Dŵr Cymru Welsh Water

IAP Response

# Ref B2.11.WSH.CE.A1

# Water Resilience Investment Case

1 April 2019

# Contents

# Executive summary

Our September 2018 Business Plan contained a number of investment proposals associated with our water resilience strategy. However, it is now clear they were not presented in a way that demonstrated a clear "line of sight" between risks to resilience and the measures we intend to take. The purpose of this document is to set out in one place the methodologies, the analyses, the judgements and the information that together explain the decision-making processes that we undertook and the justifications for the proposals that emerged.

The point of departure for our approach to resilience is the strategic framework provided by "Welsh Water 2050", which was shaped by the long term aspirations of our customers and other stakeholders in relation to the services that we provide. One of the principal features of Welsh Water 2050 was a full appreciation of the long term risks that we face and the need for a comprehensive resilience planning approach to deal with them.

As the bulk of this paper explains, this has been applied for the purposes of developing our proposals for AMP7. Beginning with the identification of all of the major risks that we face, together with their likelihood, we systematically analyse their potential effect on our assets and systems. From this, we can assess the consequences for service and thereby customer and environmental outcomes.

Equipped with this information we are then in a position to prioritise risks for intervention. We do this by evaluating the probability of risks occurring and their potential impact. Having identified the priorities the next stage is the assessment of options for risk mitigation and management. For this we apply our "five Rs" categorisation to ensure that we examine all of the different strategic approaches to risk mitigation.

To evaluate the options, we carry out a rigorous optioneering process involving consideration of alternative ways of addressing the priority risk in question, quantification of whole life cost, potential interaction with other programmes or priorities, and the prospective benefits for customers and the environment.

The result of this process, for water, is a programme comprising 11 elements for AMP7. These are summarised below. The way in which the framework summarised above has been applied to arrive at each one is described in the rest of this paper.

Delivering investment across the 5 qualities ('Rs') of resilience for our water system

| Resilience mitigation | Investment programme | | Proposed programme total budget (post-efficiency) | Proposed enhancement (post-efficiency) |
|---|---|---|---|---|
| Reliability | WS2 | **Improving Felindre WTW quality resilience (60%)** | £4.505m | £2.703m |
| | WS7 | **Hereford water supply resilience** | £13.601m | £13.601m |
| | WS5 | **Post tensioned concrete tanks replacement** | £13.581m | £13.581m |
| | WS3 | **Capel Curig WTW abandonment** | £2.101m | £2.101m |
| Redundancy | WS6 | **Extending our south Wales grid** | £19.908m | £19.908m |
| | WS9 | **Additional storage at Llwynypia Quarry tanks** | £3.229m | £3.229m |
| | WS1 | **Installation of contact tank cleaning assets at water treatment sites** | £10.180m | £10.180m |
| | WS4 | **Network resilience schemes** | £5.308m | £5.308m |
| Response and recovery | WS10 | **A range of projects to improve our emergency planning capability** | £0.541m | £0.541m |
| Reflectiveness | WS11 | **Information systems projects to provide greater resilience** | £29.602m | £29.602m |
| | WS8 | **Critical trunk mains assessments** | £3.627m | £3.627m |
| Principal use adjustment | | | | £10.044m |
| **Total Resilience enhancement investment (post-efficiency)** (Line 14) | | | | **£114.426m** |

## Delivering for our customers

This work will meet the following customer promises:

**Clean, safe drinking water for all:** Providing water that our customers can trust is clean and safe to drink.

**Put things right when they go wrong**: Reduce the need for reactive maintenance, deliver effective approaches to response and recovery

**A more sustainable and prosperous future for communities**: Improving the environment for our communities to enjoy.

## Delivering our strategic responses

In Welsh Water 2050, we set out to deliver 18 strategic responses. This investment will contribute to the following:

**Enough water for all:** Confronted with an increasing water supply demand gap due to population growth and drier summers due to climate change, we will use our Water Resource Management Plan to ensure the water supply demand balance to 2050.

**Improving the reliability of drinking water supply systems:** Faced with an increased risk of outages due to agricultural run-off, extreme weather events, and terrorism, we will build more flexibility and integration into our water treatment and supply systems.

**Protecting our critical water supply assets:** With increasing risks of disruption (for example, from severe weather events resulting from climate change and increased reliance on technology) and limited customer tolerance of supply outages, we will improve the resilience of critical water assets which have high consequences of failure.

**Achieving acceptable water quality for all customers:** Ageing water mains and more extreme weather events increase the risk of supplying water which is discoloured or has a poor taste.

**Smart water system management:** Capitalising on technological advances such as remote sensing and automation will allow our system to become more resilient by mitigating problems before they have an impact.

## Achieving our measures of success

For PR19, we will measure our performance based on measures of success (MoS). This investment will contribute to achieving the following MoS:

| Measure of Success | End of AMP6 position | End of AMP7 position |
|---|---|---|
| Wt1: Tap water quality compliance risk index (CRI) | 0 | 0 |
| Wt2: Water supply interruptions | 12 | 8 |
| Wt3: Acceptability of drinking water | 2.4 | 2.0 |
| Wt4: Water mains bursts | 133.2 | 128.4 |
| Wt5: Water process unplanned outages | 1.57% | 1.57% |
| En4: Leakage | 171 | 148.4 |
| Ft1: Risk of severe restrictions in a drought | 4% | 0% |
| Ft5 Asset resilience (water resources) | 92.2% | 95.5% |
| Ft6: Asset resilience (water network + above ground assets) | 84.0% | 86.5% |
| Ft7: Asset resilience (water network + below ground assets) | 47.0% | 56.0% |
| Co2: Employee training and expertise | 95% | 95% |

# 1 Customer and stakeholder views relating to resilience

## Need for investment

It is critical that our customers have confidence in our ability to maintain good levels of service, even when faced with unexpected or unlikely events. Building our resilience means increasing redundancy in the system so we are less reliant on single points of failure, increasing the resistance of our assets to current and future risks, becoming more reliable and improving our ability to respond to shocks and recover from them. Strengthening our resilience will allow us to improve our service and maintain high levels of customer trust.

Our water assets are increasingly under pressure from climate change, environmental change and changes in consumer behaviour and lifestyle. Alongside these long-term pressures we are experiencing increasingly unpredictable and extreme weather events. In the last 12 months alone, we experienced a severe winter storm in early spring (storm Emma) followed by a heatwave and an exceptionally dry summer. These challenges will become more pressing as the climate changes, and we need to be prepared, to ensure we can continue to deliver our customers the service they expect.

## Views of our customers and stakeholders

We have used targeted engagement as well as a comprehensive ongoing programme of gathering customer and stakeholder insight to inform our investment decisions.

Our engagement and research work has helped us to understand:

- our customers' and stakeholders' views and perceptions of risk and resilience;
- their preferences in relation to the different mitigation solutions available to us; and
- their willingness to invest for future resilience.

### Customer views on resilience

We carried out specific customer research work relating to resilience in the early stages of our PR19 planning. This aimed to understand how well customers comprehend resilience issues in relation to water services and to what extent customers believe we should be addressing resilience issues in our business.

From this research we know that our customers believe that risks such as extreme weather, terrorism and contamination are important to manage. This understanding has fed into our prioritisation of risk.

At a strategic level, for our long-term resilience planning, we published our 'Welsh Water 2050' vision for public consultation on our proposed strategic responses. Following this consultation, which resulted in over 20,000 responses as well as 17 detailed responses from stakeholder groups, we mapped each of the strategic responses according to how customers & stakeholders perceived their importance. This helped to prioritise areas for investment.

Our customer research on resilience included testing possible solutions, as well as investigating customers' willingness to invest for future generations. We found consistent support across customers as a whole for prioritised and affordable investment now to mitigate the effects of potential extreme events in the future.

## Stakeholder views on resilience: the Welsh context

The Welsh Government has emphasised the importance of resilience within the water industry in Wales. For example, its statutory Strategic Priorities and Objectives Statement to Ofwat, published under section 2B of the Water Industry Act 1991, said, "*Ofwat has a key role to play in the delivery of a resilient water sector. Ofwat's approach and regulatory framework should encourage, enable and incentivise resilience both in regard to short and long–term challenges. Companies are responsible for ensuring their assets and the services they provide are resilient against natural hazards and other problems that can be reasonably anticipated and that their services are resilient against asset failure and other threats*."

In terms of the broader agenda, "A resilient Wales" is a statutory well-being goal under section 4 of the Well-being of Future Generations (Wales) Act 2015 and, for example, includes, "*the capacity to adapt to change (for example climate change)*". In addition, the Environment (Wales) Act 2016 advocates a Sustainable Management of Natural Resources approach, defined as "*using natural resources in a way and at a rate…to maintain and enhance the resilience of ecosystems and the benefits they provide…"*.

We believe that the investment we are proposing for AMP7 responds to the strategic objectives of the Welsh Government. It forms a programme of well targeted measures that will significantly strengthen the resilience of some key parts of the water services that our current and future customers rely upon.

Alongside the Welsh Government, we engaged with several stakeholders including Natural Resources Wales, British Trust for Ornithology, Citizens Cymru Wales, Waterwise, Wildlife Trust Wales, RSPB Cymru, Salmon and Trout Conservation UK, The Canal & River Trust, Chartered Institute of Plumbing and Heating Engineering, Brecon Beacons National Park Authority, and the Campaign for the Protection of Rural Wales during the development of Welsh Water 2050.

Stakeholders are supportive of the approach we are taking to identifying and mitigating future trends we face and they have welcomed a collaborative approach to addressing the future problems Wales will face through the development of partnerships.

# 2 Our approach to identifying and prioritising risk

## Resilience in the Round

Our approach to building Resilience in the Round can be broadly described under a series of stages:

**Risk identification:** We take a structured approach to identifying risks using many different sources to identify acute shocks, which may impact our business immediately and the future trends, which will impact on our business in the longer-term.

**System impacts:** The impacts that these shocks and future trends will have on our systems from source to sea are assessed. We also assess the impact on other systems, on our customers and on the environment.

**Risk prioritisation:** The risks are prioritised based on their likelihood of occurrence and the impact. This prioritisation is undertaken both within programmes of work and across programmes.

**Low likelihood, high impact risks screening:** The high likelihood, high impact risks are prioritised and addressed under business as usual investment. The low likelihood, high impact risks are prioritised in a separate stream and addressed under our resilience investment programme. The risks prioritised within this investment case are those where the impact is of a significance to make it intolerable to our customers. For example, this might be because the risk would impact a large number of our customers, or because it would impact interdependent systems, for example, flooding of a highway.

**Mitigation options:** Options to mitigate the risk are developed. We follow an efficiency hierarchy: first removing the root cause through upstream management or encouraging customer-led actions; secondly considering changes to operation or leveraging the existing capabilities of the system to reduce risk; and finally building smart solutions to address our risks.

Across the hierarchy, we consider innovation, best practice research, and how we can work with other stakeholders who have an interest in improving resilience across systems.

**Optioneering:** The identified options are screened through feasibility work and then valued using our service measure framework and assigned a whole-life cost, calculated using our unit-cost database. A cost-benefit ratio is calculated to prioritise the options. Assessment of benefits to customers form an important part of this process.

**Preferred options:** The preferred option is progressed to implementation through the Operations Team, In-house Delivery Team, Network Alliance, Direct Procurement for Customers (DPC) or Capital Delivery Team.

**Monitor and review:** We monitor and review our investment using our Performance Commitments.

Our decisions at each stage are based on the evidence we obtain from our customer and stakeholder engagement including overarching customer and stakeholder engagement and project-specific engagement. It is also overseen by the risk and value challenge at a project-level and strong Board governance at a company-level.

## Identification of risks, future challenges and impacts

We have a variety of processes for identifying current risks, future trends and their potential impacts at the strategic, tactical and operational levels of our business. These are set out in Figure 1 overleaf.

### Strategic processes

Strategic risk prioritisation is managed by our Board. The corporate risk register is informed by high impact risks from across the business, identified in the operational and tactical risk prioritisation processes. Longer term trends such as climate change and changes in customer expectations have

been identified and prioritised through Welsh Water 2050, which focuses on future trends that will impact our business over the next 30 years.

Through this work we identified a set of strategic responses for the business that would help us prepare for the long-term challenges highlighted in the study. We published this work for public consultation, to help us understand the relative importance of each strategic response to our customers. Taking on Board over 20,000 individual responses to the consultation as well as 17 detailed responses from stakeholder groups, we ranked each strategic response according to its perceived importance.

## Tactical processes

Tactical risk prioritisation is managed by the Directors of Service and focuses on risk prioritisation across catchments or asset portfolios. The methods of risk identification and prioritisation within catchments include the business risks register, which focus on risks across the asset base; Drinking Water Safety Plans, which take a structured approach to risk assessment across all clean water assets; the Portfolio Risk Assessment, which assesses risk of failure across our impounding reservoirs; Water Resources Management plan, which analyses our risk relating to the volume of water available for supply; Zonal Studies, which analyse and catalogue root cause of problems within water distribution zones and service resilience approach, which identifies asset and systems risks within a catchment.

We also have a robust post-incident review procedure. This procedure was used following serious incidents that have tested our resilience, including the Hereford raw water quality incident in 2015, Storm Emma, and the drought of 2018. These post-incident reviews are led by a member of the Executive Leadership Team and bring the operations, emergency management, communications and planning teams together to review the root cause of the incident, the preparedness and emergency response, temporary and permanent mitigation measures put in place and communications to the public.

Many of these risks and issues are being addressed through our wider programme and business-as-usual work.

## Operational processes

Operational risk prioritisation is managed by Heads of Service level. It focuses on risk identification and is facilitated through the asset resilience scorecards for risks to critical assets and Investment Manager (our corporate asset risk system) for risks to other assets.

The first step in building our asset resilience scorecard was screening our operational assets to identify the ‘critical’ assets. We have identified 40 critical above ground water network plus assets and 287 critical sewers in the scorecards we are using for AMP7. The assessment of criticality is linked to the potential impact of failure on the local environment.

At an asset and operational level, our asset managers and operations leaders own the asset resilience scorecards and review them at least annually. Through a set of targeted questions, they establish the resilience status of each critical water asset, including any dependency on external systems such as power and access. The resilience measures include flooding, erosion, power, access, security, temporary works, duplication, storage, condition, treatment, control systems and asset failure.

The structure of the asset resilience scorecards allows us to identify gaps in resilience either by asset or by resilience measure. Appendix B shows examples of the structure of the scorecard. This structure supports a multi-dimensional approach to prioritising programmes and encourages efficiencies in delivering solutions.

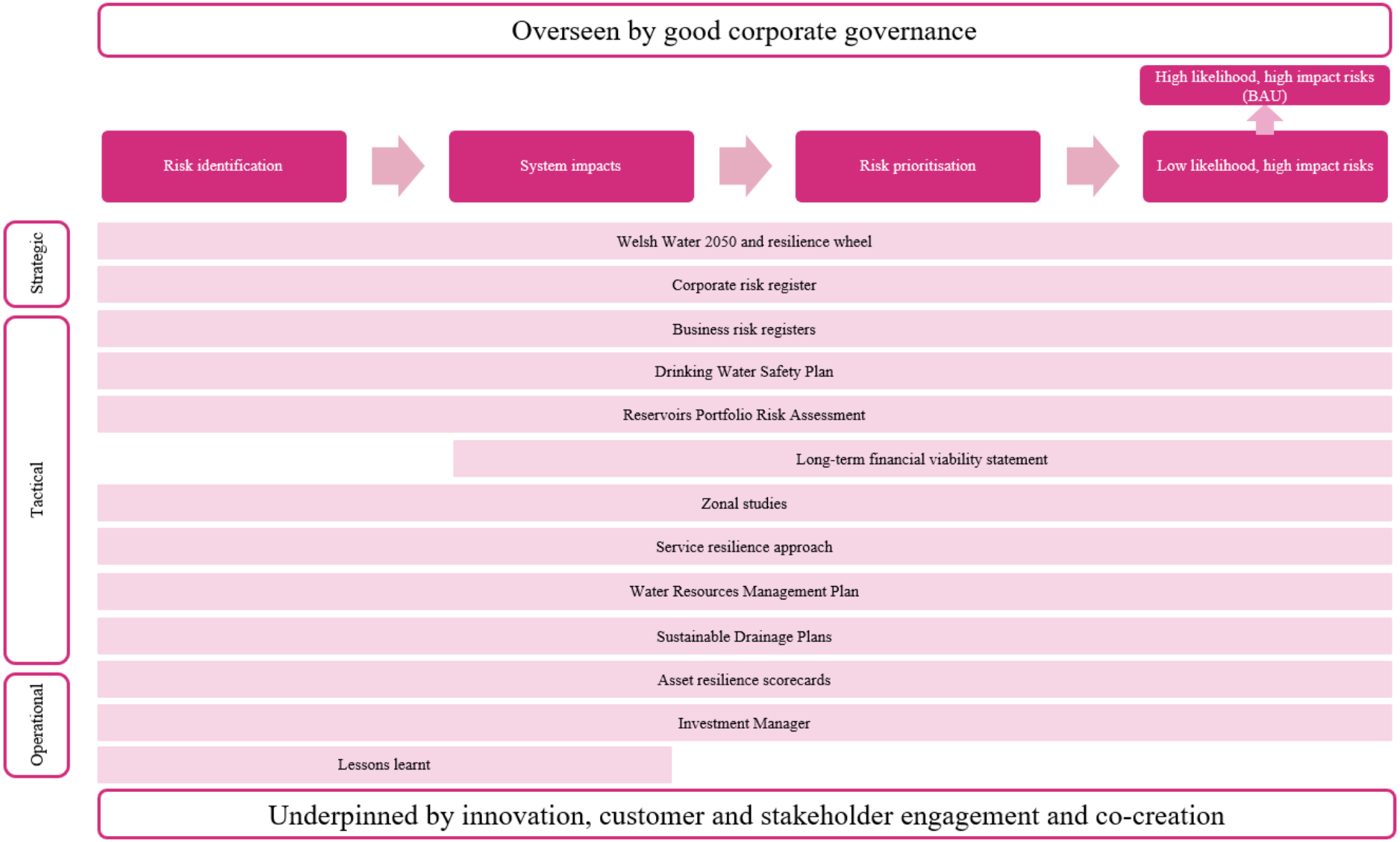


*Figure 1 Risk identification processes*

## Prioritising our risks and our resilience investment programme

Our business as usual activities and expenditure address high-likelihood risks. This leaves us with low-likelihood, high-impact risks, for consideration as resilience investments.

Comparing resilience risks from the different sources is difficult due to the differences in scale – company- wide versus asset level, low probability high impact. Developing this methodology is a key next step for us in developing our approach to resilience and this will be set out in more detail in our Resilience Action Plan on 22nd August 2019, as suggested in IAP action WSH.LR.A2. For PR19 we reviewed risks from the various sources shown in Figure 1 and prioritised consistently across the water business. We then combined the water risks with the prioritised risks from wastewater and retail to prioritise across the company as a whole. The initial review was facilitated by our Head of Water Assets and the Managing Director of Water Services. The combined review took place with the Executive team. The final investment programme was derived from this combined prioritisation process. The Board challenged our prioritisation and the selected investments.

The prioritisation included consideration of risks identified through the strategic, tactical and operational risk identification processes, explained in more detail below.

### Strategic risks

Key messages coming out of the Water 2050 review that we have reflected in our assessment of risk are:

- Climate change: Extreme weather events such as high intensity storms and flooding are likely to increase in frequency and intensity due to climate change. Drought scenarios are also more likely. High intensity storms can impact our water service by causing landslips and run-off and reducing the quality of our raw water sources. Extended periods of time without rainfall cause strain on our operations ability to treat and distribute sufficient water to customers.
- Customer service expectations: The digital revolution and lifestyle changes are altering our customers' expectations of what good service looks like
- Smart water system: Technology is developing quickly, giving us the opportunity to improve the service performance and resilience of our assets through remote sensing, data analysis and automation and solving problems before they impact on our business or the environment.
- Worst served customers: Faced with increasing customer expectations for a good service at all times, we need to address the longstanding service complaints of 'worst served customers' to ensure that everyone receives an acceptable level of service.

### Tactical processes

Our review of the tactical risk identification results highlighted the following key messages:

Business risk register: All risks are being dealt with through business as usual processes or in other investment cases

Lessons learnt review: Concerns were raised about the adequacy of our response during an asset failure and our ability to minimise interruptions to supply. The number of pinch-points that exist in our network was highlighted as reducing our flexibility. Some specific concerns were raised following bacteriological failures at Mynydd Llandegai WTW and Sluvad WTW and raw water quality concerns at Broomy Hill WTW in Hereford.

Drinking Water Safety Plans: Risks associated with water quality are recorded in DWSPs which adopt a risk matrix approach of impact and probability contributing to overall risk score. We report any significant risk changes to the DWI on an annual basis. Water quality risks are categorised according to their quality area; catchments, treatment works, service reservoirs and network. We presently have two level 5 risks both attached to water treatment works and a further 115 level 4 risks split across the four

areas. The level 5 and some of the level 4 risks with a high likelihood and high impact are included in other investment programmes including asset maintenance, improving customer acceptability of water and the Cwm Taf Water Supply Strategy project.

Three risks were escalated from this process for consideration in the resilience risk review: Inability to clean contact tanks, treatment of sludge at treatment works and the suitability of treatment at Capel Curig treatment works.

Risks arising from the Portfolio Risk Assessment, Water Resources Management plan and Zonal Studies are included in other investment cases so no risks were escalated to the resilience risk register.

Service resilience review: This process highlighted additional detail relating to pinch-points in the network and also identified a problem with the design of service reservoirs clustered in the Rhondda area of the SEWCUS zone.

## Operational processes

At an operational level, we reviewed the risks on Investment Manager and concluded that our capital maintenance processes were working well to manage these.

The review of the asset resilience above ground scorecard highlighted the Hereford area as a pinch-point where a major population centre is served by only one water resource. The review recommended an approach to improving resilience performance by focusing on the treatment works in this area.

With below ground assets the scorecard has highlighted that we are missing condition information for a large proportion of our critical mains. Closing these gaps will give us an improved ability to prioritise the remaining resilience risks and for this reason is the first priority for investment. The second highest priority identified is to put in place plans for dealing with asset failures, where they do not currently exist, and reducing the impact to customers and the environment.

A full resilience risk register was developed bringing together the results of the strategic, tactical and operational reviews. The register includes an explanation of the reasons for prioritising some risks over others. The register is included in Appendix A. The risks prioritised for investment in AMP7 are shown in the table below.

| Risk ID | Need | Risk identification approach |
|---|---|---|
| 17 | Improve resilience of contact tanks at treatment works | DWSP, Lessons learnt reviews |
| 32 | Improving treatment of sludge at treatment works | DWSP, Site surveys |
| 18 | Address risk of quality failure at Capel Curig | DWSP |
| 32 | Hereford water supply resilience | Asset resilience scorecards, lessons learnt reviews |
| 22 | Improve network storage | Lessons learnt reviews |
| 23 | Improve network flexibility | Service resilience, lessons learnt reviews |
| 36 & 41 | Reduce risk of failure of critical trunk mains | Asset resilience scorecards |
| 24 | Improve our emergency planning capability | Lessons learnt reviews |
| 27 | Reduce risk of failure of post tensioned concrete tanks | Service resilience |
| 8 | Continue to invest in IT | Welsh Water 2050 |

# 3 Developing solutions to mitigate the prioritised risks

In planning and prioritising investments, we use the 5Rs framework; the four 4Rs set out by the Cabinet Office (Resistance, Redundancy, Reliability and Response & Recovery) as well as 'Reflectiveness'; a quality we believe is essential for incorporating lessons from previous experience into our plans for the future. We consider options and deliver activities across all of the 5Rs. Our overarching investment planning approach is explained in more detail in supporting document 5.1 of our Business Plan.

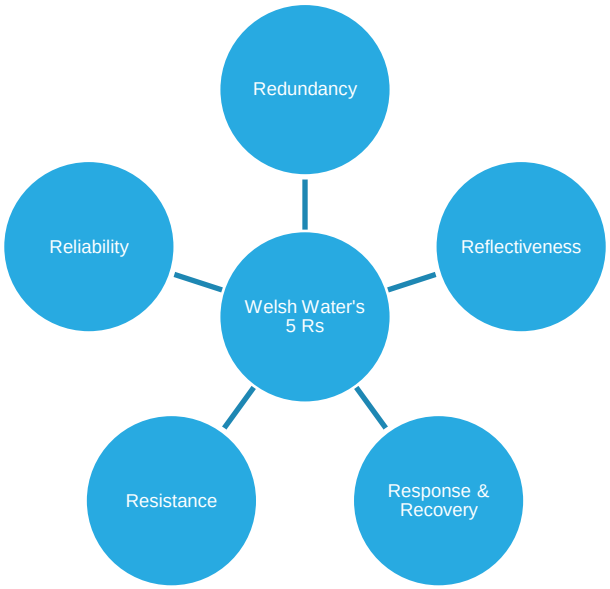


*Figure 2: Our 5Rs mitigation approach*

Our programme is also set within the framework of our legal duties relating to the environment, biodiversity, drinking water quality and supporting national security. We are very mindful of the role we play in delivering the Welsh Government's policies for the water industry, as well as its broader, agenda, such as that set out in the Well-being of Future Generations (Wales) Act 2015.

Following selection of our prioritised risks we spent time developing outline solutions and considering the costs and benefits. We then undertook a further round of review and senior management challenge to identify the options that have formed our selected plan.

The table below shows the projects selected to meet the needs that had been prioritised.

The detailed options appraisal is addressed separately for each investment in section 4

| Risk ID | Solution ID | Proposed solution | Type of mitigation | Selection criteria |
|---|---|---|---|---|
| 17 | WS1 | Package of improvements to bypassess | Redundancy | We identified all risk points and found that bypasses could remove the risk as cheapest option. Replacing tanks would not reduce the risk further. |
| 32 | WS2 | Improving sludge facility at Felindre | Reliability | This site has the biggest risk of this type due to the number of people served. |
| 18 | WS3 | Abandon Capel Curig | Reliability | Most cost beneficial option – also increases network flexibility |
| 32 | WS7 | Additional storage at Broomy Hill WTW | Reliability | Provides ability to manage the loss of supply risk in medium term |
| | | Feasibility of new supply for Hereford | Redundancy | This ensures we can properly investigate long-term options for management of the supply risk |
| 22 | WS9 | Additional storage at Llwynypia | Redundancy | The largest storage pinch-point was in the SEWCUS zone. |
| 23 | WS4 | Improve network flexibility | Redundancy | We prioritised our pinch points across the company and are addressing the most urgent priorities. |
| 36 & 41 | WS8 | Undertake condition assessments and develop response plans for critical mains | Response and Recovery<br>Reflectiveness | This programme is a deliverable improvement to our resilience position for critical mains |
| 24 | WS10 | Improve our emergency planning capability | Response and Recovery | This investment allows us to tackle the most beneficial of our emergency planning improvements. |
| 27 | WS5 | Reduce risk of failure of post tensioned concrete tanks | Reliability | The programme is the most cost beneficial approach to removing risk |
| 8 | WS11 | Improved capability for modelling and understanding risk through predictive analytics and automated responses | Reflectiveness | Improved technology and data analytics will enable us to drive innovation and efficiency in the prioritisation and delivery of improved services and resilience to customers. |

# 4 Optioneering detail for each Resilience investment

## Overview

Following the processes identified in section 2, this section sets out in more detail, for each individual element of investment:

- **The need for investment,** including a description of the key risks that will be addressed through the investment;
- How we are **building on progress** from AMP6, to make the most of our investments over time;
- The **options that we have assessed** to respond to the investment need, and the **preferred option**;
- Any **residual risk** remaining, following investment in AMP7;
- **Innovation** that forms part of each project or programme;
- **Benefits** that we expect to deliver for **our customers** and for **other systems**, reflecting any interdependencies
- The **measures of success,** or performance commitments, that we will use to monitor delivering of these investments.

# Installation of contact tank cleaning assets at water treatment sites

Investment Ref: WS1

## Need for investment

This investment is needed to increase resilience to biohazards at water treatment sites, which pose a threat to public health. These biohazards include cryptosporidium and other bacteriological risks. They can be caused by poor raw water quality, animal activity and ingress into the tanks.

Although cryptosporidium and other bacteriological outbreaks have a low likelihood of occurrence, they could result in boil orders or supply outages for our customers. It is important that we can adequately clean our treatment assets to minimise the risk. From our review of the DWSPs we have identified that ten water treatment works contact tanks do not meet the latest standards. DWI have stated, that any tank that cannot be taken out of service for maintenance is regarded as an inoperable asset. This highlights the severity of the risk and the urgency of the need for investment. New equipment is needed to ensure that these asset are fit for purpose.

The impact of a bacteriological outbreak at these ten water treatment works could be loss of supply to 538,221 customers.

In line with industry best practice, it is expected that regular inspection, cleaning and sampling of tanks used for the disinfection and storage of water reduces the risk to water quality of a cryptosporidium or other bacteriological failure. Several of our contact tank assets were originally designed as single compartment tanks with poor access and without the facility to isolate them whilst maintaining supply to customers. This is a requirement as outlined in the UK Water Technical Guidance Note No.9 (TGN9), which states that facilities should be available to isolate the structure to maintain supply.

The supply network has seen unprecedented demand in recent years in response to droughts and water demand and this has reduced the ability to remove the tanks from service for cleaning and inspection that was historically possible. The drivers for our programme are therefore new resilience standards evolving from service failures and DWI requirements which we cannot ignore.

## Options appraisal

In developing this investment case we have undertaken a comprehensive review of our DWSPs, water quality data, recorded operational constraints and lessons learned following unplanned events.

Three options were considered to improve supply resilience:

**Option 1: reactive only - £0 planned expenditure**

This option focuses on business as usual at the site and we will continue to perform remote live cleaning of tanks i.e. scheduled periodic maintenance. This would have the lowest cost but would not provide the minimum asset standard and will result in higher bacteriological risk to customers.

**Option 2: additional tanks - £10m-30m planned capital expenditure**

The option 2 was to install additional tanks which could systematically allow one tank to be isolated, cleaned and inspected. Whilst the regular cleaning of the contact tanks will significantly reduce the risk of bacteriological growth, this option was most expensive and provided similar benefits to the third option.

**Option 3: bypass pipework - £10.18m planned capital expenditure**

Finally, option 3 to install bypass pipework and associated structures to allow the existing tanks to be taken offline was investigated. The installation of bypasses effectively produces a similar benefit of installing an additional tank, where supply to customers can be maintained while also being able to

perform a full inspection and clean of the existing tank. The installation of a bypass at our highest priority tanks will be a much cheaper option than new tank and produce all of the same benefits.

## Preferred option

Following a cost-benefit analysis, the selected option was to install bypasses at all but one of our highest priority sites, with an additional tank installed at the remaining site.

The bypass schemes consist of installing additional pipework, valves, instrumentation, chemical dosing modifications and improving access to the existing tanks. Using a bypass system will provide similar benefits to installing an additional tank but is more cost-effective and allows for optimisation of existing infrastructure.

The proposed new tank at Mynydd Llandegai was preferred following a bacteriological failure in 2016 where further inadequacies of the existing tank were identified.

These combined measures will allow us to perform full inspection and cleaning as per industry best practice to ultimately reduce the risk of bacteriological growth and boil orders or interruptions to supply to 538,221 customers.

## Residual risk

The success of this option relies on the effective operation of the bypasses. Therefore, these will require regular maintenance so that the tanks can be taken offline for inspections and cleaning.

## Summary of innovation in this programme

An important part of our innovation is batching and timing of investment programmes for more efficient delivery through our Alliance partners. We are proposing to complete the contact tank bypasses earlier in the AMP to allow inclusion in the cleaning programme.

We are also implementing flow cytometry analysis at our Glaslyn Laboratories to give us a greater understanding of the microbiological quality of our water from source to tap to support optimum treatment and we are implementing predictive modelling to highlight areas at risk of water quality failures by our in-house data scientists.

## Benefits for customers

This programme will improve resilience to cryptosporidium and other bacteriological-causing water quality incidents for 538,221 customers. This programme retains the customers' confidence in a clean, continuous water supply.

## Benefits for other systems

Our work to prevent cryptosporidium and other bacteriological outbreaks will reduce the likelihood of supply outages to key services that require service reliability, such as hospitals, and will reduce the likelihood of a spike in use in the energy network from a large-scale boil order.

## Measures of success

The investment to improve contact tank cleaning will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Tap water quality compliance risk index (Wt1) | 0 | 0 |
| Water process unplanned outages (Wt5) | 1.57% | 1.57% |

# Improving Felindre WTW quality resilience

Investment Ref: WS2

## Need for investment

Felindre WTW is our largest WTW, both in terms of volume output and number of customers it supplies (512,000) and is therefore a strategic asset, which is too big to fail.

With increasing extreme rainfall events and prolonged drier summers due to climate change, raw water quality is deteriorating. This is resulting in increasing volumes of sludge of low solids content from the treatment process.

The volume of wastewater and liquid sludge produced by this works is amongst the highest in the company. With limited space available on site to store sludge, pressure is put on upstream treatment processes, primarily first and second stage filtration, if a disposal route is not available. Minimum filter run times are restricted to 20 hours, which during periods of poor raw water quality could restrict treated water output by as much as 20Ml/d. Should there be a treatment failure at either works, which would call for runtimes on filters to be reduced, available space to process and store additional volumes of wastewater and processed sludge would soon be exhausted. The ability to comprehensively process wastewater and treat and dispose of sludge at treatment works when raw water quality is poor is fundamental to the provision of water supply to 512,000 customers.

In addition, there is currently only one local sludge disposal route open to us for this site, due to the low solids content of the sludge. We increasing volumes of sludge predicted due to climate change, we need to open up further economic disposal routes. To achieve this the sludge would have to be processed further to increase the dry solids content. If the disposal route were not available, the company would incur significant cost in transporting the liquid sludge to a processing site a considerable distance away.

Sites like Felindre WTW need to be optimised to respond to the changing raw water quality, especially as unplanned outages are not feasible due to the large population served. The installation of improved sludge handling facilities will improve the capability of the treatment process to adapt to changes in raw water quality and will open up further disposal routes for the sludge produced as it will be of a higher solids content.

This investment is required in AMP7 as we are seeing increasing frequency of poor raw water quality restricting the treated water output at Felindre WTW, which increases the risk of interruptions to supply to 512,000 customers.

## Building on AMP6 progress

Base maintenance is essential to the upkeep of this critical asset. In AMP6, interventions at this asset include media replacement in the CoCoDAFF flotation unit, installing a new chlorination plant and repairs to pipeline from the granulated activated carbon.

Regular monitoring of this asset identified these additional works to satisfy forecasted fluctuations in raw water quality, ensuring resilience at Felindre WTW.

## Options appraisal

Three options were considered to manage sludge production at Felindre WTW:

**Option 1: Reactive only - £0 planned expenditure**

This option is a business as usual scenario which would lead to a continuation of the existing issues and increase the future risk to water quality. Ongoing base maintenance has proved to be insufficient to address the increasing risk of poor raw water quality. There is no planned expenditure associated with this option.

**Option 2: increased sludge storage - £1.0m planned capital expenditure**

Increasing sludge storage at site to provide some additional resilience was considered. However, the increasing volumes of sludge will still need to be disposed of and unless the quality of the sludge is improved, the costs of sludge disposal will increase. There is also an increasing pressure to reduce tanker movements at Felindre WTW due to the narrow roads leading to the treatment works which is currently causing disruption to residents. We have made a commitment to residents to reduce transport movements through the villages which effectively eliminates this option.

**Option 3: de-watering treatment - £2.703m planned capital expenditure**

This involves the installation of a de-watering treatment processes. This option will improve the capability of the treatment process to adapt to changes in raw water quality with increased control over upstream treatment processes during periods of raw water quality deterioration. This option will also open up further disposal routes for the sludge produced as it will be of a higher solids content

## Preferred option

The preferred option at Felindre is the installation of advanced thickening processes for dewatering of existing wastewater reducing the total volume of liquid sludge produced. The solution proposed includes a centrifuge dewatering plant, polymer dosing plant, thickened sludge holding tank, waste water pumps, thickened sludge pumps and associated civil and electrical components. The proposed solution will improve the capability of the process of adapting to changes in raw water quality and secure additional disposal routes.

The cost of the preferred option is £5.35million. These costs were established by our Capital Alliance Partners, Arcadis and have been drawn up based on previous projects and our Unit Cost Database.

We have analysed the costs of the proposed schemes and £1.8m of the total cost is spend to addresses maintenance issues, which would unless addressed now would prevent the centrifuge from operating optimally.

## Summary of innovation in this programme

We will undertake scientific evaluation of different methods of sludge dewatering, including the current industry standard, centrifuging. We will also look at the alternative disposal routes available.

## Benefits for customers

Installation of advanced de-watering processes at this key asset will improve resilience to water supply to 512,000 customers.

## Benefits for other systems

Fewer tankers will be required to dispose of sludge with less congestion on local roads for residents and businesses and a reduced carbon footprint of our operations.

## Measures of success

The Felindre WTW investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Tap water quality compliance risk index (Wt1) | 0 | 0 |
| Water process unplanned outages (Wt5) | 1.57% | 1.57% |

# Capel Curig WTW abandonment

Investment Ref: WS3

## Need for investment

Capel Curig WTW is a single source of supply to approximately 750 customers. Extreme weather, particularly high temperatures and heavy rainfall in the catchment area can lead to a deterioration in raw water quality, particularly high levels of organic compounds and subsequently it is at risk of trihalomethane (THM) failure in its treated water.

In recent years, predominantly in summer months, high levels of THM have been more frequently detected in treated water leaving the works with concentrations peaking at 79µg/l in August 2017.

The treatment process at Capel Curig is a two-stage uncoagulated filtration process with ozone as the primary treatment to treat surface water. This process has not been able to deal with the levels of raw water organics. The use of ozone treatment at Capel Curig has now been deemed an inefficient method of breaking down organic compounds in the raw water and is not in line with current industry best practice for removal of dissolved organics as a primary treatment process. Our own experience has illustrated that due to fluctuations in raw water colour together with inconsistent contact time, ozone has proved ineffective at reducing disinfection by-products at Capel Curig to an acceptable level.

The incident at Broomy Hill WTW, which saw the treatment works shutdown for 24 hours due to the inability for the treatment process to treat the poor raw water quality has emphasised the need for a proactive approach to avoid unexpected supply outages. A post-incident review report recommended reviewing the treatment processes at sites with similar susceptibility. This is particularly relevant to Capel Curig WTW as we have had to shut down the works during periods of poor water quality.

With increased high temperatures and heavy rainfall in the catchment, this asset will require significant modification to produce water of a suitable quality in the future.

## Options appraisal

Three options have been considered for AMP7:

**Option 1: ongoing maintenance - £0 planned expenditure**

Option 1 is continuing ongoing maintenance and monitoring of levels. However, due to the limitations of the existing treatment processes, ongoing maintenance will not address the increasing frequency of poor raw water quality. Tankering activities would have to continue during periods of high THMs in treated water, which risks microbiological contamination and is therefore not acceptable as a long term option.

**Option 2: upgrade and replacement - £1.5m planned capital expenditure**

Option 2 is the significant upgrade or replacement of the existing WTW. This would improve resilience to fluctuating raw water conditions during extreme weather events. However, previous upgrades within the existing works footprint have not proved enough. To fully resolve this issue the works would require at least a coagulation, clarification filtration and disinfection stage to enable sufficient removal of organic material and reduction of disinfection by-products. This would require a new full facility, which would be the most expensive option.

**Option 3: closure and abandonment - £2.101m planned capital expenditure**

Option 3 is the closure and abandonment of the WTW. This would also require bringing in an alternative water supply for customers who currently receive water from Capel Curig WTW. However, this would improve water supply quality particularly with respect to trihalomethanes for customers currently served from Capel Curig following a change of raw water supply.

The 40-year cost of the first 2 options will be significantly more expensive than closure of the WTW with negligible improvements to the level of service provided to the customer.

## Preferred option

We recognise that Capel Curig WTW cannot maintain a reliable supply in its current configuration and so the proposal is to close and abandon the treatment facility (option 3).

The preferred option will also include laying new trunk and distribution mains to supply customers. The alternative treated water to supply existing customers will come from Llyn Conwy WTW where a new main will connect to the existing network at Betws-y-Coed which will significantly improve the quality of water supplied to customers. The additional infrastructure required for this option includes:

- Laying 6.5km of 150mm pipe using open-cut technique from Betws-y-Coed to Capel Curig.
- A 5.5kW pumping station to overcome an altitude difference of 190 metres between the two villages.

The total cost for the completion of these two activities is £2.101 million including efficiencies and risk expenditure for laying main in the part of the route where rock is present at surface level. The cost of option 3 is the most cost-effective of the three options over a 40 year project lifecycle.

Costs for the abandonment of Capel Curig WTW has been obtained through an update of a previous scope of works that was designed in 2009. Costs have been put together using our Solution Target Pricing Tool which makes use of our Unit Cost Database.

## Summary of innovation in this programme

The options development and assessment has taken a strategic and holistic review of water resources across the water resource zone. We have looked at options such as Ion exchange and tried interim mitigation such as bubble diffusers to reduce THMs.

The selected option will increase resilience of the water supply system without the need for extensive upgrades or installation of new treatment processes. It will also reduce the costs associated with operation and maintenance of this ageing asset.

## Benefits for customers

750 customers will see an improvement to water quality by changing supply to Llyn Conwy WTW from Capel Curig WTW. They will also see an improvement to unplanned outages.

## Benefits for other systems

Due to the age of this asset, the existing processes are energy intensive. Therefore, this project will provide environmental benefits through removal of an inefficient treatment facility.

## Measures of success

The investment to abandon Capel Curig WTW will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Tap water quality compliance risk index (Wt1) | 0 | 0 |
| Water process unplanned outages (Wt5) | 1.57% | 1.57% |
| Acceptability of drinking water (Wt3) | 2.4 | 2.0 |

# Network resilience schemes

Investment Ref: WS4

## Need for investment

We have a number of critical trunk mains that are a single source of supply to populations. During extreme weather events, for example, drought and freeze-thaw, these single sources of supply are at risk due to insufficient water resource or bursts.

The schemes currently identified for development, which serve a population of approximately 450,000, have been prioritised using a risk assessment identifying single source water supplies, areas which have a history of interruptions and the population affected following a main burst. The recent lessons learnt from the 2018 freeze thaw and drought events have reinforced the priority of this investment. We will incorporate best practise from other companies into our solution delivery. More detail on the following schemes is provided in our business plan supporting document 5.8H Appendix 1.

### Bwlch Tunnel Bypass, Alwen Trunk Main

The Bwlch Tunnel in North Wales is a critical section of trunk main between our Alwen WTW and Bretton WTW networks. We want to provide a bypass main, both for resilience and to remove the bottleneck resulting from its current limited capacity. The scheme will allow us to move water in both directions in the future, reducing risks of supply interruptions and increasing operational flexibility during a drought.

### Improved Cross Connections within the Rhiwbina system

Our SEWCUS (South East Wales Conjunctive Use System) has a capacity limitation in the section between Rhiwbina and Cefn Mably Service Reservoirs (SRVs) in Cardiff. This restriction means 200,000 customers are at risk of interruptions to supply. We want to enhance service by providing better connectivity in this area, allowing us to move more water in both directions depending on need.

### Additional Main at the River Usk Crossing at Priory Wood

Three mains cross the River Usk at Priory Wood near Newport in South East Wales; a twin raw water supply to Court Farm WTW and a single potable supply from Priory Wood WPS to Catsash SRV. Failure of the potable main at this critical point would mean that 20,000 properties would be without water for over six hours. We plan to duplicate the potable main here to reduce this risk and so improve resilience. The removal of a capacity bottleneck will be an additional benefit.

### Duplicate Crossing of the Llangunnor Main

Parts of Carmarthenshire suffer frequent interruptions to supply in periods of peak demand with up to 7,500 properties losing supply for up to 12 hours. This project will improve resilience by providing a new main from Llangunnor SRV across the River Tywi in Carmarthen.

## Options appraisal

### Bwlch Tunnel Bypass, Alwen Trunk Main

For the North Wales Alwen trunk main:

**Option 1: laying new mains - open cut- £3.0m planned capital expenditure**

Option 1 consists of laying 500m of new 800mm diameter main using open-cut construction methods. Additionally, the works would involve installing valves, monitoring and control equipment to act as a bypass for the Bwlch Tunnel. The subsequent infrastructure would provide 35 Ml/d capacity.

**Option 2: laying new mains- pipe-jacking - £4.6m planned capital expenditure**

Option 2 is very similar to option 1 but uses pipe-jacking rather than open-cut construction. This avoids private gardens and deep excavations at a higher cost and with no additional benefits.

**Option 3: new northern connection - £10.0m planned capital expenditure**

Option 3 considers an alternative new northern connection between the Alwen and Bretton systems. However, this requires approximately 6km of new main in hilly terrain plus new pumping station. Therefore, this option has much higher costs and no additional benefits.

**Option 4: Reactive only - £0 planned expenditure**

This option is a business as usual approach which does not improve resilience but leaves customers vulnerable to lengthy interruptions to supply in the event of tunnel failure. A burst on the most critical section of the Alwen main could represent 8 minutes on our Customer Minutes Loss Measure of Success, the same as our company-wide target for 2025, which is an unacceptable risk. There are no capital costs associated with this option.

### Improved Cross Connections within the Rhiwbina system

To address the resilience issues in the SEWCUS system, three options have been considered.

**Option 1: new pipeline construction- £1.0m planned capital expenditure**

Option 1 consists of constructing two new 500m pipelines of 500mm diameter (including valves and metering) to connect an existing 20" main in the Rhiwbina system to the Llanishen East and West mains from Cefn Mably SRV. This is cheapest option of the three.

**Option 2: new pipeline, alternative route - £1.0m planned capital expenditure**

The option 2 offers similar benefits to that of the first option but considers an alternative route for the new pipeline. The proposed route runs north of Llanishen Reservoir taken off the existing 24" main using a single new 1450m long 600mm diameter main, rather than the two smaller diameter pipes. This option has a higher cost and lower benefit cost ratio. There is also some uncertainty regarding the condition of the existing 24" main and what length of replacement is needed. The single main is less flexible than the twin pipes suggested in option 1.

**Option 3: reactive only - £0 planned expenditure**

This option provides no improvement in service to the 200,000 customers at risk and does not support our long-term strategy for the region. There are no capital costs associated with this option.

### Additional Main at the River Usk Crossing at Priory Wood

To increase resilience at the River Usk crossing, three options have been considered.

**Option 1: new pipeline - £0.8m planned capital expenditure**

The option 1 proposes construction of a 50m 610mm diameter pipeline under the River Usk (including valves and meters). This intervention provides additional resilience and capacity to the supply network and retains the existing 'industrial' main for future use.

**Option 2: conversion of existing main - £1.5m planned capital expenditure**

Option 2 involves converting the existing 36" industrial water main for potable use. This makes use of an existing asset but reduces future operational flexibility. There are also significant practical concerns raised in the feasibility report regarding swabbing the 'highly chlorinated' industrial main, managing WTW discharge wash water etc. Therefore, this option carries a higher residual risk including utilisation of an aged asset and resulted in a much lower benefit cost ratio than option 1.

**Option 3: reactive only- £0 planned expenditure**

This option does not address the risk of the asset or demonstrate an improvement in service to the 20,000 customers.

### Duplicate Crossing of the Llangunnor Main

To improve supply resilience in Carmarthen three options were considered.

**Option 1: new main under river Tywi - £0.8m planned capital expenditure.**

Option 1 includes laying 2km of new 225mm diameter main across fields and under the River Tywi (including new valves and meters). This new pipeline will improve resilience by providing a new supply route into the area of need.

**Option 2: new main over river Tywi- £2.0m planned capital expenditure.**

Secondly, option 2 considers laying 1.6km of new 225mm diameter main alongside the A40 and over the River Tywi. This will be achieved by using the Pont Lesneven and an adjacent railway bridge. The result is a shorter route for the new pipework but has serious practical constraints with rail and river bridge crossings. Several other big issues are with the major traffic management required and the safety risks of working alongside the busy A40 trunk road.

**Option 3: reactive only - £0 planned expenditure**

This business as usual option offers no service improvement for customers who have suffered frequent supply interruptions.

## Preferred option

### Bwlch Tunnel Bypass, Alwen Trunk Main

The option that offered the highest benefit cost ratio was to lay a new bypass for Bwlch Tunnel using open-cut construction. Other than the 'reactive only' option which failed to address resilience issues, this option will cost the least – approximately £3 million. The result will be a more resilient trunk main between Alwen WTW and Bretton WTW networks.

### Improved Cross Connections within the Rhiwbina system

The preferred solution was to lay two new pipelines of 500mm diameter. The added resilience of having two mains in parallel was a key factor in a much higher benefit cost ratio than that of the larger single new pipeline. This option provided the simplest means of providing additional capacity, resilience and operational flexibility.

### Additional Main at the River Usk Crossing at Priory Wood

With over double the benefit cost ratio score, the preferred option was to construct 50m of new 610mm diameter pipeline under the River Usk. This option was overwhelmingly favoured over the option of converting the industrial water main due to the high risks of sterilising the existing main to be suitable for potable water whilst also not addressing issues with ageing pipework. The new pipework under the river means that the industrial main can be utilised for other requirements in future.

### Duplicate Crossing of the Llangunnor Main

The preferred option to improve Carmarthen water supply resilience had a much higher benefit cost ratio than other options. The solution is to lay new pipework under the River Tywi, rather than alongside the A40 and over a railway bridge. The high risks associated with construction adjacent to this existing infrastructure ruled out option 2. The new pipework under the river improves resilience in the most effective way.

## Benefits for customers

This programme of works will significantly increase the resilience of some of our major supply networks by reducing the number of single sources of supply and bottlenecks, improving the resilience of our service to approximately 450,000 customers.

## Measures of success

The network resilience investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Water supply interruptions (Wt2). | 12 | 8 |
| Water process unplanned outages (Wt5) | 1.57% | 1.57% |

# Post-tensioned concrete tanks replacement

Investment Ref: WS5

## Need for investment

A structural assessment has found that a series of four SRVs in the Rhondda valley are at risk of catastrophic failure due to their structural integrity. As these reservoirs were constructed at the same time and are of identical design, therefore they are likely to fail within a close period of each other.

This system is in series and only feeds from one treatment works so any failure would cause the system below it to not be able to feed customers. With no alternative supply source into this region, failure could mean up to 24,000 customers losing a supply for greater than 3 hours and may affect the service to 39,000 customers.

The risk of catastrophic failure at an unknown time and the large number of customers impacted has highlighted the need for resilience investment at these sites to mitigate the risk.

## Building on AMP6 progress

### AMP6 Progress

At each SRV a high-level feasibility report has been undertaken regarding the replacement and repair of these tanks. The objective of these reports was to identify:

- the needs and root cause of any issues, with a view to developing suitable solutions;
- the options, scope and cost associated with reinforcing the structures, to ensure the structural integrity and resilience of the SRV; or
- the options, scope and cost associated with replacement of the existing SRV.

Additionally, a summary of the costs from the high-level feasibility assessments was undertaken, which informed the optioneering process.

## Options appraisal

The three considered options to address the issue at the SRVs:

**Option 1: reactive only - £0 planned expenditure.**

This business as usual option does not address the issues identified. There is a risk of contamination of water through contact with the aging structure. Furthermore, a structural failure could lead to a catastrophic collapse of the structures releasing up to 2250m$^3$ of water per tank onto the nearby properties. There are no capital costs associated with option.

**Option 2: replace existing tanks- £13.581m planned capital expenditure**

Option 2 was to demolish the existing tanks and replace them with new storage tanks on the same sites due to limited space at the site.

**Option 3: refurbish SRVs - £3.0m planned capital expenditure.**

Option 3 was to refurbish the four SRVs to extend their design life. However, due to the structural condition of the tanks and their close proximity to one another, we have been advised by a structural engineer that effective repair is not feasible.

## Preferred option

Option 2 was selected following a cost-benefit analysis. The tanks are over 50 years old, therefore full replacement with new structures of safe and proven design will minimise the risk of asset failure and produced the highest positive benefit cost ratio. The new structures will provide a significant increase in resilience of the supply network for the 39,000 customers.

## Delivery risk

Operations have confirmed that the site cannot be taken off-line completely for the duration of the works, to allow demolition of the existing tanks and construction and commissioning of new. At present, Operations take one tank at a time out of service during regular maintenance; a process that can often last for 2 to 3 weeks at a time. This procedure will have to be repeated for the replacement of the tanks, albeit extending over a longer period.

Therefore, the tank replacement will be in a phased approach with each new tank fully tested and commissioned prior to taking the next tank off-line, in readiness for demolition. This will necessitate temporary valves and pipework to maintain operation.

As a result, it will be necessary to demolish a tank which is immediately adjacent to a live tank. It will thus be required to monitor the effect of the adjacent demolition works on the tank, in order not to further compromise its structural integrity.

## Summary of innovation in this programme

Hydraulic modelling will ensure that we identify the optimum configuration to maintain sufficient storage in the network where it is most needed.

## Benefits for customers

Proactive replacement of the SRVs will provide greater reliability of water supply to 39,000 customers.

If we waited for catastrophic failure before replacing the tanks, it would result in high volumes of retained water flooding the local area. There are several residential streets which would be at risk of flooding. Additionally, a catastrophic failure would result in a prolonged water supply outage, potentially lasting several days. However, this programme will significantly reduce the risk of these events, increasing long-term resilience of these SRVs.

## Measures of success

The investment for post-tensioned concrete tank replacement will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Water supply interruptions (Wt2) | 12 | 8 |
| Water process unplanned outages (Wt5) | 1.57% | 1.57% |
| Asset resilience (water network + below ground assets) (Ft7) | 47.0% | 56.0% |

# Extending our South Wales Grid

Investment Ref: WS6

## Need for investment

Our two largest supply zones are South East Wales Conjunctive Use System (SEWCUS) and the Tywi Conjunctive Use System (TCUS). The SEWCUS zones distributes water from 12 WTWs to the Newport, Cardiff and South East Wales valleys areas and serves 1,435,000 customers. TCUS zone distributes water from Felindre WTW, our largest WTW facility to 600,000 population. These zones are adjacent but there is very little connectivity between these areas of supply.

Drought places a risk of supply interruptions of between 12 and 24 hours for 54,283 properties at the furthest extents of these two networks. When the overall network is experiencing high demands, such as during the 2018 heatwave, these properties will be the worst affected.

In addition, TCUS is heavily reliant on Felindre Water Treatment Works, which is the largest treated water input into this system providing an average of 118 Ml/d. In the event of a failure approximately 240,000 properties and business would be affected by an outage once the limited network treated water storage has been used.

Similarly, two of the WTWs in the SEWCUS zone, Cantref WTW and Pontsticill WTW have experienced landslips due to heavy rainfall. These landslides have the potential to cause unexpected supply outages.

The SEWCUS and TCUS zones also have strategic importance for the resilience of water supply in the South of England. The SEWCUS zone is the best placed zone to provide water for the Severn Trent operating area in the case of a drought. However, without an east-west connection to the TCUS zone to serve our existing customers, there may not be sufficient water resource in the SEWCUS zone.

## Customer and stakeholder support

Consultation with customers as part of Welsh Water 2050 showed that they prioritised ensuring future reliability of water supply.

Customers explained that water sharing initiatives (across Wales) are very well supported. The idea of raising revenue by selling water with England is also well supported, providing this is at low environmental cost.

## Building on AMP6 progress

In AMP6, we have completed feasibility studies to improve connectivity between SEWCUS and TCUS. These studies showed that the installation of additional connectivity will improve the resilience of both zones by improving the connections.

## Options appraisal

There are three options that were considered to improve the east-west links of South Wales.

**Option 1: reactive only - £0 planned expenditure**

This business as usual option fails to address the resilience and operational needs of supply to South Wales. Therefore, this exposes more than 50,000 customers to potential supply interruptions of 12 to 24 hours, which is an unacceptable risk.

**Option 2: new pipe and pumps- £22.0m planned capital expenditure**

Option 2 involves:

- installation of 12 km of 900mm PE pipe – from Cefn Hirgoed to Llantrisant;
- installation of 4km of 900 mm PE pipe – from Port Talbot to Margam; and
- new pumps identified to move 311l/s @ 66 metres head at Cefn Hirgoed PS.

This option will cost £22m and provides a bi-directional transfer of 30Ml/d from West (TCUS) to East (SEWCUS).

**Option 3: new bi-directional main- £37.5m planned capital expenditure**

Option 3 is to install a bi-directional main between Cefn Hirgoed SRV in TCUS and Tongwynlais SRV in SEWCUS for 30-50 Ml/d. The estimated cost is £37.5m. This would be a stronger and more flexible link between the two zones than Option 2 but provides only a slightly higher reduction in risk for a significant extra cost.

## Preferred option

The preferred solution is option 2 which provides fully bi-directional transfer at a capacity of 30 Ml/d. This option generated a benefit cost ratio of 1.4, over double than that of option 3 whilst also costing less. By maximising capacity of the new pipework, the resilience of the supply network is guaranteed and can allow further growth and development of Wales.

## Residual risk

The proposed link provides for 30 Ml/d to be transferred between the two zones. This may not be enough to manage all the risks we face. We will continue to monitor the risk position as the populations of both areas grow and operational events occur to assess whether further improvements would be valuable.

## Benefits for customers

The biggest customer benefit will be a more robust water supply network for 1,435,000 customers, particularly when facing extreme weather events. This will result in shorter and less frequent outages through provision of alternative sources for supply.

The benefits of this project will be to provide a bidirectional water supply from the SEWCUS to TCUS of at least 30 Ml/day. This volume of water will provide for up to 60,000 properties or 25% of the total average demand from Felindre Water Treatment Works (TCUS) in the event of a catastrophic failure at the site or periods of extreme demand. It will also provide the opportunity for Felindre WTW to reduce outputs for maintenance activities.

Similarly, there is a restriction of 18Ml/d on abstraction of the Wye and Usk rivers which puts strain on the SEWCUS system in times of drought. This bi-directional water supply allows the TCUS to support the SEWCUS zone in these circumstances.

## Benefits for other systems

This programme of work has strategic significance for water resilience across the UK. We are exploring water trading options with other companies. The SEWCUS zone is the best placed zone to provide water for the Severn Trent operating area in the case of a drought. It is also the primary source for potential bulk supply transfers to Thames Water. This has been the basis of discussions between ourselves. Thames, Severn Trent and United Utilities. However, without an east-west connection to the TCUS zone, to serve our existing customers, there may not be sufficient water resource in the SEWCUS zone to allow this transfer.

## Measures of success

The additional interconnectivity investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Water supply interruptions (Wt2). | 12 | 8 |
| Risk of severe restrictions in a drought (Ft1) | 4% | 0% |
| Asset resilience (water network + below ground assets) (Ft7) | 47.0% | 56.0% |

# Hereford water supply resilience

Investment Ref: WS7

## Need for investment

Currently there is only one water treatment works that supplies Hereford, Broomy Hill WTW, which serves a population of 117,000. The raw water source for Broomy Hill is the River Wye. However, this river experiences significant fluctuations in water quality during river spate conditions after extreme rainfall events. Therefore, treatment facilities require a wide range of capabilities to cope with the varying inflow qualities.

Broomy Hill WTW supplies ten service reservoirs, 22 water pumping stations, 218km of trunk supply mains and 1100km of distribution mains and the inability to maintain a clean water supply would cause a significant shock to 61,000 properties and businesses. Therefore, Broomy Hill WTW has been identified as a critical asset due to the impact if it were to fail. This asset fits the DWI description of “too big to fail”.

The Hereford water supply system currently lacks resilience in the event of fluctuations in raw water quality due to extreme rainfall or pollution to the river. The system does not have sufficient storage capacity to provide supply for 24 hours in the event of a failure at Broomy Hill WTW. Additionally, there is no bank side storage facility at the works. This means that any water abstracted from the river is pumped directly into the front end of the coagulation stage with no designated run to waste facility, which would enable the diversion of any sub-optimal treated water.

In addition, there are regular electricity brown-outs in the area that can last up to 6 hours. These can halt our water treatment process and pumping stations, resulting in interruptions to supply.

## Customer and stakeholder support

Consultations were undertaken during the Welsh Water 2050 exercise, including in-depth customer involvement session in Hereford, showed that customers recognise that short-term interruptions to water supply are tolerable but can severely impact day-to-day tasks, whilst a long-term loss of supply is unacceptable. Many businesses admitted that long-term water interruption over 24 hours would force closure.

## AMP6 Incident

On the 24th August 2015, variable and uncharacteristic raw water conditions presented challenges to the automated coagulant dosing at Broomy Hill WTW. With the automated coagulation dosing unable to treat the water effectively at the clarification stage, and the best efforts of Operators and Process Scientists to manually adjust chemical dosing, the works had to be shut down to prevent turbidity levels from breaching Regulation 27 disinfection turbidity limit of 1NTU at the point of disinfection.

With no dedicated run to waste at the works, the decision was made to isolate one compartment of the final water tank to run the non-compliant water to this sacrificial tank. However, treatment at the front end did not improve quickly enough to allow water to be diverted back into supply and the works had to be shut down again to allow time to empty the filled compartment of the final tank.

For planned isolation and cleaning of the tanks the water is usually drained over a 2-day period through the wash water system. However, to drain the tank quickly an over pumping arrangement had to be set up to discharge the water to the river and to the sewer. This temporary discharge to the River Wye was notified as an emergency discharge to the Environment Agency who classified this as a Category 4 pollution incident (minimal impact).

Under normal conditions, waste wash water and sludge from the works are mixed and discharged to the sewer with a maximum discharge of 40 l/s. Following advice from the wastewater network modelling team this was increased to 70 l/s for the duration of the incident. Tankering of wastewater to Eign WwTW was also arranged to maximise the capacity of wastewater storage.

Once the works was restarted and the flows were compliant at the point of disinfection, flows were put into the final water tank compartment and put into service.

This incident resulted in a 24hour works outage. During the outage, storage within service reservoirs in the distribution system depleted significantly but with careful balancing of flows across all tanks, combined with supplementing flows through tankering to some reservoirs, no supplies were lost to customers, nor was there any breach of final water quality parameters.

## Options appraisal

A solution to improve resilience of the Hereford water supply has been considered in two parts a short to mid-term solution that supports customer supply during response and recovery works; and a long-term solution that provides greater resilience to the supply system.

### Short to mid-term solution

This site is supplied by raw water directly from the River Wye and there is no current raw water storage provision

**Option 1: reactive only- £0 planned expenditure**

This is a business as usual option where no investment is planned to reduce the risk of supply interruptions in the short to medium term. There is a risk that we again have a problem with the raw water quality that we cannot resolve in time to avoid interruptions to supply.

**Option 2: increase storage- £13.601m planned capital expenditure**

A study considered the options for both raw water and treated water storage at Broomy Hill WTW. The proposal is to increase the 13.6Ml of treated water storage on site to 47Ml of treated water storage, which would provide around 48 hours of storage.

### Long-term solution

There is no easy long-term solution to the supply of Hereford. The fluctuating water quality of the River Wye makes reliance on this as the sole raw water source potentially high-risk.

**Option 1: reactive only- £0 planned expenditure**

This is a business as usual option where no investment is planned to investigate long term risk reduction options for the Hereford area.

**Option 2: - £50.0m planned capital expenditure**

Although the short to mid-term solution of additional storage at Broomy Hill WTW is needed, an additional level of resilience is required to secure supply to the city due to fluctuating water quality of the River Wye. This will require a feasibility study to investigate long term options. The capital expenditure shown is a high-level cost estimate based on developing a new source and getting the water to where it is needed.

## Preferred option

### Short to mid-term solution

The preferred short to mid-term solution consists of constructing new on-site storage. This would enable the works to continue to supply water until spate conditions had been abated and the river was available for abstraction. These works will also involve improved instrumentation to enable more ‘advanced’ detection of deteriorating water quality to avoid another water quality incident similar to August 2015.

### Long-term solution

The preferred long-term solution is to identify a suitable additional water source for the catchment. We are proposing to complete a feasibility study on this within AMP7 to ensure we fully investigate the

options before committing to a course of action. Possible alternatives could involve connecting to existing SRVs or laying new trunk mains to connect to other WTW. This study to identify a supplementary water source would identify a sustainable solution should the River Wye experience high turbidity or a pollution incident for longer periods.

The cost of this project with be £14.6 million. The cost of the storage has been developed using our unit cost database and a nominal amount has been included for the feasibility study.

## Residual risk

This project will provide additional time to resolve problems in the Hereford area but will not remove the root cause of there being only a single source. This means that a small risk of a serious interruption will remain until a longer term solution has been identified and delivered.

## Summary of innovation in this programme

By undertaking a full feasibility study we will be able to consider a wide range of innovation options before committing to a long-term solution for the area.

## Benefits for customers

In the short term, there will be reduced risk to 61,000 properties and business of supply interruptions at Broomy Hill WTW due to poor raw water quality or energy brown-outs.

This feasibility study will give the 117,000 customers in the Hereford catchment confidence in their future water supply. The implementation of creating an additional water source would enable the system to be significantly more resilient to pollution of the River Wye through provision utilising multiple water sources.

## Benefits for other systems

Hereford County Hospital is located in the city centre and is supplied by Broomy Hill WTW. Ensuring constant supply is vital and the additional storage will allow the WTW to continue to supply treated water whilst River Wye water quality is poor.

Bulmers (Heineken) and other businesses reliant on consistent water supply will benefit from this scheme through significantly reduced supply interruptions.

There will be environmental benefits from reduced discharge into the wastewater network. By providing greater storage capability, incidents similar to the one in August 2015, where significantly higher discharges were over pumped into the sewer system and river, can be avoided.

## Measures of success

The Hereford water supply resilience investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Tap water quality compliance risk index (Wt1) | 0 | 0 |
| Water supply interruptions (Wt2). | 12 | 8 |

# Critical trunk mains assessments

Investment Ref: WS8

## Need for investment

The primary driver for this investment are the interdependencies that the water supply network has with other infrastructure sectors. In particular, we have identified the 53 highest risk locations where trunk sewers cross major roads, rail and river crossings. Pipe bursts at these interactions would have such a significant impact on people, the economy and the environment.

Pipe bursts are challenging to remediate in favourable conditions. However, incidents at these critical locations could result in lengthy unplanned outages of water supply for 70,000 customers and flooding and disruption to the transport sector with impacts on the environment.

## Building on AMP6 progress

During AMP6, we spent £22m on reactive trunk main repairs and replacements throughout Wales. In order to adopt a more proactive approach, we have used asset resilience scorecards to highlight critical trunk sewers that cross other infrastructure, such as railways, roads and river crossings. Any network failure in these locations would have the greatest impact on people, the environment and the economy.

## Options appraisal

**Option 1: reactive only - £0 planned expenditure**

This business as usual option does not address resilience issues at these crossing locations. Without understanding the condition of our key trunk mains, the opportunity to proactively remediate pipes and prepare for emergency situations becomes significantly reduced.

**Option 2: assessments on critical trunk mains - £3.627m planned capital expenditure**

The option 2 is to carry out assessments on the 53 highest risk trunk main - road, rail and river crossings. This will allow mitigation and preventative works to be identified and carried out and emergency plans made for the event of failure in the future.

To create full resilience of these crossings will require engineering works, in some cases moving the pipes and in others providing duplication. We have settled on a staged approach to improving resilience by concentrating on building event mitigation plans rather than jumping to the expensive, comprehensive solutions.

## Preferred option

The preferred solution is to carry out assessments of the 53 highest risk trunk main-road, rail and river pipeline crossings across our area. The approach is two-phased. The first phase consists of condition assessments of critical crossings. Understanding the condition will allow us to understand the risk of failure and the urgency of implementing full resilience schemes.

The second part of this work is to develop emergency repair plans, allowing for a rapid repair in the event of a failure. The plans will define the location of isolation valves, how to restore supply, how to fix the burst and the plant, specialist skills and spares required to do this. This will inform our plant and spares inventory and future training needs.

## Residual risk

Access and other constraints may prevent a complete assessment of some trunk mains. This may add difficulty in determining the condition of these pipes.

## Summary of innovation in this programme

Innovations in condition survey techniques for trunk mains will be adopted to allow us to develop suitable methods to inspect our often difficult to access mains and provide us with a picture of the risk

they present. These innovation techniques include: electro-scan, radar flow survey and sonar. We are also undertaking research on the use of drones to monitor for leakage.

## Benefits for customers

By conducting proactive assessments of these critical trunk mains crossings, we will be able to reduce the risk of unplanned interruptions to supply across our operating area for 70,000 of our customers. We will also be able to plan the remedial works reducing the costs and disruption to customers.

## Benefits for other systems

The impacts of trunk mains burst at one of the 53 strategic locations would have a significant impact on the transport network, for example, the London to Swansea main train line or the M4 motorway. This would cause significant disruption and have a significant impact on the economy of Wales.

## Measures of success

The critical trunk mains assessments investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Water supply interruptions (Wt2) | 12 | 8 |
| Water mains bursts (Wt4) | 133.2 | 128.4 |
| Leakage (En4) | 171 | 148.4 |

# Additional storage at Llwynypia Quarry tanks

Investment Ref: WS9

## Need for investment

Our Llwynypia Quarry SRV, near Tonypandy in the Rhondda Fawr valley, serves over 11,000 customers. The site comprises two storage tanks.

Llwynypia Quarry SRV is heavily relied upon as a storage facility to supply the South East Wales Conjunctive Use system during droughts and asset failures. As the frequency and length of droughts increase due to climate change impacts, the stress on this asset is likely to increase. Without this asset, the risk of interruptions of supply to 11,000 customers would increase. Therefore, this programme is essential to prevent unexpected supply outages.

## Building on progress

### AMP6 Progress

In AMP6 we spent £20m on SRV maintenance for a range of schemes including some feasibility studies for Llwynypia Quarry tanks and Hirgoed refurbishment.

## Options appraisal

Three options were investigated to improve resilience of these SRVs.

**Option 1: Reactive only- £0 planned expenditure**

This option does not address the risk of interruptions to supply to the 11,000 customers.

**Option 2: new tanks with a capacity of 4,840m$^3$ - £3.229m planned capital expenditure**

Option 2 is to build four new tanks. This would more than double the current operational capacity to over 4,840m$^3$ and provides 24hrs of retention at maximum outlet flow.

**Option 3: new tanks with a capacity of 4,070m$^3$ - £2.715m planned capital expenditure**

Option 3 is to build four new tanks with a reduced storage capability of 4,070m$^3$ volume, rather than 4,840m$^3$. This reduction provides 24 hours of retention but at average outlet flow.

## Preferred option

The chosen option was to replace all four tanks with four new tanks with an operational capacity of over 4,840m$^3$. A key consideration was the provision of enough retention at the site to provide 24 hrs supply at maximum outlet flow rather than the average usage. This option reduces the risk of a supply interruption from four 12-24 hour outages a year to two 3-6 hour outages a year for 11,000 customers.

## Residual risk

The increase of storage will provide us with additional redundancy during a drought or asset failure, in particular trunk main bursts. However, trunk mains will continue to deteriorate and result in more frequent bursts. Therefore, as a stand-alone solution, this is a short to mid-term fix. When combined with the other programmes such as “critical trunk mains assessments” and “network resilience schemes” this becomes a suitable long-term approach.

## Summary of innovation in this programme

Construction of tanks is an area where we are working with our suppliers to develop off-site construction techniques using standard and improved quality processes.

## Benefits for customers

This scheme will see a significant increase in redundancy of the water supply network and reduce the risk of interruptions to supply for 11,000 customers.

## Benefits for other systems

The South East Wales is one of the most heavily populated regions. Therefore, maintaining a consistent water supply is essential for domestic and business purposes. The increase of emergency storage at Llwynypia Quarry SRV will allow resilience during the low probability, high-risk asset failures for this area of Wales.

## Measures of success

The improvement to storage investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Water supply interruptions (Wt2) | 12 | 8 |
| Asset resilience (water network + below ground assets) (Ft7) | 47.0% | 56.0% |

# A range of projects to improve our emergency planning capability

Investment Ref: WS10

## Need for investment

We recognise that however good our planning and risk assessment, there will always be risks that we cannot predict; the 'unknown unknowns'. Depending on the nature of such an event, it could potentially impact up to 3 million customers. While the types of issue likely to cause an emergency, such as prolonged drought or critical failure of a mains requiring tankering aren't particularly high risk, the consequences of such an event would have an impact on many customers and other stakeholders.

We know that our customers expect us to be able to react rapidly to emergency events to restore normal operations.

Customers view any interruption to water supply very unfavourably and so capacity in an emergency is a priority for us. Any lack of investment in emergency planning will put at serious risk our ability to respond to any incident that may occur within our network. An event of any duration is likely to result in multiple complaints and loss of trust in our company.

## Building on AMP6 progress

Over AMP6, we experienced several extreme weather events, including freeze thaw periods and extreme drought over summer 2018. We have learned lessons from these events to improve our response to future emergency events.

During AMP6 we have invested in the following areas:

- Emergency equipment storage.
- Command and control centres.
- Business continuity facilities.
- Emergency equipment.
- Planning around emergency situations (e.g. a review of our impounding reservoir inundations plans).

## Options appraisal

**Option 1: reactive only- £0 planned expenditure**

This business as usual option, includes no increase in investment and does not help us proactively prepare for resilience.

**Option 2: optimise emergency planning- £0.541m planned expenditure**

This to arrive at this option we reviewed options presenting a range of level of investment in this area. We maintain an incident tracker, setting out lessons learnt from across our incidents in water. This was used to determine options. Through our governance processes, these options were reviewed by our executive team, and a preferred option selected, which is a mix of small solutions designed to individually supplement our response capability.

At a programme level, we have determined that we need to invest proactively across all of the 5Rs, and this represents a significant element of our response and recovery programme.

## Preferred option

Our proposed AMP7 expenditure is more than AMP6 due to a greater focus on resilience and greater preparedness from our experiences and lessons learnt from recent spells of extreme weather. In particular, we will optimise tanker base locations and other emergency equipment and we will enable tankering into hydrants. We also plan to develop quiet pumps for our tankers to reduce noise complaints when we must use them.

## Residual risk

This programme aims to react quickly to any emergency conditions so there is a residual risk that even with plans in place, that the solution could not be deployed fast enough leading to leakage or periods of no supply.

However, the scale of the emergency could be larger than anticipated and the proposed solution is not enough to continue operation as usual.

## Summary of innovation in this programme

We are working closely with other water companies and suppliers to ensure we maintain the best possible equipment to allow us to respond to emergencies.

## Benefits for customers

Improving our provision for emergency situations will improve our customers confidence in their water supply and will aim to reduce the length of time of any outages. Customers have shown willingness to tolerate short periods of downtime so working to reduce these times will improve the customer experience.

Many businesses rely on a secure source of water, and any outages or periods of poor quality could result in loss of income or business closures.

## Benefits for other systems

Improved response to emergencies will reduce the impact any events will have on neighbouring systems, from impact to the transport network to ensuring water supply to key services which require a robust supply of water, like hospitals.

Being able to respond promptly to incidents will support the collaborative approaches to emergencies planned for by the Local Resilience Fora.

## Measures of success

The emergency planning investment will be measured against several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Water supply interruptions (Wt2) | 12 | 8 |
| Water process unplanned outages (Wt5) | 1.57% | 1.57% |

# Information systems projects to provide greater resilience

Investment Ref: WS11

## Need for investment

If we are to strengthen our long term resilience, we need to harness emerging technological opportunities to improve our understanding of our water networks, including their interdependencies and vulnerabilities.

We believe that the ever increasing capability of Information Systems (IS) could enable us to understand and control our assets better. It will also improve our ability to respond in real-time in the event of an unexpected incident.

With increased information systems (IS) capability, we will be able to understand and control our assets better. We will also be able to respond better in real-time in the event of an unexpected incident.

This enabling investment will benefit all our programmes and all our customers.

A better understanding of events as they happen across the network will improve our response to failure incidents and strengthen our ability to cope with challenging conditions, such as heavy and prolonged rainfall or drought. The aim is also to improve our ability to have centralised and flexible response. Improving our IS systems will also allow us to identify the early warning signs of asset failures and respond before major incidents occur so that we can mitigate the impacts.

## Building on AMP6 progress

Our approach to using Information Systems (IS) to improve resilience was developed across AMP6. The primary activity was to leverage data and IT to deliver an improved streamlined process and more efficient operations. Across the last investment cycle the focus was on improving the key areas of telemetry, control and automation allowing real time decisions to be made about the operation of assets while also allowing for centralised oversight.

## Options appraisal

We have developed a vision and strategy for AMP7, and it was fundamental that our options were aligned with this. Our vision is to invest in people and technology to improve predictive capability, use artificial intelligence and continuous improvement through machine learning.

We have adopted an agile approach to development across our IS portfolio. Given the speed of IS technology development, we must avoid unnecessary obsolescence. We therefore want to retain maximum flexibility to utilise the IS solutions that emerge in the years ahead. Enabling this adaptability was also a fundamental part of our options assessment.

We reviewed options to invest in our underlying infrastructure, improve our ability to analyse data, and have a direct interface with customers. Through our governance processes, options were presented to our executive team to support decision-making.

## Preferred option

Our preferred option combines IS activities that will align with our 2025 IT strategy, fundamentally improving our underlying infrastructure and our analytics capabilities. This will lead to improved customer experience. In particular, we are proposing the development of a system that will track our jobs and allow customers to live track technicians. This aligns with best practice from a range of other sectors, and with feedback from our customers.

Currently, some assets require manual intervention on site, which given the geographical constraints of our operational area can be challenging. Developing IS systems that would allow for a centralised response would improve response times and allow for solutions to be tailored to the particular incident.

Our IS programmes would allow for more effective operation and troubleshooting.

## Residual risk

As noted above, whilst additional IS investment improves our capability to reflect, learn and respond, it can also increase our vulnerability to cyber-attacks.

## Summary of innovation in this programme

Innovation is at the heart of our approach to IS. These include:

- implementation of real time monitoring, both of assets and of technicians carrying out jobs to improve the customer experience;
- integration of IT and operational data collection. This will allow us to take a bigger picture view of the data gathered and increase collaboration between; and
- testing of robotic process automations.

## Benefits for customers

Investment in our IS systems will have a related effect of reducing disruption to service and increasing reliability in the future. Our planned investment in live updates for customers will also improve their overall experience in interacting with our business.

## Benefits for other systems

Our IS system is fundamental to so many of our other systems. As set out above, this programme is a critical enabler for resilience. It will benefit across our water system, our people system and beyond.

## Measures of success

The IS investment is an enabler and will ultimately contribute to improvements to several PR19 Performance Commitments. These are:

| | End of AMP6 position | AMP7 Target |
|---|---|---|
| Asset resilience (water network + above ground assets) (Ft6) | 84.0% | 86.5% |
| Asset resilience (water network + below ground assets) (Ft7) | 47.0% | 56.0% |
| Asset Resilience (impounding reservoirs) (Ft5) | 92.2% | 95.5% |

# 5 Cost efficiency and innovation

## Cost efficiency

Our costs are built up using our Unit Cost Database (UCD), and then efficiencies are applied, based on the recent performance of our Capital Delivery Team and Alliance partners. The efficiency challenge that was used in our plan is set out in Supporting Document 3.6 of our business plan.

The post-efficiency costs for each element covered in this paper are presented below:

| Investment programme | | Resilience enhanced budget post-efficiency challenge |
|---|---|---|
| Installation of contact tank cleaning assets at water treatment sites | WS1 | £10.180m |
| Improving Felindre WTW quality resilience | WS2 | £2.703m |
| Capel Curig WTW abandonment | WS3 | £2.101m |
| Network resilience schemes | WS4 | £5.308m |
| Post tensioned concrete tanks replacement | WS5 | £13.581m |
| Extending our South Wales Grid | WS6 | £19.908m |
| Hereford water supply resilience | WS7 | £13.601m |
| Critical trunk mains assessments | WS8 | £3.627m |
| Additional storage at Llwynypia Quarry tanks | WS9 | £3.229m |
| A range of projects to improve our emergency planning capability | WS10 | £0.541m |
| Information systems projects to provide greater resilience | WS11 | £29.602m |
| Principal use adjustment | | £10.044m |
| Total Resilience enhancement investment (post-efficiency) (Line 14) | | £114.426m |

Major capital investment schemes are delivered by our Capital Delivery Alliance and our in-house engineering team. Our Capital Delivery Alliance consists of three consortia partnerships and has been in place since 2015. The Capital Delivery Alliance contract is a long-term arrangement extended to 2025, which will allow us to deliver significant improvements in efficiency.

There are benefits to working collaboratively with our partners, including:

- Providing visibility of the AMP7 programme so that the Alliance can start advanced planning for AMP7 in AMP6.
- Creating a rolling three-year programme to enable planning and packaging of work based on geography and/or technical specifications to reduce design input, increase supply chain leverage and use of standardised products and offsite construction.
- Reducing project management costs through packaging of work into programmes.
- Closer integration with our operations teams in the design phase to align outcomes (service) and costs (whole life costing) with the long-term needs of the business.

This approach enables a consistent size of our capital programme, enabling our supply chain partners to work with a stable resource level, avoiding the wasted costs incurred at previous regulatory reviews in both downsizing delivery resource and then rebuilding again a couple of years later.

## Innovation

We have an innovation strategy, which seeks to deliver our long-term plan "Welsh Water 2050" and support our mission to become a truly world class, resilient and sustainable water service for the benefit of future generations". Our enablers are (also shown in 3):

- **Co-creation and communication:** We will co-create and co-deliver solutions in Wales' unique environment with our partners, and work to communicate our innovation challenges and successes, so as to help develop and improve the regulatory frameworks we work within
- **Resources:** We will assign appropriate resources to innovation, and leverage our skills, time, funding and partnerships so that we are able to deliver the strategic outcomes committed to in Welsh Water 2050
- **Processes and systems**: We will adapt our process and systems to improve traction, to embed value, and provide sound governance so as to better evolve and develop new ways of working
- **People and culture:** We will build an innovative culture, where our people are supported to innovate, learn and succeed by testing ideas through a learn fast and scale up quickly approach

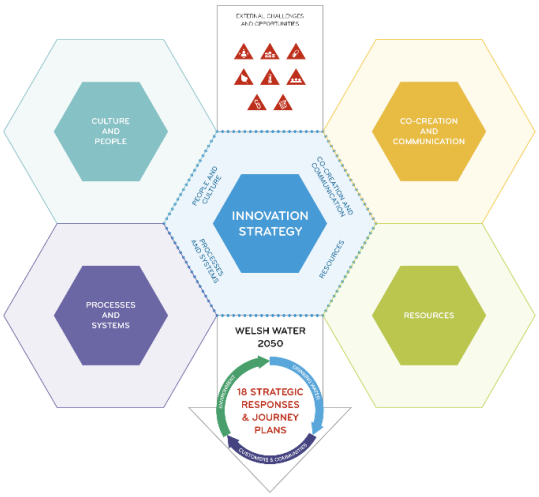


Figure 3: Enablers of innovation

One of our company values is to be ‘open to new ideas’; we encourage development of an environment in which our people are enabled to innovate and take reasonable risks to test their ideas. To support this, we will work with governments to review the regulatory landscape in which we work. By working openly in this way, we can develop the regulatory framework we work within and enable innovative solutions to be co-created and delivered for and with our customers. Our ‘WaterSource’ approach to catchment management including our ‘weed wiper’ partnership is an example of our innovation in practice. See our PR19 Business Plan supporting document Ref 3.3 Innovation for further details.

## Partnering and co-creation

Working closely with our partners is essential to the way we plan to work in the future. Our 2050 strategy highlights this through identifying partners for each of our programmes of future work.

We have a strong relationship with our customers, as well as with external partners such as universities, third sector organisations, our supply chain, regulators, and the Welsh Government amongst others. We recognise that we are unable to achieve our commitments for the future alone, and that we must be flexible in the way we engage with our customers. It is important that they both support our innovations and are part of the solutions.

We aim to enable further innovation by working closely and more openly with our partners to create an environment that supports co-creation and transparent communication. To achieve this, we aim to:

- develop and implement a joined-up approach to working with strategic partners, identifying suitable routes for co-creation and co-delivery in the long term, such as the approach taken to Greener Grangetown;
- collaboratively build a strong evidence base to support improved regulation and policy, making the most of relationships with academic and research institutions such as the GW4 and NERC;
- co-deliver pilot projects with the partners including the supply chain, customers, the third sector and regulators, such as those planned for the Brecon Beacons Mega Catchment;
- build on the success of projects such as RainScape and Rhondda Fach Water Resilient Communities to roll-out new ways of working with partners; sharing cost and benefits equitably;
- build on our existing successes (such as the Innovation Conference) and global relationships to share lessons, pilots and successes across Wales and beyond. We will also continue to build and improve our internal communication and delivery channels so that the right messages are shared with the right people and at the right time;
- develop strong, long-term multi-sectoral partnerships to help deliver innovation for the long-term benefit of water services in Wales; and
- with our supply chain, enable innovation by having the Capital Alliance which fosters innovation and collaboration.

We also recognise our interdependent risks and the need to work closely with power companies (such as WPD and SPEN), the transport network (Transport for Wales) and emergency services to enable us to tackle our interdependent resilience. We continue to assess and understand the changing risks associated with our interaction with highways, railways and other utilities.

# 6 Value for money and affordability

## Impact on customer bills

We understand the importance of balancing the need for investment with the affordability of our bills. We believe the investment will help to deliver the level of service our customers and regulators expect, and represents an optimal approach for sustained long-term improvement.

We confirm that we undertake the best value options to meet our requirements, through our gateway delivery process. We also create schemes that provide us with benefits in the long term. Due to our unique customer ownership model, the costs savings accrued will be passed on to our customers through affordable bills.

Our overall PR19 Business Plan including the water resilience investments resulted in a £22 reduction in customer bills. Customer acceptability testing of our plan found that 92% of our customers found the plan acceptable and 95% found it affordable. Further information of this research including the bill and service package options can be found in our PR19 Business Plan supporting document Ref 1.1 Customer engagement.

## Value for money

We understand the need to demonstrate value for money in everything that we do. In arriving at our preferred solution to the challenges we face in terms of resilience, we have considered the costs and benefits different options to make sure that any investment represents value to our customers.

Avoiding future costs as part of these programmes is key to delivering value for money.

The programmes of work have been developed so that they are delivered in conjunction with other programmes of work. For example, Newport tunnel has been selected, so that it can be delivered in conjunction with planned maintenance.

As outlined in the previous section of this document, we will also seek to ensure value for money by promoting innovation throughout delivery, by learning lessons from the work we have delivered to date, and by working closely with our partners to encourage best practice and incentivise efficiency.

We are assured of the value for money of our schemes by taking them through a risk and value process. This quantifies the cost and risk of each option and the option with the best benefit cost ratio is chosen unless there is a specific reason that this option is not appropriate.

# 7 Delivery

## Procurement

We procure using our Capital Delivery Alliance for most projects.

Information systems (IS) products and services are also procured under a different framework, which is managed by our Business Information Systems (BIS) directorate.

## Programme

We have a gateway approval process that all capital projects must pass through so that there is sufficient scrutiny and challenge from senior management.

There are six stages of the capital investment process and a gateway between each stage. The gateway defines the requirements that are to be met before a project can be approved to move to the next stage. The gateways are as follows:

1. Commit to risk;
2. Commit to feasibility;
3. Commit to solution;
4. Commit to delivery / start on site; and
5. Commit to handover.

Our Capital Programme group (CPG) has the delegated authority to approve projects through the gateways. The approach provides strong governance for approving investment decisions and is transparent and fully auditable.

Where advantageous, we will explore opportunities to advance the progression of the scheme by working closely with our collaborators and our delivery partners.

## Risk mitigation and customer protection

As part of our feasibility assessments, we have sought to understand and document the key risks associated with the planning and delivery of our resilience projects. This information will feed into a risk register that we will use throughout the delivery of the project to actively manage risk – by continually identifying areas of risk and implementing mitigation measures.

We have experience of successfully delivering projects of this nature and magnitude alongside our partners and believe that the risks outlined can be managed to make sure the project is delivered to target and does not adversely impact the interests of our customers.

We have identified a suite of ODIs associated with the performance commitments related to this investment case (as set out above).

# 8 Assurance

## Board assurance

We use the “Three Lines of Defence” model to mitigate risk of non-compliance with our processes and policies.

- First line of defence is ownership and management of risk. This is fulfilled by our operational teams and managers.
- Second line of defence is risk management and risk control. This is fulfilled by our compliance team and internal committees.; and
- Third line of defence is independent review and oversight. This is fulfilled by internal and external auditors, including our technical adviser on regulatory reporting issues (Jacobs Engineering Group) who review our approach to risk and request evidence of risk review in the business.

We have a business assurance “risk assurance map”, which shows the route to escalate risks from the “bottom up”, and the Executive Team have a “top down” discussion of risk every month.

The Audit Committee oversees the risk management process and procedures and reports to the Board. There is an annual risk and compliance statement declaration each year, overseen by the compliance function.

We will continue to apply these effective governance systems for our proposed AMP7 investment programme.

## Cost assurance

We have taken steps to provide accurate scheme costs which were derived from our Unit Cost Database (UCD).

The UCD model is updated annually and externally verified every five years to make sure that costs remain current. This assurance was undertaken by Mott MacDonald by comparing to ‘industry average’ from blending a selection of other water companies’ cost information.

We plan to continually review the costs of the scheme as we move into the detailed design phase. We will seek to drive cost efficiencies in order to keep customer bills affordable.

## Customer consultation assurance

Our customers have indicated that they are very supportive of investments to improve resilience including safeguarding our environment for future generations, putting things right when they go wrong and creating a better future for all our communities.

The approach that we have taken to seek our customer views has been reviewed by our Customer Challenge Group.

## Future assurance

We have strong governance procedures for the planning and delivery of our capital investment. Our Board and audit committee will continue to provide high-level assurance and governance so that we deliver these much-needed improvements in the interests of our customers.

We employ a number of systems and processes to continually monitor and review resilience, at a strategic, tactical and operational level, as shown in Figure 3. These are outlined in further detail in. our IAP test response on securing long-term resilience (B2.7.WSH.LR).

We are currently developing our resilience plan, building on what we currently do. This will be shared with Ofwat in August 2019. This will build on our current processes and will set out our assurance processes for resilience, from risk identification through to mitigation options, monitoring and learning.

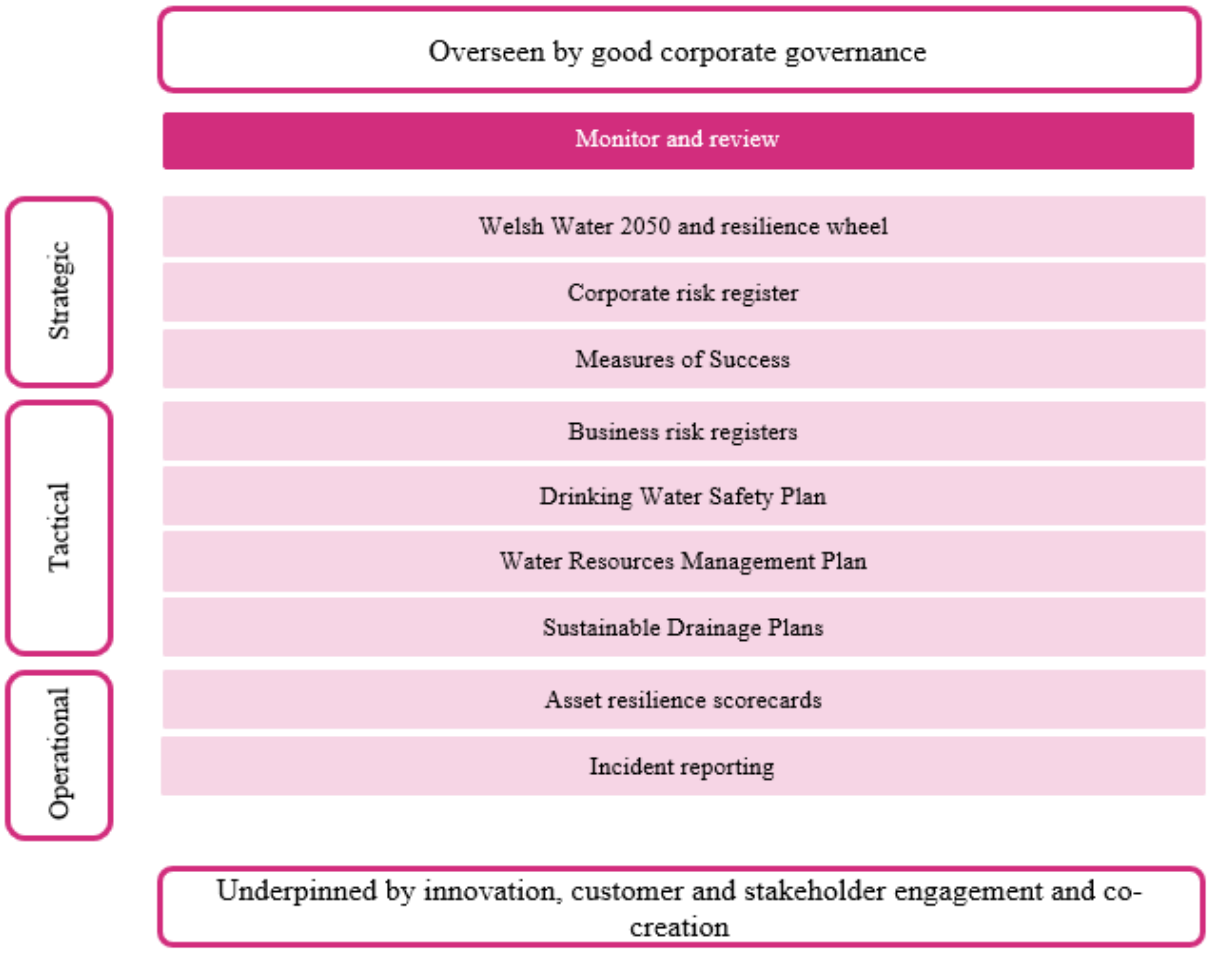


Figure 4: Our monitoring and review process for resilience investment

# Appendix A: Resilience risk register

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 1 | Water 2050 | Water quality | Land management practices in our catchments is out of our control and can affect the quality of our raw water. | Yes | The lead in time for impacts to be felt is long so we should start on a programme of catchment improvements at the earliest opportunity. Develop a programme for catchment management. |
| 2 | Water 2050 | Water Resource | In some areas our customers may be at risk of supply restrictions due to inadequate resource availability | Yes | Ensuring an available supply is fundamental to our service so develop a Water Resources Management Plan ensuring no customer has a risk of restriction even in a 1 in 200 year drought. |
| 3 | Water 2050 | Treatment Asset Resilience | Consider rationalisation of treatment works to reduce operating costs and provide flexibility in ability to use alternative supplies. | Yes | Our current system is not optimal and leaves areas of vulnerability. Identify opportunities to rationalise sites and prioritise those that solve the most significant operational problems where they are cost beneficial. |
| 4 | Water 2050 | Loss of supply to customers | Provision of 8 hours of storage capacity (at peak flow) at treatment works to mitigate treatment failures and retain supplies to customers | Yes | During recent incidents we have had near misses where additional storage would have given us more time to resolve issues. We need to identify highest priority locations for improvements, providing resilience to the most customers |
| 5 | Water 2050 | Treatment - Chemical free treatment | Our water treatment processes use a lot of chemicals. This creates a lot of deliveries and the supply chain is not robust. Consider chemical free treatment to cut dependence and minimise environmental impact | No | Technology not yet robust enough for use at strategic assets. Monitor developments in the industry and trial any promising technologies but do not invest at this time. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 6 | Water 2050 | Loss of supply to customers | Our network is not well connected and leaves areas with too high a risk of supply interruptions. | Yes | The lack of flexibility is a key difficulty. To resolve all pinchpoints will take significant investment over a number of AMP periods. Programme to be prioritised. The link between our SEWCUS and Towy systems is the first priority as these are the largest population centres. |
| 7 | Water 2050 | Customer service | Worst served customers - We have a register of c. 1000 customers receiving significantly worse service than the majority of customers. Customers expect a standard level of service. | Yes | It is important to address this - which is a serious service failure for too many customers but include a modest programme within AMP7. Invest in long standing problems where operational solutions have not resolved customer issues - targeting the largest clusters of customers. |
| 8 | Water 2050 | Customer service | Customer service - customers expect us to adapt our service to be comparable with companies in other sectors and adopt modern technologies. If we don't adapt then they will lose their trust in us. | Yes | Our customer research highlighted that keeping up to date with service technology was expected as a key priority. Review options for enhancing our service offering. |
| 9 | Water 2050 | Customer service | Smart water system - technology is advancing and gives us greater capability of identifying problems before service failures occur. | Yes | In order to continue to improve customer service and meet our commitments we will need to adapt our analysis and technology capability. Include element in plan for ongoing improvements. |
| 10 | Water 2050 | Water Quality | There are too many properties in Wales using lead pipes for their supply and risking serious health problems | Yes | This is a priority for DWI and Welsh Government. Include as a specific investment programme. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 11 | Business risk register | Drought resilience | There are areas of our region where customers supply is at risk in times of drought. | Yes | Ensuring an available supply is fundamental to our service. The plan for strengthening supplies should be informed by the drought plan. Small schemes for addressing local pinchpoints should be addressed in our base plan |
| 12 | Business risk register | Treatment Works failure | We need to ensure we have up to date total loss contingency plans for treatment works failures so that service disruptions are minimised. | No | Updating of total loss contingency planning is business as usual – no need for additional investment. |
| 13 | Business risk register | Trunk main failure feeding Cardiff | Failure of 48" main feeding Cardiff, failure would lead to flooding of M4 and significant loss of supply | Yes | The impact of this failure would be too large and there are concerns about the condition but total replacement would be too costly at this time. |
| 14 | Business risk register | Failure of Dam | Failure of a dam leading to loss of life | Yes | We have S10 legal requirements that we must meet. Included in a separate reservoirs programme. |
| 15 | DWSP Catchments | Water quality | Land management practices in our catchments is out of our control and can affect the quality of our raw water. | Yes | This is important for long term planning. It has been selected for investment in relation to risk 1. |
| 16 | DWSP Catchments | Water quality | Risk of pollution reaching treatment works could be reduced by installing full coverage of pollution monitors to reduce risk. | No | Our highest risk source on the River Dee is protected. These monitors are expensive and prone to failure. We will keep other sites under review as technology develops. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 17 | DWSP WTW | Water quality | Unable to clean some contact tanks due to single compartment construction. Risks bacteriological failures. | Yes | We have seen failures as a result of this problem. This risk needs to be addressed. Identify all sites where this is a problem and develop solution options. |
| 18 | DWSP WTW | Water quality | Deterioration of raw water impacting performance or customer service, particular locations of concern are Pontsticill, Capel Curig, Cefn Dryscoed and Llechryd | Yes | Maintaining the quality of our water is fundamental to our service. Develop options for mitigating risks at the named sites then consider the cost benefit analysis before agreeing programme. |
| 19 | DWSP Networks | Water quality | Risk of bacteriological failure at a Service reservoir | No | Our current base maintenance programme is working well in managing this risk. There is no need for a significant investment programme. Maintain base investment and continue cleaning programme and reactive repair. |
| 20 | DWSP Networks | Water quality discolouration | Risk of customers receiving discoloured water | Yes | DWI have issued legal enforcement notices relating to discoloured water but this isn't a resilience risk. Develop a programme of work under enhancement including manganese removal and mains replacement and cleansing. Follow investment with flushing plans. |
| 21 | Lessons learnt | Water quality | Contact tanks unable to be cleaned identified as problems following bacteriological failure at Mynydd Llandegai WTW and Sluvad WTW | Yes | Duplicate with item 17, for contact and final water tanks. This is too high an impact and needs to be progressed. |
| 22 | Lessons learnt | Strategic asset failure | A number of incidents in the SEWCUS zone have caused interruptions or near miss of interruptions because there | Yes | This is the largest zone serving 1.43 million people. We cannot risk wide scale interruptions. Undertake a full review of storage needs and assess the cost benefit of improvement options. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| | | | was insufficient storage to allow us time to make repairs. | | |
| 23 | Lessons learnt | Extreme weather pinch points | Network storage and interconnectivity pinch points have caused problems in extreme weather | Yes | Small schemes identified in base maintenance but also strategic investment to tackle low probability high impact risks to be prioritised. Consider links between our largest population centres as a priority (SEWCUS and TCUS) |
| 24 | Lessons learnt | Extreme weather pinch points | Emergency planning capability can be improved to respond better to incidents | Yes | We can make improvements in this area at a relatively low cost and hence improve customer service in the event of operational problems. |
| 25 | DWI Audits | Strategic asset failure | Ponsticill and Bolton Hill WTW Audit led to recommendations on reliability of supply. Ponsticill was identified as an asset that cannot be taken out for maintenance without causing supply problems. Bolton Hill is a single point of treatment for a large area and the DWI highlighted concerns that these types of assets should be protected. | No | These recommendations do not drive investment in themselves but they should be taken into account in designing new or upgraded treatment works |
| 26 | Service resilience assessments | Strategic asset failure | We have identified a number of locations where pipes are housed in tunnels. These are high cost and long duration to repair if they fail. | Yes | The consequence of failure of these assets on service would be significant because of the long repair time but the costs of full solutions are expensive. Investigate fully our tunnel assets and develop plans to mitigate risks of service failure and Health and Safety. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 27 | Service resilience assessments | Strategic asset failure | Rhondda Fach service reservoirs. A number of assets of same age and construction technique have developed risks that need addressing in the short term to mitigate total loss of assets. | Yes | There would be no operational response available to maintain service in the event of these assets failing. A solution needs to be progressed. |
| 28 | Asset resilience scorecards Network + above ground | SEMD Asset Resilience | We will meet 100% at each of our sites on completion of the new Bryn Cowlyd WTW | No | No need for further investment in AMP7 as critical assets programme is complete. |
| 29 | Asset resilience scorecards Network + above ground | Power Asset Resilience | A number of our sites have limited back up power overall Resilience is at 74% | No | We have sufficient mitigation in place currently. The cost of backup power is balanced against downstream storage volumes. We also have priority power agreements in place with the Electricity Supply company. |
| 30 | Asset resilience scorecards Network + above ground | Control Asset Resilience | Control resilience is at 89% | No | Base maintenance will maintain this position so no need to prioritise improvements. |
| 31 | Asset resilience scorecards Network + above ground | Treatment Asset Resilience | Treatment resilience is high at 97% | No | Risks manageable through operational intervention so no need to prioritise improvements. |
| 32 | Asset resilience scorecards Network + above ground | Failure Asset Resilience | Failure resilience is low at 43% over our critical assets. Of greatest concern are Broomy Hill and Felindre that are two large single points of supply with no failure resilience. They are also fed from river sources that could experience poor water quality. Felindre sludge system is not resilient due to unsecured disposal route | Yes | These assets fall into the category of “too big to fail”. This type of risk has arisen in other areas of the register. Prioritise the assets that have the highest risk of failure. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 33 | Asset resilience scorecards Network + above ground | Access Asset Resilience | Access resilience is at 94% | No | Only under the most extreme circumstances would we not be able to access our critical sites so no need to prioritise improvements. |
| 34 | Asset resilience scorecards below ground | Control Asset Resilience | Our asset resilience score for control is 45%. | Yes | Recent severe weather impacts on supply reliability have been extended in duration due to insufficient network control. This investment has been prioritised as these are critical assets and it will make an immediate impact on our CML performance. |
| 35 | Asset resilience scorecards below ground | Isolation Asset Resilience | Our asset resilience score for isolation is 51%. | No | We need an increased understanding of the position before we can prioritise investments. We will use AMP 7 to gather further data. |
| 36 | Asset resilience scorecards below ground | Temporary Works Asset Resilience | Our asset resilience score for temporary works is 46%. | No | We need an increased understanding of the position before we can prioritise investments. We will use AMP 7 to gather further data. |
| 37 | Asset resilience scorecards below ground | Duplication Asset Resilience | Our asset resilience score for duplication is 35%. | Yes | Progress the schemes to duplicate assets at critical points or to bring supply from other areas. In particular the West East West transfer between our SEWCUS and TowyCUS systems, as this has the biggest impact. |
| 38 | Asset resilience scorecards below ground | Storage Asset Resilience | Our asset resilience score for storage is 32%. | No | We need an increased understanding of the position before we can prioritise investments. We will use AMP 7 to gather further data. |
| 39 | Asset resilience scorecards below ground | Access Asset Resilience | Our asset resilience score for access is 55%. | No | We need an increased understanding of the position before we can prioritise investments. We will use AMP 7 to gather further data. |

| Risk ID | Risk source | Risk Type | Description | Decision | Reason for decision |
|---|---|---|---|---|---|
| 40 | Asset resilience scorecards below ground | Erosion Asset Resilience | Our asset resilience score for erosion is 55%. | No | We need an increased understanding of the position before we can prioritise investments. We will use AMP 7 to gather further data. |
| 41 | Asset resilience scorecards below ground | Condition Asset Resilience | Our asset resilience score for access is 34%. | No | We need an increased understanding of the position before we can prioritise investments. We will use AMP 7 to gather further data. |

# Appendix B: Asset resilience scorecard examples

## Excerpt from the water above ground assets scorecard

| Asset Name | Asset Type | Score (avg) | SEMD | Flood Resilience | Coastal Erosion Resilience | Power Resilience | Control Systems | Treatment Resilience | Failure Resilience | Access Resilience |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Pumping Station | 50% | 0% | 100% | 100% | 0% | 100% | N/A | 0% | 50% |
| B | Treatment works | 91% | 100% | 100% | 100% | 50% | 90% | 90% | 95% | 100% |

Company score (avg) 70%

## Excerpt from the water below ground assets scorecard

| Pipe ref | Resilience score (Avg) | Control | Isolation | Temporary works | Duplication/ reconfiguration | Storage | Access | Erosion River / Coastal | Asset condition / Performance |
|---|---|---|---|---|---|---|---|---|---|
| 1000000 | 75% | 50% | 50% | 100% | 0% | 100% | 100% | 100% | 100% |
| 2000000 | 69% | 50% | 50% | 100% | 0% | 50% | 100% | 100% | 100% |

Company score (Avg) 72%