the minimum levels of resilience expected. This does not necessarily mean standardisation as this will constrain the number and type of solutions, which will reduce resilience. But there needs to be greater discussion between companies about how they tackle resilience and there needs to be a resilience standard. The Water and Wastewater Resilience Action Group could play a role in setting such a standard which could be a qualitative measure of resilience as opposed to a quantitative metric. Companies should report against a set of resilience criteria. This should be qualitative but will ensure all company boards have properly assessed resilience in a way that goes beyond their risk register. This could link to the sector strategic dashboard.

9. Ensure existing plans are stress-tested

When: *2015 - 2020*
Lead: *Governments to set framework for work*
Involved: *Water companies, regulators, governments, civil society*

The water sector has a lot of plans that relate to resilience. But this level of planning may lead to complacency and ultimately lower resilience. All companies need to have a process in place, including board assurance, to review and stress-test plans as widely as possible. This should include a consideration of cascade failures, the reliance on the resilience of other sectors and the risks related to cyber security, which means better multi-sectoral planning and co-ordination. There should be co-ordinated scenario planning at a regional or river basin level, involving multiple water companies. There needs to be a discussion of how strategies can go beyond planning for recovery and move to planning for adaptation of systems to prevent events from occurring or to offset the impacts of events and trends. There may be a need to consider short and long-term resilience in different ways, one with procedures and the other with strategic frameworks. And there needs to be a way to stress-test long-term resilience to trends and to develop approaches that deliver both long and short-term resilience rather than having potential trade-offs between the two. There should be a review of mutual aid arrangements and a consideration of how to deal with wide-scale incidents that affect multiple water companies. Finally there is an urgent need to develop contingency plans for what to do when events go beyond the scope of the existing planning horizons.

10. Establish a water and wastewater resilience action group

When: *During 2016*
Lead: *Water UK to initiate*
Involved: *All water stakeholders*

There are varying views on who should lead on resilience and a number of groups and organisations are considering resilience at present, but these tend to be exclusive. The constrained membership of these groups leads to a restrictive set of ideas, could lead to inaction or deferred responsibility and is in itself not resilient. It is clear that most people see resilience as a shared responsibility between government, regulators and water and wastewater service providers. But this could lead to inaction or deferred responsibility. In light of this it is recommended that a resilience action group for water and wastewater is established - this must have a wide-ranging remit. The group (referred to in this report as the resilience action group) could be hosted by a recognised sector body such as Water UK and should include water companies, governments, local government, regulators, customer groups, community groups and social and environmental NGOs, with observers and invitees from other sectors as appropriate. It should be independently chaired (meaning that the chair should serve in a personal capacity). The remit of the group should be to define qualitative standards, look at the picture across England and Wales and share best practice. Any new resilience action group needs to engage widely and have an open membership structure. Once established the resilience action group should determine its own terms of reference, method of working and areas of activity.

1. Introduction

The Task and Finish Group was set up to understand the current resilience landscape in England and Wales in order to make recommendations to the sector and to Ofwat for short and long-term improvements. The group was established in early 2015 by Ofwat, chaired by Jacob Tompkins from Waterwise, and consists of experienced professionals from across the sector with a wide variety of backgrounds. All participants represented themselves as individuals on the group, rather than their organisations.

The members are:

- **Jacob Tompkins (chair) – Waterwise**
- **Kat Austen – iilab (Information Innovation Lab)**
- **Richard Aylard – Thames Water**
- **Sarah Bentley– Severn Trent Water**
- **Tim Bowen – Costain**
- **Jerry Bryan – Albion Water**
- **Diane McCrea – Consumer Council for Water**
- **Rose O'Neill – WWF**
- **Colin Fenn – WWF/Hydro-Logic**
- **Nicci Russell – Ofwat**
- **Heather Smith – Cranfield University**
- **John Spence – Southern Water**
- **Jean Spencer – Anglian Water**

The group has conducted a significant amount of work over the last six months. As well as the group itself meeting regularly, other stakeholders have been involved in shaping the recommendations through surveys and questionnaires, and were invited to a workshop in September 2015 to comment on the draft recommendations.

The group focused on six work packages, with a sub-group for each work package being drawn from the group. The first three work packages developed the evidence base from which the recommendations are drawn.

- **WP1: Definition of resilience for water and wastewater**
- **WP2: Review of the current UK structures to ensure resilience for water and wastewater**
- **WP3: Consideration of resilience from the following perspectives - economic, environmental, customer/social, physical, technological, climatic, security, regulatory/ political, financial, human resources and supply chain.**
- **WP4: Engagement with stakeholders**
- **WP5: Dissemination of findings**
- **WP6: Report to Ofwat**

The group aimed to operate in an open and transparent way and engage as widely as possible. A Linked-in group was set up for anyone to post comments and share documents. The group drew on external expertise as much as possible; for example, using existing Water UK networks to access technical experts. A sector-wide workshop was held in September to test and challenge the initial

recommendations from the group (more details on this workshop can be found in Appendix C).

A significant amount of analysis supports the recommendations made. This analysis took the form of three distinct blocks of work:

1. **Understanding resilience drivers from a wide set of perspectives.**
2. **Interviewing water sector professionals from a variety of organisational levels to gain an insight into the challenges and blockers to resilience and opportunities presented by resilience building.**
3. **Reviewing published material by water companies to identify how prominently resilience features.**

In this report we first present the ten recommendations that the Task and Finish Group has identified to help facilitate resilience-building in the water and wastewater sectors. The details of the analysis that has been undertaken by and for the group are then set out. We used this analysis to draw out the main resilience challenges and identify specific areas that need to be addressed. We then set out how we tested the ten recommendations through an sector-wide workshop. Finally, the next steps are presented.

This report will feed into Ofwat's work on developing the framework for PR19 (called Water 2020). We expect that Ofwat will provide an early response to the recommendations in December, followed by further work in 2016 and beyond. The Task and Finish Group will disband in early 2016 after a workshop in January to communicate the recommendations to a wide-range of stakeholders.

This is the final report of the Task and Finish Group. However, we by no means see this as the final word on resilience in the water and wastewater sector. We hope that the report and recommendations will lead to a wider debate on resilience within the sector. The group members will be championing the implementation of the recommendations and we welcome criticism, comments and suggestions relating to the recommendations.
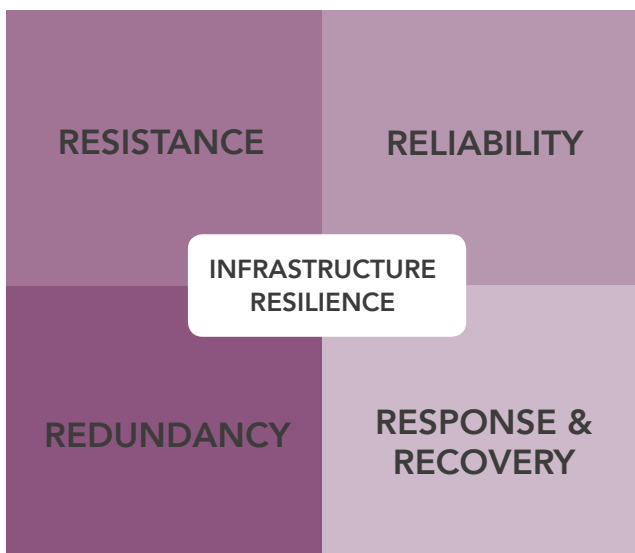
2. Analysis of the resilience landscape

The Task and Finish Group considered existing sources of information on resilience in order to understand the resilience landscape. This included reviewing water sector guidance, wider (non-water sector) guidance and academic literature in order to understand the common basis from which all infrastructure operators/essential service providers consider resilience. This review helped shape the Task and Finish Group's definition of resilience.

In this section we summarise the key points from the literature review. We end the section with a discussion of the Task and Finish Group's definition of resilience.
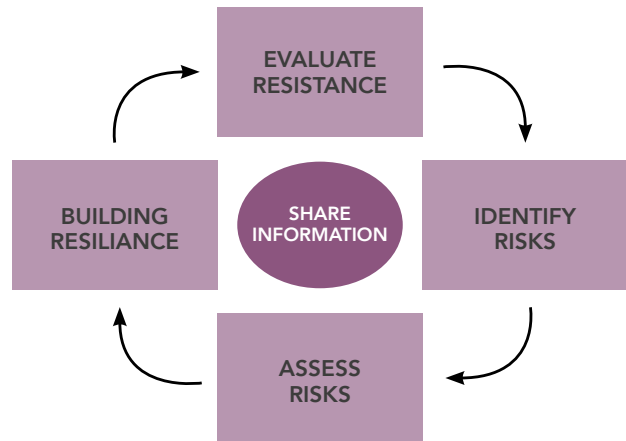
2.1 Cabinet Office guidance

A report on natural hazards and infrastructure was published by the Cabinet Office in 2011, called "Keeping the country running". It highlighted how building resilience in infrastructure is important to reduce vulnerability, specifically to natural hazards. The aim of the guide is to support a range of key stakeholders to improve the resilience of infrastructure. The Cabinet Office defines resilience as "the ability of assets, networks and systems to absorb and adapt to or rapidly recover from a disruptive event". It states that resilience is secured though a combination of activities or components.

The Cabinet Office has produced a framework for understanding the resilience of critical national infrastructure. The figure below outlines the components of infrastructure resilience that should be considered when putting together a resilience strategy. The Cabinet Office states that interventions to build resilience should contain the component(s) most appropriate to the issue being addressed. If applied to assets within water companies it would help towards assessing the current state of the infrastructure aspect of resilience.

In order to evaluate progress in building infrastructure resilience, the Cabinet Office developed a Resilience Cycle. It offers a method of evaluation in order to consistently identify risks and work around the cycle to ensure resilience has been built to manage the identified risks. This process is ongoing, with the identification and building of resilience to risks sitting alongside continued identification of new ones.

An important element is the sharing of information, which is central to this cycle. Critical national infrastructure has a number of key interdependencies (e.g. water companies are dependent on electricity supply and communications, so the sharing of information is important but is often a step that is overlooked.

The Cabinet Office framework is naturally focused towards infrastructure resilience (as that was the remit of their work). However, a water company is built up of far more subsystems than just the infrastructure elements which have an influence in determining overall resilience. For example, the economic aspect of proving the cost benefit analysis of new assets, or the environmental sensitivity balance that needs to be achieved for water abstraction to be sustainable. Regardless of the type of resilience being built there needs to be an ongoing evaluation process such as the resilience cycle framework discussed above. This framework is applicable to more than just infrastructure resilience and could be applied to governance, environmental and policy aspects of building resilience in water companies.

2.2 World Economic Forum guidance

Another framework that is applicable to the water sector is one that has been developed by the World Economic Forum (WEF). This is part of a pioneering effort to construct a diagnostic framework that applies the concept of resilience to assess national preparedness for global risks. In many ways it is an expansion of the Cabinet Office's components of infrastructure resilience.

MACRO SYSTEM

	COUNTRY				
SUBSYSTEMS	ECONOMIC	ENVIRONMENTAL	GOVERNANCE	INFRASTRUCTURE	SOCIAL

COMPONENTS OF RESILIENCE		ECONOMIC	ENVIRONMENTAL	GOVERNANCE	INFRASTRUCTURE	SOCIAL
RESILIENCE CHARACTERISTICS	ROBUSTNESS	ROBUSTNESS	ROBUSTNESS	ROBUSTNESS	ROBUSTNESS	ROBUSTNESS
	REDUNDANCY	REDUNDANCY	REDUNDANCY	REDUNDANCY	REDUNDANCY	REDUNDANCY
	RESOURCEFULNESS	RESOURCEFULNESS	RESOURCEFULNESS	RESOURCEFULNESS	RESOURCEFULNESS	RESOURCEFULNESS
RESILIENCE PERFORMANCE	RESPONSE	RESPONSE	RESPONSE	RESPONSE	RESPONSE	RESPONSE
	RECOVERY	RECOVERY	RECOVERY	RECOVERY	RECOVERY	RECOVERY

This framework has been designed to assess the national resilience of a country. It treats the country as being built up of a combination of subsystems in order to assess the overall resilience. This is a systems method of thinking that provides a foundation to assess resilience through five components of resilience. These components are:

- **robustness**
- **redundancy**
- **resourcefulness**
- **response**
- **recovery**

The approach adopted in the WEF framework is in many ways comparable to that developed by the Cabinet Office for infrastructural resilience. The difference is that the WEF framework considers the whole system which is broken down into five subsystems: economic, environmental, governance, infrastructure and social. Even though this framework is designed to assess national resilience of a country, both the sub systems and components are wholly applicable when looking at creating an assessment of resilience of the water sector.

2.3 Academic research overview

A study of the relevant academic literature was performed to further inform the group's recommendations. A short summary of salient points is presented below.

Resilience of water systems
Like any complex system, resilience of water systems can be defined in terms of their response to specific threats over time (Haimes, 2009). Many factors are implicated in water resilience (Matthews, 2015), such as water scarcity for both green and blue water, water quality, flooding, waste water, salinisation, and economic scarcity where social resources required to successfully adapt to physical water scarcity fall short (Ohlsson, 2000), and it is the factors that feed into their provision that determine the resilience of the system with respect to a particular threat.

A distinction can be made between man-made resilience issues, and those that occur naturally - for instance water scarcity as a result of natural conditions of low water availability in comparison to water scarcity mainly induced by a large human demand relative to natural availability (which can also happen in water-abundant areas) (Schyns et al, 2015). This is an engineering resilience perspective, and one which has been largely adopted by the UK in its approach to resilience more broadly, and in this report. In the literature, alternative views of resilience exist - for instance a more socio-ecological view of resilience looks at resilience of a system in terms of the repercussions on both human needs and ecosystem needs, seeing them as intrinsically linked. In such cases resilience is defined not as how well a system recovers from or adapts to events, but in terms of "the amount of disturbance a linked social-ecological system can absorb before reorganizing into a new state characterized by a different set of processes and structures." (Garmestani et al. 2014).

In order to solve resilience problems in such a complex system, it is necessary to move away from focusing on components in the system to looking at the system's interconnectedness (Helbing et al, 2012), including links to systems that may be seen as discrete, such as the electricity network (Matthews, 2015) or a country's legal framework (Garmestani et al., 2014). Approaches to water resilience in the scientific literature call for solutions as multifaceted and complex as the water system itself (Wong and Brown, 2009, Kennedy et al. 2012, Ashley et al 2003, 2005).

As Kennedy et al. write: "Building resilience is not simply an engineering problem involving more dams and canals. It is a socioeconomic phenomenon that requires a highly interdisciplinary approach, including analysis of governance and social systems, as well as hydrology." (Kennedy et al. 2012). In this direction, access to a diversity of water resources, including centralised and decentralised sources, is argued by Wong and Brown to be a resilient approach for water sensitive cities (Wong and Brown, 2009). In a similar vein, the urban harvest approach, which taps into both primary and secondary water resources at a local for sustainable urban resource planning (Agudelo-Vera et al 2012).

Kennedy et al. also suggest thinking across geographical boundaries in terms of resource management. Novel technological approaches can provide greater efficiency in the allocation of scarce resources (Anzaldi, 2014, Helbing et al., 2012) and quick response to threats such as flooding (Young-Il and Kim, 2015) and water quality measurements (Shin et al., 2009). Yet, the strategies by which these technological advances are leveraged must be carefully chosen as there is a risk that the "smart city" paradigm will be pushed forward not for the purposes of resource efficiency, but rather for promotion of consumption of digital goods, resulting in ineffective interventions in resource use obfuscating an actual lessening or absence of effect on resilience (Viitanen and Kingston, 2014).

In terms of governance and social systems, Ostrom has shown that collective governance of resources, including water resources, has success on a local scale (Ostrom, 1990). Here, the advent of big data can be of use in facilitating a more integrated approach to governance by leveraging social interest. Open data and citizen science approaches can augment water treatment and provision services (Buckingham Shum et al. 2012), and lessons from disaster response in Kathmandu suggest that local open data ecosystems can aide rapid response to events (Soden et al., 2014).

Appendix A contains the supporting references for this section.

2.4 Ofwat guidance

In July 2015, Ofwat published 'Reliable services for customers – consultation on Ofwat's role on resilience'. In this document, Ofwat explained that they wanted to build on existing understanding rather than create new definitions. They were guided and informed by the wording of the duty (which is summarised below) and current UK and Welsh government resilience policies and guidance.

"The Water Act 2014 adds a new duty to our primary duties: to 'further' the resilience objective (in England and Wales). It highlights the need for long-term resilience of water and wastewater systems and service provision when faced with increasing external stresses, such as environmental pressures, population growth and changes in consumer behaviour.

It also highlights the need to:

- *promote long-term planning and investment, and the use of a range of measures to manage water resources in sustainable ways; and*
- *increase efficiency in water use and reduce demand for water to minimise pressure on water resources."*

2.5 Defra and Welsh Government guidance

Defra guidance

Defra's Strategic Policy Statement (SPS) to Ofwat, published in 2013, identified the challenge of increased water scarcity due to climate change and demographic trends and highlighted an increased emphasis on resilience, long-term planning and customer choice. It requires Ofwat's regulatory decision making to support the Government's vision for the water sector, as set out in Water for Life (Defra's 2011

document), by contributing to an innovative, sustainable, resilient and customer focused sector.

As a matter of priority Defra expects Ofwat to keep under review the impact of its regulatory approach on the overall resilience of water companies' networks. The SPS also recognises the challenging trade-offs Ofwat faces in ensuring a fair deal on customer bills by continuing to drive efficiency, whilst also ensuring companies can raise the revenue they need to fund management of their assets and investment in resilience. This includes careful consideration of the appropriate balance between ensuring that bills remain affordable in the short term and that companies are investing to ensure resilience in the face of long-term pressures.

Welsh Government guidance

In the Environment (Wales) Bill, resilience, when applied to ecosystems, is defined as the ability of an ecosystem to withstand or recover from disturbance and its capacity to survive and adapt so that its biological diversity, natural processes and the provision of ecosystem services are maintained.

The Well-being of Future Generations (Wales) Act (2015) sets out 'a resilient Wales' as one of seven well-being goals. It defines a resilient Wales as a nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change (for example, climate change).

The Water Strategy for Wales and the Environment (Wales) Bill, both published by the Welsh Government in 2015, set out the principles of ecosystem resilience. In these documents resilience is seen in terms of a focus on the ecosystem as a whole, rather than individual elements; joining up the different issues and aspects of the environment.

Welsh Government is also keen to stress the links between sustainability and resilience. The Environment (Wales) Bill defines the objective of the sustainable management of natural resources as to maintain and enhance the resilience of ecosystems and the benefits they provide, and, in so doing, meets the needs of present generations of people without compromising the ability of future generations to meet their needs.

2.6 The Task and Finish Group's Definition of Resilience

The group has developed a definition of resilience for the sector:

Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future.

One of the first activities of the Task and Finish Group was to develop a definition of resilience for the water sector. Resilience was defined from first principles and then compared against extant definitions. There was a focus on a practical definition that would have relevance and resonance at a strategic and operational level within water companies and the water sector. The group also took the

decision to approach resilience from a customer-centric viewpoint. This led to a definition which covered more than just infrastructure.

Consideration of the interviews, surveys and the workshop feedback (see sections 3.3, 3.4 and 5) led to changes in wording, such as highlighting both present and future provision and protection, in order to recognise that actions that increase short-term resilience could reduce it in the long term. There were more changes, specifically around the concept of anticipation, after the stakeholder workshop.

The majority of respondents and workshop attendees were broadly happy with the proposed definition of resilience, but there was a wide range of views and opinions with some preferring a Cabinet Office infrastructure-centric definition and others viewing the concept of recovery as being outside the scope of resilience as it deals with failure. Clearly there are a number of definitions of resilience used in the sector and one of our key conclusions is that any work on resilience must state which definition it is using; this led to our first recommendation which highlights the need for agreement on a shared definition (or definitions) of resilience for the sector.

3. Identifying and understanding the key issues

The Task and Finish Group carried out analyses in three areas to help identify and understand the resilience challenges and what needs to change to enable the water sector to meet them. In this section we describe the three main tranches of work undertaken by the Task and Finish Group:

- *Resilience perspectives*
- *Analysis of water companies' plans*
- *Interviews/surveys with water sector professionals*

Although the analyses carried out by and for the Task and Finish Group have helped inform the recommendations, the Group recognise that the analyses are by no means comprehensive.
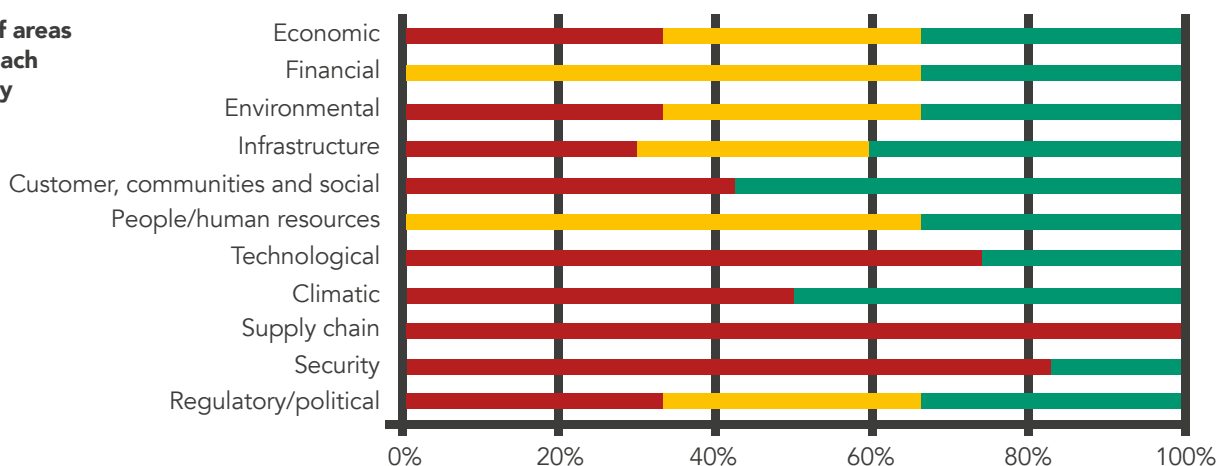
3.1 Resilience perspectives

The threats to the resilience of the sector were considered by the group from the following perspectives: economic; financial; environmental; infrastructure; customer, communities and social; people/human resources; technological; climatic; supply chain; security and regulatory/political.

They were categorised by the Task and Finish Group using a RAG (traffic light) status that represented whether the threats were considered to be significant (red), had some mitigation measures in place (amber), or were fully mitigated so that resilience was increased or provided an opportunity (green).

The table below summarises the outcome of the analysis (fuller details are contained in Appendix B). The proportion of indicators at red or amber highlights the need for action, particularly as only two of the eleven perspectives are without any 'red' areas:

Proportion of areas assessed in each RAG category

Some of the threats to resilience are not uniform across the country. Differences arise from a number of factors; these include geography, the existing network, socio-economic factors and climate. It is important to recognise that the analysis is not an exact science; however, the overall range of threats and mitigation measures highlights both the diversity of the resilience landscape and the scale of the challenges faced by the sector.

In almost all of the areas considered there were significant threats to the resilience of the sector. Some of the threats affect the ability to deal with resilience issues from the other perspectives; the main example of this is the economic perspective where a lack of investment would have a knock-on impact on the resilience in other areas, in particular infrastructure, the environment and climate.

We assessed that the financial perspective did not present any red threats to resilience. This reflects the work that has been undertaken by Ofwat to ensure that companies are financially sustainable, with safeguards in place to protect customers, and to move to greater ownership and management of risk by companies. It should also be noted that safeguards exist in case of financial collapse.
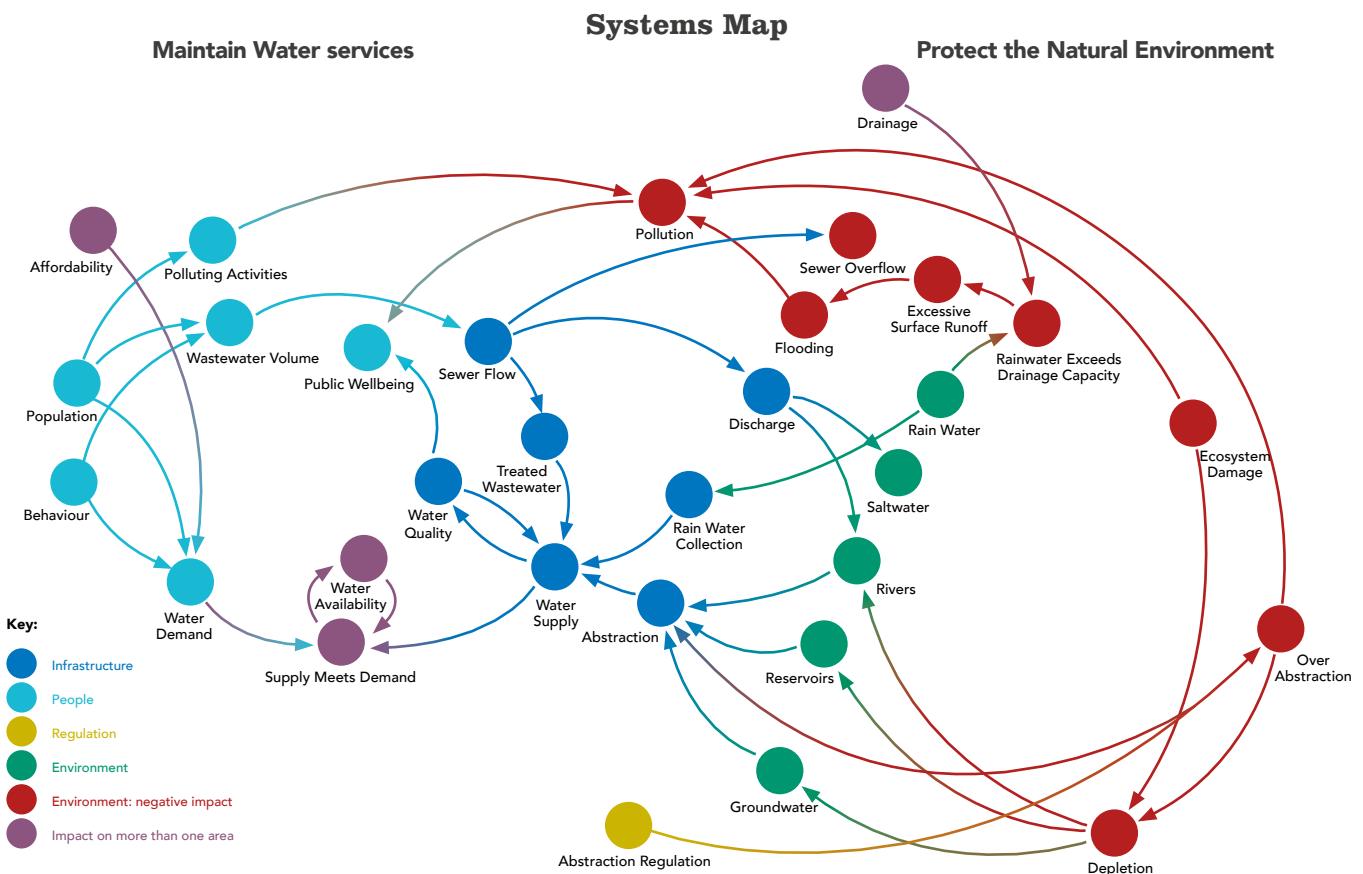
People/human resources also did not present any red threats. This reflects the mobility of the overall workforce both in the UK and beyond which helps mitigate potential skills shortages. However both of these are still amber.

The perspectives highlight areas that are not often discussed in the context of resilience. For example, the technological perspective is often considered as a key enabler for efficiency and innovation, but without safeguards in place, over-reliance on technology could inadvertently erode resilience. In particular, the availability of data and telemetry are critical factors and these systems need to be resilient. We need to be vigilant as well as innovative when introducing new technology. Also, as recent events have highlighted, cyber security is becoming an increasingly important consideration.

'Customer, communities and social' is another perspective that is often overlooked. The general public are not passive players, with resilience events simply affecting them; we recognise that they have an important role in helping to build resilience and in agreeing its boundaries. Whether through helping to shape future investment proposals, changing behaviours to increase resilience, or community-level direct action to deliver protection, we see that this area offers significant opportunities that have not been fully utilised. An important enabler to unlock this opportunity is to build understanding and raise awareness; this will ensure the public is better-informed to be able to participate fully in decisions.

A systems map was derived using the perspectives matrix, in order to identify points at which interventions in the current system can be made to improve water resilience in the UK. Systems maps allow a visual representation of a complex system or scenario, through which important leverage points and feedback loops can be identified. They can be useful in addressing policy and social issues, where they can show the relationships between different aspects of a problem. By understanding the important components of a system in relation to a set of goals, it is possible to determine which changes to the system will elicit which outcomes.

Systems Map

Link to the live version of the map

In this case, a systems map focused on the two main outcomes that were identified as indicators of resilience in the UK water system by the Task and Finish Group (maintaining water and sewerage services and protecting the natural environment). The components and links within the system were derived using the perspectives matrix, and grouped according to type. In the system map, arrows show relationships of effect between different important components of the system.

The map contains the most pertinent factors that emerge after extensive analysis of the input from the Task and Finish Group. The following relationships can be highlighted:

- Precipitation and drainage, given how they affect water availability and flooding, are key factors in water resilience.

- Population growth (driving growth in industry, agriculture, etc.) affects water usage which is also multiplied by behavioural factors.

- Some water resilience outcomes need to be addressed both from within and outside the water sector; for instance, a chain of events might be: changes in global food supplies affecting land use, affecting both water use and water pollution from agriculture.
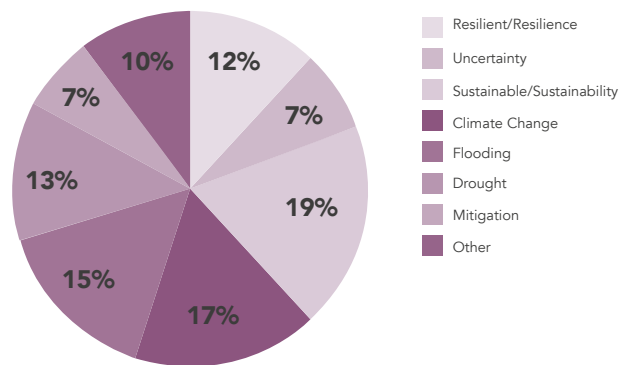
The systems map visually represents the interdependencies within the sector. There are also many other interdependencies outside the sector that are much wider and too complex to include on this version of the systems map. It is important that these interdependencies are understood because they are integral to the overall resilience of the sector. In particular, the sector is vulnerable to cascade failures from a variety of causes, including cyber attacks and breakdown of the supply chain. The systems map will continue to evolve and can be explored interactively.

These perspectives help shape the resilience debate by promoting a broad consideration of the issues. We encourage those involved in planning for and delivering resilience to use the perspectives to help challenge and refine their own work. Further details of the analysis, including the red, amber and green areas for each perspective, can be found in Appendix B.
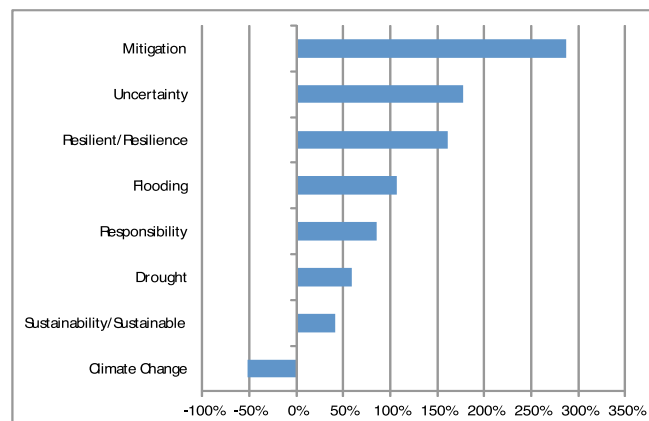
3.2 Analysis of company plans

The emergence of resilience and related themes can be evidenced by analysis of company plans undertaken by the group. We undertook a simple count of key words across a range of plans produced by the water sector, including the latest:

- Water Resource Management Plans

- Business plans submitted as part of the last Price Review

- Strategic Direction Statements

- Drought Plans

- Climate Change Adaptation Reports

- Sustainability Reports

Legend: Resilient/Resilience, Uncertainty, Sustainable/Sustainability, Climate Change, Flooding, Drought, Mitigation, Other

There were close to 28,000 references to the key words – resilience/resilient, uncertainty, sustainability/sustainable, climate change, flooding, drought, mitigation, gold command, emergency, responsibility, extreme event and adaptability.

The graph depicts the results of the analysis[1]. As well as specific references to resilience, the challenges (climate change, uncertainty) and the impacts (drought, flooding) also emerge as key themes across the various plans.

We took a closer look at two of the documents (the Strategic Direction Statements published in 2007 and the 2014 business plans) to consider how resilience has emerged as a key theme over time. The chart shows the differences (percentage change) in the number of references to resilience and related themes in these documents. The chart highlights the increasing prominence of resilience as an issue. There is also clearly a drive to recognise uncertainty (and perhaps volatility) and the need for action (mitigation against the challenges).

References to climate change had a noticeable decrease. This could be explained in part by the fact that all water companies had to produce statutory climate change adaptation reports in 2010 and having separate, stand-alone reports meant that the 2014 business plans could simply refer back to them. In addition, companies could be focusing on specific climate change impacts (drought, flood etc) rather than using the generic term.

The results should be treated as indicative, as a simple word count cannot fully reflect the depth of importance of a given issue, but the analysis is nevertheless useful in highlighting the emerging themes from company plans.

[1] We excluded references to 'drought' in Drought Plans, 'sustainability' in Sustainability Plans and 'climate change' in Climate Change Adaption Reports as these could have skewed the results.

3.3 Interviews from informed / key stakeholders

The Task and Finish Group undertook a series of structured interviews with key stakeholders during July 2015. There were 21 participants, 16 of whom represented water companies. The purpose of these interviews was to gather detailed feedback on the following areas:

• Defining resilience

• Resilience of the water and wastewater sector

• A long-term planning framework for resilience

• Funding resilience

• Responsibility for resilience

Defining Resilience

Question: Interview participants were asked for input to the definition of resilience as created by the Task and Finish Group: 'Resilience is the ability to cope with, and recover from, disruption, trends and variability in order to maintain services for people and protect the natural environment now and in the future'.

Synopsis: Overall, participants felt that the definition covered the main bases of what they were trying to build resilience to, especially through looking at temporal variations. It was also noted that the definition lent itself to more than just asset-building measures and focused on the environment as something to protect, further than just to ensure the continuity of services. However, the inclusion of trends or variability, particularly in the context that trends could be 'recovered from', was considered illogical by some.

Conclusion: The responses were consistent with the comments at the Resilience Workshop and the online surveys. The final definition (Recommendation 1) now includes 'and anticipate' in response to the feedback received to address the confusion over the response to trends, a term which had been used to reflect the different timeframes over which challenges to resilience emerge.

Resilience of the water and wastewater sector

Question: Participants were asked to rank how resilient they felt the water and wastewater sector was, against the definition (from 1 being a low level of resilience to 5 being highly resilient).

Synopsis: All participants answered either 3 or 4. However, this masks the contrasting views in the justifications for the rankings with views ranging from resilience is 'improving quickly' to 'but reducing', and being resilient is something 'we plan to be' and that they were 'more resilient than 20 years ago'.

Conclusion: Overall, the lack of measures makes it difficult to objectively assess resilience of the water sector. Recommendation 8 is designed to address this. There are clear differences in resilience and planning requirements between water and wastewater services. This is reflected in Recommendations 5 and 10.

A long-term planning framework for resilience

Question: Participants were asked to comment on the degree to which a long-term planning framework for resilience existed, and what more could be done to improve such a framework.

Synopsis: Comments were wide-ranging, covering the need for more joint working across organisations to the need for a sectoral approach to climate change. The concept of mutual aid was a theme that occurred frequently within the interviews, particularly relating to whether plans were shared with other organisations. When asking about how formal the mutual aid agreement is one participant answered 'I think if we tried to formalise it, it would prove very complicated'. One participant's water company 'put out a call for "who can supply us with water in the next 25 years" … we only got one serious proposition'.

Conclusion: Overall, there is considerable focus on local planning; but there is a need for a long-term national planning framework. Recommendations 4, 7 and 10 all address this. Mutua aid is specifically reflected in Recommendation 9.

Funding resilience

Question: Participants were asked to describe risks to achieving resilience in the future.

Synopsis: Participants felt the main risk was infrastructure and asset failure, with wide-ranging justification including companies not having the correct standard of headroom built in to deal with extreme events and uncertainty about the future impact of climate change. There was concern about the clarity for funding resilience and the balance between investing in infrastructure and ensuring that bills remained affordable for customers. Participants wanted customers to have a greater role in the consultation processes, particularly on the inter-generational issues (paying for future resilience now; the 'main challenge is what customers are willing to pay for').

Conclusion: Overall, failure of infrastructure/assets was seen as the biggest risk to resilience, but there was a lack of clarity in terms of how to justify and fund improvements. This is covered by Recommendation 3.

Responsibility for resilience

Question: Participants were asked who should take responsibility for resilience in the water sector.

Synopsis: Participants initially pointed to water companies - reflecting that most participants were from water companies - and their responses reflect a clear need for water companies to deliver a reliable service for customers and the environment. In terms of setting and enforcing standards, a clear role for governments to set standards, and regulators to enforce standards, emerged.

Conclusion: Overall, water companies should deliver resilient services, but standards need to be set by governments and enforced by regulators. This delineation of responsibilities is reflected in Recommendation 8.
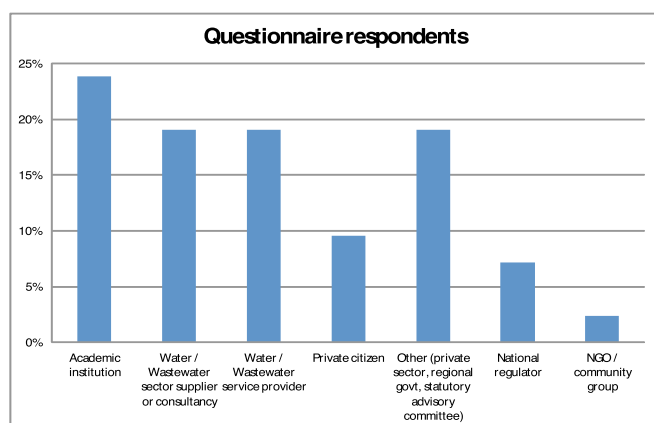
3.4 Online surveys

Two online surveys were opened to stakeholders during August 2015. Whilst one survey targeted those familiar with the UK water and wastewater sector, the other was specifically aimed at those not so familiar with the sector. This approach enabled the group to benefit from both perspectives developed through experience and new perspectives.

The surveys were designed to elicit responses on the following areas:

• The definition of resilience

• How resilient is the sector and to what challenges/risks? (asked only to those familiar with the water and wastewater sector)

• Strategies for long-term trends and short-term shocks

• How to promote resilience

• Measuring resilience

• Responsibility for resilience

There were 65 survey responses, although not all respondents answered all questions. The chart shows the distribution of those respondents who identified the stakeholder group they represented:

The definition of resilience

Question: Respondents were asked whether they agreed with the definition of resilience as created by the Task and Finish Group: 'Resilience is the ability to cope with, and recover from, disruption, trends and variability in order to maintain services for people and protect the natural environment now and in the future'

Synopsis: There was significant support for the definition of resilience as presented, with just over 60% of respondents expressing support. The reasons for disagreement can be summarised as the need for more clarity, concern about the inclusion of 'trends' and the question as to whether a definition was needed at all.

Conclusion: Most respondents felt that a resilience definition was required, although some wanted to modify the working definition provided. The responses were broadly consistent with the comments at the Resilience Workshop and the interview responses. The final definition (Recommendation 1) now includes 'and anticipate' in response to the feedback received to address the confusion over the response to trends, a term that had been used to reflect the different timeframes over which challenges to resilience emerge.

How resilient is the sector and to what challenges/risks?

Question: This question was posed only to those respondents familiar with the water and wastewater sector.

Synopsis: Nine people responded to this question, seven of whom assessed the sector as 'somewhat resilient', with two assessing it as 'non-resilient'.

Conclusion: The respondents mentioned a wide-ranging set of challenges/risks, many of which were cross-sector and national issues. This suggests there is a need for planning beyond traditional water company boundaries, and for a wider range of factors that could affect service delivery to be taken into account. The risks and challenges identified were used to cross-check the completeness of the resilience perspectives (presented in section 3.1).

Strategies for long-term trends and short-term shocks

Question: Respondents were asked whether the same strategies could be used to ensure resilience to long-term trends and short-term shocks.

Synopsis: There was a fairly even split in responses. Many respondents felt that a consistent framework could be applied (analysis, ownership, action and review) and different responses - tactical plans and long-term strategies, or low-frequency/ high-consequence events and more mundane risks - developed from it.

Conclusion: *Although the results were inconclusive in terms of whether the same strategies could be used to ensure resilience to long-term trends and short-term shocks, those disagreeing did highlight the need to stress-test existing strategies against both drivers. This concept of stress-testing features in Recommendation 9. The need to understand risk and failure was also supported – this is covered in Recommendation 6. Recommendations 1, 5, and 10 also contribute to clarification of the best strategies to address both types of problem.*

How to promote resilience

Question: Respondents were asked to state their top three key activities to promote resilience in water and wastewater services provision.

Synopsis: Responses can be grouped into five areas: (i) having a definition for resilience, (ii) understanding risk, (iii) promoting proactive solutions and customer-focused measures, (iv) cross-sector collaboration and (v) strengthened regulation and stronger leadership.

Conclusion: *Key points that emerged were the need to make sure customers were better informed about resilience related matters - the role of customers in shaping future resilience plans was seen as critical. These points are reflected in Recommendation 2. Drainage was also specifically mentioned as a focus area. A clear need was identified for a more co-ordinated and cross-sectoral strategic mode of working, including setting up a national initiative for resilience, which is reflected in Recommendations 10 and 3. Further, Recommendations 1, 2, 5 and 10 call for the involvement of a broad set of stakeholders beyond the water sector. These findings are supported by the group's review of the academic literature, which calls for a cross-sectoral approach to ensuring resilience in complex systems.*

Measuring resilience

Question: Respondents were asked how resilience in the water and wastewater services sector could be measured.
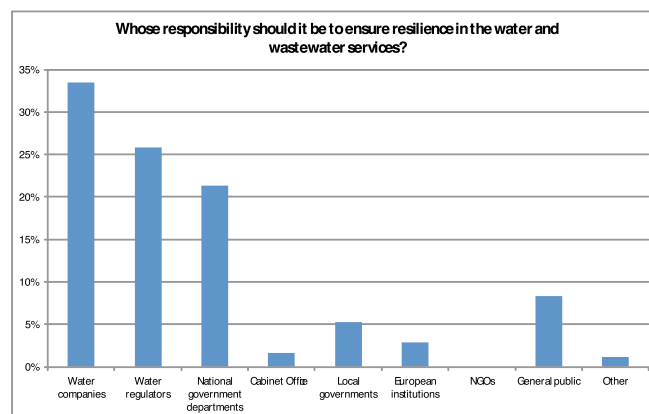
Synopsis: There were a variety of responses, including existing Outcome Delivery Incentives and more forward-looking, risk-based measures.

Conclusion: *Again, the responses were wide-ranging and covered many of the areas commented on in the Workshop, with the addition of incorporating the human element of employee satisfaction. There was clear support for a framework to be established, and a need for standards to be appropriate to the level of risk.*

Responsibility for resilience

Question: Respondents were asked to rank who should be responsible for ensuring resilience in the water and wastewater services sector.

Synopsis: In absolute terms, water companies and regulators were the most popular choice, with national government departments (third. However, taking priority order into account, the order emerges more clearly:

Whose responsibility should it be to ensure resilience in the water and wastewater services?

Conclusion: *These results are consistent with the results seen elsewhere. Survey participants clearly identified three main stakeholders (water companies, water regulators and national governments) as having responsibility for ensuring water and wastewater services are resilient. This is reflected in the allocation of overall responsibility of the recommendations amongst stakeholders.*

4. The main resilience challenges

It is clear that there are many pressures facing the water sector that will test its resilience in the short, medium and long term. These range from trends in demographics to the impact of climate change. The resilience challenges are not just in the future as we have seen the impact of severe weather affecting water and sewerage services; in particular, the 1995 and 2011/12 droughts and the floods of 2007 and winter 2013/14.

From our analysis, presented above, we have formed three main groups of challenges that impact the resilience of the sector. In brackets we show how the challenges are aligned to the recommendations:

- A step change in approach is needed to build resilience with a greater need for partnership and softer infrastructure solutions where appropriate. This step change will, in particular, require far greater engagement with customers to understand their expectations on service levels and to enable a more active role for customers in building resilience. [Recommendations 1, 2, 6 and 10]

- A clear overview of the resilience of the sector does not exist; this has come from a lack of an agreed definition of resilience, a dearth of consistent measures and no fixed resilience standards. [Recommendations 1, 8, 9 and 10]

- It is unclear as to whether the current structure of the sector and the form of economic regulation encourage legitimate resilience investments to be made. It is also unclear if decisions are being made on the appropriate geographical scales to build resilience in an effective way. [Recommendations 3, 4, 5, 8, 9 and 10]

We discuss these challenges further in this section.

The pressures mean that we are at a critical point where choices need to be made about the long-term future of water supply and demand and about drainage and sewerage. These are not only UK issues and are being seen worldwide where a patch-and-mend approach to existing infrastructure is not sustainable and a more systemic approach is needed. Continuing with the patch-and-mend approach will lead to an increased frequency of service failures. We see that step changes are needed to build resilience.

- There is a need for modern infrastructure which can be delivered through economies of scale and with enough capacity to solve issues for generations to come.

- We need to use information and communication technologies to make our current infrastructure smart enough to adapt to change and to allow for a significant expansion of small-scale distributed infrastructure and soft infrastructure.

- We need to use social infrastructure where water companies can use a new set of social norms (e.g. where a step change in lower consumption is the norm) as the key to solving long-term problems.

In reality a combination of all three approaches is likely to be needed to address the challenges ahead. However, there are significant barriers to delivering any of these options. One of the biggest barriers is that all options require significant change and this is challenging for a sector that is traditionally conservative. Another is that building resilience has visible costs, but less visible benefits until the extra security provided by prescient investment delivers tangible benefits at some future point. The case for investment is harder to win if the event that you are trying to protect against has not previously occurred – particularly relevant for low-probability, high-impact events.

The step changes described above have implications for the public in terms of service, cost and behaviour. These include:

- Understanding the need to invest now to increase resilience that will lead to efficiencies and benefits in the long run.

- The implications and cost of accepting an increased risk of failure.

- Adapting personal behaviour to help build resilience.

All of these approaches will require significant customer engagement not only for them to gain legitimacy but also to help shape and prioritise how resilience is built. The public must have trust and confidence if we expect them to pay more in the short term to receive a long-term benefit, or understand failure, or if we expect them to actively change their behaviour. There is already a lot of understanding of these issues in the water and wastewater sector and progress has been made to improve engagement, particularly at PR14 (the most recent five-year price review), but there is still much more to do.

We have seen examples of local initiatives with strong social engagement being highly effective. In particular, the highest impact is found where local engagement is set in a wider context of co-ordinated messaging and action (e.g. Water Saving Week, Love Your River). Engagement needs to be a two-way process and the water sector needs to be open to ideas and solutions from other sectors and from the third sector and local community groups.

A key issue that consistently appeared in our analysis was confusion surrounding the definition of resilience. Since resilience rose to the top of the agenda after the 2007 summer floods a number of definitions of resilience have been proposed, yet none have become commonly used. A lack of a simple, clear and agreed definition means that engagement with customers can appear muddled and unfocused. We see evidence of this from Ofwat's focus groups on resilience and climate change from 2011 and more recently from customer research as part of PR14. We also observe that discussions within organisations can become confused without an agreed definition. There is a risk that work to build resilience across the sector is inefficient due to misunderstanding of definitions.

Without a clear definition it will always be challenging to measure the resilience of the sector. This is the position that we currently find ourselves in. A clear definition is the first step in arriving at a set of resilience indicators. At the moment there is no single body that has an objective overview of the resilience of the sector. This also hampers the development and agreement of standards to build resilience. Until a more complete picture of resilience is revealed the full extent of policy reform and potential investment is not known. This lack of an evidence-based overview of the sector's resilience also makes it more difficult for Ofwat to interpret their new primary duty.

The new resilience duty gives Ofwat a more explicit role in enabling and incentivising resilience in the sector. A key challenge for Ofwat, and the companies they regulate, is to collaborate effectively in order to ensure this duty translates to a tangible difference to the services customers receive. It is too early to tell whether Ofwat's resilience duty is making a difference. The duty was in place towards the end of the last periodic review (PR14) but it is not yet clear to what extent it directly influenced decisions. This is understandable given the amount of time it takes for the duty to be interpreted and embedded. However, there is widespread agreement that the approach taken at PR14 (totex, outcomes etc.) was a positive step that encouraged resilience planning and investment.

There is an emphasis now on Ofwat to set out how legitimate resilience investment is handled in the context of a price review. The regulatory framework should incentivise necessary investment in resilience, informed by customer views, in an approach where companies themselves identify and manage the risks to services and systems. The current framework has enabled significant investment in specific resilience schemes, but the cost assessment modelling approach used by regulators uses a backward-looking assessment of historic resilience expenditure as a starting point. We need a framework which incentivises companies to propose future investment that both reflects the priorities of the customers and allows them to manage risks to services appropriately. The framework needs to cover emerging and future risks that require action in the short term; this type of risk will not be accounted for in historical resilience investment.

When considering interventions to build resilience, significant questions arise on the scale at which decisions should be made. This debate is broad and raises a number of challenges, particularly when considering large-scale storage or drainage schemes:

• Are these issues to be addressed at the company, regional or national level (and/or across all these levels)?

• How should the need for these types of interventions be identified and planned for?

• Who should have ownership of distributed infrastructure?

• Should large-scale critical assets (soft or hard) be decided upon by consensus with an agreed outcome delivered by statute, or through an adversarial proposal-challenge process?

Addressing these issues will require a much greater degree of engagement than currently exists across the water sector.

Working together to deliver both nationally significant schemes and local partnership schemes (such as flood alleviation measures) will require a more outcome-driven type of regulation and new methods of working. We are seeing this change from Ofwat and from some water companies (e.g. pain-gain sharing mechanisms that are linked to levels of service) but the challenge is to make this the mainstream approach in all companies. Other regulators also need to recognise that partnership working may deliver better long-term outcomes and build resilience, but may involve short-term uncertainty; for example, catchment management schemes have a degree of uncertainty over whether they will deliver the required improvements in water quality. Likewise water companies and their investors may need to embrace short-term risk to secure long-term resilience. This short-term/long-term issue of risk balance, and general understanding of risk, arose repeatedly during our investigations.

We have used these challenges to inform our priority areas for consideration and shape our recommendations. The recommendations are not intended to fully address all the challenges. They represent positive steps to help build resilience and are a staging point on a much longer journey.

5. Refining the recommendations - sector workshop

In September 2015, a workshop was held at Severn Trent Centre, Coventry, to test and challenge the draft recommendations from the Task and Finish Group. The workshop brought together senior professionals from across the sector. In total 45 people attended the workshop, representing a wide range of interest groups including water companies, governmental bodies and customer representatives.

The focus of the day was to receive as much feedback as possible on the definition of resilience (Recommendation 1) and the other nine recommendations. The feedback was elicited through a series of small group exercises, with each group run by an independent facilitator. The table below summarises the strength of support for each of the recommendations as they stood on the day of the workshop. More details of the workshop can be found in Appendix C.

The views from the workshop were then considered by the Task and Finish Group and used to refine the recommendations. All the recommendations have been improved since the workshop. This step was important in developing recommendations that had buy-in from the wider water sector. The figure below summarises the end-to-end process of developing the recommendations.

Recommendation	Strength of Support
Agree a shared definition of resilience for the sector.	←→
Increase public engagement and education.	↑
Clear routes for funding legitimate resilience measures.	↑
Coherent planning for resilience at both a national and regional level.	←→
Improved understanding of risk and failure.	↑
Establish wastewater, sewerage and drainage plans.	←→
Ensure services are resilient under different water sector structures.	↑
Develop benchmarking, standards and metrics.	↑
Ensure existing plans are stress-tested.	↑
Establish a water and wastewater resilience forum (sic).	←→

Formation
• Task and Finish Group formed (Early 2015)

↓

Key challenges identified
• Existing resilience guidance and literature reviewed
• Additional analysis - resilience perspectives, water company plans, surveys and online

↓

Draft recommendations produced
• Ten draft recommendations to address key challenges

↓

Testing / refining
• Workshop to review and challenge draft recommendations
• Task and Finish Group review comments to refine recommendations

↓

Final recommendations published
• Task and Finish Group publish final recommendations

6. Recommendations

1. Agree a shared definition of resilience for the sector

When: *During 2016*
Lead: *Water and Wastewater Resilience Action Group (see Recommendation 10)*
Involved: *All bodies involved in planning and delivering water resilience*

There are numerous definitions of resilience in the water sector. A coherent set of definitions (or definition) for resilience that is accepted by everyone is essential. Checking if companies are resilient when their definitions of resilience vary is difficult. Any board discussions of resilience or reporting should include which definition of resilience is being used. This includes the work of governments where definitions may vary between departments. The Water and Wastewater Resilience Action Group should act as a central body to collate and publicise the varying definitions of resilience (see Recommendation 10). For reference this is the definition we are currently using:

'Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future'

This definition should be reviewed periodically by the Water and Wastewater Resilience Action Group.

2. Increase public engagement and education

When: *2015 - 2020*
Lead: *Water companies and governments*
Involved: *All sector and non sector partners, including stakeholders and third parties*

Using a common definition, or set of definitions, there is a need to engage the wider public, particularly in relation to risk, and to develop a common understanding of the acceptability of risk. This engagement should be twofold. Firstly it should involve the provision of pertinent information on a wide scale on an ongoing basis, with the aim of enhancing public understanding of water systems. Secondly it should aim to ensure this information is transformed into active engagement - which will lead to positive environmental behaviour - the public should be given an active role in resilience, both in terms of adaptation and mitigation.

The action to deliver this recommendation sits with all bodies in the sector. But it sits primarily with water companies who must undertake much more active engagement and with governments who, whilst they are unlikely to do any public outreach in this area, must reinstate areas where they have removed information provision, like the reintroduction of the water cycle as a key element of the national curriculum. The water sector should, where possible, continue to increase access to data, subject to commercial confidentiality and security exemptions. The sector strategic dashboard currently being developed by water companies, regulators and other stakeholders could be a helpful contribution to facilitating that access. More open data would assist better public understanding and engagement and could promote innovation and understanding and increase resilience through crowd sourced solutions and oversight.

3. Ensure clear routes for funding legitimate resilience investment

When: *By 2017, in time to inform PR19*
Lead: *Ofwat and water companies*
Involved: *Water companies, investor community, customer bodies, wider water sector stakeholders*

There should be a clearer and smoother pathway for funding legitimate resilience building measures. Ofwat should provide water companies with a clear framework; it is important that water companies retain ownership of their plans built using this framework. There needs to be clear guidance from Ofwat on its treatment of resilience investments when it considers business plans. There needs to be flexibility to fund innovation against a wide assessment of costs and benefits and future generational aspects should be factored into assessment of business plans. At the same time water companies and customer groups must develop improved methods to test customer acceptability of risks and costs - willingness to pay is a poor representation, as those who experience disruption are willing to pay more in the future and the water companies need to do more in-depth engagement and deliberative work with all their customers to build and maintain a real understanding.

There needs to be a better consideration of the most appropriate mix of hard infrastructure (below ground networks and large physical assets) and soft infrastructure (such as community led projects or sustainable urban drainage systems) for individual circumstances. This requires a clearer framework for developing, regulating, funding and evaluating soft infrastructure and community based resilience. Ofwat should specifically look at how and whether its framework could enable water companies or others to fund distributed assets and / or to manage assets at a community level. This would assist in promoting partnership working between water companies, NGOs and community groups. The water companies must do more of these projects and Ofwat should facilitate and encourage this.

4. Ensure coherent planning for resilience at both a regional and national level

When: By 2020
Who: Water companies, Environment Agency, Natural Resources Wales
Involved: Water sector bodies and NGOs

There is a question around how geographical planning scales and how national versus local priorities affect resilience. There must be more inter-company discussion and co-ordination around water resources. There should be a revitalisation of supra-regional and national planning for water resources.

A newly formed project group, under the auspices of Water UK and which includes water companies, Defra, Welsh Government, Ofwat, the Environment Agency, Natural England and Natural Resources Wales,, is considering "What are England and Wales' long-term planning needs?" and "What are the practical steps required to meet these needs?". The project will allow for the development of a high level strategy and framework for the long-term planning of water resources in England and Wales. It will aim to strengthen the overall resilience of water resources for all users, and to protect the environment. The project will enable the strengthening of future resource planning guidelines; a more integrated approach to water resource and drought plans; consideration of minimum levels of service and risk levels. It will inform consideration of the need for a National Policy Statement. There is also a need to ensure that large infrastructure projects, both hard and soft infrastructure, are progressed efficiently once a decision has been made and these projects should be assessed, overseen and delivered in the context of national and regional plans.

5. Establish wastewater, sewerage and drainage plans

When: 2020 – 2025, with a Drainage Road Map produced during 2015 -2020.
Who: Governments, water companies, local authorities
Involved: Regulators

There must be national wastewater and sewerage strategies and each company should have a sewerage and wastewater plan. This should link to SuDS, wider drainage issues (highway and land drainage) and rainwater and greywater harvesting through the parallel development of drainage plans. Potentially these plans should be statutory, and there may be scope under the existing statutes.

There is good connectivity here with the work of the 'Delivering 21st Century Drainage Programme Board'. This programme is UK wide and comprises representatives from governments, regulators, operators, environmental NGOs and stakeholders. It aims to gather evidence to enable governments and the sector to map out the future of drainage systems across the UK over the next two or three decades. It is intended that the evidence-based research will support the development of resilient drainage systems; including highlighting options for changes to regulation, legislation and technology, and that this will enable the expectations of customers to be delivered. The programme also aims to enable the affordable and practicable control of discharges from drainage collecting systems which remain compliant with EU requirements; and to set out how and at what cost the sector will begin to address the various longer-term pressures that drainage systems face including those from climate change. This will form an important part of the evidence base on which long-term wastewater, sewerage and drainage plans should be based.

6. Improve the understanding of risk and failure

When: 2015-2020
Lead: Environment Agency, Natural Resources Wales, water companies

There needs to be broad discussion, involving all parties including customers, leading to agreement on the level of service which should be achieved in each area. This would be based on better understanding and communication of the risks faced by the water sector, of the costs of failure, and of the costs and benefits of measures to avert, manage and recover from failure. Coping strategies for dealing with 'beyond resilience' emergencies (black swan events) also need to be agreed, in advance of their occurrence. Progress in these matters will enable water companies to focus on the risks to critical assets and services, and to plan for the effective delivery of services in critical conditions, with a mandate from their customers and society, and from their regulators and government.

Another requirement is an appreciation by all that some failures will occur, notwithstanding best plans being laid and large investment being made; for example, zero leakage and never having supply interruptions is unhelpful thinking. Risk could also be better understood and dealt with through more open data, enabling wider scrutiny of water and wastewater management. This could link to the sector strategic dashboard that is currently under development.

7. Ensure services are resilient under different water sector structures

When: By 2017
Lead: Governments and Ofwat

The UK and Welsh governments should undertake work to analyse the impact of differing water sector structures on the

delivery of resilience. Irrespective of any future model of delivery the common issue here is whether the water undertakers have structural capacity to deliver resilience. The key questions are who within each structure is responsible for resilience planning; is there structural capacity to deliver this; and will the regulatory regime enable resilience. Ofwat's approach and assessment of impacts needs to enable and incentivise resilience in a fragmented and / or evolving sector where not all the stakeholders are within the regulatory, licensed, regime. This does not just apply to the scale of the water and wastewater undertakers - it also applies to the skill set and objectives within the undertakers.

This means that where statutory, policy and regulatory changes are proposed that may impact on company structures there should be a requirement for impact assessments to explicitly consider the effect on resilience of services.

8. Develop benchmarking, standards and metrics

When: By 2017
Lead: Ofwat, water companies and Government
Involved: Water companies and wider water sector stakeholders

Ofwat and water companies need to work together to develop a method of comparing resilience, reflecting customer views, local context, the environment and company ownership of plans. Such metrics need to be at a level of detail appropriate to the scale of the risk (i.e. measurement of resilience to material risks); be practical to measure; measure impacts on customers and the environment; and establish the minimum levels of resilience expected. This does not necessarily mean standardisation as this will constrain the number and type of solutions, which will reduce resilience. But there needs to be greater discussion between companies about how they tackle resilience and there needs to be a resilience standard. The Resilience Action Group could play a role in setting such a standard which could be a qualitative measure of resilience as opposed to a quantitative metric. Companies should report against a set of resilience criteria. This should be qualitative but will ensure all company boards have properly assessed resilience in a way that goes beyond their risk register. This could link to the sector strategic dashboard.

9. Ensure existing plans are stress-tested

When: 2015 – 2020
Lead: Governments to set framework for work
Involved: Water companies, regulators, governments, civil society

The water sector has a lot of plans that relate to resilience. But this level of planning may lead to complacency and ultimately lower resilience. All companies need to have a process in place, including board assurance, to review and stress-test plans as widely as possible. This should include a consideration of cascade failures, the reliance on the resilience of other sectors and the risks related to cyber security, which means better multi-sectoral planning and co-ordination. There should be co-ordinated scenario planning at a regional level or river basin, involving multiple water companies. There needs to be a discussion of how strategies can go beyond planning for recovery and move to planning for adaptation of systems to prevent events from occurring or to offset the impacts of events and trends. There may be a need to consider short and long-term resilience in different ways, one with procedures and the other with strategic frameworks. And there needs to be a way to stress-test long-term resilience to trends and to develop approaches that deliver both long and short-term resilience rather than having potential trade-offs between the two. There should be a review of mutual aid arrangements and a consideration of how to deal with wide-scale incidents that affect multiple water companies. Finally there is an urgent need to develop contingency plans for what to do when events go beyond the scope of the existing planning horizons.

10. Establish a water and wastewater resilience action group

When: During 2016
Lead: Water UK to initiate
Involved: All water stakeholders

There are varying views on who should lead on resilience and a number of groups and organisations are considering resilience at present, but these tend to be exclusive. The constrained membership of these groups leads to a restrictive set of ideas, could lead to inaction or deferred responsibility and is in itself not resilient. It is clear that most people see this as a shared responsibility between Government, regulators and water and sewerage service providers. But this could lead to inaction or deferred responsibility. In light of this it is recommended that a resilience action group for water and wastewater is established - this must have a wide ranging remit. The group could be hosted by a recognised sector body such as Water UK and should include water companies, governments, local government, regulators, customer groups, community groups and social and environmental NGOs, with observers and invitees from other sectors as appropriate. It should be independently chaired (the chair should serve in a personal capacity). The remit of the group should be to define qualitative standards, look at the picture across England and Wales and share best practice. Any new resilience action group needs to engage widely and have an open membership structure. Once established the resilience action group should determine its own terms of reference, method of working and areas of activity.

7. Next steps

This report was presented to Ofwat and the sector on 1 December.

It will inform Ofwat's development of the regulatory framework for PR19, called Water 2020.

In December 2015 Ofwat will publish its initial response to the report, alongside its approach to resilience and a consultation on Water 2020.

The group also looks forward to other key players in the sector taking forward its recommendations.

Appendix A: Academic Review References

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🔴 Significant threat to resilience.

🟡 Some threat but mitigated.

🟢 Opportunity/mitigation to improve resilience

Resilience perspective: Economic

🔴
- Too narrow a view taken by regulator of beneficial investment resulting in under-investment i.e narrow cost benefit analysis based solely on willingness to pay rather than more strategic view

🟡
- Managing and preparing for growth and demand resulting in additional demand on scarce resources and pressure on discharges.
- Short-term economic recession affecting customers' ability to pay and willingness to invest results in investment in resilience being postponed, leading to increased risk in short/medium term.

🟢
- Ofwat resilience duty enables long-term strategic assessment.
- A stable regulatory framework that is necessary to attract long-term investors with a (relatively) low cost of capital.

Resilience perspective: Financial

🟡
- Need ability to withstand cost shocks.
- Need sufficient liquidity to be able to finance functions and maintain investment if debt markets closed
- Returns and levels of risk attract long-term investors.
- Sufficient headroom to withstand interest rate changes.
- Sufficient headroom in gearing or ability of investors to inject additional equity in the event of low/negative RPI (which affects key financial ratios).
- Customers need to continue paying their bills – mass non-payment would result in financial distress. (There is no example of this in utilities but has happened elsewhere e.g. the poll tax.)
- "Shipwreck clause" in licence protects financeability in the event of very material cost shocks.

🟢
- Securitised companies required to have at least twelve months liquidity to finance operating costs and capital investment.
- Water Act and licence conditions ensure services continue to be provided in any case – e.g. Special Administration arrangements.
- Consideration of different pricing models that could promote more responsible use of water by customers.

Resilience perspective: Environmental

🔴
- Ability of water companies to be able to deal with impacts of pollution on water sources (e.g. diffuse pollution by metaldehyde or point source pollution by trade effluent discharges) AND ability to prevent pollution/minimise impact on the environment from water and sewerage company activities.
- For some companies the scale of the requirement to restore sustainable abstractions is such that it removes current headroom in long-term supply/demand balance and resilience in the event of drought and it will be difficult to find replacement sources of supply.
- Flood capacity – resilience of assets to withstand flood and respond to impact of events.

🟡
- Managing and reducing greenhouse gas emissions and water footprint for a resilient future.
- Resilience of biosolids to land disposal route – loss of route (eg Foot and Mouth, flooding and land bank restriction due to loss of confidence by supermarkets/maltsters) would result in sludge to landfill at excess cost and/or serious pollution risk.
- SuDS (Sustainable Urban Drainage Systems, including ponds, wetlands, swales, permeable pavements etc) provide opportunities to slow water down, reducing risk of flooding. Amber rather than green because often difficult/expensive to retrofit.

🟢
- Biosolids Assurance Scheme (BAS) mitigates some risk.
- New collaborative approaches, including paying for ecosystem services, opens new opportunities to mitigate risk and improve resilience.
- Modelling and scenario planning to understand and plan for the impact of more frequent extreme weather events.

Resilience perspective: Infrastructure resilience – impacting on provision of services for customer and environment

- Interconnectivity of supply and adequate storage capacity - insufficient headroom, and interconnectivity to move available water around, to cope with drought resulting in increasing levels of restrictions (from hosepipe ban to standpipes or rota cuts) and damage to other abstractors (especially agriculture), the environment and wildlife.
- Lack of interconnectivity resulting in increased risk and incidence of interruptions to supply.
- Assets not constructed to withstand flooding, fire and other hazards, affecting ability to continue to operate and provide services.

- Ageing assets – current levels of serviceability have been maintained with benefit of innovation and efficiency but will this be sufficient to maintain resilience in the long term given very long replacement cycles (c 100 yrs mains and >800 years sewers) i.e. adequately maintained/operated in the short term, but is it sustainable in the long term?
- Ability to accommodate changes that affect the flow of water through the system – e.g. drastically reduced wastewater flow that could result in increased blockages and septicity of sewage in the pipes.
- Awareness of actions in other sectors that might impact on water provision – e.g. increased hydroelectric energy provision, changing agricultural practices.

- Ability to deal with incidents and events through emergency response, working in collaboration with other regional agencies.
- Willingness of customers to engage and change their behaviours – reducing water consumption; reducing FOGs (Fats, Oils and Greases) and wet wipes disposed of into sewers thereby reducing blockages.
- Abstraction reform and trading of licences has the potential to increase flexibility in the allocation of scarce resources; trading payments enable investment in water efficiency e.g. targeted agriculture irrigation instead of spray irrigation (see report on lessons from Australia http://www.anglianwater.co.uk/about-us/statutory-reports/markets-water-shares-and-drought-lessons-from-australia.aspx).
- Invest in diversity of infrastructure solutions to increase agility to respond to stress e.g. SuDS.

Resilience perspective: Customer, Communities and Social

- Resilient communication channels (including telephone, email and social media) – customers need to be able to contact companies 24/7.
- Ability to be able to support customers and vulnerable groups (e.g. customers on Water Care Register) 24/7.
- Ability to maintain services in face of social unrest.

- Communities and customers' resilience/self-help and ability to respond e.g. through flood warning groups.
- Investment in activities that promote new social paradigms that help support resilient behaviours.
- Empower communities to actively participate in water stewardship (this is a broader and more active form of the resilience/self-help point above which implies more agency on behalf of the citizens).
- Investment in increased discourse between citizens, communities, government and companies.

Resilience perspective: People/Human Resources

- Ageing workforce resulting in loss of skills and experience and risk of lack of a skilled workforce available to replace them. Lack of science teaching and engineering increases risk.
- Manpower availability generally e.g. flu pandemic or industrial action.

- New generation with new ideas, innovation and more flexible/different ways of working.

Resilience perspective: Technological

- Data storage and retrieval security and resilience.
- Access to remote site information via telemetry e.g. the loss of telemetry alarm information would hinder ability to manage assets.
- Mobile worker communication would likewise hinder management of services.

- Ability to invest in future technology to remain efficient and improve services.

Resilience perspective: Climatic

- Impact of severe weather events and climate change (including wetter winters, drier summers and sea level rises) - ability to deal with varying rates of climatic change.
- Impact of sea level rises and over-abstraction increasing saline intrusion.
- Land use change driven by changes in climate may increase water stress. This could be driven by global and not just regional changes.
- Population changes (unpredicted mass migration) driven by climate change could place increased stress on our services and the environment.

- Actions to minimise carbon and water footprints for a resilient future.
- Wetter winters should result in more water available in winter which can be stored and released in summer to provide resilient water supplies for all – public water supply, agriculture and the environment. Initiatives (such as Water Resources East Anglia and Water Resources South East) promote collaborative approaches to long-term water resource planning on a multi-sector basis.
- New approaches to water resource planning are being developed – such as Robust Decision Making and Adaptation Pathways – that plan for uncertain futures and many scenarios and do not assume just one deterministic future.
- Land use change driven by changes in climate may decrease water stress. This could be driven by global and not just regional changes.

Resilience perspective: Supply Chain

- Loss of energy supply e.g. power supplies.
- Loss of critical chemicals, fuel, and other supplies.
- Shortages / long delivery times of specialist equipment.

Resilience perspective: Security

- Cyber security risk via insider or external threat.
- Risk to security from actions by staff due to poor/lack of internal or external clearance.
- Physical risk by poor compliance with SEMD (Security and Emergency Measures Directive) and associated annual audit.
- Poor control of vandalism, theft (especially metal and fuel) and impact of fly-tipping.
- Terrorist threat.

- Increasing awareness of risks and need for mitigating actions.

Resilience perspective: Regulatory / Political

- Lack of clear policy direction by governments due to reshuffles and loss of focus on resilient water and wastewater services.
- Reduced ability to respond to emergencies due to breakdown in collaborative groups as a result of changes in local government and associated groups.

- If not well-managed that market reform results in lack of clarity on accountabilities and communications during emergency events.
- Market reform needs to be implemented carefully with long-term resilience and climate change in mind.

- Increased political engagement by public and communities – giving clear steer on importance of resilience and support for action/need for investment.
- Openness around water-related data.

Appendix C: Outcomes from the Resilience Workshop (September 2015)

An important stage in the Task & Finish Group's work was the sharing of their draft recommendations. This testing occurred on 25 September 2015 at a workshop hosted by Severn Trent in Coventry. 45 people attended the workshop, representing a wide range of interest groups including water companies, governmental bodies and customer representatives.

Objectives of the Workshop

The workshop was designed to review each of the ten draft recommendations. Small groups led by an independent facilitator discussed and debated five recommendations each. This enabled all ten recommendations to be explored in detail. The debate on each recommendation was structured around a hypothesis-typically how the recommendation would work in practice, or why it was needed. This allowed the group to explore the strength of each recommendation.

Overview of the workshop outcomes

Recommendation 1: Agree a Shared Definition(s) for the Sector – general consensus that the definition covered the right areas, but the words needed to be tweaked. The inclusion of 'anticipate' was welcomed. There was strong support for the inclusion of 'disruption', but the support for 'trends' was noticeably mixed. While 'coping' was a hot topic of discussion, no clear consensus on an alternative was reached.

Response: It was clear that a broader view, encompassing both trends and disruption needed to be covered by the definition. The definition has now been modified.

Recommendation 2: Increase Public Engagement and Education – there is a need to be proportionate as there are no easy wins. Inclusion of the water cycle and resilience in national curriculum, inclusion of water resources as part of the weather forecast and the need to increase involvement by making water and wastewater services more visible emerged as the most impactful ideas.

Response: These suggestions are reflected in the recommendation for public engagement and education.

Recommendation 3: Funding resilience – emerging consensus on the need for regulators to provide certainty and clarity on how resilience investments are dealt with and how they should be supported and funded.

Response: The need for clear guidelines from the regulator, within a framework of company ownership of plans and risk management, is emphasised in the final recommendation.

Recommendation 4: Coherent planning for resilience at both a national and regional level – planning on risk and resilience, with the customer in mind, is required across sectors rather than just within sectors. However, there was some scepticism that greater national planning might not lead to action on the ground. There was a strong feeling that industry disaggregation and fragmentation is in conflict with longer-term resilience for the sector.

Response: The final recommendation highlights the need for action once decisions on planning have been made.

Recommendation 5: Establish wastewater, sewerage and drainage plans – overall, the group concluded that they recognised the need for establishing sewerage plans but didn't fully agree with the proposed solution.

Response: The final recommendation reflects concerns raised and is now better aligned with existing initiatives.

Recommendation 6: Improve understanding on risk and failure – it was recognised that a more open discussion on risk and what this means in terms of failure would be beneficial. Open data could help but there were some concerns over the potential for data misinterpretation and misuse. Discussions on risk are best taking place when no incidents are occurring.

Response: The UK's open data policy has so far benefited the country, and the public are credited with using open data well and responsibly. An open data policy allows for all conclusions to be verified - or debunked - by third parties, which gives oversight within the community using the data, and improves trust and relations between customers and companies. This will also facilitate understanding of risk in the public realm. Open data has been also included within final recommendation 2

Recommendation 7: Ensure services are resilient under different water sector structures – there was a strong view that resilience requirements need to inform the structure of the future sector rather than planning for resilience once the sector has been restructured. There is a clear need to understand the consequences of making structural changes. Thorough investigation is needed to make sure resilience is well catered for in any future structure. Action will be required in tandem with any further development of upstream competition.

Response: The final recommendation calls for an evidence-based approach to understanding both the current structure and the impact of changing structure within the sector.

Recommendation 8: Develop benchmarking, standards and metrics – in general there was a lot of support of developing resilience metrics, but not necessarily traditional-style metrics. It was clear that a "one-size-fits-all" approach is not appropriate given the diverse nature of resilience risks.

Response: This is reflected in the final recommendation.

Recommendation 9: Ensure existing plans are stress-tested - the group considered that there was a relatively large gap that should be addressed, indicating that current planning is not sufficient to meet the resilience challenges. Delegates were concerned that, whilst there have been a series of recent near misses, capacity to deal with very large events does not appear to have increased.

Response: This is reflected in the final recommendation.

Recommendation 10: Establish a water and wastewater resilience forum (sic) – no clear need emerged; if such a forum was established, there would be a need for very clear terms of reference with time-lined targets. There was concern that 'forum' implies 'talking shop' and a greater focus on action was needed.

Response: Although no clear need was identified during the workshop, our previous research identified this as an important factor in achieving resilience. As such, it is the group's recommendation that an action group be established with clear terms of reference to ensure impact.