



Resilience Track Record: Case studies of delivering resilience and learning from our experiences

Chapter 4: Supplementary document

Document Reference: S4002

This document includes corporate, financial and operational case studies of our track record for delivering resilience. It also describes the major events of AMP6, lessons learned and improvements delivered.

United Utilities Water Limited



Contents

1	Introduction	2
2	A history of resilience	2
2.1	Resilient water supplies through integration of sources	2
2.2	Resilient water supplies through leakage control and demand reduction	4
2.3	Ensuring wastewater services are resilient	5
2.4	Sustainable catchments	8
2.5	Systems thinking to enhance situational awareness and avoid disruption	11
2.6	Resilient finances to protect customers.....	12
3	How we have learnt from our recent experiences	15
3.1	Sweetloves Water Quality Incident – July 2015	15
3.2	Franklaw Water Quality Incident – August/September 2015	16
3.2.1	Customer views on the Franklaw incident.....	17
3.2.2	Our response – building resilience.....	17
3.3	Storms Desmond and Eva - December 2015.....	20
3.4	National Flood Resilience Review	22
3.5	Buckton Castle Water Quality Incident – December 2016.....	24
3.6	Freeze thaw event – February/March 2018.....	25
4	A resilient base to build on	27

1 Introduction

Resilience is not a new concept: it has been at the heart of our thinking for many years. In this document we describe some of the significant improvements that we have made to resilience over the last 30 years. The service that customers and the environment receive today has improved year on year, but we recognise there is more to do. The incidents that we have experienced this AMP have been regrettable but have provided a wealth of learning and have already led to improvements that we will continue to build on in AMP7. We are also fully aware of the threats of population growth and climate change amongst other trends that will threaten our ability to maintain services in future and that customers expectations are ever increasing. Our historical record of proactively enhancing resilience combined with our ready willingness to learn from experience should give confidence that we are well placed to meet the challenges ahead.

2 A history of resilience

This section describes some of the key resilience improvements we have delivered since privatisation in 1989.

2.1 Resilient water supplies through integration of sources

During the 19th Century the booming industrial powerhouses of Manchester and Liverpool needed more water to support their growing populations. Liverpool Corporation looked south, to North Wales with a dam on the River Vyrnwy supplying water since 1892. Over the years additional lines were added to the Vyrnwy aqueduct with the final fourth line completed in 1946. Water supplies to Merseyside were also bolstered through the Bala Lake Regulation scheme from the 1950's through to the 1970's which supports our abstraction from the River Dee near Chester.

Manchester Corporation looked to the Lake District, with the Thirlmere Aqueduct delivering the first supplies in 1894 to add to the existing local supplies from the Longdendale valley. A second major source was identified at Haweswater in the early 20th Century but it wasn't until 1934 that work began and it took until 1955 to complete the work. The final major supply aqueduct built prior to privatisation was the Lancashire Conjunctive Use Scheme constructed by the North West Water Authority in the early 1980's to meet growing demand.

On privatisation in 1989, 95% of customers were supplied in two large and effectively discrete supply zones, a northern zone supplying Lancashire and Manchester and a southern zone supplying Cheshire and Liverpool. The drought of 1995/96 was more severe for sources in the Lake District than for those in Wales so the bi-directional Rivington Aqueduct was constructed to enable the southern supply zone to support the northern supply zone. The connection of the two zones created the largest integrated water supply system in the country at that time, albeit the Rivington Aqueduct provided limited connectivity. Connecting the two zones means that the risk of drought restrictions being required is reduced as we can shift water around more flexibly if the drought hits more severely in the north or south of the region.

Whilst having these large water sources in the Lake District and North Wales continue to supply the majority of water to customers today. Maintaining the long and critical aqueducts that transfer the water to Manchester and Liverpool is challenging as they cannot just be turned off and emptying them was impossible without significant disruption to water supplies for large numbers of customers. The Rivington Aqueduct whilst useful in a drought is much too small to singlehandedly replace one of the major sources.

Figure 1: The Vyrnwy dam built by Liverpool Corporation

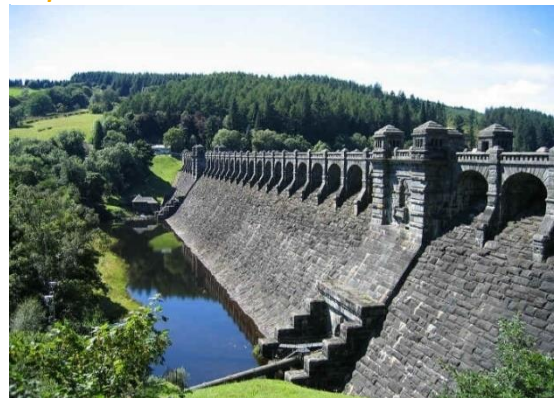


Figure 2: Ceremony in Manchester marking the opening of Thirlmere in 1894



In the early 2000's we identified that cleaning the northern section of the Dee Aqueduct and the need to carry out a full inspection and additional maintenance on the Haweswater Aqueduct would result in a significant supply-demand shortfall. We needed to do something to enable us to take our large aqueducts out of service. We recognised that any significant change to our regional supply system had to also take into account other drivers including:

- abstraction reductions to meet the requirements of the European Union Habitats Directive and Water Framework Directive
- increasing drought frequency and uncertainty due to climate change; and
- securing sufficient supply availability to carry out inspections and urgent refurbishment on critical sections of the Haweswater Aqueduct in the last two years of AMP5.

Six options were considered to address the strategic issues. All options contained a west east connectivity element albeit of different sizes and/or points of connection. One option considered building a new Dee Aqueduct parallel to the existing one, however this would be operationally redundant following the cleaning of the existing Dee Aqueduct. Only one of the options met all of the requirements of the key drivers as shown in Table 1. This was a new link main connecting Liverpool to the north of Manchester (shown as strategic option 1).

Table 1: High-level review of options to meet the multiple strategic drivers

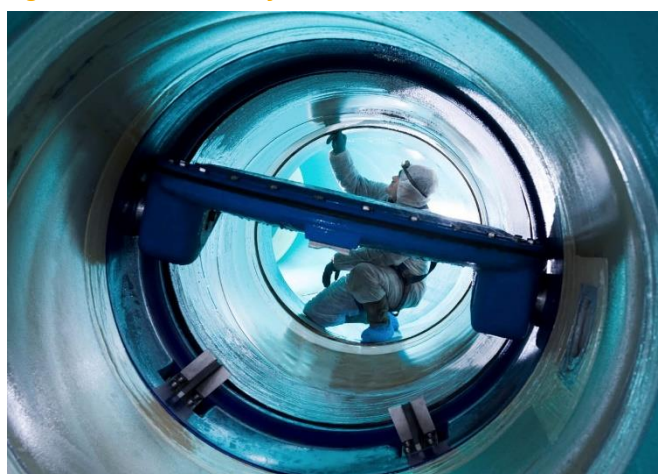
Project Driver	Strategic Option Number					
	1	2	3	4	5	6
Dee outage	Y	Y/N	N	N	Y	Y/N
Climate change	Y	N	Y	Y	N	N
SEMD	Y	Y/N	Y/N	N	N	N
HA outage	Y	N	Y/N	N	Y/N	N
Habitats and Water Framework	Y	N	Y	Y	N	Y
Key:	Y	Requirements of driver fully met				
	Y/N	Requirements of driver partly met				
	N	Requirements of driver not met				

The resulting 1.2m diameter, 55km long main named the West East Link Main (WELM) was completed in 2011. Previously, the only connectivity across the system was via the Rivington Aqueduct. However, the new main would enable west to east connectivity and produce a much more integrated strategic zone.

As well as enabling key large diameter trunk mains to be switched off for maintenance, the new link provided a significant benefit to our supply demand balance as it provided more flexibility to move water around during droughts and therefore balance risk should there be more of a shortfall in the north or south of our region. Our regional supply system is now more resilient to different droughts and the impacts of climate change; during the extended dry weather in 2018 both of our West/East strategic trunk mains, West East Link Main and the Rivington Aqueduct have been transferring supplies from the relatively healthy western part of our region to the drier east.

Despite multiple sustainability reductions at water sources around the region the WELM, coupled with baseline demand management activities, has allowed many of these to be implemented without supply or demand investment in previous planning cycles. It also underpins our

Figure 3: Construction of the West East link main



current relatively low extreme drought risk position as recently assessed in our draft Water Resources Management Plan, and provides greater flexibility to explore long-term water trading opportunities to deliver resilience benefits beyond the North West region. It also provides supply system resilience and flexibility to other hazards, for example, in the event of a pollution event on the River Dee.

The completion this AMP of the Thirlmere link to West Cumbria further integrates our regional system and enables more customers to benefit from the resilience of a variety of major sources. More detail on the new Thirlmere link can be found in our supplementary document S4003, section 4.3.2.

2.2 Resilient water supplies through leakage control and demand reduction

Demand management is a key component of our strategy to balance supply and demand and build resilience to drought and other hazards. We have significantly reduced leakage since 1996 to help achieve and maintain a high standard of water supply reliability (Figure 4). Since 2010, we have significantly enhanced water efficiency promotion and overall water demand is fairly stable at approximately the lowest level for at least the last 25 years, despite the economic recovery after the 2008 financial crisis apparently driving a minor increase in demand.

Leakage management contributes to the overall reduction in demand and plays a key role in our management of water resources.

We have met or exceeded our regulatory leakage target for over 10 years, despite experiencing two severe winters in 2009/10 and 2010/11 and a late freeze-thaw event in 2018. We achieved this by carrying out an extensive range of leakage control actions at significant cost. We continually strive to improve and ensure that we are operating as efficiently and effectively as possible. This means that we have managed to achieve our lowest ever leakage in 2016/17. As the result of a much colder winter in comparison to recent years, including a severe freeze thaw event in March 2018, the level of total leakage increased slightly in 2017/18. We are employing additional leakage resources and expect to see leakage reducing again in 2018/19.

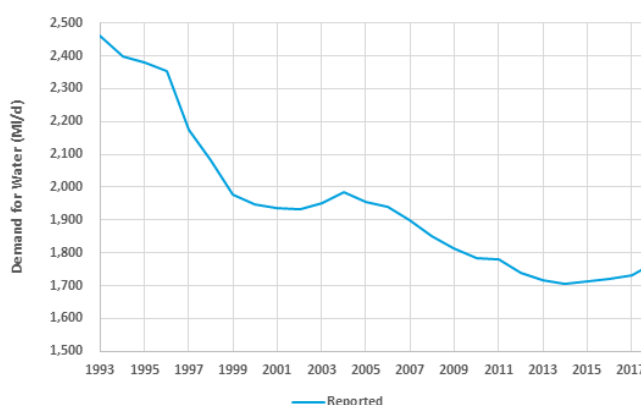
In order to realise this leakage level we have committed significant operational and capital resources through:

- maintenance of our monitoring equipment which identify leaks within district metered areas;
- widespread pressure management to reduce the breakout and flow rate of leaks;
- good quality data and continual review of our leakage management and information systems;
- efficient leakage detection and repair using the latest technologies;
- replacement and refurbishment of poor performing water mains;
- providing free supply pipe repairs for domestic customers; and
- improving customer and community awareness (leakline campaigns).

As a water company we have a statutory duty to promote the efficient use of water as required by the Environment Act 1995 and the Water Industry Act 1991. We also recognise the important contribution water efficiency actions have in achieving and maintaining an adequate and sustainable supply-demand balance.

Although no mandatory water efficiency targets have been imposed by Ofwat since 2015/16, in the demand forecast from our Water Resources Management Plan 2015 we committed to continue to achieve, as a minimum, a continued

Figure 4: Overall demand for water has been falling



annual saving of 1 litre per property per day through the planning horizon. It should be noted that although the target savings remain at the same level as our previous Water Resources Management Plan, water efficiency savings become progressively harder to achieve, so we need to continually innovate and adapt our approach in this area.

We have a number of policies that impact directly on the water efficient behaviour of customers. These include policies related to water efficiency, supply pipe repairs and replacement, sustainability and carbon emissions, and a Free Meter Option scheme.

Building on previous activities, we continue to:

- supply free, easy to install water efficiency devices which can be ordered via agents, online or picked up at some of the events we attend;
- run our education programme for primary schools across the North West, which includes topics such as the water cycle, water safety, and water efficiency; and
- carry out free visits to customers' homes to fit free water efficiency devices.

We are mindful that in order to maintain a downward trend in water consumption in the long-term we need to keep our approach fresh. We are constantly looking for ways to enhance our offering to customers through research and partnership working, and we have undertaken customer research to understand the benefits, barriers and motivations to desired behaviours and willingness to act to achieve greater water efficiency. We will use the results of the research to better inform our approach and we will continue to drive behavioural change through our customer messaging via community engagement; social media and digital presence; alongside more traditional printed messaging on customer correspondence.

2.3 Ensuring wastewater services are resilient

Improvements to sewerage and sewage disposal to meet the basic requirements of public health for the people of the North West were driven by rapid industrialisation in the 19th century. Since the construction of these initial drainage systems we, and our predecessors, have evolved our service to reliably meet the changing needs of the people and the environment of the North West under a range of shocks and stresses.

Investment and subsequent improvements as a result of privatisation have been extensive and the following case study demonstrates the increasing resilience of Davyhulme, our largest wastewater treatment works.



Davyhulme Wastewater Treatment Works: a history of resilience at our largest treatment works

Davyhulme is the main treatment works serving the city of Manchester and one of the largest in Europe. It was opened in 1894, and has pioneered resilient treatment of wastewater.

With the rapid growth of population in the late nineteenth century due to the industrial revolution and the proliferation of toilets that were not connected to a treatment system the rivers around Manchester were becoming grossly polluted. In response to this the City of Manchester decided to build two deep level sewers to intercept existing sewers. When the first one reached Davyhulme, further extension was blocked by the Manchester Ship Canal, and so a treatment works was built there.

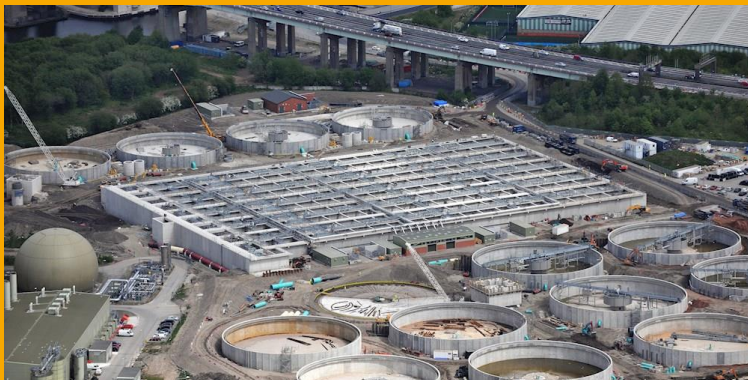
Treated sludge was loaded into ships and discharged into the Mersey estuary from 1898. Over the next hundred years, seven ships were used to transport the sludge.

A second deep level sewer, started in 1911, eventually reached the works in 1928, and to cope with the increased flows, half of the sewage was fed into a new Activated Sludge plant. A second Activated Sludge plant was built between 1955 and 1966.

In order to improve the water quality in the Mersey estuary, a pilot Biostyr plant was built in 1992, and a much larger one was completed in 1998. These processes significantly improved effluent quality and protected the Mersey estuary from the impact of high concentrations of ammonia thereby starting to reverse the historic decline in the ecological status of the river, estuary and surrounding coastline. The robust processes at Davyhulme and the scale of the works provide substantial environmental resilience to variations in volume and quality of sewage produced by Manchester. The degree of streaming and flexibility of the sequential processes enable us to consistently and reliably treat Manchester's effluent whilst protecting and enhancing the environment.

Innovation has continued, with the commissioning of the world's largest thermal hydrolysis plant in 2013, using a new process to break down sludge, which generates methane as a by-product, enabling the site to be self-sufficient for gas and electricity, greatly improving resilience to the price of power as well as improving the sustainability of the plant. In 2018, further enhancements were completed which included replacement of one of the activated sludge plants with a fully nitrifying activated sludge plant. This has resulted in the effluent performance improving yet further and greater resilience to variations in flow associated with heavy rainfall.

Figure 5: Modernisation project at Davyhulme completing 2018



Resilience to shocks and stresses has been central to the development of Davyhulme over the years. We have effectively responded to the needs of customers and the environment with robust and resilient interventions that are designed to meet the needs of today and prepare for the demands of the future.

Delivering resilient environmental improvements

Since privatisation we have adopted a proactive approach to wastewater planning in the North West. We have set clear and stretching plans to maintain operating standards and to control service risk across an extensive asset base.

We operate a 25-year asset planning process, which has shaped ambitious 5-year investment plans that have delivered significant environmental improvements efficiently and effectively. Our asset management approach has resulted in significant investment in customer and environmental service benefits over the last 30 years.

At privatisation we inherited a wastewater asset base which afforded simple primary and secondary treatment to sewage at inland treatment works with virtually no tertiary treatment and minimal if any treatment of coastal discharges. The sludge arising from treatment was disposed of at sea. The UK's adoption of the Urban Wastewater Treatment Directive (UWWTD) and its translation into English law in 1990 led to significant planning and investment in the North West at the 1994 and the 1999 reviews, as our region has a long, heavily populated coastline. The Directive required minimum standards for treatment of wastewater and for the disposal of sewage sludge. Secondary treatment, as a minimum, at our wastewater treatment works for most settlements of more than 2,000. To deliver this in a cost effective way we innovated and delivered new treatment techniques such as

Figure 6: Sludge vessel being loaded in 1898 - featured in the Manchester Evening News



secondary Biological Aerated Flooded Filters at a number of new coastal works and tunnel systems to protect huge lengths of coastline.

The UWWTD specifically required elimination of sewage sludge disposal at sea, which the government announced would be phased out by 1998. This saw the end of our sludge to sea operations and the ships that transported sludge down the ship canal: a process that had been carried out for a century.

To secure a resilient sludge process we built a sludge incinerator at Shell Green to process sludges from the urban areas of Manchester and Merseyside. The incinerator has served us well in providing a flexible and varied path for managing sludge disposal. However, digestion techniques have improved, such as the enhanced Thermal Hydrolysis Plant we have developed at Davyhulme where we now generate more biogas than ever before alongside an enhanced treated sludge. The solid waste stream from these improved digesters is a valuable product for agricultural use, so we are now moving away from routine sludge incineration. Our ambition is to recycle 100% of biosolids to agriculture, as the lowest cost and most sustainable disposal route.

Whilst the UWWTD continued to require significant investment at the 1999 and 2004 price reviews, other legislation, including, the EU Habitats Directive, EU Bathing Water Directive and progress in meeting River Quality Objectives have driven further investment to meet ever tighter environmental standards.

In AMP3, 2000 to 2005, we delivered the largest Unsatisfactory Intermittent Discharge (UID) programme in the industry. This was a step change in our asset base and has led to significantly improving the performance and resilience of our wastewater network and reducing the frequency of spills to the environment of the North West, with a steady reduction in the number and severity of pollution incidents from our network since privatisation. This investment was critical in modernising many of our overflows and providing the building blocks for our move towards a more dynamic system with real time control across our wastewater network.

The North West is particularly susceptible to intense localised rainfall, with a legacy of property flooding from sewers, one of the worst service failures associated with our business. Unique in the UK, over half of the sewers in the North West carry both foul and surface water; these assets are particularly susceptible to overloading during heavy rainfall, with the associated heightened flood risk. Since privatisation we have delivered some of the country's largest sewer flooding reduction schemes and substantial offline and online storage solutions to reduce and mitigate the risk of sewer flooding. Whilst we have made substantial improvements in our sewer flooding performance over the last 30 years there is still much work to be done. Our current and future approach to managing this risk is documented in our operational resilience supplementary report S4005.

Into AMP4 and AMP5, 2005 to 2015, we invested in delivering advanced tertiary treatment processes to meet the demands of the Water Framework Directive (WFD). Standards to meet good ecological status in the waterbodies of the North West are stringent as we have large urban areas that often drain to relatively small watercourses. The limits expected in the WFD are also under constant review as innovations allow for ever improving discharge standards. In AMP6 we have focused on enhancing tertiary treatment processes for ammonia and phosphorus removal, to meet the targets required under the Water Framework Directive. We have been instrumental in developing and implementing Nereda a new secondary treatment process that has promising removal rates across a range of pollutants.

During AMP6 we have developed on our experience and success from the Sustainable Catchment Management Programme (SCaMP) as applied to raw water catchments, and we have developed an integrated catchment strategy for wastewater drainage. Through this strategy we are making great progress in developing innovative 'low tech' assets, fit for purpose for small treatment works. However, we believe that improving water quality standards cannot be met in isolation, and that wider environmental pressures, such as flooding and climate change, must also be considered. Therefore, a more holistic and collaborative approach is required, in order to make catchments and communities more resilient to these pressures. We are expanding our catchment management approach beyond our obligations, to include partners and to drive for more integrated and sustainable solutions that deliver long-term benefits, thereby contributing to a more resilient North West. This means that as we address our regulatory requirements in the next few years, we will be applying our integrated catchment approach to develop solutions that sustainably treat phosphorus and other nutrients across a range of shocks and stresses, whilst also delivering additional resilience and natural capital benefits.

Throughout the AMP cycles we have the number of treatment assets under review as there are circumstances where closure, transfer and combining flows is the best option for customers and the environment. Closure and transfer of flows from small rural treatment works has been particularly successful. As assets age and environmental standards become tighter there is an optimum time for combining treatment assets. We consider this option for each investment need and are confident that it has been and will continue to be, a successful strategy for improving the overall resilience of our wastewater service.

Compliance of designated coastal bathing waters with the standards of the Bathing Water Directive has improved significantly since privatisation and is an improvement we are particularly proud of. Much of this improvement is a consequence of our investment in removing or improving many point sources of pollution such as storm overflows or sewage treatment works.

We have also invested in coastal models to support knowledge in the performance of bathing water and the impact of various inputs. This has meant that the Environment Agency's analysis of the factors affecting water quality now often shows that intermittent and diffuse sources are increasingly becoming the cause of microbial noncompliance of bathing waters.

Through the successful Turning Tides partnership we are committed to the process of maintaining the bathing water quality and supporting further improvements where they are required.

We have a successful strategy to support growth and development within the northwest. This flexible approach has allowed for an expanding customer base whilst maintaining a robust customer service and environmental compliance. We also aspire to improve the services we offer to developers and deliver timely interventions to enable growth at the lowest whole life cost. This supports the customer promises to reliably dispose of wastewater, give value for money and protect the environment. We will continue to work to ensure that new developments are effectively drained and the connected wastewater is treating to the required standard in order to protect watercourses now and in the future.

We have developed strong relationships with developers and planning authorities to meet the needs of customers and growth in demand that comes from a rapidly growing and changing region. In 2018 Deloitte commented *"Manchester has firmly established itself as one of Europe's fastest growing cities... Backed by significant investor confidence, a strong business community, and an influx of new talent, the demand for property, particularly in the residential market, has never been more evident¹."* We have also made plans for the future as population growth in Manchester has required a significant modernisation of Davyhulme WwTW.

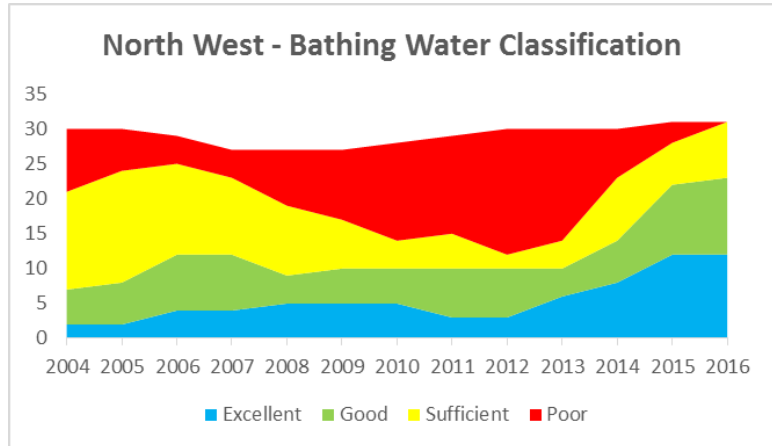
Through Natural Course (an EU LIFE funded partnership project) and the Defra Urban Pioneer we have further strengthened relationships with Greater Manchester Combined Authorities and we are embedded within their planning process for an ambitious development plan.

2.4 Sustainable catchments

United Utilities is the largest corporate land owner in the UK, with over 56,000 hectares of land of which 47,000 hectares is water catchment. Approximately 50% of water supplied to customers comes from these catchment sources. Sustainable management of this land is therefore key to a resilient water supply, but with wider resilience benefits to society such as flood relief, carbon storage, biodiversity and mental health.

In 2005, we were the first water company to undertake a large-scale investment programme on catchment land, driven by the need to improve the condition of the 56,000 hectares of land in our ownership. Much of this land is

Figure 7: Trend in North West bathing water classifications



¹ <https://buyassociation.co.uk/2018/02/16/manchester-named-one-europe-fastest-growing-cities/>

home to nationally significant habitats for animals and plants, with around 30% designated as Sites of Special Scientific Interest (SSSI). Unfortunately, many of these fragile habitats in our upland catchments have been deteriorating over the years due to industrial air pollution, agricultural activities, wild fires and climate change. Agricultural policies have also encouraged farmers to drain the land and intensely manage livestock on the fells, at the expense of water quality, the landscape and wildlife.

Figure 8: Degradation of the uplands due to overgrazing, fires, erosion of channels and the exposure of bare peat.



Years of drainage of the uplands to increase agricultural productivity had caused the 5,000 year old peat bogs to dry out and erode, releasing colour and sediment into watercourses as well as releasing millions of tonnes of carbon dioxide into the atmosphere contributing to climate change. Consequently, over the last thirty years there has been a substantial increase in the levels of colour in the water sources prior to treatment from many upland catchments. The loss of peat soils during heavy rainfall events contributes to significant peaks in turbidity levels that can challenge the treatment processes involved in removing it for supply to customers

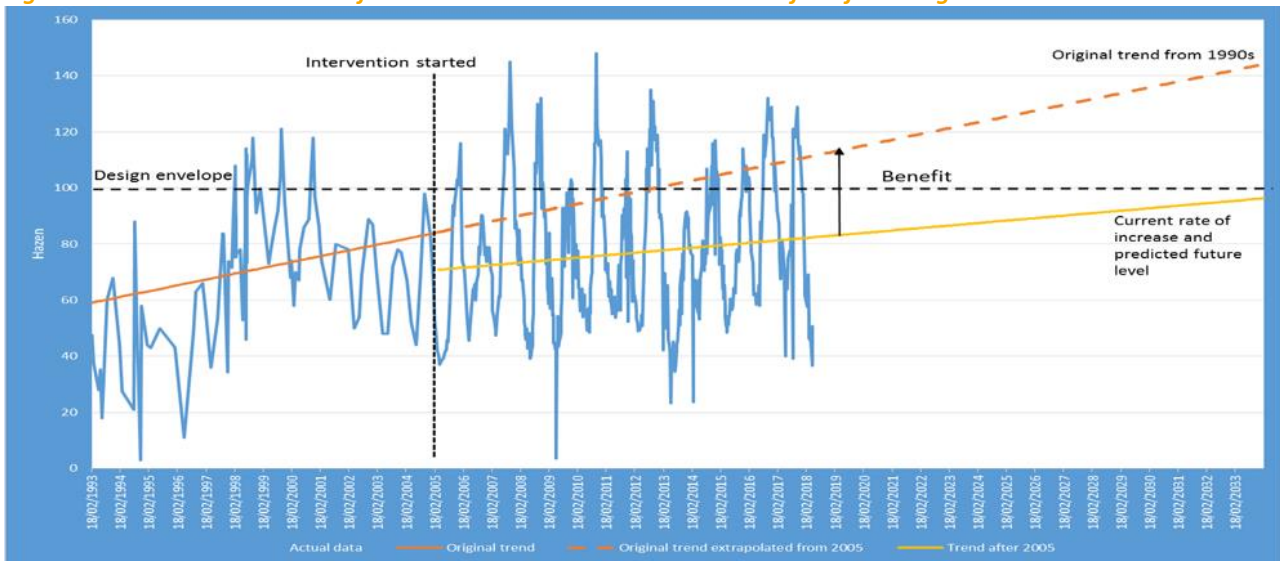
Improving the condition of catchments has multiple resilience benefits:

- Improve flood response to intense rainfall by slowing the flow and increasing flood resilience
- Improved moorland habitat and resilience to climate change as a healthier ecosystem is better able to cope with the stress imposed by extremes of wet and dry weather
- Contributing to climate change mitigation as healthy moorland is an effective carbon sink
- We will exceed government targets for biodiversity with 99.4% of our owned SSSI's in 'favourable' or 'unfavourable recovering' condition in 2015. In the Peak District before we launched SCaMP this had been assessed at 14%
- Sustainable income for tenants with farm infrastructure upgrades to enable tenants to access higher level stewardship schemes, providing a revenue payment to sustain their income.
- Enhancing and supporting recreation on our land, with the associated physical and mental health benefits
- Protecting heritage of the land
- Protect and improve water quality which reduces or delays the need for future investment for additional water treatment

To begin to reverse the long term trends and challenge the tradition of relying on engineering solutions for raw water quality issues, we began our innovative Sustainable Catchment Management Programme (SCaMP). The first phase 'SCaMP1' was undertaken between 2005 and 2010 and we invested £10.8m primarily aimed at improving the condition of 13,000 hectares of SSSI in the Peak District and Bowland areas and to meet government biodiversity targets whilst also increasing water quality benefits through a holistic approach across the catchment. The second phase 'SCaMP2' was undertaken between 2010 and 2015 and we invested £11.6m on the Haweswater and Thirlmere Estate in Cumbria, on the West Pennine Moors in Lancashire and contributed to the restoration of the non-owned catchment of Kinder and Woodhead in the Peak District. SCaMP 1 and 2 generated £4 million grant income for tenant farmers to implement measures to protect water quality and biodiversity.

The restoration implemented has been successful in slowing the deterioration in raw water quality as shown in Figure 9.

Figure 9: Reduction in the rate of raw water colour deterioration at Arnfield following SCaMP



Although the continuing deterioration means that we may still need to consider an investment at some delayed point in future to increase resilience at the water treatment works, the wider benefits from the catchment management have been significant. These wider benefits include the improvement in biodiversity, and the increase in vegetation cover shown in Figure 10. The long-term nature of environmental change, particularly in restoring fully functioning peatlands could take several more decades. As a member of the Moors for the Future partnership, we have developed a long-term plan for the on-going management and improvement of the catchment.

Figure 10: Benefits delivered at Arnfield Reservoir through moorland restoration



The current SCaMP programme being delivered between 2015 and 2020 focuses on 31 drinking water 'Safeguard zones' across a much wider area of water catchment land than we previously targeted, regardless of ownership. We are using the principles and ways of working developed during SCaMP 1 and 2 to target a range of water quality issues from colour, pesticides and algae in surface water to nitrates and solvents in groundwater. Although across an area ten times bigger than the previous projects, we are spending ten times less by working in partnership with other land owners and funders to combine our areas of interest.

2.5 Systems thinking to enhance situational awareness and avoid disruption

Our business model is built on the concept of production lines and systems thinking:

- Systems thinking is a management discipline that concerns an understanding of a system by examining the linkages and interactions between the components that comprise the entirety of that defined system
- The whole system is a systems thinking view of the complete organisation in relation to its environment. It provides a means of understanding, analysing and talking about the design and construction of the organisation as an integrated, complex composition of many interconnected systems (human and non-human) that need to work together for the whole to function successfully
- Whole systems are composed of systems, the basic unit, which comprise several entities (e.g. policies, processes, practices and people) and may be broken down into further sub-systems
- Whole system success requires a performance management system that is pitched above the level of individual systems and their functional leadership. Features may include group or team-level goal-setting, development, incentives, communication, reviews, rewards, accountability. The aim is to focus on what binds individuals together and what binds systems together rather than functional silo performance
- A whole system can succeed only through managers collaborating in and across a number of functional systems.

Anticipating variability is embedded in our drive toward systems thinking and developing our situational awareness. This means thinking of our entire network of assets as one big system, understanding how the operation of each component affects others and managing it as such. In AMP6, we are investing in our new wholesale operating model and are progressing the roll-out of this unique capability. Our production line model is well established, and we opened our Integrated Control Centre (ICC) in 2015. This has increasingly become a central hub for operational resilience and control of our operations and proved to be a tremendous asset during our handling of the major incidents we had to address in 2015. Our new telemetry backbone has been successfully installed, which provides the 'data highway' between our sites and the ICC, enabling enhanced monitoring and intervention. This facilitates a change from being reactive to pre-emptive – ultimately enhancing how we operate by monitoring risk and taking early actions to eliminate potential failures and minimise costs.

A practical example of this is ERWAN (Event Recognition on the Water Network), which is a machine we have built that learns the typical patterns of the system from our network of sensors, identifying the 'normal' system signature for each area and then recognises any deviation to this signature, generating an alert and probable root cause. As the system continues to operate, ERWAN continuously learns and adapts. It's now monitoring our network's signature and alerting us to early signs of a deviation, the root cause of which could, for example, be the beginnings of a water mains leak or a pressure valve which is starting to fail. In our Integrated Control Centre ERWAN alerts a team who perform complex diagnoses remotely and mobilise field technicians to address the detected issues and minimise the impact on customers. Our aim is to have resolved the issue or implemented short term mitigation so that customer service remains unaffected.

We have then gone further and linked this system thinking and machine learning approach with our new customer information tool – GO-PRO. Inspired by bulk communication tools used by the Red Cross and several police forces, it allows us to proactively communicate updates to all customers within an area via SMS text, automated voice and email. This targeted approach supports our traditional methods of broader reach communications via our web and social media channels. This proactive approach avoids customers having to contact us, allows us to track read receipts from customers and provide customers an update through their preferred channel.

This early work in AMP6 has shown promising benefits that indicate the value this could deliver for customers in the long term. We have seen a 70% reduction in customers contacting us about events and incidents where we have been able to predict and respond to a system deviation (such as a burst water main) and communicate any impacts to customers before they contacted us.

Our long term ambition is that no customer ever has an interruption to their water supply and we believe we can achieve this with further investment in our systems thinking and machine learning approach during AMP7 to deliver a radical new standard to customers on such an important priority for them.

2.6 Resilient finances to protect customers

Our financial strength is driven by two key factors: subjecting ourselves to the scrutiny and rigour associated with being a publicly listed company and our long-term and responsible approach to financial risk management. We have a duty to stakeholders to ensure financial resilience over the long-term. Financial resilience means we have access to sufficient financial resources so we can act to protect customers from the occurrence of unusual or extreme events². It also ensures that we can continue to attract the finance required to fund our customer-focussed long-term investment programme at the lowest possible cost.

Our financial resilience assessment is set out in section 4.6, chapter 4 of our AMP7 business plan and in S4006 – Financial resilience assessment. Below we highlight two particular examples of our track record in delivering financial resilience.

Sustaining access to the debt capital markets during a global financial crisis

The 2008 global financial crisis known as the “Credit Crunch” is widely considered by many economists to have been the worst financial crisis since the Great Depression. As the credit crisis unfolded, many investors began to avoid risk with the effect that liquidity started to freeze up, preventing many borrowers from accessing the credit markets.

During this period, there were a number of high profile corporate failures across the globe brought about, in part, from this reduction in liquidity. To name a few – in the US, Bear Stearns (Mar 2008), Lehman Brothers (Sep 2008), Washington Mutual (Sept 2008), Chrysler (May 2009) and in the UK, Northern Rock (Sept 2007), Royal Bank of Scotland (Apr 2008), HBOS (Sept 2008), Bradford & Bingley (Sept 2008).

Our responsible approach to financial risk management ensured that we remained financially resilient during the period of the 2008 crisis (late 2007 until 2009). We achieved this through an effective combination of prudent levels of headroom and liquidity, which meant we were able to wait until markets improved before needing to raise new finance, and maintaining robust credit ratings to be able to efficiently access the debt capital markets.

At the height of the crisis in March 2008, we had over 24 months of liquidity, which meant we were in an extremely robust position heading into the crisis. This level of liquidity is supported by our longstanding board policy of maintaining between 15 and 24 months of financial headroom on a rolling basis.

Committed borrowing facilities constitute a significant element of our liquidity as illustrated at 31 March 2018, where these comprised half of our £1 billion of available liquidity. These facilities are arranged on a bilateral rather than a syndicated basis with multiple counterparties, which spreads the maturities more evenly over a longer time period, thereby reducing the refinancing risk by providing several renewal points rather than a large single refinancing point.

Our approach over the past three AMPs of targeting credit ratings of at least A3/BBB+ has proven that such ratings offer robust access to debt capital markets including in times of market disruption and efficient debt financing costs compared to lower ratings. Our current credit ratings of A3 Stable/A- Stable place us as the highest rated privately owned water company.

Despite the widespread global loss of liquidity and seizure of credit markets experienced during the 2008 financial crisis, we were able to raise over £1.8 billion in debt finance during the period.

To evidence the impact of credit ratings on market access and financing costs we have included charts below which show periods of market disruption and how our credit spread and the iBoxx GBP ‘A’ and ‘BBB’ index spread to gilts reacted. These graphs show that during periods of market weakness (highlighted in red) – including the 2008 global financial crisis - our credit spread reacted similarly to the ‘A’ band corporate index, whereas the BBB band corporate index (which includes lower rated credits than us) widened materially more.

² Extreme events are those assessed as being low likelihood but high impact scenarios or a plausible combination of multiple events occurring in an AMP, which have a collectively high impact.

Chart showing periods of market disruption, Source: Goldman Sachs and Bloomberg as at 20 July 2018

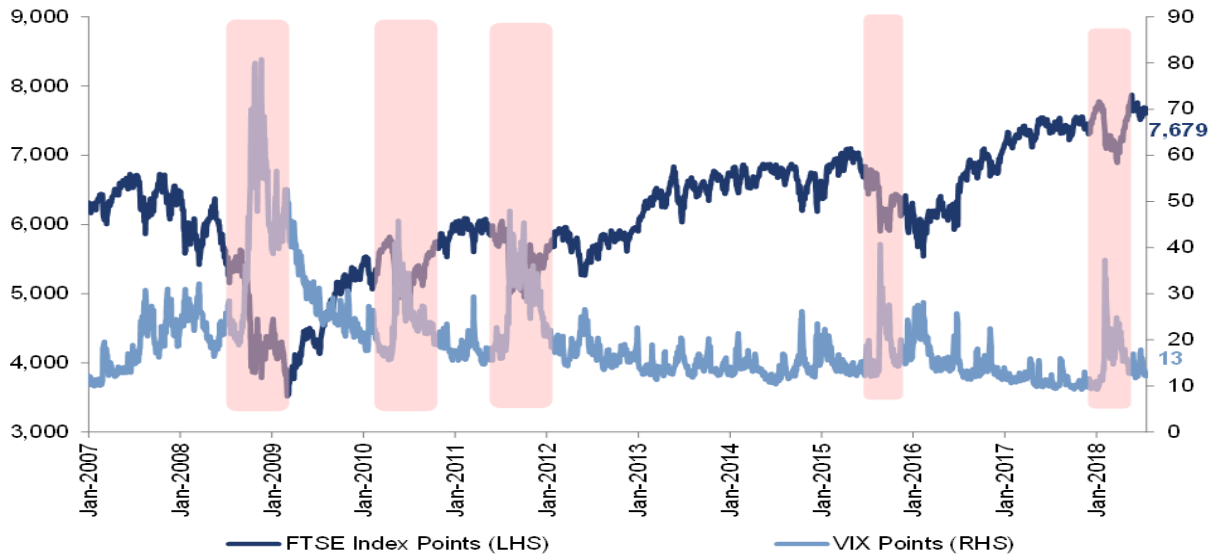
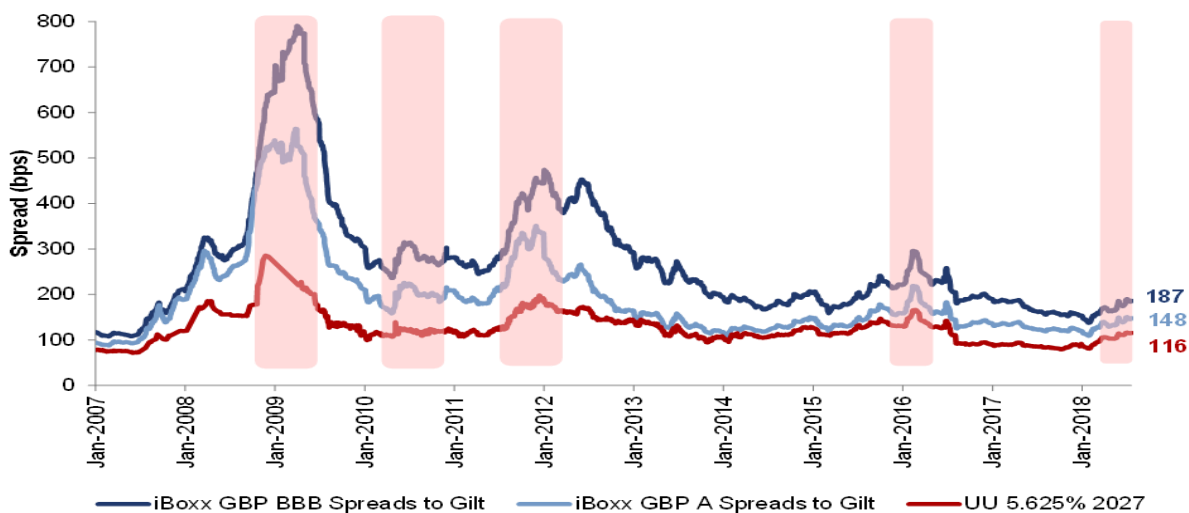


Chart showing our credit spread versus A and BBB rated sterling corporate credit, source: Goldman Sachs and Bloomberg as at 20 July 2018



This indicates that at times of market disruption, access to funding by corporates in the BBB rated index might be more problematic and is likely to be materially more expensive. This is further supported by U UW having one of the lowest cost of debt in the industry, underpinned by efficient treasury management. See section 4.7, chapter 4 of our AMP7 business plan for more information on our financial resilience assessment.

UK leading approach to pension scheme risk management

Treasury risk management has been a core competency for U UW for over two decades and by 2008 treasury risks were being effectively managed through a governance framework and dashboard reporting of the principal financial risks faced by the company.

During 2009, the treasurer was given wider responsibility to extend financial risk management to encompass the defined benefit pension schemes in response to increasing pension deficits, increased future service costs and the determination by Ofwat that pension risks should no longer be considered to be an open ended customer risk. At PR09, Ofwat set out a very clear position that pension deficits at that point should be crystallized and borne 50:50 by the company and customers with no further deficit repair contributions made at future price reviews.

In response, we sought to apply our sector leading treasury skills to provide increased governance and financial risk management to the pension schemes. From a governance perspective, we established a Joint Working Group (JWG) comprising representatives from both the company and the Pension Trustee, along with trustee advisors. The JWG terms of reference sought to promote joint working for the mutual long-term benefit of both parties - rather than the short-term adversarial approach more typically seen in many companies.

Having established a governance framework to promote long-term stewardship, the JWG then set about reviewing and assessing the risks faced by the pension schemes. This identified two principal risks being (1) the asset and liability mismatch risk associated with the investment strategy; and (2) the cost of accruing future service benefits.

(1) Tackling the asset liability mismatch

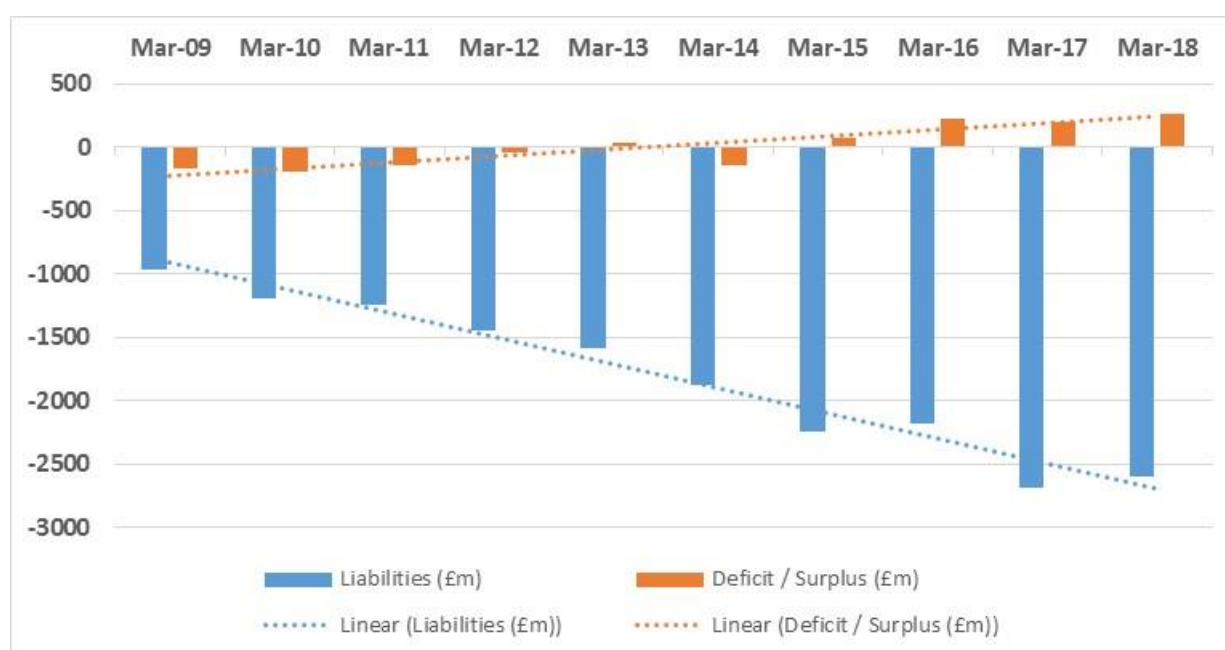
As with almost all UK pension schemes, our pension schemes were heavily invested in equities with only modest investments in lower risk fixed income securities (gilts and bonds). There was no hedging of inflation, interest rate or mortality risk resulting in significant risk exposures.

While the desired end point of a much closer alignment of asset and liability risks was clear, the method of getting there represented a complex challenge - with lower investment risk resulting in the actuaries' assessment of a higher deficit - thereby proving a prohibitive barrier to potential de-risking activity. At this point, many companies simply continued with the status quo and the significant risks from running an asset liability mismatch rather than accept a higher deficit.

The JWG recognised these risks and challenged themselves to develop a solution. This came in 2010 with the implementation of the highly innovative and unique Inflation Funding Mechanism (IFM). At its core, this solution was remarkably simple. The move in investment strategy to lower risk fixed income securities (gilts and bonds) led to a reduction in the nominal investment returns which left unchecked would have increased the deficit. However, hand in hand with this change, the company agreed the pension schemes would also adopt a higher risk position on inflation - with the IFM recognising this inflation risk and providing a payment mechanism linked to the inflation return accruing to the company on the RCV - making use of the company's natural hedge.

This innovative and novel approach allowed us to move away from the heavily focused equities investment strategy to one with lower risk fixed income securities (gilts and bonds) with a duration matching interest rate hedge overlay, while maintaining the existing level of deficit contributions.

UW IAS19 pension scheme liabilities and deficit/surplus over the last decade



As illustrated in the chart above, this risk management approach has successfully insulated our pension schemes from the impact of the low interest rate environment over the last decade. On an IAS19 basis, the reducing interest rate

environment has seen our pension liabilities increase from c£1 billion to c£2.5 billion while the deficit of c£200 million has been transformed into a surplus of c£250 million.

In the late spring of 2018, with our pension schemes in a strong funding position, the JWG have been able to further accelerate our de-risking and have now fully decoupled the pension schemes reliance on the IFM for its inflation protection, replacing this with a market derived hedging solution.

Today our pension schemes are invested in low risk fixed income securities (gilts and bonds) with a liability duration matched interest rate and inflation hedge. Leaving the remaining risk of mortality, which was assessed as the least volatile risk, to continue to be monitored and managed. In recent years, the rate of increase in mortality has slowed and as future outperformance accrues to the pension schemes this risk will be progressively hedged.

(2) Managing future service costs

Having gone to the lengths of actively managing the accrued pension benefit risk, it was important that future benefits accruing should be funded on the same basis. This approach forced us to face into the difficult issue that, valued in this way, pension benefits accruing were simply unaffordable when benchmarked against other companies.

Again we could have sought to accept this significant risk but instead we engaged with employees and amended benefit packages to manage the overall affordability of the pension benefits offered. Initially it was necessary to do this in 2010 and more recently, we have had to take further action in 2018, due to costs once again increasing as a consequence of the progressively lower interest rate environment. Our financial strength is driven by two key factors: subjecting ourselves to the scrutiny and rigour associated with being a publicly listed company and our long term and responsible approach to financial risk management. We have a duty to stakeholders to ensure financial resilience over the long-term. Financial resilience means we have access to sufficient financial resources so we can act to protect customers from the occurrence of unusual or extreme events³. It also ensures that we can continue to attract the finance required to fund our customer focus long term investment programme at the lowest possible cost.

3 How we have learnt from our recent experiences

In recent years we have experienced a number of major incidents. We have had significant boil water incidents in Greater Manchester in 2015 and 2016 and in Lancashire in 2015. We also experienced wide area flooding incidents across our region in the winter of 2015/16 due to storms Desmond and Eva. We are sorry for the disruption caused to customers and we have learnt from these experiences to significantly improve our resilience.

3.1 Sweetloves Water Quality Incident – July 2015

In July 2015 we lost treatment at Sweetloves water treatment works in Bolton. We removed the plant from supply and subsequently reintroduced the supply with a precautionary boil notice. Some 80,000 customers were variously affected by loss of supplies, having to boil water and discoloured water for a period of four to five days. The multiagency debrief into the incident identified lessons including delays in escalating the incident to partner agencies and inaccuracies in expressing the affected area in terms local authorities could relate to. One quote from the multiagency debrief sums up our response: *“United Utilities acknowledged that they became too focused on resolving the technical issue rather than informing partners and seeking support.”*

³ Extreme events are those assessed as being low likelihood but high impact scenarios or a plausible combination of multiple events occurring in an AMP, which have a collectively high impact.

3.2 Franklaw Water Quality Incident – August/September 2015

Franklaw Water Treatment Works is located in Lancashire and is our third largest treatment works. It supplies water to 329,000 households and businesses in North Lancashire including the major towns of Blackpool and Preston. The network consists of a complex network of aqueducts and water mains with water stored in 15 service reservoirs and towers. It takes several days for water leaving Franklaw to reach the ends of the network.

Figure 11: Franklaw Water Treatment Works



On Thursday 6 August 2015 a proactive and precautionary public information notice to customers across Lancashire to boil their water was issued following detection of *Cryptosporidium* in routine sampling at Franklaw Water Treatment Works. This was an unprecedented scale for a water quality incident and a multi-agency incident response was established. We undertook additional sampling, commenced customer and stakeholder communications and a regime of flushing and cleaning got underway. The criteria for lifting the boil water notice was agreed with Public Health England and following further positive results on 15th August a decision was made to install Ultraviolet (UV)⁴ treatment in the network

to all impacted areas that couldn't be rezoned to other sources. On 27th August we lifted the boiled water notice for some customers but it wasn't until 6th September that the notice was lifted for all customers.

Post-incident investigations identified that the likely cause was rainwater contaminated with *Cryptosporidium* leaking through a joint in the Barnacre service reservoir structure and entering the water supply. This source was being used temporarily to provide Franklaw with mains water to use in the process whilst the usual source was shutoff to repair a leak. Despite enhanced surveillance, Public Health England found no evidence of increased illness in the affected area.

We were prosecuted for this event and received a fine in October 2017. In his summing up, The Honorary Recorder of Preston, Judge Mark Brown, criticised us for not undertaking on this occasion a complete risk assessment process on site before altering the treatment works water supply, although he outlined that there was no outbreak of cryptosporidiosis in the community which was directly linked to the incident. However, he acknowledged the disruption, inconvenience and concern there would be for the public during this time. In deciding on the value of the fine, the judge took into account the significant investment incurred on remedial work, including the UV treatment and compensation paid out to customers. He accepted that we showed a very responsible attitude from the start of the incident and described our response as "text book". He recognised that we did our best to ensure the risk to public health was minimised.

From an incident of this scale, there is clearly substantial learning for ourselves and other water companies to ensure resilience is improved for all customers. We learned a lot from these incidents and so we actively shared our knowledge with peers in the industry

[Feedback from water industry attendees at post-Franklaw seminars]

"Excellent post incident review and interesting to see significant shift in company attitude post the incident"

"I think UU were incredibly open"

"A great example of sharing learning across the industry"

"Your team all seem to have learnt a lot from the event so ... you seem to be in a very good place for the next AMP."

100%

of attendees said it will help them look at making improvements in their own organisations

⁴ Ultraviolet treatment uses special lamps that emit UV light of a particular wavelength that attacks the genetic code of the microorganism and rearranges the DNA /RNA, eliminating the microorganism's ability to function and reproduce. If a microorganism can no longer reproduce, it cannot replicate, therefore it cannot infect other organisms with which it has contact. This process of exposing water to UV light is simple but effective, destroying 99.99 percent of harmful microorganisms without adding any chemicals to water.

and in other sectors too. In particular, we hosted a series of seminars to disseminate lessons learned. The lessons learned handout from these seminars is included as supplementary document S4007. By sharing this knowledge we hope that we have contributed to future industry resilience by helping to avoid future incidents, assist with quick recovery and build confidence in the resilience of the public water supply.

3.2.1 Customer views on the Franklaw incident

Around 5 months after the incident we undertook some customer research to understand what customers thought about the incident and our response to it. We found that customer satisfaction remained high in the affected area with 83% satisfied or very satisfied with the service provided. However this was 7% lower than amongst customers who had not been affected with 40% of affected customers admitting that the incident had lowered their opinion of us. The main reasons given for that change in opinion were that:

- we should have been more prepared and dealt with the incident better;
- it took too long to resolve; and
- there was a lack of or delayed information to customers

Follow up research undertaken in 2017 found that the decline in opinion has been sustained two years on. This shows that significant service interruptions can have a lasting impact on customers' perceptions of service.

Domestic and business customers were asked questions about information provision, communication channels, how we handled the incident, the amount of compensation paid, bottled water use and whether they had reverted to their previous consumption pattern. They were also asked about the relative impact different types of incident would have on them. The feedback has shaped our activity since the incident.

3.2.2 Our response – building resilience

Immediately after the Franklaw incident and prior to the judgement, the United Utilities Board appointed Mark Clare, the Senior Independent Non-Executive Director, to carry out a review of the company's risk processes and resilience response. The report identified 33 separate improvement actions that has led to a significant amount of activity and investment with the result that the company has vastly improved its resilience position. We can separate these improvements into four themes: incident management, customer and stakeholder management, operational practices and risk and resilience.

Incident management

Managing an incident of this scale is complex. It is not just the physical recovery of service that is challenging, it is also about meeting the needs and expectations of a wide variety of customers and stakeholders for support and information. Since the incident, we have thoroughly rewritten our incident management procedures adopting Cabinet Office best practice guidance. We have included more prescription and advice to the full range of responder roles and addressed the different challenges presented by such large incidents. An extensive section on managing customer impacts, including alternative supplies priorities is included.

Over 200 senior and front line managers have received strategic and tactical manager training and this is now a standard role requirement. Major incident leadership training is being rolled out to selected senior managers. Improved training and development for our duty managers and other control room roles has also been delivered. We have introduced more crisis exercising into our business with a greater emphasis on multiagency exercises including 'Triton II' in 2016 with our Greater Manchester Resilience Forum partners and 'Lonesome Pine' in 2017 with our Cumbrian partners. Exercises with Cheshire and Lancashire are planned for 2018.

We have developed a comprehensive set of network contingency plans detailing the valve operations required to remove a treatment works from supply and rezone to alternative sources where this is feasible. We have shared our above ground asset data on a shared, secure website 'Resilience Direct' to facilitate multi-agency plan development and incident management. During incidents we can share maps of affected areas for agencies to overlay on their data sets to enable full situational awareness for our response partners.

Customer and stakeholder management

The area of customer and stakeholder communications has seen significant transformation since Franklaw. We learned a considerable amount about the differing needs of different customers, the information expectations and rapidly changing communications channels. The customer experience of an incident today would be significantly improved as a result of the changes we have made.

Communicating quickly with large numbers of customers is complicated and different customers have different needs when it comes to communication. We learnt the importance of constant communications, of providing information in multiple languages and of having a physical presence in the affected area for customers to drop in, ask questions and gain updates. Social media needs to be able to scale up and down quickly based on demand and you have to accept that you cannot control all the messaging in an online world. The need for clear information and the range of questions we need to be able to respond to is vast. Daily liaison with stakeholders like Trading Standards, Food Standards Agency and Public Health England is vital to help spread a consistent message. The Federation of Small Businesses are also a crucial support to retail businesses.

To better assist vulnerable customers during incidents we have developed data sets combining intelligence from multiple sources and launched a new Priority Services programme to greatly improve support to all customers and offer bespoke support where appropriate in incidents. Priority Services was developed in partnership with organisations such as Age UK, MIND, The Alzheimer's Society and Citizens Advice Bureau and sets a new benchmark for the sector. The scheme aims to provide dedicated support for those customers who are experiencing short or long-term personal challenges in their lives, such as physical or mental health difficulties, as well as those struggling financially.

We've also instigated data sharing agreements with our Local Resilience Forums to share sensitive properties and vulnerable customer data confidentially. We have agreed a memorandum of understanding with the British Red Cross to assist us in supporting vulnerable customers during incidents. In terms of resilience, understanding individuals' needs within this customer group better enables specific communications and bespoke support to be given. Knowing when and where this additional support is required ensures disruption is minimised as responses can be delivered in a tailored and proactive way to customers.

Other customers need specific support such as educational establishments. Our approach during Franklaw was to setup a dedicated team to contact schools, liaise with the custodians of school keys and deliver bottled water and refills for water coolers. After the event we gave schools advice on cleaning tanks as part of the return to normal school maintenance and collected the empty bottles. Our approach was commended by Lancashire County Council and would be replicated in any future incident.

Figure 12: Providing bottled water to schools



We announced quickly that compensation would be paid to all affected customers proactively. We had a clear process and handling claims were clearly communicated. Compensation was paid to households irrespective of payment history and paid as a cheque, not as a credit to the bill. This approach was agreed with the independent Customer Challenge Group, 'YourVoice' and with the Consumer Council for Water. All domestic compensation cheques were issued by 21st September. Commercial customers were supported through the process by a dedicated case worker with accountant support. The quick response to compensation worked well and is a good model if required in future.

Operational practices

There were lessons out of Franklaw in the area of people, processes, assets and supply chain. There were some positive lessons to come out of Franklaw such as witnessing an overriding desire among our people to do the “right thing” for customers. This includes the support to front line operations from across the business, all teams working extended hours and working at pace to put things right. The duty to protect public health was clearly recognised and highly trained and experienced United Utilities employees were key to eliminating multiple root causes and to identifying the actual root cause. Our sampling and testing processes enabled rapid identification of the issue and we escalated the problem quickly, which identified the need for a boil water notice to be put in place promptly. We were able to call on a very responsive supply chain to quickly deliver mobile Cryptosporidium monitoring rigs, UV treatment units from around the industry and the successful and rapid deployment in extremely challenging construction environments.

Figure 13: Installing start up to waste at all treatment works



However, we identified a number of areas for improvement across a number of risk management processes. We have implemented mandatory water quality awareness training for all staff who support the water team. Over 1,000 contractors and employees have also completed calm network training since 2013 and we have established a technical training centre to enhance future awareness. We are also leading the WaterUK group to develop new industry standards. We have established a specific Water Quality Risk Board with the authority to stop projects if there are concerns. A site standards league table has introduced new visibility and internal competition to drive further improvements at our treatment works.

We have centralised the development of Drinking Water Safety Plans to drive greater consistency and higher standards with a deep dive review of all assets. We have implemented more robust service reservoir assessments including the use of flood tests. We have developed new tools to enable visualisation of our network to support planning and for proactive communication with customers. Our engineer led hazard review (Hazrev) has been completed at our highest risk treatment works with all works on track for completion. Site specific disinfection procedures have been reviewed, updated and audited. We have also refreshed and made more robust our mandatory planned work risk assessments. We have updated all procedures, alarm settings, response plans and installed new instruments and telemetry systems. We have a new network technical team in place from November 2017 that operates 24 hours a day supporting operational teams, improving issue detection and directing proactive action and field deployment from the centre.

Figure 14: Installing UV treatment during the Franklaw incident



We have invested in AMP6 on physical improvements to enhance resilience. The most significant investment has been the installation of shut down and start up to waste at all of our treatment works. Start up to waste enables us to stabilise treatment processes to ensure water quality is consistent and compliant before sending it into distribution. Without this capability

there is a risk of substandard water being delivered when a treatment works is restarted following a shutdown. With start-up-to-waste we can take a highly precautionary approach and shutdown treatment works whenever an issue occurs, safe in the knowledge that it can be safely restarted once the issue is resolved. When complete, we will be the first water company in the UK to have this capability across all treatment works, which offers much greater flexibility to prevent incidents occurring in the first place. We have also installed UV at high risk water treatment works and are developing the ability to be able to quickly deploy it anywhere in the region. We have covered all filters and chambers downstream of the first stage filters to reduce the risk of contamination. We have improved the identification and control of critical valves and purchased a stock of mobile Cryptosporidium monitoring rigs. We have also purchased additional network supply vehicles to enable water to be delivered direct to the network wherever it is required.

Risk and resilience

We have made some improvements to our risk management framework. Post-Franklaw, we appointed Arcadis to undertake an independent review of our risk management processes. Arcadis concluded that the existing process was well structured but was not fully embedded. They found there was good quantification of risk, with clear targets and active senior management engagement. They did however identify the need for a clearer link between top down risk assessments and bottom up risks captured on site and enable a two way flow of data between the risk levels. They also felt that the process could be better integrated between business units and systems and that there was a need to clarify accountability for risk identification and management.

We have made a number of improvements to the risk management framework including the creation of a risk breakdown structure to ensure that risks are assessed on a consistent basis. We also strengthened our existing asset planning processes to make risk management more prominent in decision making and make business cases stronger. We are still in the process of enhancing processes and systems to better support risk capture and control effectiveness evaluation.

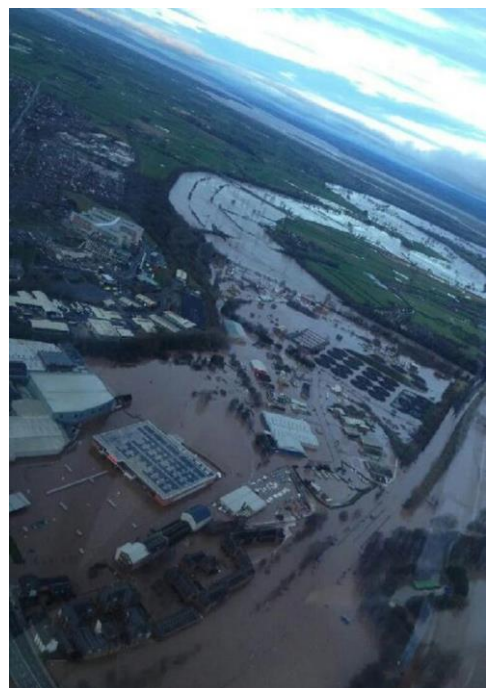
We also employed Arup to undertake a review of single points of failure within our water and wastewater systems and ensure the risk posed by those facilities is adequately captured. We have then costed potential solutions to reduce that risk and, where cost effective to do so, will look to reduce the risk posed by single points of failure over time.

3.3 Storms Desmond and Eva - December 2015

Two storms, Desmond and Eva, in December 2015 saw unprecedented rainfall volumes and river levels that caused impacts to communities across Cumbria, Lancashire and parts of Greater Manchester. These rainfall events also caused widespread disruption to our assets and operations across the North West. The ground was already saturated following high rainfall volumes in November, whilst December was the wettest month in the UK since records began in 1910. During Storm Desmond, 405mm (almost 16") of rainfall was recorded at Thirlmere in 38 hrs (which is a new UK 48-hour record). Storm Eva on 26th December caused significant rises in river levels in East Lancashire, North Manchester as well as causing further flooding problems in parts of Cumbria and North Lancashire. During Storm Eva, Bury and Rochdale sewage treatment works were completely flooded. Bury in particular received unprecedented levels of flooding covering 85% of the site. Power supply to the sewage treatment works was interrupted for several days, and all electrical panels and equipment required extensive work to rebuild and commission. Three pipebridges and a rising main were washed away by swollen rivers.

On December 5th and 6th, storm desmond caused a significant impact across Cumbria with 76 sewage treatment works affected in some way. Carlisle and Kendal treatment works were the worst affected with

Figure 15: Aerial view of Carlisle flood with our wastewater treatment works visible in the centre



significant repairs also required at Appleby, Penrith, Ambleside and Cockermouth. At Carlisle parts of the works were under 12ft of water which led to the need to replace or refurbish:

- All of the kiosks containing electrical panels
- Sludge treatment process
- Ferric dosing plant
- Final effluent pumping station outfall
- The engineering workshop and ground floor offices

This said the damage at Carlisle could have been much worse had we not learned lessons from the 2005 and 2009 flood events and factored quick recovery into our repairs and refurbishment works. Following the lessons learned from the previous flood events, plans were in place to react to the storms quickly, with established recovery plans including the provision of storage for new parts and standby generation to power all site assets, as well as having planned processes in place for the immediate communication of issues and information to stakeholders affected.

We were able to work closely and efficiently with the multi-agency strategic command partners due to the long term engagement we have had following the 2005 and 2009 events. The Local Resilience Forum structure, in particular, has been beneficial when the new incidents hit us in Cumbria.

Staffs working time was monitored and rest periods enforced, whilst engineering support was crucial on site and significantly assisted in the recovery.

During storms Desmond and Eva we had crews working around the clock to return assets to operation and provide as near to normal a service to customers as was possible. At Carlisle communications equipment was moved to the second floor after floods in 2005, meaning we only had to get power back to the building – this meant that all communications were re-established immediately facilitating the incident management calls and sharing of information.

Customer and environmental impact

During storm Desmond approximately 1,000 properties temporarily lost supply in Cumbria and Lancashire. Most customers has supplies restored within 24 hours and all customers supplies were restored within days of the initial flood event. A precautionary boiled water advice notice was issued to 373 properties because of the risk of flood water contamination. The vast majority of notices were lifted within two weeks, all affected customers were provided with bottled water during the period of these notices. We called on mutual aid to get some tanker support from Yorkshire Water and Northumbrian Water.

There was also an environmental impact where sewage treatment works were damaged. During both incidents, we undertook environmental monitoring of the stretches of river with the most severely impacted sewage treatment works. This highlighted that the impacts of loss of treatment were generally fairly small in the initial period because of the dilution of effluent in the very high river flows. Over the passage of time, the impact became more pronounced for those sewage treatment works with prolonged recovery times. This highlights that the speed of recovery is a key issue for the wastewater asset base if environmental damage is to be minimised.

Identifying interdependencies

During Storm Desmond in December 2015 the water level in the River Lune was threatening to overtop flood defences protecting an electricity sub-station and representatives of Electricity North West, the police and fire services made the decision to switch it off. As well as households losing power, many of our pumping stations in the Lancaster area stopped operating leading to loss of water supply for a number of customers. We had agreements in place with temporary generator providers so were able to procure a number of generators at short notice and supplies for most customers were restored quickly. It was challenging though as the loss of power meant mobile phone masts were not functioning so we couldn't contact field staff to coordinate the installation of generators without them leaving the city. Roads were flooded so access was difficult in some cases. Customers struggled to contact us as most landline phones also now need mains power and the social networks many customers now contact us on are not accessible if

Wi-Fi routers have lost power. Customers couldn't buy bottled water without cash as card machines in shops either weren't working or couldn't access the internet to process transactions. The incident highlighted for us the increasing reliance on all services of a reliable electricity supply and the importance of us working with other utility providers particularly electricity, telecoms and roads to manage the risk of service failures for customers.

Lessons learned

Many of the lessons learned from Franklaw benefitted our responses to Storms Desmond and Eva but, being very different events, there were some specific lessons that we took from the floods:

- Alerting and activation – we felt we could have done more to prepare in advance and to have recognised the seriousness of the incidents more quickly. As a result we have developed comprehensive in-house triggers for assessing emerging weather threats and agreed a process for assessing those triggers on a regular basis, engaging with the Environment Agency where appropriate. We put in place a structured approach to suspend planned work to release staff more readily for incident response and to get responders on a 'readiness to move' instruction more rapidly. We also developed new processes for cascading messages more quickly to front line staff. We also enhanced our contingency planning to be more specific about the type of generators required and the type of panels likely to need replacing post-flood. We are also looking at the use of drones to help us survey flooded sites.
- Command, control and coordination – we are developing the concept of forward incident control hubs to provide better local support and visibility of incident leaders. We would also in future better coordinate the various visitors to damaged sites (such as Environment Agency and loss adjusters) to ensure they are properly supported without distracting front line staff from critical service recovery work. We will also prompt the multiagency incident team to establish an advisory cell with the NHS and Public Health England to assess any immediate and longer term health implications. We are developing our relationship with electricity distributors to enable greater information sharing in future.
- Capacity – we are looking to bolster the arrangements for centralised procurement of spares and emergency equipment in incidents and ensure that spending limits on purchase cards are automatically lifted during an emergency. We also identified the need to provide better welfare facilities for front line responders particularly outside of normal hours. We are also strengthening the concept of pooling resources across areas and teams during an incident and working with our supply chain to identify which of our contractors are best able to respond quickly and which we need to work with to improve.
- Regulators and customers – We are developing more self-service mechanisms for data to enable stakeholders to access information they need without having to request data from front line responders. The need for a customer communications strategy will be managed by the centre and not by those in the field. We are considering embedding media personnel in forward incident hubs to assist information flows. We also need to work with the Environment Agency at multiple levels as not all messages to the regional Environment Agency was cascaded down to local staff, leading to confusion.
- Transition to recovery – The incident team will be more pro-active in controlling the flow of personnel back to their day jobs until the recovery is confirmed to have stabilised. We will also review all strategic projects in the area affected to more quickly identify potential delays to delivery, for example, delays to environmental surveys.

3.4 National Flood Resilience Review

Following the floods in December 2015, the government announced a National Flood Resilience Review. As part of that review, water companies were asked to:

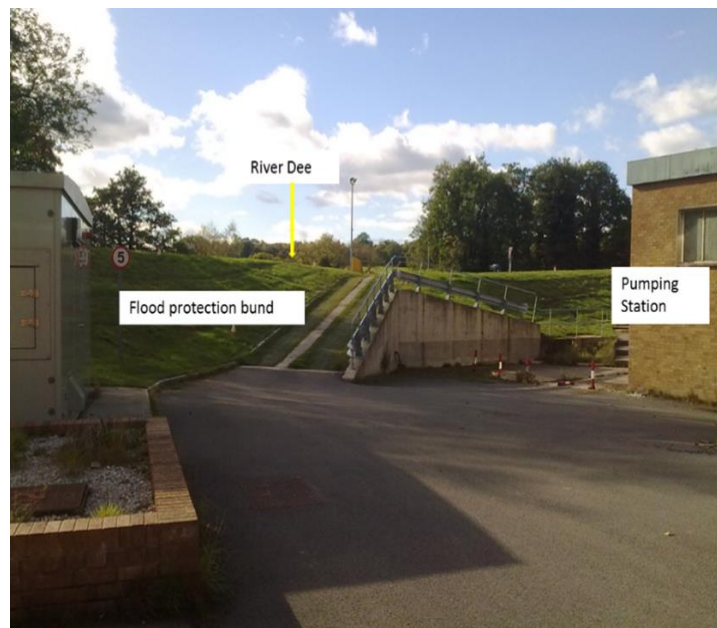
- report on assets serving over 10,000 customers at 1 in a 1000 year flood risk;
- procure temporary flood barriers for water treatment works serving more than 25,000 people, where practical;
- look at mutual aid arrangements including other utilities to share barriers; and

- respond to the expectation that permanent flood protection will follow for sites at risk in the medium term.

We had previously assessed flood risk to our sites but decided to redo the analysis with the latest flood maps. Our analysis found only three of our water treatment works serving more than 25,000 people was at risk of flooding from a 1 in 1000 year event: Ulpha, Huntington and Ennerdale. Ulpha does flood on a regular basis but the site can be switched off without impacting customer supplies. We have also taken steps in the past to move equipment above the flood level so that when flooding does occur, the site can be brought back on line as quickly as possible. As the flood water can enter the site from multiple angles, a temporary barrier would not be effective and the cost of building a permanent barrier around the whole perimeter would be prohibitive. Due to the lack of customer impact we decided that no further action was required at this site.

Huntington water treatment works is not within the flood risk zone but the river intake was vulnerable to flooding from the River Dee. This risk had already been addressed in 2003 with the construction of a permanent flood barrier designed to protect the site from at least a 1 in 100 year flood.

Figure 16: Permanent flood barrier protecting Huntington inlet pumping station



Ennerdale is within the flood risk zone of the River Ehen in West Cumbria, according to the Environment Agency flood risk maps. The site has not flooded in living memory and did not flood during the storms that so devastated other parts of Cumbria in 2005, 2009 and in 2015. Ennerdale will no longer be used as a water treatment works once the Thirlmere link main has been completed as part of the West Cumbria supply demand solution, as described in our supplementary document S4003, Section 4.3.2. A permanent barrier is therefore inappropriate. We have however purchased a temporary flood barrier that is stored at Ennerdale but is kept on a trailer so can be redeployed elsewhere. Once Ennerdale closes it will be moved to the most suitable location to protect assets whose flooding could lead to service loss.

Figure 17: Temporary flood barrier being deployed in-situ at Ennerdale Water Treatment Works



We continued the analysis to all above ground assets across water and wastewater. Up to 130 water assets and 1,500 wastewater assets could be at risk of flooding from one or multiple sources. However not all of those sites, if lost, would result in an impact to customer service or the environment. The Environment Agency flood maps used to undertake the analysis are also not accurate enough to be confident that this is a true picture, to really assess the risk it requires a site specific survey and across such a large asset base, this takes time and is costly. We have therefore embedded flood risk assessment into our more generic resilient measure called 'Water service resilience', described in our supplementary document S3001. As one of many hazards that have the potential to knock out critical sites, we think it is appropriate to consider further flood protection only where customers support further risk reduction as part of a most cost-beneficial solution.

We will continue to review whether the provision of more temporary flood barriers is worthwhile. We have engaged through WaterUK to assess the potential for more mutual aid provision of flood protection equipment both between water companies and inter-utility. The mutual aid programme is kept under constant review. We will look for opportunities to cost-effectively provide permanent solutions but in many cases we think the very high cost makes them undesirable. Permanent flood barriers provide resistance to flooding, we think the other 3R's of reliability, redundancy and response often offer better value for money but the most appropriate solution needs to be assessed on a case-by-case basis.

3.5 Buckton Castle Water Quality Incident – December 2016

In December 2016, a treatment failure at Buckton Castle Water Treatment Works, supplying areas of east Manchester, resulted in boil water advice around 17,000 properties. The multiagency report identified good practice, all of which had been improved based on lessons from earlier similar events. These are some of the quotes from the report:

- Promptness of alerting public and schools through the use of United Utilities staff to deliver leaflets and media messaging from all agencies
- Managing to keep schools open safely avoiding major disruption
- Quickly identifying criteria by which to remove the boil water notice, meaning that all agencies knew what we were working towards
- Utilisation of lessons learnt from previous water outage incidents in Greater Manchester and Lancashire
- Multi-agency meeting quickly convened with appropriate agencies involved, ensuring an efficient response
- Identification of vulnerable people was well coordinated with all agencies quickly sharing appropriate data.
- Use of Ordnance Survey mapping was well received as it enabled a spatial overview of affected properties and vulnerable sites.
- Good utilisation of council resources to make contact with vulnerable residents
- Bottled water was effectively prioritised and relevant supply chains and stocks quickly bolstered
- Clear and consistent messaging around public health advice resulted in a sense of public confidence in the response
- Clear, regular and relevant briefings were distributed by United Utilities which enabled the multi-agency response to be fluid and informed

Whilst disruptive to customers and highly regrettable, this incident highlighted how much the various improvement activities since 2015 have significantly enhanced our response and the customer experience during an incident.

We again undertook customer research after the incident and, unlike post-Franklaw, the customers impacted by the incident reported very little change in opinion or trust of United Utilities after the event. Customer satisfaction remained high with 86% of residential customers and 79% of business customers satisfied or very satisfied with the service provided. We continue to develop our response and recovery processes so that when they are called upon we can deliver an even better customer experience in future. Our approach to response and recovery is described in more detail in our supplementary document S4005, section 4.

3.6 Freeze thaw event – February/March 2018

We have invested heavily in the development and implementation of operational systems thinking, with the operational, customer and Integrated Central Centre (ICC) teams operating as an integrated team. Fundamental to the effective operation of this model is high quality situational awareness – ensuring that live granular data is marshalled within the ICC and available to the centre and our field teams, so that issues are identified quickly and action planned and taken. We have also invested in telemetry and data systems, including system wide coverage of flow and pressure sensors within the water network, live asset data (e.g. quality, flow, levels) and GIS visualisation of customer service with live and historic data at customer level.

Winter Readiness Plan

As part of our normal preparation for winter weather, we took a number of actions from November 2017, so that we were prepared for adverse weather. These actions included carefully managing major and minor outages at our water treatment works and treated water storage systems and increasing our leakage detection effort and the number of repair contract staff, even though leakage was well within target. In addition, our overarching digital marketing customer campaign including on Facebook, Twitter and YouTube was running from 17 January 2018 and achieved 3.78 million views of our winter advice for customers.

Initial Freeze Phase

In preparation for and in advance of the severe weather, we participated in multi-agency conference calls on 26th and 27th February 2018 and initiated our own incident. The incident was managed, as is normal, with a task team structure focused on managing impacts within specific areas – including health and safety, maintaining customer service, providing advice to customers, access, and securing operational performance. Access to sites was very difficult during this period.

Preparation for the Thaw Stage

As part of the incident and during the ‘freezing part’ of the event (from 28th February), the team undertook a detailed extendibility exercise, assessing and planning for a number of thaw scenarios across the business. For the Water business one of the key activities was assessing the impact on leakage breakout and therefore customer service – with scenarios assessed including a prolonged period of freezing weather, a gradual thaw (with a lower impact of leakage) and a rapid thaw (resulting in a rapid increase in leakage). At this stage we planned for the worst case scenario of a rapid thaw and took a number of early actions to enable us to respond quickly should this scenario occur.

We also initiated a number of proactive actions, including:

- suspension of some of our large planned asset improvement works – enabling all water treatment works to return to maximum output to increase treated water storage within the system;
- development of a detailed customer communications plan, including the production of specific video content to help customers manage frozen pipes within their homes;
- planning for an increase in customer calls by re-deployment of customer advisors;
- cancelling all non-urgent work;

Figure 18: Challenging access conditions in the freeze (March 2018)



“United Utilities planning ahead of the event (based on learning from previous events) meant that the company had built up sufficient reserves of water to deal with the anticipated spike in demand and additional field staff and call centre staff were in place to maintain both customer contact and mains repair response times at levels comparable to normal operations.”

Ofwat letter to United Utilities CEO 19th June 2018

- securing additional leakage repair resources;
- increasing of out of hours resource levels across the business;
- increasing the manning of our 20 Alternative Supply Vehicles (30,000 litre HGV tankers capable of pumping drinking water directly into the network); and
- increasing the availability of bottled water in case of a large scale interruption to over 80,000 bottles.

These actions were implemented as quickly as practicable and were all in place for the start of the thaw.

Response to the Thaw Stage

On Saturday 3rd March 2018 the focus of the incident shifted to implementation of the detailed plans, developed through the initial stages of the incident, by an integrated team involving the Water, Customer, ICC and repair contract teams with round the clock coverage.

“United Utilities’ ability to monitor the network and its access to real time information on network performance, enabled it to identify the source of leaks and respond and complete repairs quickly.”

Ofwat letter to United Utilities CEO 19th June 2018

The team focused on:

- progressively increasing production to meet increased leakage driven demand;
- proactively managing supplies within the network and between storage facilities – so that there was sufficient water at all stages to meet demand across the whole of the region with minimal customer impact;
- managing customer communication – both proactively and in response to contacts for loss of supply; and
- deploying Alternative Supply Vehicles where necessary to pump water directly into the network whilst repairs were undertaken and thereby maintaining supply to customers.

This approach proved to be very successful with no service reservoirs running empty and water treatment works production being maintained throughout. There were a significant number of single properties reporting ‘no water’ caused by freezing of internal pipework and customers were advised appropriately. In addition, between 3rd and 5th March there were about 40 ‘no water’ and ‘poor supply’ events where there were more than 3 contacts, although the customer impact was managed effectively with low customer contact rates, given the scale of the weather impact, where Priority Service Customers were affected by a supply interruption, bottled water was delivered to their door.

The approach to customer communication was managed very effectively by our dedicated customer team, with over 90,000 proactive communications to customers via Email, SMS and Voice blast and an additional 677 calls to Priority Service Customers, and with over 175,000 views of our incident web page and updates.

“It is encouraging to see that United Utilities was proactive in communications with customers and used a range of different channels to raise awareness, provide advice on preparing for the expected cold weather and to update customers during the incident.”

Ofwat letter to United Utilities CEO 19th June 2018

We made 100 proactive social media winter advice posts during December to March and the ‘how to’ video contents with pipe lagging, stop tap advice and help others messaging had 200,000 views over that same period.

On Twitter our promoted/targeted posts had over 50,000 views with an average of over 100 clicks through per day to our website WinterWise advice. During the week of our type 3 incident, we responded to over 200 direct messages on Facebook, compared to around 80 the previous week; and on Twitter, we responded to 2,300 tweets compared to 1,100 the previous week.

4 A resilient base to build on

The investment we have made in our assets, people, systems and processes particularly over the last few years has enhanced our ability to deliver a resilient service for customers. This has been demonstrated both in our overall improvement in customer satisfaction and in how well we have coped in recent incidents such as the freeze thaw event in February/March 2018. Through the remainder of AMP6 and into AMP7 we will continue to build on the good resilience base that we have created, focussing on areas that have the greatest scope to deliver the resilience improvements that customers expect such as our water and sewerage networks. We will continue to play an active role in the industry as we determine what good resilience looks like and how we ensure we deliver a resilient water and wastewater service for customers today and for future generations.