C5 B

Cost and Efficiency

C5B Technical Annex 02
Trunk Mains and Pipe Bridges Investment Case:
Technical Approach and Business Case

NTPBP-INV-TRU-0526

BRISTOL WATER

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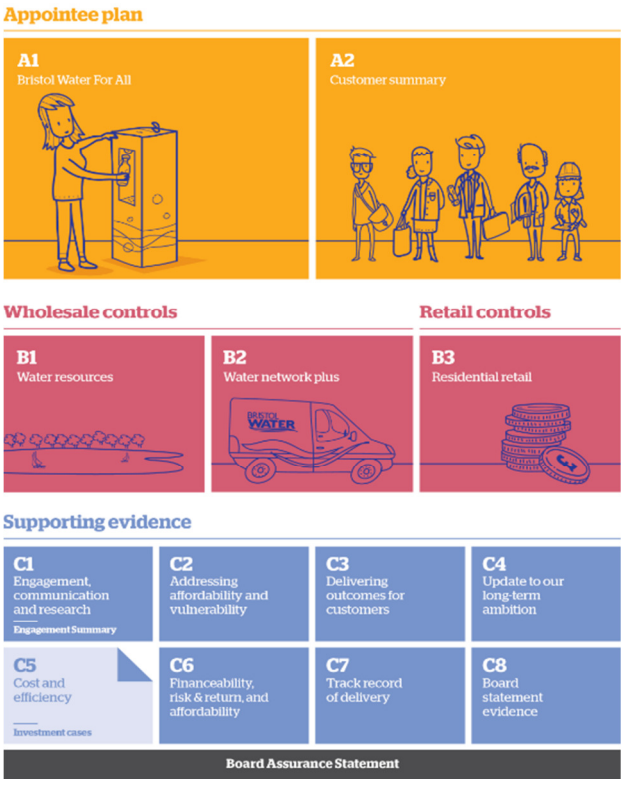
1 Foreword

Trunk mains are defined as mains whose primary purpose is to convey potable water in bulk from a treatment works to a service reservoir or pumping station for distribution, but without direct customer supply from the main. Trunk mains are generally considered to be mains of 12" (300mm) in diameter and above. However, smaller mains that transfer potable water between a treatment works and reservoir, or between reservoirs, with no customer supplies directly from the main are also classified as trunk mains. We currently have 828km of trunk mains that we operate and maintain.

The purpose of this document is to set out our customer led, outcome focused plan which will mitigate risks posed by and associated with trunk mains.

The investment case, one of twenty one, will summarise the facts, risks and investment requirements for trunk mains for the next review period for 2020 to 2025. This investment case will also summarise performance for trunk mains for the current review period from 2015 to 2020 and our methodology for determining and delivering the future trunk mains strategy.

This investment case document is a technical annex to section C5B of our overall business plan submission, as illustrated by the diagram below:



This investment case is aligned to the Water Network Plus Wholesale Control aspect of our business plan. It is recommended that this investment case is read in conjunction with the PR19 Investment Case Summary Document[1] which outlines in detail our methodology for defining investment.

[1] Bristol Water PR19 Investment Cases Summary Document NTPBP-INV-PR1-0635

2 Executive Summary

In order to provide customers with a Safe and Reliable Supply, we will focus on maintaining the level of risk posed by our 828km of trunk main. We will achieve this by using our totex investment approach which includes investment of base maintenance and capital expenditure of £10.732m. We will deliver twelve interventions that will contribute towards the water quality compliance, supply interruptions, leakage, mains bursts and customer contacts about water quality – appearance performance commitments. We will challenge ourselves to deliver more efficiently and apply innovation to the process we adopt to distribute water. When considering our efficient and innovative approach, we plan to deliver our trunk mains capital programme for £9.873m.

At Bristol Water we have completed an extensive customer engagement programme which has identified that one of five key priorities for customers is that we keep the water flowing to their tap and one of our four key outcomes is that we provide a Safe and Reliable Supply.

This investment case will address operational, maintenance or quality issues by utilising a totex approach to determine necessary capital maintenance investment to manage deteriorating assets and water quality commitments.

To deliver our customers' priorities, we will measure progress via performance commitments for which we have set delivery targets both for the end of AMP6 and for AMP7. In AMP7, the trunk mains measures are supply interruptions (target 1.80 minutes per property), leakage (target 36.5Ml/d), mains bursts (target 133/1000km), customer contacts about water quality - appearance (target 0.43 per 1,000 population) and water quality compliance, which is measured against our target for the compliance risk index (target 0). Our compliance risk index performance commitment replaces our current water quality measure of mean zonal compliance.

Unplanned customer minutes lost has been used throughout AMP6 to measure and report on performance related to supply interruptions. It will be replaced by the supply interruptions performance commitment in AMP7. The unplanned customer minutes lost performance commitment was not met for 2017/18. The average amount of minutes lost per property per year (at 73.7 minutes) was significantly affected by an exceptional burst event at Willsbridge in July 2017, which we explained in a detailed case study in our 2017/18 mid-year performance report. In terms of water quality, our current measure is mean zonal compliance, for which we are forecasting to miss our AMP6 target of 100% by just 0.04%.

We have set the level of investment for our trunk mains so that it is sufficient to deliver our performance commitments. Our long term pipe management investment strategy applies to both distribution and trunk mains. It is our intention to replace 20km of pipe per annum to offset deterioration and maintain asset health. This length has been derived on the basis that we are experiencing a deterioration rate in the range of 0.3-0.5% per annum. This will ensure the continued performance of our trunk mains and enable us to continue to deliver a safe, high quality, and reliable drinking water supply to our customers.

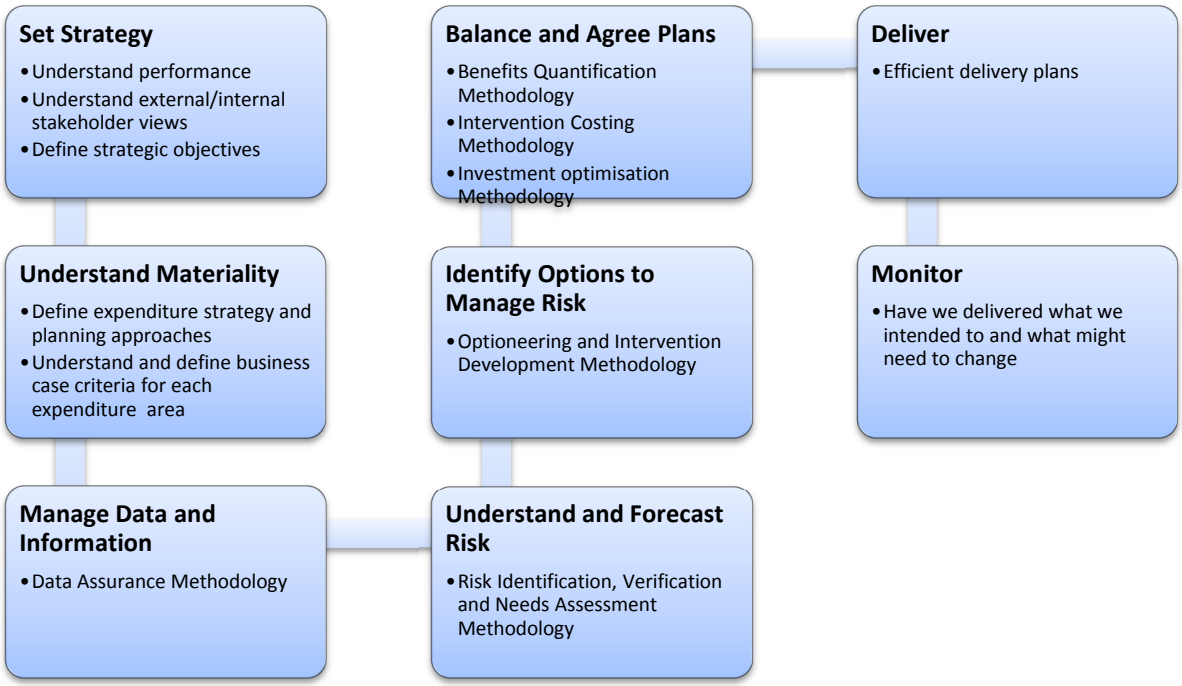
We will achieve this in a number of ways;

- By replacing strategic valves and hydrants and improving access to, and monitoring of, critical trunk mains in order to reduce supply interruptions;
- By slip-lining trunk mains to reduce the number of customer contacts regarding appearance; and
- By investing in improving the safety of our pipe bridge assets.

Should we fail to invest in trunk mains or not achieve the associated performance improvements mentioned above, there is a risk that our trunk mains will fail, leading to poor quality water and an unreliable supply of water to our customers. Consequently, we will not provide our customers with the Safe and Reliable Supply that is a key outcome for them.

In order to ensure that we meet customers' preferences and mitigate the risks associated with trunk mains, we have adopted an asset management totex focused approach as set out in Figure 1.

Figure 1: Approach to meeting Customer Priorities and Mitigating Risks:



This approach enables us to demonstrate full 'line of sight' from customer priorities, through risk review, options analysis and investment optimisation, to outcomes and benefits provided for our customers.

We plan to invest £10.732m to manage the health of our trunk mains from 2020 to 2025 to achieve the performance commitments associated with the outcome 'Safe and Reliable Supply', as set out in Table 1.

We have set ourselves a challenging target of improving our cost efficiency by 8% during AMP7. This will be achieved by delivery of our business transformation programme resulting in a post-efficiency investment of £9.873m.

Costs are allocated to the Treated Water Distribution business unit. Investment is all related to maintaining the long term capability of our infrastructure assets.

Table 1: Performance Commitments Targets and Percentage Contribution

Performance Commitment	Unit	2019/20 Baseline	2024/25 Target	Total Targeted Performance Commitment Improvement in AMP7	Trunk Mains % Contribution to Performance Commitment Target
Water Quality Compliance (CRI)	Index	1.27	0	1.27	47.90%
Supply interruptions	Average mins per property	12.20	1.80	10.40	46.37%
Leakage	Ml/d	43	36.5	6.5	0.21%
Mains bursts	Per 1000km	142	133	9	0.72%
Customer contacts about water quality – appearance	Contacts per 1,000 population	0.93	0.43	0.50	10.48%

Our AMP7 investment in trunk mains will help ensure our assets are being maintained appropriately to deliver resilient water services to current and future generations.

For water quality compliance, in total 47.90% of performance improvement is achieved through interventions within our investment cases. The remaining performance improvement will be achieved as a result of operational activities such as mains flushing.

Full details of our outcomes, performance commitments, and outcome delivery incentives are provided in Section C3 of our business plan.

3 Background To Our Investment Case

3.1 Context

Trunk mains are mains whose primary purpose is to convey potable water in bulk from a treatment works to a service reservoir or pumping station for distribution, but without direct customer supply from the main. We currently have 828km of trunk mains, which accounts for 12% of our total network by length. They are primarily made of asbestos cement, cast iron, ductile iron, spun iron and polyethylene. These five materials make up 88% of the trunk main network.

The trunk mains investment case includes all above ground pipes, pipe bridges, associated support structures and sleeves. As well as below ground assets accommodating trunk mains such as tunnels, culverts and sleeves.

This investment case will cover the renewal, replacement or maintenance of all existing potable trunk mains. Renewal and replacement of trunk mains will include all associated works, such as replacement of isolation valves, hydrants and air valves.

Assets related to trunk mains, but excluded from this investment case, include:

- Cables, ducting, junction boxes and joint pillars laid with the trunk main;
- Maintenance of flowmeters, air valves, pressure release valves, pressure safety valves or other flow valves and their associated chambers; and
- Pipelines within pumping stations and pipelines within the boundary of a treatment works site.

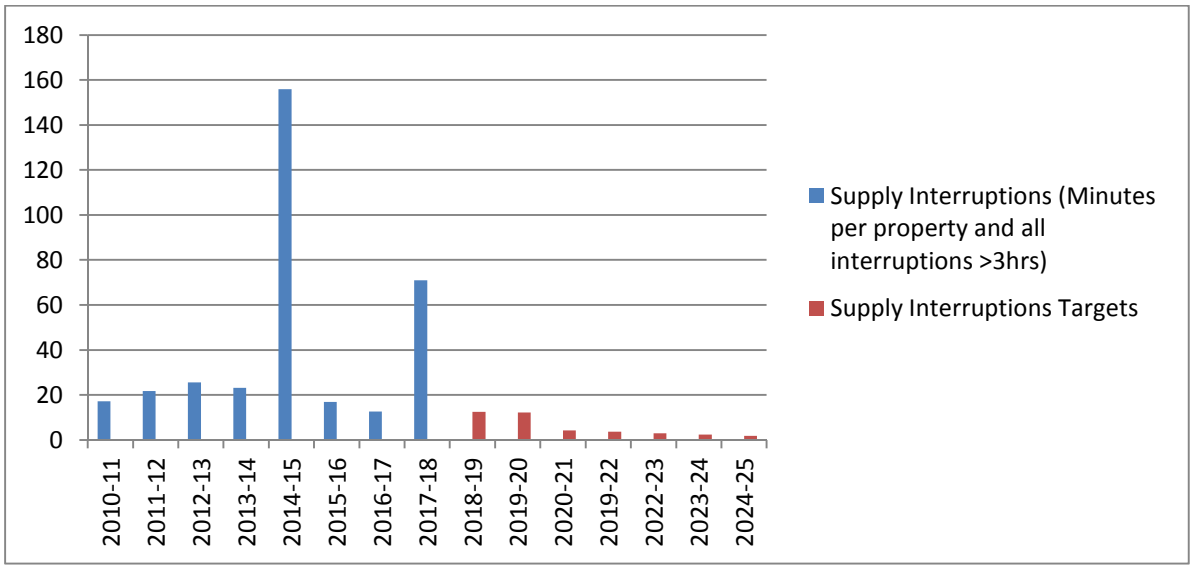
The primary objective of the trunk mains investment case is to maintain a stable level of risk within the distribution network that translates into a reliable and acceptable level of service for our customers. We also need to ensure that planned investment is sufficient for routine and reactive maintenance to ensure continuation of business as usual activities such as undertaking repairs.

Our primary risk associated with our trunk mains network is deterioration of our trunk main pipe assets. Deterioration of our trunk mains leads to interruptions to supply and to problems with the appearance of water.

We have received 6,181 customer contacts in the last five years (April 2012-March 2017) regarding the appearance of their water, equating to 51/10,000 population. We have taken two hundred and seventy nine samples as part of the water quality sampling programme, (April 2012-March 2017) which had levels of iron over the water quality regulations compliance limit of 200 micrograms/litre.

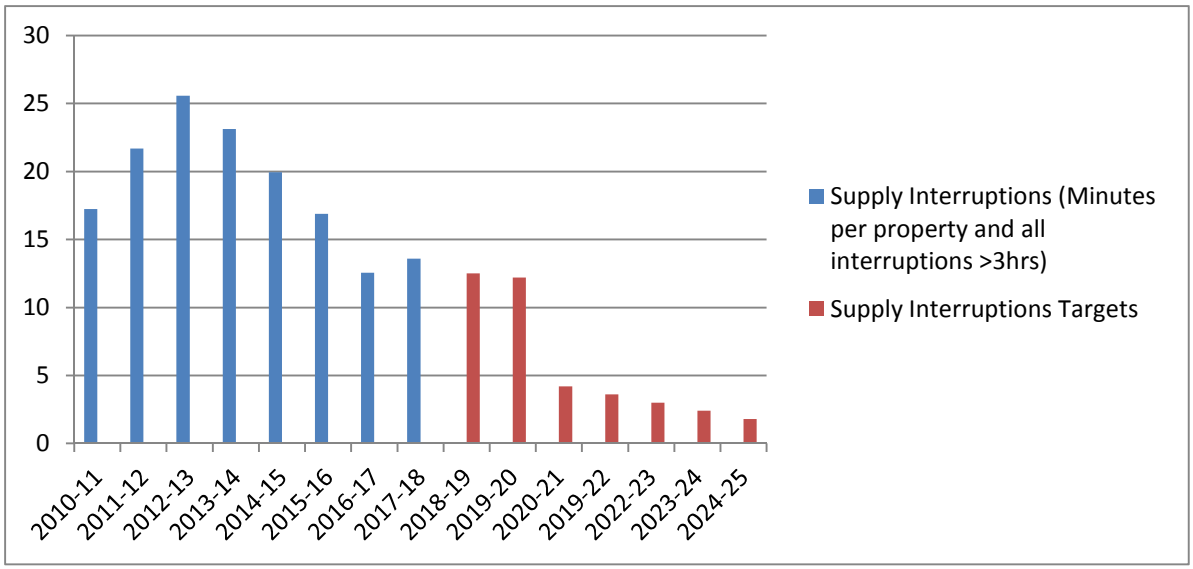
Historic supply interruptions are shown in Figure 2 below, together with the targets for AMP6 and AMP7.

Figure 2: Historic Supply Interruptions



The peaks in supply interruptions in 2014/15 and 2017/18 are attributable to just four incidents. When these outliers are removed from the data, the underlying trend shows historic improvement across AMP6, as shown below in Figure 3.

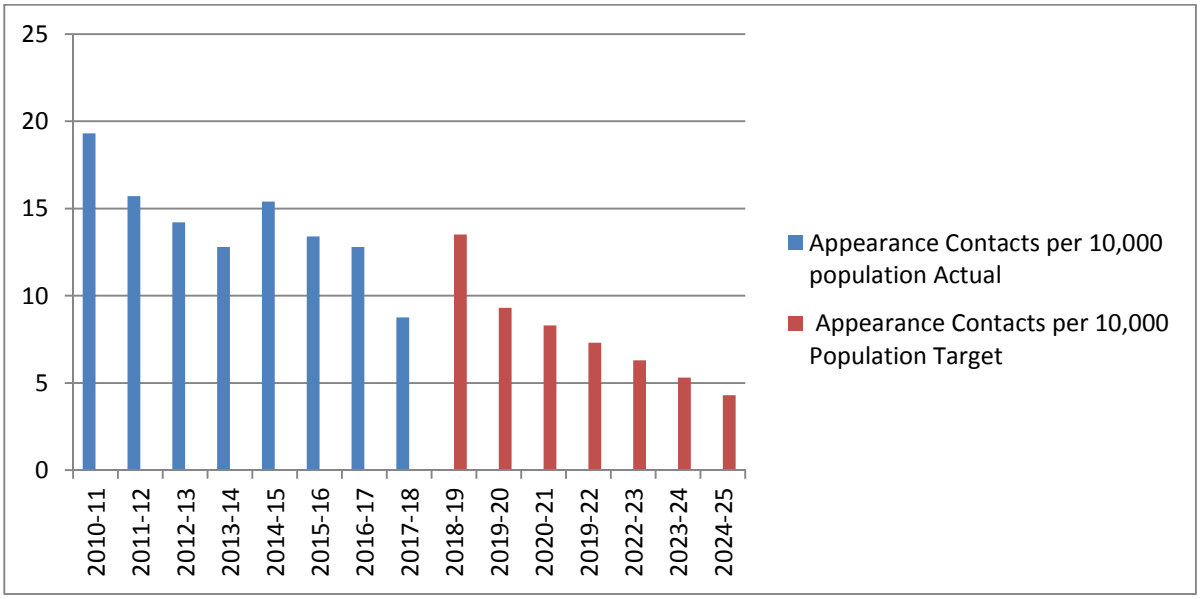
Figure 3: Historic Supply Interruptions with Outliers Removed



A key factor in reducing supply interruptions is the ability to bypass a failed section of main, by connecting across adjacent hydrants. Our existing hydrants prevent this as they permit flow in one direction only, risking our ability to reduce supply interruptions.

During AMP5 and AMP6, the majority of investment in trunk mains was related to the slip-lining of 59km of mains, to improve customer contacts regarding appearance. As a result, these customer contacts per 10,000 population have fallen from nineteen in 2010 to thirteen in 2017 (see Figure 4).

Figure 4: Number of Customer Contacts Regarding Appearance per 10,000 Population



Corrosion of iron trunk mains causes sediment to be conveyed to downstream zones, leading to dirty water. To inhibit this process, the upstream trunk mains are slip-lined and following this slip-lining, all downstream zones are flushed to remove any residual iron sediment.

The efficacy of the AMP5 relining schemes have been investigated in detail; and confirmed in a report to the Drinking Water Inspectorate entitled 'Report to DWI on Efficacy of AMP5 Slip-lining Schemes'.

Due to the need to flush the downstream zones, there is expected to be a lag between the completion of a slip-lining scheme and any corresponding decrease in customer contacts regarding appearance. Whilst the AMP5 slip-lining schemes were completed in 2015, the flushing was completed in 2016. The full benefits of the AMP5 slip-lining schemes therefore appear in the 2017 figures.

During AMP6 we plan to complete the equivalent of 21km of trunk mains slip-lining to reduce the number of customer contacts regarding appearance caused by iron pipe corrosion. One AMP6 scheme was originally identified as a slip-lining scheme to reduce the number of customer contacts regarding appearance, generated by expected flow reversal. Through a series of trials, we are demonstrating that there is the potential to deliver the same benefits by applying the methodology of Predictions and Control of Discolouration in Distribution Systems. This methodology to manage our network in a more advanced manner, was possible in this particular situation.

We have developed a burst model that provides data and information on pipe deterioration and burst frequency. The model assesses both trunk and distribution mains, to determine the length of mains most likely to burst based on age, material and diameter. For PR19, these targeted mains were ranked to identify those sections of main that provide the most benefit if replaced. The highest ranking mains

were then developed into interventions. This approach is presented in the Application of the Burst Model Report[2]. The analysis shows that there are 323km of distribution mains which are more beneficial to replace than any section of trunk mains.

In broad terms, the trunk mains risks affecting our ability to maintain a Safe and Reliable Supply for our customers, or to keep our customers safe, arise from:

- Corrosion in mains leading to discoloured water or water with a high iron content;
- Pipe and joint degradation leading to asset failure, potentially leading to significant loss of supply in terms of duration and number of customers affected;
- Degradation of valves leading to an inability to isolate mains for repair; and
- Risk to public and operator safety due to inadequate guarding on existing pipe bridges.

The interventions proposed within this investment case are needed to address these risks.

This investment case is also interdependent with the following investment cases as they share the same performance commitment targets:

- Distribution Mains; shared targets of supply interruptions, leakage, mains bursts, and customer contacts about water quality – appearance;
- Water Pumping Stations – shared target of supply interruptions;
- Bulk Meters and Pressure Control Valves; shared target of leakage;
- Network Ancillaries; shared target of water quality compliance (CRI) and leakage;
- Network Monitoring; shared targets of supply interruptions, leakage, mains bursts, and customer contacts about water quality – appearance;
- Leakage; shared target of leakage.
- Treatment Works Strategic Maintenance; shared target of water quality compliance (CRI);
- ICA and Telemetry; shared target of supply interruptions; and
- Resilience; shared target of supply interruptions.

3.2 Strategy

Developing the investment needs for our 828km of trunk mains is underpinned by our long term corporate strategy which has the vision ‘Trust beyond water - we provide excellent experiences’. Our Outcomes Delivery Framework together with our Strategic Asset Management Plan provides the strategic framework that supports this vision and enables investment in our trunk mains to clearly focus in delivering against outcomes and performance commitments.

Our long term strategy, as set out in the outcome Delivery Framework (section C3 of our business plan), has a focus on resilience and a growing need to ensure that our assets are, and remain, well

[2] Bristol Water, 2017. *NTPBP-MET-APP-0004 - Application of the burst model.docx*

maintained and effective in meeting our performance requirements. There are three strategic drivers identified that together, ensure we meet our current and future needs for customers and stakeholders. These are:

- **Operational Resilience** - performance commitments to reflect reliability, resilience and quality of water
- **Customer Focused** - performance commitments to reflect customer service and affordability
- **A Sustainable Business** - performance commitments to reflect the environment representing our community and sustainable resources.

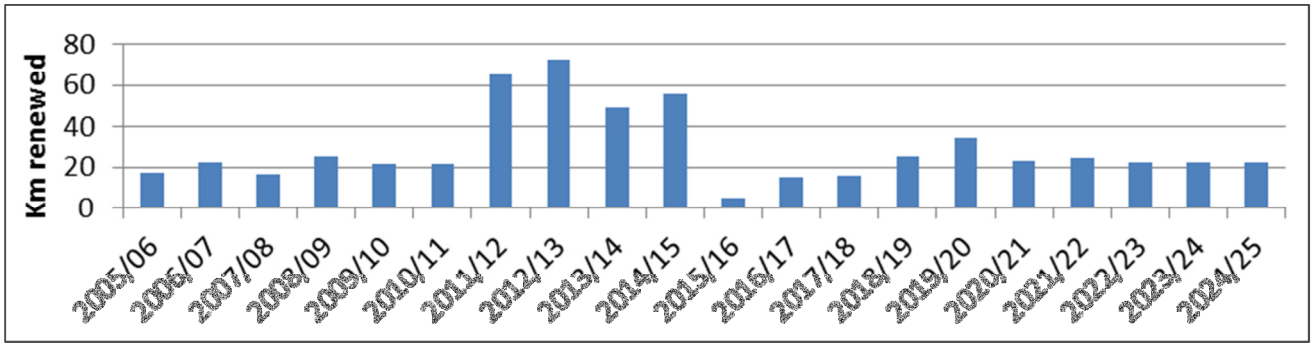
Within this strategy there is a specific outcome (Safe and Reliable Supply) and specific performance commitments (supply interruptions, leakage, mains bursts and customer contacts about water quality – appearance) that have strategic targets and incentives that will be directly influenced by our investment needs for trunk mains.

Our Asset Management Strategy has objectives developed in alignment with the long term strategy and delivery of corporate objectives and outcomes. These objectives cover both our short-term needs and longer-term aims, and drive the capability development plan and asset planning activities. Delivery of the investment for our trunk mains will be driven through the Asset Management Framework, which is designed to enable the efficient and effective planning and delivery of all our asset related activities, to successfully deliver our business and customer outcomes. The framework aligns to, and interacts with, our corporate drivers, which in turn are there to deliver the external expectations and requirements placed upon us by our stakeholders.

We need to ensure that planned investment is sufficient for the continuation of business as usual activities (such as walking the length of mains and checking valves) and routine and reactive maintenance, and the continued provision of high quality water to our customers.

Our long term pipe management investment strategy applies to both distribution and trunk mains. It is our intention to replace a steady 20km of pipe per annum to offset deterioration and maintain asset health. This length has been derived on the basis that we are experiencing a deterioration rate in the range of 0.3-0.5% per annum. Figure 5 below identifies the length of pipe we have replaced per annum since the beginning of AMP4, and the predicted replacement through to the end of AMP7. This strategy translates into a stable and acceptable level of service for our customers.

Figure 5: Historical and future pipe replacement lengths for distribution and trunk mains



Our Strategy for Trunk Mains also aligns to the Water Resources Management Plan 2019 options appraisal (where we aim to reduce leakage by 15%) and reflects the blend of activities that are recommended from that work.

One of our four customer outcomes is maintaining a Safe and Reliable Supply. Reducing the impact on our customers from burst mains is a key strand to our strategy for delivering this outcome.

3.3 Customer priorities

Customer priorities relating to our outcomes and performance commitments have been determined through our extensive programme of customer engagement and research. During the development of our business plan, we have engaged with over 37,000 customers and conducted over fifty pieces of research. By delivering customer engagement, we have ensured that we can build on the customer insights that we have gained, producing a business plan influenced by our engagement events. This ensures that at Bristol Water we have engaged effectively with our customers on longer-term issues, and have taken into account the needs and requirements of different customers including those in vulnerable circumstances and also our future customers.

Through this process our customers have told us that their top priorities have remained largely unchanged from PR14 and have been identified as:

- You can get a bill you can afford;
- Keeping the water flowing to your tap;
- Help to improve your community;
- Save water before developing new supplies; and
- You get the best possible experience every time you need us.

Our engagement with our customers has resulted in the development of four specific outcomes for PR19, which capture what our customers and stakeholders have said. These are:

- Excellent Customer Experiences;
- Safe and Reliable Supply;
- Local Community and Environmental Resilience; and
- Corporate Financial Resilience.

In order to deliver our customers' priorities and outcomes we will measure progress via twenty six performance commitments for which we have set delivery targets.

There is a clear relationship between our investment in trunk mains and our Safe and Reliable Supply outcome.

We undertook more detailed discussions at phase 2 of our engagement process; gathering evidence which gave us a wealth of information about how our customers' view Bristol Water, our services, and long term plans (see section C1 of our business plan for further details). We also explored short and

long-term trade-offs in decision making and asked customers to tell us how we should approach long term issues of resilience and how we could best respond to service interruptions. When discussing the Safe and Reliable Supply outcome with our customers, we found that they are understanding of one-off events, and often focus more on how we can improve our response to them. We asked them about investment in water quality and reliability and we asked what areas they felt most comfortable investing in. In our March 2018 customer panel, our customers prioritised reliability above local environment, resilience and customer experience[3]. Detailed analysis of customers' views on this area can be found in section C3 of our business plan.

We consulted on three potential scenarios in relation to our Safe and Reliable Supply outcome, as summarised in Figure 6 below.

Figure 6: The Three Potential Scenarios for our Safe and Reliable Supply Outcome

			2024/25 target		
Service	**Performance Commitment**	**2020 target**	**Slower improvement plan**	**Suggested improvement plan**	**Faster improvement plan**
Water quality	Compliance risk A lower score reflects a lower risk of water quality problems	1.22	0.7	0	0
Interruptions to supply	Supply interruptions greater than 3 hours (average minutes per property)	12.2	4.2 66% improvement	1.8 85% improvement	1.5 88% improvement
Water that doesn't look clear	Number of customer contacts about the appearance of tap water (contacts per 10,000 customers)	9.3	9.3	4.3 54% improvement	3.2 66% improvement
Water that doesn't taste or smell right	Number of customer contacts about the taste and smell of tap water (contacts per 10,000 customers)	3.0	3.0	2.5 17% improvement	1.4 53% improvement
Protection against a major water supply event	Risk of a major event - population centre size protected against critical asset failure	Centres over 25,000 people*	Centres over 25,000 people	Centres over 10,000 people (10 year programme)	Centres over 10,000 people (5 year programme)
Forecast increase to the average bill from additional investment			£5	£14	£18

*With 5000 customers in these centres remaining at risk

Results show affordability concerns have driven some customers to choose the slower plan, whereas customers also value the service improvements in the suggested plan. In summary, we consider that a plan with a lower bill level with the suggested improvement plan is more likely to be acceptable to more customers (particularly low-income groups). You can see more about how the feedback from our draft business plan consultation influenced each of our performance commitments in section C3 of our business plan.

The level of support for our plan expressed by our customers, both those we have engaged with over a period of time and those we met for the first time, gives us confidence that our final business plan strikes the right balance of delivering service improvements that customers value at a price that is acceptable to the majority.

[3] A4g: Customer online panel March 2018

This investment case describes how we will achieve the suggested improvement plan and associated level of performance through our investment in trunk mains, specific details can be found in section 3.4.

3.4 Asset Health Performance Commitments, AMP7 Performance Commitments & outcome Delivery Incentives

The health of our assets is a key element in delivering resilient water services to our customers This investment case supports our Safe and Reliable Supply outcome, by investing in our trunk mains assets in order to provide high quality, reliable supplies for present and future generations.

The Safe and Reliable Water Supply outcome will be measured through a set of associated performance commitments. Our investment in trunk mains will support the achievement of the performance commitments set out in Table 2.

Table 2: Associated Performance Commitments

Performance Commitment	Unit	2019/20 Baseline	2020/21	2021/22	2022/23	2023/24	2024/25	Performance Improvement Required in AMP7
Water Quality Compliance (CRI)	CRI Index Score	1.27	0	0	0	0	0	1.27
Supply Interruptions	Average mins per property	12.20	4.2	3.6	3.0	2.4	1.8	10.40
Leakage	Ml/d	43	42	41	39.5	38	36.5	6.5
Mains Bursts	Per 1000km	142	133	133	133	133	133	9
Customer Contacts About Water Quality – Appearance	Contacts per 1,000 population	0.93	0.83	0.73	0.63	0.53	0.43	0.50

With regard to asset health performance commitments, our investment in trunk mains will help ensure our assets are being maintained appropriately for the benefit of current and future generations. We measure our asset health through some specific performance commitments, which for trunk mains are customer contacts about water quality – appearance and mains bursts. These performance commitments enable Ofwat on behalf of customers to compare our asset health performance across AMP6 and AMP7, and to compare our asset health performance with that of other water companies.

Full details of our outcomes, performance commitments, and outcome delivery incentives are provided in Section C3 of our business plan.

A detailed diagram illustrating the full line of sight between customers, outcomes, performance commitments, and outcome delivery incentives related to this investment case, is included in Appendix A.

3.5 Compliance Obligations

Statutory and compliance obligations have influenced the development of interventions in this investment case and the investment for AMP7. Relevant legislation is detailed below.

We have a statutory obligation under the Health and Safety at Work Act 1974 to ensure that our assets are safe for those working on or near them, or anyone who may be on or near them. This includes our above ground pipe bridge assets.

Within this investment case there are specific risks that we are seeking to mitigate in order to ensure continued compliance with these obligations. They are explained in section 4.2.

3.6 AMP6 Investment and Performance

A summary of our AMP6 investment in trunk mains is provided Table 3 below. This investment supports our ability to meet our performance commitment for unplanned customer minutes lost, leakage, mains bursts, and negative water quality contacts. Our investment in AMP6 will also underpin our performance commitments in AMP7.

AMP6 investment related to trunk mains is summarised in Table 3. We have re-categorised data used in line with the scope of our investment cases. For historic data we have used the 2016/17 wholesale cost assessment data (data tables 1 and 2). Forecast data has been derived from PR19 data (data tables WS1 and WS2).

Table 3: AMP6 capital investment

Year	Trunk Mains capex (£m)
2015/16 actual	1.351
2016/17 actual	2.431
2017/18 actual	3.299
2018/19 forecast	3.861
2019/20 forecast	0.271
AMP6 forecast	**11.213**

The AMP6 performance commitments that are related to trunk mains investment, and our performance, is given in Table 4.

Table 4: Historic AMP6 Performance Related to Trunk Mains

Performance Commitment		2015/16	2016/17	2017/18	2018/19 (Forecast)	2019/20 (Forecast)
Unplanned Customer Minutes Lost						
Bristol Water	Target	13.4	13.1	12.8	12.5	12.2
	Company Performance	15.5	13.1	73.7	12.5	12.2
Leakage (Current Leakage) (Ml/d) (annual)						
Bristol Water	Target	48.0	47.0	45.0	44.0	43.0
	Company Performance	44.2	46.4	46.6	44.0	43.0
Mains Bursts						
Bristol Water	Target	142	142	142	142	142
	Company Performance	113	153	179	142	142
Negative water quality contacts						
Bristol Water	Target	2422	2409	2322	2275	2221
	Company Performance	2329	2162	1711	2275	2221

Unplanned customer minutes lost is included as it has been used throughout AMP6 to measure and report on performance related to supply interruptions. It will be replaced by supply interruptions in AMP7. The unplanned customer minutes lost performance commitment was not met for 2017/18. The average amount of minutes lost per property per year (at 73.7 minutes) was significantly affected by an exceptional burst event at Willsbridge in July 2017, which we explained in a detailed case study in our 2017/18 mid-year performance report.

With regard to leakage, at PR14, we set ourselves challenging leakage targets; to reduce leakage by 12% between 2015 and 2020. Our 2017/18 performance was below target due to a number of factors primarily the exceptional weather at the beginning of 2018. We underperformed against our target for 2017/18 due to the exceptional weather in 2017/18. Excluding our estimate of a 1.7Ml/day impact of the cold weather in March 2018, our actual current leakage performance after technical data adjustments improves from 46.6Ml/day to 44.9Ml/day. This would have been in line with our target of 45Ml/day. Towards the end of 2017/18 we began to see benefits from our deployment of additional resource and the impact of improving the effectiveness of our leakage response. We have implemented an action plan to improve on our Leakage performance to ensure we meet our AMP6 target. We are currently forecasting to achieve the final year AMP6 target of 43 Ml/d. Our investment in AMP6 will also underpin our performance commitment for Leakage in AMP7. Full commentary on our Leakage performance is provided in our 2017/18 Annual Performance Report.

The number of negative water quality contacts regarding appearance is included as it has been used throughout AMP6 to measure and report on performance related to customer contacts regarding water appearance and taste/odour. It will be replaced by two performance commitments in AMP7, customer contacts about water quality – appearance, and customer contacts about water quality – taste/odour.

4 Developing Our Investment Plan

As we have discussed earlier, the starting point for investment case development is to understand our customers' priorities and determine associated performance commitments. We have adopted totex principles to determine how we should invest in order to deliver these priorities and associated commitments. The totex approach we have adopted considers which the best solution is because it is the lowest cost over the whole life of the asset, regardless of whether it is operational or capital expenditure.

Whilst we do not currently have health and risk indices across our asset groups, we do have a wealth of data. In some cases, analytical models such as the mains deterioration model, provides us with a view of how our assets are performing, as well as a view on their deterioration. The following section describes the process we have created and followed in order to develop our investment cases.

4.1 Investment Case Development Process

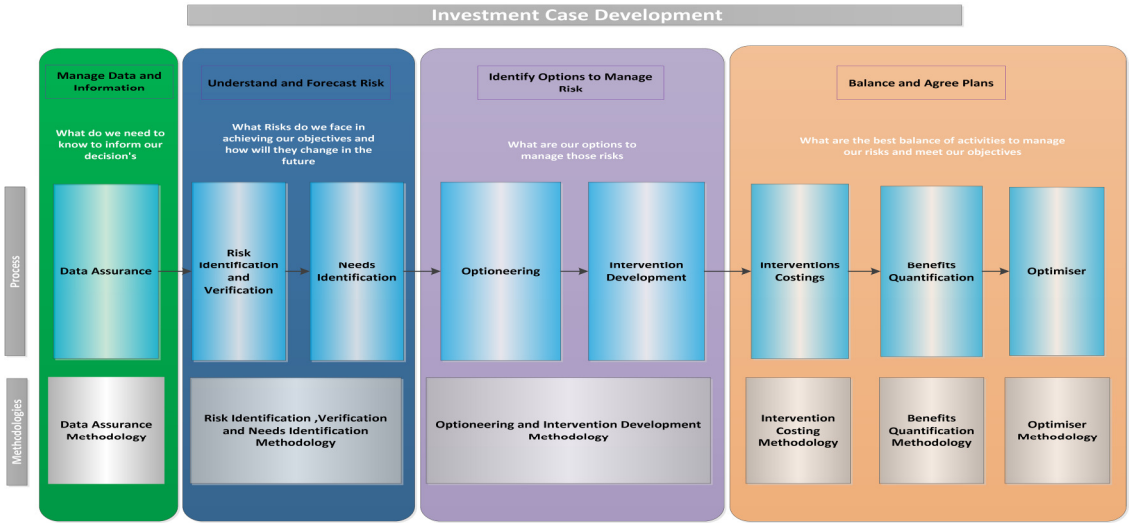
We have created and implemented a process that is supported by a set of six methodologies. When developing the methodologies, we wanted to ensure that they:

- Deliver what the customers have asked for;
- Satisfy our business needs; and
- Deliver a high quality business plan in accordance with Ofwat's Company Monitoring Framework.

The collective application of these methodologies has enabled us to develop investment proposals that are well evidenced through a line of sight approach, ensuring our investment plan achieves the required targets at the optimal cost.

Figure 7 illustrates, at a high level, the process required to identify risks that require addressing in AMP7, and the subsequent development of appropriate interventions.

Figure 7: Investment case process overview - Level 1 diagram



4.1.1 Data & Data Assurance

The development of our investment cases is dependent on having consistent, accurate and assured data. We therefore recognise that we must be able to demonstrate the quality of the data and information used in the development of our investment cases.

Wherever possible, we have utilised data from our core company systems in order to undertake our analysis and we have sense checked the quality of data as we have used it.

However, in addition we have applied a data assurance methodology. We have assessed data quality in terms of completeness, accuracy and reliability. In addition, the methodology also assesses whether data is used as part of the Annual Performance Report to Ofwat, and hence already subject to existing Annual Performance Report assurance mechanisms.

In total we have developed twenty one investment cases. The values of these investment cases range from less than £1m to over £37m. Our overall capital investment plan totals circa £212m.

We have selected a sample of nine investment cases, and have applied detailed data assurance based on their value and complexity. The total value of these nine investment cases represents 66% (circa £140m) of the total capital investment plan, and represents two hundred and eighty six individual data types. We have evaluated all two hundred and eighty six data types and we have evaluated them for quality and their use in the Annual Performance Report process. The overall data quality assessment identified 93% of the data as being good quality, and 55% as having been used and assured through the Annual Performance Report process.

The following sections detail the results of the data assurance and Annual Performance Report assessments undertaken for this investment case.

Quality Assessment

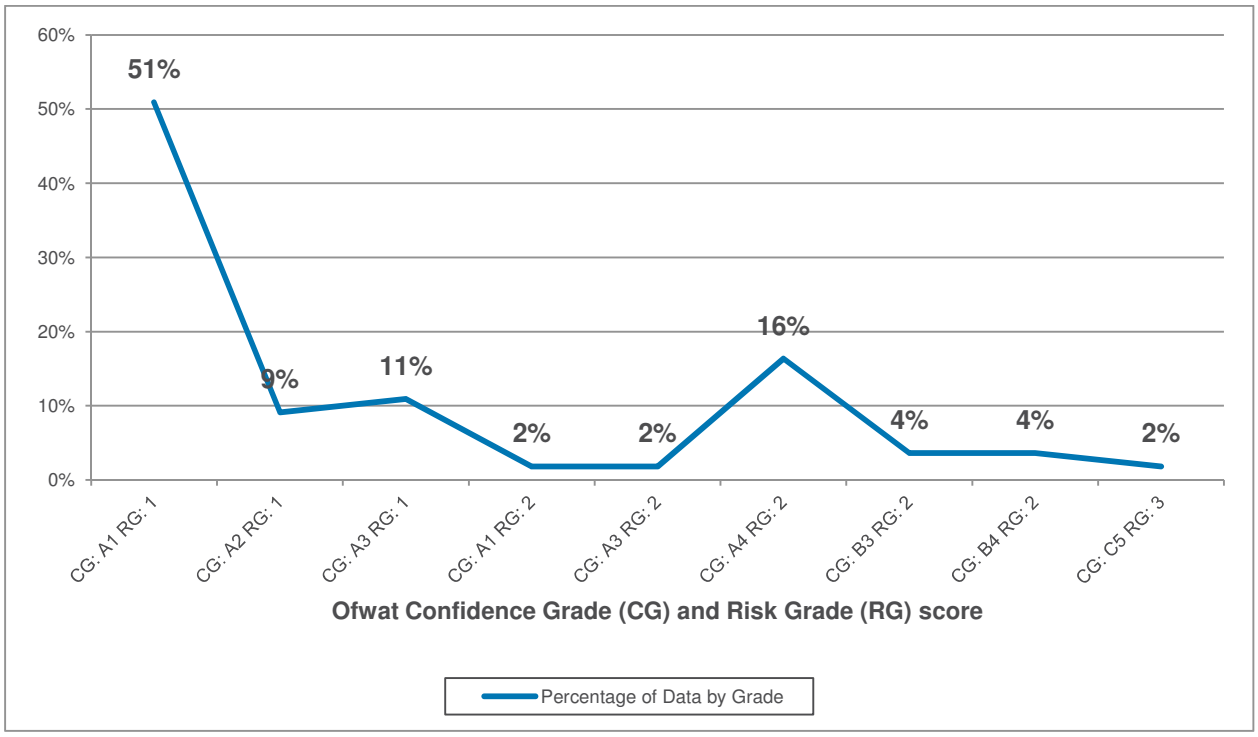
Each data point used in this investment cases, it has been assured for completeness, accuracy, and reliability, and has been given an overall score for quality in terms of a Risk Grade score between 1 and 5 (1 being good quality, 5 being poor quality). The risk grade has subsequently been aligned to the equivalent Ofwat Confidence Grade scores A1-D6 (A1 being highest confidence, D6 being lowest confidence).

A list of data used in this investment case is provided in Appendix B (actual data sets can be provided upon request). A total of fifty five specific data types were identified of which fifty four (98%) have been assessed as having good quality (Confidence Grade A1-B4 and Risk Grade 1-3).

Following a review it was found that the remaining 2% of data was mainly text or qualitative assessments rather than quantitative. This data will be included for enhancement as part of our business as usual approach to continually improve the quality of our data, which is outlined in our data and information strategy.

Figure 8 summarises the number of data types scored against Ofwat Confidence Grades and Risk Grades.

Figure 8: Percentage of Data Types by Ofwat Confidence Grade and Risk Grade



Annual Performance Report Assessment

The fifty five data types have also been assessed in their utilisation in the Annual Performance Report. This process is subject to both internal and external assurance and has governed methodologies that

are applied in the provision of Annual Performance Report data tables. The assessment of the Annual Performance Report submission and application of the methodologies are formally governed and recorded.

Fifty five data types, 20% of the data used in this investment case, were assessed as already required for Annual Performance Reporting and therefore subject to the assurance requirements as set out in Annual Performance Report methodologies.

4.1.2 Risk Identification, Verification & Needs Assessment Methodology

The purpose of our risk identification, verification and need assessment is to ensure that:

- The risks that we are currently facing are captured in a single risk register;
- Each risk is assessed and verified to determine details about the nature and magnitude of the risk and whether any mitigation is currently planned in this AMP period;
- Each risk is scored on a common basis to allow risks to be compared; and
- The most significant risks are identified, and that for each a clear and uniquely referenced statement of need is produced to define the problem as clearly as possible, and to identify what benefits or performance commitments mitigation of this risk will achieve.

The risk score is the product of the likelihood and consequence, each is scored 1 to 5 and then multiplied together to provide a potential maximum risk score of 25.

Risks scoring 15 to 25 are the most significant strategic risks, and these were developed into needs statements.

Those scoring 10 or 12 were subject to a further round of review. Where the risk was confirmed, it was developed into a needs statement. Where the risk was not confirmed (for example it is currently being addressed in AMP6 or the risk was assessed to be not as significant as initially scored), it was not considered further as part of the PR19 investment planning process.

The risks scoring 1 to 9 were considered to be risks of a lower priority and were therefore not considered further as part of the PR19 investment planning process.

The risks that were not considered further as part of the PR19 investment planning will continue to be monitored and assessed as part of the live business and on-going business as usual risk management process. Where there is a need to mitigate these risks within the AMP, we will respond with appropriate action, such as increased base maintenance.

Further development of our business as usual risk management process is on-going and we are looking to innovate by developing smarter systems to optimise this process.

We developed need statements for all selected risks.

4.1.3 Optioneering and Intervention Development Methodology

The next stage in our process is to develop options of how we could meet the needs of the selected risks.

To generate the options, data was gathered from a number of sources (see Appendix B). This included meetings with stakeholders and historical records, including reviews following operational events, previous scheme proposal reports and previous options assessment reports.

We then progressed to data assimilation, analysis and consultation with key stakeholders. Multiple options were developed and recorded. These options were reviewed and all options identified as not viable were discarded.

All viable options were identified as proposed interventions with a unique reference number and were taken forward for further scope development, benefits calculation and costing.

4.1.4 Intervention Costing Methodology

In order to provide assurance of our investment costs and to ensure standardisation, we engaged ChandlerKBS as our costing partner. They were selected in part due to their ability to provide us with industry comparable cost data, often at intervention level. They supported us in several ways:

- In some instances development and analysis of intervention costs, and
- Support to build our cost database.

Indirect overheads, such as contractor costs, design costs, contract management, and our overheads have been applied at intervention level. Wherever possible we used our data or if unavailable, we used industry average costs.

Therefore we had to assess the expected capital cost of each intervention.

Expected Capital Cost (capex after)

If we deliver the capital intervention in a planned way, we have labelled it as ‘capex after’. This is the expected capital cost of the intervention.

Cost estimates were usually based on high level scopes, which contained activity schedules, and sketches provided by ourselves, and were developed using the cost model we developed with ChandlerKBS.

4.1.5 Benefits Quantification Methodology

The benefits for each intervention are those which are considered to affect company performance during subsequent AMP periods.

Benefits can be assessed as either being:

- Direct – savings in reactive capex or savings in operational expenditure (opex); or
- Indirect – improvement in performance commitments or other resultant effects on the company's performance.

Both direct and indirect benefits are considered and quantified.

Direct Benefits

We have a totex approach which considers both capital and operational expenditure.

Expected Capital Cost (capex before)

If we deliver the capital intervention in an unplanned way, we have labelled it as 'capex before'. This is the reactive cost that would potentially arise if we had to deliver the intervention in an unplanned way.

We could respond to this scenario in one of two ways:

- 'Patch and Repair' or
- Implementation of the intervention in an un-programmed accelerated manner.

The capex before was estimated for each intervention. For most interventions the estimate is site specific. A risk factor, taken from the likelihood score recorded in the risk register, was applied to the initial capex value to produce the final capex before value.

Where a 'patch & repair' solution would not be appropriate, should the risk materialise, this would lead to the immediate implementation of the intervention. The cost of the intervention in this scenario is the expected capital cost of the intervention (capex after); with the application of a suitable uplift to cover the costs associated with fast-tracking the intervention, for example, the cost of labour at premium rates.

The expected capex before effectively formed the 'Do Nothing' option.

Expected Operational Cost (opex before & opex after)

In most cases we have made an estimate of the operational expenditure levels either with investment - opex after or without investment - opex before. Opex includes power, chemicals, materials, contract hire and in house labour.

Opex before represents the opex expenditure associated with not mitigating a risk through capital investment, for example, increased maintenance visits or replacement of components.

Opex after represents the additional opex cost to the business after the implementation of an intervention. These could include negative values associated with predicted savings associated with increased plant efficiency or performance, or positive values where there is an operational cost increase, for example greater inspection levels.

Indirect Benefits

To measure our performance against our customers' priorities and the associated performance enhancements associated with interventions; we measure the impact that each intervention had on the performance commitment measure.

Other Benefits

In addition to the performance commitments described above, other indirect benefits which do not relate to performance commitments were calculated and recorded in the benefits calculations where appropriate. This includes avoidance of health and safety penalties, customer compensation payments, and environmental penalties. These benefits have been monetised.

Once the benefits were prepared, the interventions were put forward for investment optimisation.

4.1.6 Investment optimisation & Intervention Selection

The investment optimisation process determines which interventions are selected to provide the optimal AMP7 investment plan, by delivering the targeted performance commitment improvements, at the lowest cost. We have utilised a water industry standard system (Servelec 'Pioneer') to optimise our AMP7 investment plan. Pioneer provides the functionality for us to assess all interventions developed across all of the investment cases. It will assess the interventions both individually and in comparison to other interventions. It is a decision support tool that produces an optimal investment plan to meet the targeted performance commitment improvements required in AMP7.

The Pioneer investment optimiser model assesses interventions primarily on the overall benefit, which takes account of performance and whole life costs. The investment optimiser calculates the whole life cost as the net present value over forty years. This determines if an intervention is cost beneficial.

We will select interventions for one or more of the following reasons:

- The intervention is mandated (i.e. Drinking Water Inspectorate - water quality requirement);
- The intervention is cost-beneficial; or
- The intervention is required to achieve the performance commitment targets.

Any performance commitment improvement obtained from mandated or cost-beneficial interventions will contribute to overall performance improvement.

A series of business reviews and sense checks of the investment optimiser results have been undertaken prior to finalising the AMP 7 investment plan.

We can of course model any number of scenarios, and during the process of engaging our customers we ran three scenarios as described in section C1 of our business plan (slower Improvement plan, suggested improvement plan and faster improvement plan).

4.2 Applying the Investment Process to Trunk Mains

Each of the following sections describes the specific details associated with the application of the investment case development process for trunk mains.

4.2.1 Risk Identification, Verification & Needs Assessment

There were seventy two risks identified in the Strategic Risk Register[4] associated with this investment case. Every risk went through a process of assessment, scoring, and review, following the Methodology of Risk Identification, Verification and Needs Identification.

Thirty seven risks were selected and developed into need statements. The risk descriptions, scoring and associated needs statements are captured in the Strategic Risk Register. Details of the selected risks are provided in Appendix C.1.

Thirty five risks were not selected and these risks return to being monitored and reviewed under our business as usual risk management process. Details of the non-selected risks are provided in Appendix C.2.

An example of a non selected risk is given below in Table 5.

Table 5: Example of Unselected Risk

SRR ID	IC No	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR436	1	Nr Kendall Close, Yate	If the 355mm polyethylene main under a railway bursts then this may cause Interruptions to supply for our customers and disruptions to the railway.	1	3	3	2	4	4	4	4

In the example above, assessment of the risk determined that the main is a polyethylene main with no history of bursts and is unlikely to fail within a twenty year planning horizon and therefore was allocated a likelihood score of 1. The main is laid within a concrete duct and this mitigates damage to the railway

[4] Bristol Water, 2018. *NTPBP-CAL-STR-0127 Strategic Risk Register (WIP).xlsx*

by directing water from any burst away from the railway. The impact of a burst if it did occur could be severe in terms of customers losing their supply, however this is counter balanced by the low likelihood of the burst occurring, and overall the risk is scored 4.

The 'line of sight' for the whole process, beginning with the selected risks, the source of the risk, a record of source documents used to verify the risks, and the needs statements, is captured in the Trunk Mains Investment Case Interventions Register[5].

4.2.2 Optioneering & Intervention Development

In order to establish the options, data was gathered from a number of sources (see Appendix B). This included meetings with stakeholders, Laboratory Information System (LIMS) data, pipe bridge survey records, customer contact data relating to customer contacts regarding appearance, historical performance data for mains bursts and supply interruptions, and historic reports such as the 2016 Hotwells tunnel inspection report'[6] and the Pucklechurch to Willsbridge isolation valve report[7].

As described in section 4.2.1, thirty seven risks were selected and developed into needs statements. Further investigation of these needs included data assimilation, analysis and consultation with key stakeholders. Multiple options were developed and recorded for each of the thirty seven needs statements. These options were peer reviewed and all options identified as not viable were discarded. Viable options were converted into interventions. Each intervention had its costs and benefits assessed.

For example, against the selected risk regarding the risk of injury to the public by falling from a pipe bridge, eight options were identified and one of these was developed into an intervention, as shown in Table 6.

[5] Bristol Water, 2018. *NTPBP-CAL-TRU-0137 Trunk Mains IC Intervention Register.xlsx*
[6] Bristol Water, 2016. *Data - Hotwells_2015 - Inspection report J Rippon.doc*
[7] Bristol Water, 2008. *Willsbridge to Pucklechurch 36valve replacement.pdf*

Table 6: Example of Options Selection for SRR622

SRR Ref	SRR Revised Risk Description	Mitigation Options				Proposed Interventions	
		Proposed Option Name	Proposed Option Description	Option Viability?	Option to be Developed into an Intervention?	Ref No	Intervention Title
SRR622 (Risk Score = 12)	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves	Install security measures at 50 selected locations	Select 50 pipe bridge and pipe crossing locations. At these locations, install deterrents or security fencing on pipe bridges and crossings to reduce the likelihood of members of the public climbing on and walking over these assets.	By making improvements at 50 locations the benefit will be limited.	N	n/a	n/a
		Accept risk and do nothing	Take no action to reduce the risk presented by pipe bridges and crossings in the Bristol Water network. Accept the possibility that members of the public could come to harm if accessing BW assets and take liability if and when this occurs.	Bristol Water is committed to health and safety and therefore this option is not acceptable.	N	n/a	n/a
		Install security measures	Install deterrents or security fencing on pipe bridges and crossings to reduce the likelihood of members of the public climbing on and walking over these assets.	Risks will be mitigated but spend will not be targeted and is therefore inefficient.	N	n/a	n/a
		Carry out risk assessments and install security measures at high-risk locations	Programme of risk assessments and surveys of circa 330 pipe bridges and production of an asset inventory for these assets. Identify the most high risk locations of pipe bridges and crossings by identifying those close to children's playgrounds, public footpaths and commonly used routes around schools. At these locations, install deterrents or security fencing on pipe bridges and crossings to reduce the likelihood of members of the public climbing on and walking over these assets.	By targeting the highest risk-locations for improvements, the maximum possible benefits will be derived from the intervention in the most efficient way.	Y	1.001.002	Pipe Bridge H&S Improvements
		Turn pipe crossings into footbridges	Build a footbridge over every pipe crossing. This makes every location safe without obstructing access.	Risk greatly reduced at all locations and BW liability removed but spend is not targeted and is inefficient. Residual risk that child can fall off bridge.	N	n/a	n/a
		Turn pipe crossings at high-risk locations into footbridges	Identify the 50 most high risk locations of pipe bridges and crossings by identifying those close to children's playgrounds, public footpaths and commonly used routes around schools. At these locations, build a footbridge over the pipe crossings.	Risk greatly reduced at some locations and BW liability removed. All risk remains at sites not addressed.	N	n/a	n/a
		Bury pipes under watercourses	Replace overground pipe crossings with buried pipework. Open cut through the watercourse, fluming the flow.	All risk removed at all locations but spend is not targeted and is therefore inefficient.	N	n/a	n/a
		Bury pipe crossings at high-risk locations under watercourses	Identify the 50 most high risk locations of pipe bridges and crossings by identifying those close to children's playgrounds, public footpaths and commonly used routes around schools. At these locations, replace overground pipe crossings with buried pipework. Open cut through the watercourse, fluming the flow.	All risk removed at some locations. All risk remains at sites not addressed.	N	n/a	n/a

A total of twenty six interventions were identified in this way. These included in some cases, multiple interventions against a single selected risk and these were identified as mutually exclusive during intervention optimisation.

A summary of all selected risks and their associated options is included in Appendix D. A summary of all non-selected risks is given in Appendix C.2.

Once interventions were developed, costs were prepared which are discussed in section 4.2.3.

4.2.3 Intervention Costing

In this investment case, the majority of interventions costs were calculated in collaboration with ChandlerKBS, based on activity schedules and sketches supplied by Bristol Water. ChandlerKBS utilised a combination of a water industry unit cost database and Bristol Water's unit cost databases to complete cost estimation in accordance with their own assured methodology. Indirect overheads (contractor on-costs including preliminaries, design costs, contract management) and Bristol Water overheads were then applied at intervention level. These overheads were based on Bristol Water data where available, or industry average where Bristol Water data was not available. The costed activity schedules were returned to us for peer review, leading to further refinement in collaboration with ChandlerKBS. Often, we used historical data to cross check through this process.

One intervention was costed in-house and this was based on historical project costs.

Seven interventions were costed by external consultants Minerva. They costed the interventions based on their experience of undertaking the same work elsewhere in the UK and the associated time and expertise requirements. The costed interventions were returned to us for peer review, leading to further refinement in collaboration with the consultants.

The following specific additional comments apply to three of the interventions:

- Isolation valve replacement at Pucklechurch-Willsbridge main is based on installation of six valves. Isolation valve replacement on Purton-Pucklechurch main is for replacement of three valves and therefore half the costs of Pucklechurch-Willsbridge main were used.
- Pipe Bridge Health and Safety improvements costs were based on a GIS desk based study to determine the number of potential pipe bridge site. Twenty nine sites were visited to check for pipe bridges and the type of improvements required at each site and this data was extrapolated to produce an activity schedule for all expected sites.
- We provided ChandlerKBS some quotes for bespoke steel pipework for Hotwells tunnel pipework and costs for some specialised monitoring equipment for installation of Leakage Monitors.

The cost for each developed intervention is presented in Appendix E. An example of how those costs have been developed is outlined below.

Cost Example: Isolation Valve Replacement on Pucklechurch-Willsbridge Main

Investment is required to replace three valves on the Pucklechurch-Willsbridge main. A timely intervention now will avoid unplanned supply interruptions in the future and the implementation of a significantly greater intervention in the future.

We have established a cost of undertaking the works of £0.653m; this includes labour and materials as well as contractual costs. The latter includes items such as (but not limited to) contractor accommodation, contractor management, contractor overhead and profit and design.

We have then applied Bristol Water's overhead of £0.145m for activities associated with the intervention such as project management, land and compensation, legal, environmental costs, commissioning /handover, contract management, operations and system support, consultants and administration.

All of the direct costs above gave us an intervention cost of £0.798m to implement the intervention in a planned way (the capex after).

If however, we did not undertake the work to repair the asset proactively, then we would have to complete it reactively. Should we have to undertake this work reactively it would be completed as a 'patch and repair'. We have therefore used the patch and repair cost of replacing a single valve calculated as £0.133m. We would expect to pay a premium for an emergency response, for example, labour rates at premium working agreement levels, materials at short notice, transport of materials at short notice, specialist support, and design out of hours. Our assessment is that this will increase delivery cost by £0.066m leading to a total cost of £0.2m (£0.133m plus £0.066m). We then applied a factor to account for the likelihood of the risk materialising within the five year AMP. We have assessed the likelihood as 1 in 2, giving a reactive cost of £0.1m (£0.2m multiplied by 0.5). However, it should be noted that a reactive emergency patch and repair solution will not offer any contribution to performance improvements.

We have established that regardless of whether we undertook the above intervention in either a planned or reactive way, there would be no change in operational expenditure (opex after).

Once interventions were costed, benefits could be calculated which are discussed in section 4.2.4.

4.2.4 Benefits Quantification

Twenty six interventions were assessed for direct and indirect benefits. These are presented in Appendix E.

In terms of indirect benefits the performance commitments that relate to this investment case are discussed below.

Customer Contacts About Water Quality - Appearance

To reduce the number of customer contacts regarding appearance, we have chosen to implement fourteen trunk main slip-lining interventions. The reduction in the number of customer contacts

regarding appearance have been calculated based on the observed, reported reduction in customer contacts regarding appearance following similar slip-lining schemes implemented in AMP5.

Compliance Risk Index

Of the twenty six identified interventions, the fourteen slip-lining interventions will also contribute towards reducing the compliance risk index performance commitment, by reducing the number of iron sample failures. The expected reduction in iron sample failure is based on the observed, reported reduction in sample failures following similar slip-lining schemes implemented in AMP5.

Leakage and Mains Bursts

A further benefit of slip-lining trunk mains is that it will reduce both leakage and mains bursts by small amounts.

The leakage benefit has been calculated using industry average figures for leakage per kilometre, depending on the material and age. Mains burst reduction has been calculated based on the burst frequency predicted by our burst model.

Supply Interruptions

Two of the interventions contribute to supply interruptions by replacing a type of valve on two critical trunk mains which have historically failed closed, and which may fail closed in future. The reduction in supply interruptions has been calculated based on the burst frequency predicted by the burst model combined with the likelihood that the valve could not be reopened following a repair of a burst.

Five of the interventions contribute to supply interruptions through targeted action on the most critical mains within the network, focussing on means to make a pipe burst less likely or to reduce the impact. Inspection and testing of critical mains, strategic valve replacement and air valve replacement on critical mains, all make a pipe burst less likely, by finding and replacing critical components. Implementation of the Wayleave Management (01.002.04), Exceptional Sites (01.002.05) and Hydrant Replacement (01.002.07) interventions will all reduce the impact of a burst water main by either making the main easier to repair or by pre-installing facilities to bypass a burst section of main.

Other Benefits

In addition to the performance commitments described above, other indirect benefits which do not relate to performance commitments have been calculated and recorded in the benefits calculations where appropriate. This includes health and safety penalties, customer compensation payments, and environmental penalties. These benefits have been monetised and included on the investment optimiser input form as ‘Other Benefits’.

Once the benefits were prepared, the interventions were put forward for investment optimisation.

5 Outcome

5.1 Innovation

When it comes to delivering our programme of works we know that we must continue to be innovative and efficient. We have set ourselves a challenging target of improving our cost efficiency by 8% during AMP7. This will be achieved by delivery of our business transformation programme.

We see innovation as an integral to our everyday working at Bristol Water: We have deliberately embedded it within the business-as-usual processes of our asset management teams by embracing the full flexibility that totex and outcomes enables. We will look to be innovative in the following ways:

- **Open Innovation**: We have defined our strategic innovation challenges and run events such as our "Innovation Exchange" that invite suppliers to present their innovative solutions to predefined challenges that we set.
- **Market Scanning**: We conduct market scanning for cutting edge technology against our strategic innovation challenges and feed this into our optioneering process. In particular we subscribe to the Technology Approval Group which regularly scans and meets with water companies to unearth the most promising innovations for the sector.
- **Partnering**: we undertake leading research into areas that we provide effective solutions for the future.

We will look for innovations that mean we can contribute to our 8% cost efficiency challenge and keep our customers' bills low into the future.

In relation to this investment case, we will deliver customer value through innovative and sector leading strategies. Two examples of such are:

- Reverse trace analysis used to identify trunks main contributing to discoloured water failures; and
- The installation of leakage monitors at high risk crossing sites.

These are described in more detail below.

5.1.1 Reverse Trace Analysis

Reverse trace analysis was developed by our Network Planning team in AMP5 and further refined during AMP6. Despite having a comprehensive programme of flushing distribution zones to reduce discoloured water contacts and corresponding high iron sample failures, it was found that the problem persisted in many zones. The Network Planning team hypothesised that corrosion of iron trunk mains upstream of distribution zones was seeding the zones with iron, which then generated the customer contacts regarding appearance. The link between high iron concentrations in water and customer contacts regarding appearance is well known, but the link back to upstream trunk mains is not well understood within the industry.

Reverse trace analysis uses both Geographical Information System software and water network modelling software, together with water quality sampling data. Starting at the exact location of any high or failed iron sample or discoloured water complaint, the software traces back upstream through the network towards treatment works that produced the water, identifying any iron mains greater than 6" diameter that may have contributed to the positive iron sample. The number of high or failed iron samples or discoloured water complaints associated with any iron main enables the iron mains most likely to be contributing iron to the water to be identified.

5.1.2 Leakage Monitors

We have identified many locations where our trunk mains cross railways or rivers and which, because of the risk of injury to the public, third party damage and difficult access to the site, pose a high risk to us. The risks posed are varying risks of injury, risk of high compensation costs to compensate for inability to operate the railway line, or risk of extended supply interruption because of difficulty accessing the site to make a repair. The approach we have chosen to adopt at the highest risk sites is to install low cost leakage monitors, rather than high cost modifications to the pipework or civil infrastructure. Two leakage monitors will be installed at each crossing; one on either side of the crossing, and the philosophy is that leakage monitors will help to enable small leaks to be detected and fixed before the leak can develop into a burst main.

Such leakage monitors employ sector leading technology to enable leaks to be detected by identification of any instantaneous pressure changes in the water or by changes in the background noise transmitted in the pipe wall or transmitted in the water. Data from the monitors is transmitted back to centralised software which marshals and analyses the received data to match the measured noise and pressure signatures, to typical noise and pressure signatures created by leaks. Close matches indicate a potential leak in the main and an automated message is sent to operatives enabling them to investigate further at the location.

5.2 Selected Interventions

The twenty six interventions developed within the Trunk Mains investment case were assessed through the investment optimisation process. Of these twenty six interventions, twelve were selected. The twelve selected interventions are set out in Table 7, along with details of the associated costs.

Table 7: Selected Interventions, Costs, and % Performance Contribution

ID	Intervention Title	Total Capex (£)	Change in Opex per annum (£)	Water quality compliance (CRI)	Supply interruptions	Leakage	Mains bursts	Customer contacts about water quality – appearance
01.001.02	Pipe Bridge H&S Improvements	£454,530	£0	-	-	-	-	-
01.001.03	Isolation valve replacement on Pucklechurch-Willsbridge main	£798,165	£0	-	8.77%	-	-	-
01.001.04	Isolation valve replacement on Purton-Pucklechurch main	£399,082	£0	-	2.92%	-	-	-
01.001.08	Slipline 7" Ashley Road Roundabout to Greenbank Cemetery	£911,370	£0	1.09%	-	0.03%	0.27%	2.53%
01.001.14	Slipline 24" Chase reservoir to Lodge Road	£681,020	£0	23.71%	-	0.03%	0.01%	1.49%
01.001.16	Slipline 10" Speedwell Road to Rose Green Road	£658,660	£0	10.50%	-	0.02%	0.05%	3.77%
01.001.17	Slipline 15" Speedwell Road to Rose Green Road	£1,154,850	£0	12.60%	-	0.13%	0.07%	2.69%
01.001.20	Hotwells tunnel pipework and thrust restraint improvement works	£252,738	£0	-	-	-	-	
01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines	£892,288	£25,000	-	6.03%	-	0.33%	
01.002.04	Wayleave Management	£363,787	£0	-	2.18%	-	-	

ID	Intervention Title	Total Capex (£)	Change in Opex per annum (£)	Water quality compliance (CRI)	Supply interruptions	Leakage	Mains bursts	Customer contacts about water quality – appearance
01.002.05	Exceptional Sites - proactively investing in critical mains in advance of a major failure.	£885,500	£0	-	10.49%	-	-	
01.002.07	Hydrant Replacement	£3,279,765	£0	-	15.97%	-	-	
Trunk Mains – Total Investment (Pre-Efficiency)		**£10,731,755**	**£25,000**	**47.90%**	**46.37%**	**0.21%**	**0.72%**	**10.48%**
Trunk Mains – Total Investment with 8% Capex Efficiency		**£9,873,215**						

The Pipe Bridge H&S Improvements (01.001.02) and Hotwells tunnel pipework and thrust restraint improvement (01.001.20) works are both selected because they are cost-beneficial, helping to offset future bill increases for our customers.

The remaining interventions are selected because they provide contributions to achieving performance commitment targets.

The individual interventions are described in detail in the following sections.

Pipe Bridges H&S Improvements

Our supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Nearly two hundred potential pipe bridge locations were identified from a desk based study. The Water UK Occasional Guidance Note published in 2012[8] highlighted the need to protect the public from injury by falling from a pipe bridge or crossing.

We have a duty to protect the safety of the public. Investment is needed to survey our supply area, identify pipe bridges and crossings and make safe all locations, in order to:

- Ensure no assets pose a risk to the public;
- Ensure industry best practice is followed;
- Meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; and
- Avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.

Valve Replacement on Pucklechurch to Willsbridge and Purton to Pucklechurch Trunk Mains

The Pucklechurch-Willsbridge section of the south Bristol ring main has six 36" butterfly valves which were installed when the main was built in 1972. One valve failed shut during a burst incident in 2002. The south Bristol ring main is a key trunk main serving the east of Bristol area. Our deterioration model has predicted at least one burst on the south Bristol ring main in both AMP7 and AMP8.

The Purton-Pucklechurch Main has one 36" butterfly valve and two 24" butterfly valves which were installed when the main was built in 1973. These are roughly the same age and the same or similar diameter to the valve that failed in 2002. Purton-Pucklechurch is a key trunk main serving the strategic Pucklechurch service reservoir, which feeds the Bristol area from our largest treatment works at Purton. Our deterioration model has predicted at least one burst on the main in both AMP7 and AMP8.

Whilst it is generally possible to repair bursts on the main without customers losing their supply of water, the repair of a burst will require isolation valves on the mains to be shut and it is the risk of one of these valves failing closed which may cause customers to lose their supply of water.

[8] Water UK, 2012. *NTPBP-EXT-OCC-0130 HSE Pipe crossings and pipe bridges risk assessment (April 2012).pdf*

Investment is needed to replace the butterfly valves in order to prevent 34,000 customers losing their supply.

Slip-lining

Smaller mains of 150mm diameter or less can be flushed to remove iron sediment, but larger mains cannot. Investment is needed for rehabilitation of the larger diameter, aging, unlined iron mains, in order to:

- Supply safe water to our customers with a good appearance;
- Help meet the performance commitment for customer contacts about water quality – appearance; and
- Help meet the performance commitment for water quality compliance (CRI).

Hotwells Tunnel

The 20m deep vertical shafts of the Hotwells tunnel each house a 36" cast iron main installed in 1930. The main connects Barrow Treatment Works and Victoria Reservoir, serving central Bristol. The main at the top of the eastern shaft has a history of a high number of leakage repairs, and is located on the Portway (A4) which is a key transport route into central Bristol.

Investment is needed to carry out repair works on the leaking main and carry out associated thrust restraint improvements, to avoid the significant cost which we would incur if the main should fail at this location.

Leakage Monitors

Twenty five sites have been identified in the risk register where strategic trunk mains cross rivers or railways. At these locations, failure of the trunk main would lead to significant third party damage and cost, and in some cases, significant supply interruptions, due the criticality of the main compounded by difficult access for repairs.

Investment is required to minimise the risk of these mains failing and the supply to our customers being interrupted. Often, the pattern of pipe failures is that the main will initially leak, and over time, this leak will increase and eventually lead to a full burst of the pipe. Leakage monitors would allow any leak to be identified and rectified before a full burst occurred. Bursts can also be caused by transient pressure waves in the pipeline. Leakage monitors would allow these pressure transients to be monitored and would help to identify what action is needed to reduce the pressure transients.

‘Wayleave’ Maintenance

Effective management of the ‘wayleave’ (or sterilized strip) is essential to: maintain access for operation and maintenance; protect the public from asset failure; and to protect the asset from human intervention. Where these are not maintained, this can result in a number of adverse outcomes. The complexity and cost of planned maintenance can be increased and restricted access for repair can significantly increase the duration of any supply interruption.

Investment is required to continue to undertake a field survey to assess the current status of our existing trunk mains. Where identified by the survey, investment is required to reinstate access or make safe the sterilised strip.

Exceptional Sites

When a trunk main fails, the impact on our customers, local businesses and wider society can be significant. Such events have the potential to cause not only large scale interruptions to supply, but can also cause substantial damage to houses, roads, railways, the environment and the local economy. Internally, the impact on our business can also be far reaching, not only in terms of the financial cost, but also in terms of our reputation and our ability to meet our regulatory commitments. In the last three years, we have experienced two such events, with bursts in Kingswood and Willsbridge both placing an enormous strain on our customers and our resources.

Investment is needed to identify the critical trunk mains, identify any significant risks to those mains, and proactively implement remedial measures to reduce the risk to those mains. Such measures may include for example a localised diversion of the main or installation of tees onto a main so that a bypass can be quickly installed around a high risk section.

Hydrants

While the primary role of hydrants is to supply the fire service with a reliable source of water, they also play a key role in operation and maintenance of the network. This includes flushing and conditioning, and where through-bore units are installed, they can also become connection points for temporary overland by-passes, injection points for tankering, and access points for internal inspection and testing.

To reduce supply interruptions we will invest in replacing strategic hydrants with a type that will enable a section of main to be bypassed, thus allowing supplies to be maintained in the event of a burst. Investment is needed to replace all standard (loose jumper) hydrants located on strategic trunk mains with modern through-bore equivalents. This would increase our ability to maintain supply during burst events, as well as improve access for proactive maintenance.

This investment case is aligned to the Water Network plus Wholesale Control category of our business plan. Costs are allocated to the Treated Water Distribution Business Unit. Investment is all related to maintaining the long term capability of our infrastructure assets. Water Service and Business Unit Allocation, is summarised in Table 8.

Table 8: Water Service and Business Unit Allocation

Wholesale Control	Water Network Plus	Total
Business Unit Allocation	**04 Treated Water Distribution**	
Trunk Mains capital investment (%)	**100%**	**100%**
Trunk Mains capital investment	**£10.732m**	**£10.732m**
Maintaining the long term capability of the assets - infra	£8.590m (80%)	**£8.590m (80%)**
Maintaining the long term capability of the assets - non-infra	£1.256m (11.7%)	**£1.256m (11.7%)**
Other capital expenditure - infra	£0.886m (8.3%)	**£0.886m (8.3%)**
Trunk Mains capital investment with 8% capex efficiency		**£9.873m**

5.3 Contribution to Performance Improvement

Table 9 set outs the percentage contribution to performance commitments improvement provided by the selected trunk mains interventions.

Table 9: Contribution to Performance Commitments Targets from Selected Interventions

Performance Commitment	Unit	2019/20 Baseline	2020/21	2021/22	2022/23	2023/24	2024/25	Performance Improvement Required in AMP7	Trunk Mains Contribution to Performance Improvement
Water Quality Compliance (CRI)	CRI Index Score	1.27	0	0	0	0	0	1.27	47.90%
Supply Interruptions	Average mins per property	12.20	4.2	3.6	3.0	2.4	1.8	10.40	46.37%
Leakage	Ml/d	43	42	41	39.5	38	36.5	6.5	0.21%
Mains Bursts	Per 1000km	142	133	133	133	133	133	9	0.72%
Customer Contacts About Water Quality – Appearance	Contacts per 1,000 population	0.93	0.83	0.73	0.63	0.53	0.43	0.50	10.48%

5.3.1 Asset Health

Our AMP7 investment in trunk mains will help ensure our assets are being maintained appropriately to deliver resilient water services to current and future generations

5.3.2 Water quality compliance

For water quality compliance, in total 47.90% of performance improvement is achieved through interventions within our investment cases. The remaining performance improvement will be achieved as a result of operational activities such as mains flushing.

5.4 Non-Selected Interventions

Of the twenty six interventions developed within this investment case, fourteen were not selected because they did not provide the most cost beneficial way of meeting performance commitment targets compared to other interventions available.

The risks associated with these remaining fourteen interventions represent residual risks that will be carried during AMP7. We will continue to monitor these residual risks throughout AMP7, and if the process requires these risks to be mitigated, we will respond with appropriate action. Details of the fourteen non-selected interventions are given in Appendix F. An example is given in Table 10.

Table 10: Example Non-Selected Intervention and Residual Risk

SSR ID	Risk & Need Statement	Non-Selected Intervention & Residual Risk
SRR1002	If a strategic valve is not maintained, THEN it may lead to a delay in response to an interruption to supply to significant numbers of the population.	Non-selected intervention: 01.002.03 Strategic Valve Maintenance Residual risk: delayed response to an interruption to supply to significant numbers of the population.

5.5 Assumptions

There are a number of general assumptions that have been made in the development of our investment cases. These are discussed in detail in section 11 of the PR19 Investment Cases Summary Document[9]. Assumptions specific to this investment case are discussed below.

The intervention 'Exceptional Sites' provides benefits by proactively investing in critical mains in advance of a major failure. The identification of the sites is an ongoing process and at the time of writing, the specific locations of these sites were only known for seven out of the twelve systems within our network. The intervention was developed by means of extrapolating for the remaining five systems. Confirmation of the sites will follow as the analysis proceeds.

[9] Bristol Water, 2018. *NTPBP-INV-PR1-0635 PR19 Investment Cases Summary Document.docx*

5.6 AMP8

As outlined in section 3.2 our long term pipe management investment strategy applies to both distribution and trunk mains. It is our intention to replace a steady 20km of pipe per annum to offset deterioration and maintain asset health. We therefore anticipate that replacement rates will be similar in AMP8 compared to AMP7.

There are a number of risk items that have been developed into interventions which have not been selected for inclusion in the AMP7 business plan (as given in the Appendix F), which will be reappraised for investment in AMP8.

5.7 Base Maintenance

We have established minimum levels of investment in relation to the base maintenance of network assets, as set out in the Infrastructure Base Maintenance investment case. These minimum levels provide investment for routine and reactive maintenance, to ensure the continuation of 'business as usual'. The minimum value for mains rehabilitation is £30m. These minimum levels have been determined through a combination of analysis of historical activity and costs, deterioration modelling to establish underlying asset deterioration, and investment planning analysis. Full details are provided in the Infrastructure Base maintenance investment case.

The investment planned through this investment case contributes towards the minimum investment levels, as the selected interventions improve the performance of our infrastructure assets above current levels.

In relation to this investment case, the Infrastructure Base Maintenance investment case defines minimum levels of expenditure for mains rehabilitation. The minimum investment levels are summarised in Table 11.

Table 11: Contribution to Minimum Infrastructure Base Maintenance Investment

Infrastructure Base Maintenance Asset Group	Minimum AMP7 investment to maintain asset health (£M)	AMP7 investment provided through Trunk Mains interventions (£m)	Total AMP7 investment provided through all interventions (£m)	Additional investment requirement as Base Maintenance (£m)
Mains Rehabilitation	30.0	10.731	48.8	0

The investment provided by our trunk mains and distribution mains interventions exceeds the identified minimum base maintenance investment level. As described in section 5.2, we propose to spend more than this minimum level, as we are looking to deliver additional performance improvement to meet our performance commitment targets.

5.8 Historical & AMP7 Investment Comparison

A summary of historical investment in trunk mains is provided in Table 12 along with our AMP7 investment in trunk mains interventions. We have re-categorised data used in line with the scope of our investment cases. For historic data we have used the 2016/17 wholesale cost assessment data (data tables 1 and 2). Forecast data has been derived from PR19 data (data tables WS1 and WS2).

Table 12: Historical & AMP7 capital investment

AMP	Capital investment values	Investment (£m)
AMP5	AMP5 actual	48.539
AMP6	2015/16 actual	1.351
	2016/17 actual	2.431
	2017/18 actual	3.299
	2018/19 forecast	3.861
	2019/20 forecast	0.271
	AMP6 forecast	**11.213**
AMP7	AMP7 pre-efficiency	**10,732**
	AMP7 8% capex efficiency applied	**9,873**

Our levels of trunk mains investment has decreased since AMP5. In AMP5 we made substantial investment in our trunk mains, the majority of which related to on relining schemes, as well as delivering a installing and improving of strategic mains. While in AMP6 our investment was lower, we continue to deliver relining schemes and mains improvements. In AMP7 we are proposing to invest similar levels to AMP6, to implement cost-beneficial relining and improvement solutions to identified risks, to support our achievement of performance targets and to deliver our 20km/year mains replacement strategy.

6 Conclusions

In order to ensure our trunk mains continue to deliver our customers' priorities and meet our compliance obligations we will measure progress via performance commitments for which we have set delivery targets.

In AMP7, trunk mains measures are supply interruptions (target 1.80 minutes per property), leakage (target 36.5Ml/d), mains bursts (target 133/1000km), customer contacts about water quality - appearance (target 0.43 per 1,000 population) and water quality compliance, which is measured against our target for the compliance risk index (target 0).

An initial list of seventy two risks was narrowed down to a total of twenty six potential interventions. These interventions have been developed and assessed through our asset management totex focused approach and put forward for investment optimisation. Of these twenty six potential interventions, a total of twelve interventions were selected on the basis that they are cost beneficial interventions and meet our customer priorities and associated performance commitments.

We plan to invest a pre-efficiency total of £10.732m on twelve strategic interventions for trunk mains. These interventions will increase our operating costs by approximately £25k per annum. We have set ourselves a challenging target of improving our cost efficiency by 8% during AMP7. This will be achieved by delivery of our business transformation programme, resulting in a post-efficiency investment of £9.873m.

The interventions proposed are expected to contribute circa 46% of the supply interruptions target (1.80 minutes per property) and 10% of the customer contacts about water quality – appearance target (0.43). They also contribute towards water quality compliance, leakage and mains bursts targets.

If we fail to invest, the asset health of our trunk mains will ultimately continue to deteriorate to unacceptable levels. A consequence of asset deterioration will be an increased number of trunks mains bursts; leakage will increase; as will customer supply interruptions. We would also expect to receive more customer contact about the appearance of water, as well as failure of our water quality compliance target. This would lead to us failing to deliver our customers' priority of keeping water flowing to their tap.

Our business plan provides assurance to both achieve and monitor the delivery of its outcomes, it will meet relevant statutory requirements and licence obligations imposed by the Drinking Water Inspectorate and the UK Government.

7 Appendices

- Appendix A: Line of Sight Diagram
- Appendix B: Datasets
- Appendix C.1: Selected Risks
- Appendix C.2: Non-Selected Risks
- Appendix D: Options Considered
- Appendix E: Interventions Developed
- Appendix F: Non-Selected Interventions

7.1 Appendix A: Line of Sight Diagram

Trunk Mains Line of Sight

Investment Case
NTPBP-INV-TRU-0075

Customer Priorities

Top Quality Water Supplies

- Quality
- Reliability
- Reliability
- Quality
- Saving Water
- Leakage

Performance Commitments

Optimiser Input Form Reference

NTPBP-CAL-TRU-0345

Safe and Reliable Supply of Water

Slower Plan
Suggested Plan
Faster Plan

Compliance Risk Index

Customer High Priority
ODI — Common Penalty Only

Supply Interruptions — 4.2 | 1.8 | 1.5

Customer High Priority
ODI — Common Reward and Penalty

Mains Bursts — 137 | 137 | 137

Customer Medium Priority
ODI — Common Reward and Penalty

Local Community Resilience

Discolouration Contacts — 9.3 | 4.3 | 3.2

Customer High Priority
ODI — Bespoke Reward and Penalty

Leakage — 41 | 36.5 | 36

Customer High Priority
ODI — Common Reward and Penalty

Other Monetised Benefits

Interventions

01.001.05
01.001.06
01.001.07
01.001.08
01.001.09
01.001.10
01.001.11
01.001.12
01.001.13
01.001.14
01.001.15
01.00116
01.001.17
01.001.18
01.001.03
01.001.04
01.001.05
01.001.06
01.001.07
01.001.08
01.001.09
01.001.10
01.001.11
01.001.12
01.001.13
01.001.14
01.001.15
01.001.16
01.001.17
01.001.18
01.001.21
01.002.01
01.002.03
01.002.04
01.002.05
01.002.06
01.002.07
01.001.05
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01.001.11
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01.001.15
01.00116
01.001.17
01.001.18
01.00121
01.001.05
01.001.06
01.001.07
01.001.08
01.001.09
01.001.10
01.001.11
01.001.12
01.001.13
01.001.14
01.001.15
01.00116
01.001.17
01.001.18
01.001.05
01.001.06
01.001.07
01.001.08
01.001.09
01.001.10
01.001.11
01.001.12
01.001.13
01.001.14
01.001.15
01.00116
01.001.17
01.001.18
01.001.21
01.002.01
01.002.02
01.002.03
01.002.04
01.002.05
01.002.06

OFWAT Initial Assessment Tests

Test Area

- What is the quality of the Company's customer engagement and participation and how is it incorporated into the companies business plan and ongoing operations — Engaging Customers
- How well has the company used the best available evidence to objectively assess and prioritise the diverse range of risks and consequences of disruptions to its systems and services and engaged effectively with customers on its assessment of the risks and consequences — Securing long term resilience
- How well has the company objectively assessed the full range of mitigating options and selected the solutions that represent the best value for money over the long term and support from customers — Securing long term resilience
- To what extent has the company clearly demonstrated that it has considered whether all relevant projects are technically suitable for direct procurement for customers. Where it has one or more such projects, to what extent has the Company provided a well reasoned and well evidenced value for money assessment — Targeted controls , markets and innovation
- To what extent does the company have a good track record of producing high quality data, taking into account the company's data submission, assurance process and statement of high quality , and our 2018 assessment of the company under the Company Monitoring Framework — Securing Confidence and Assurance

Board Requirements

- Assurance that the company's business plan has been informed by customer engagement and feedback from the company's CCG about the quality of its customer engagement and how this has been incorporated into the plan — Customer Engagement
- Assurance that the company's business plan has been informed by a robust and systematic assessment of the resilience of the company's systems and services; customer views on managing resilience and a comprehensive and objective assessment of interventions to manage resilience in customers long term interests — Resilience
- How has it challenged an satisfied itself that the overall strategy for data assurance and governance processes delivers a high quality data
- How has it challenged and satisfied itself that the business plan will enable the company to meet its statutory and licence obligations , now and in the future and take account of the UK and Welsh governments strategic policy statements. — Business Planning
- How has it challenged and satisfied itself that its plan will deliver operational financial and corporate resilience over the next control period and the long term through its governance and assurance processes, taking into account of its track record of performance

Performance Commitment Key

- Common Performance Commitment
- Common New Performance Commitment
- Bespoke Performance Commitment
- Bespoke New Performance Comittment

Document Number NTPBP-MET-TRU-718

7.2 Appendix B: Datasets

This appendix lists the datasets used in this investment case and where they have been utilised.

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
interruptions_extract_04042017.csv	Customer interruptions - duration, number of customers affected, date, location (e.g. WWMD), reason, planned/unplanned	-	-	-	✓
Sample data.xlsx	Water quality sampling - all water quality samples, where, result, measure sampled for, level to pass sample	-	-	-	✓
bursts_extract_04042017.csv	Work order data associated with mains bursts	-	-	-	✓
REQ-0011	Costs for mains rehab, if possible by diameter and length of job	-	-	✓	-
REQ-0022	High consequential cost locations for pipe bursts (e.g. motorway, railways, pipe bridges, etc.)	-	-	✓	-
Logical Boundary Table (lbt_26-05-17).xlsx	Logical Boundary Table, giving all of Bristol Water's DMAs & WWMDs.	-	-	-	✓
Data - pipe IDs - mains over water.xlsx	Pipe IDs for high risk crossings where mains intersect railways, water, buildings and woodland.	-	-	-	✓
REQ-0060	Yearly spend from beginning of AMP4 to present for trunk mains and raw water mains cost centres, split into	-	-	✓	-

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
	GL codes.				
NTPBP-INT-DG3-UNP-0703 DG3 Report - All Interruptions to Supply - Oct-01 to Dec-16.xlsx	Unplanned Customer Minute Lost (DG3) Report	-	-	-	✓
Data - water_quality_discoloured_export__20170706.csv	Reverse trace modelling analysis to identify ferrous mains that would bring an improvement to water quality if relined, and written methodology stating assumptions, limitations and data sources.	-	-	-	✓
Data - Chelvey-Portishead-Avonmouth PODDS High Level Costings.xlsx	Costing example for PODDS schemes - Chelvey-Portishead-Avonmouth	-	-	✓	-
Data - ID groupings greater than 100m with address - key to GIS plots.csv	GIS plots of each group of RTA asset IDs longer than 100m, colour coded and with key and addresses	-	-	-	✓
Data - Cathodic protection 32527 - Bristol Water Quote - 2017 Monitoring.pdf	Quote for cathodic protection inspections - annual cost	-	-	✓	-

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
REQ-0114	Trunk mains collections showing asset IDs for 46" Purton-Pucklechurch main and SBRM Pucklechurch-Barrow, including all in-line valves	-	-	-	✓
REQ-0135 7 8 9 mains Lawrence Hill Church Rd Greenbank Rd.pdf	Asset IDs for proposed PR19 slip lining schemes	-	-	-	✓
REQ-0136 interruptions on selected IDs 1.001.005-018.xlsx	Interruptions to customer supply - data for last 15 years for proposed PR19 slip lining schemes	-	-	-	✓
REQ-0138 AllpipeBurst2023.csv	Burst predictions for all pipe IDs in 2023 - output from burst model	-	-	-	✓
REQ-0140_SBRM valve replacements.doc	Critical pipe model run to determine the number of properties affected (less than 3m pressure) when the South Bristol Ring Main is isolated between Pucklechurch SR and Willsbridge PS for 72 hours.	-	-	-	✓
REQ-0142 hydraulic profile-Willsbridge PS Test Pressures v2.doc	Report and graph showing pressures at SBRM River Avon crossing in Willsbridge	✓	-	-	-
REQ-0150 FW Syrinix Pipeminder-T info.msg	Cost information for Syrinix Pipeminder T devices and installation	-	-	✓	-

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
REQ-0151 FW Estimated total cost.xls Portway burst.msg	Cost of repairs following burst in the Portway (A4) in Bristol, 2001	-	-	✓	-
REQ-0155 Syrinix quote.pdf	Cost of Syrinix Pipeminder T device	-	-	✓	-
REQ-0156 Burst repair costs.xls	Examples of costs associated with trunk main burst repairs	-	-	✓	✓
REQ-0159	Supply interruptions data for 2017-18 and hypothetical value of Supply interruptions if 'big events' such as Willsbridge, Fisher Road, etc. had been avoided.	-	-	-	✓
REQ-0160 Modelling population affected by bursts.xlsx	Critical pipe model runs to determine the number of properties affected (defined as experiencing less than 3m pressure head for more than 3 hours) and the duration of the interruption in 27 locations.	-	-	-	✓
REQ-0176 Samples and Contacts.xlsx	For each of the WWMDs d/s of each proposed slip lining scheme, the total number of discoloured water contacts from 01/05/2016 to 30/04/2017 and the average iron content of samples (milligrams per	-	-	-	✓

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
	litre) from 01/12/2015 to 30/11/2016. Also data showing the total number of properties in each WWMD.				
REQ-0210 Copy of interruptions_extract_analysis.xlsx	Data showing what proportions of supply interruptions are caused by trunk mains	-	-	-	✓

7.3 Appendix C.1: Selected Risks

This appendix shows the 37 selected risks of the 72 relevant risks.

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score	Risk Confirmed?
SRR385	Steel River Avon Crossing, Willsbridge, Bristol	Interruptions and disruptions to supply critical - main burst800 Steel River Avon Crossing, Willsbridge, Bristol	4	3	3	3	4	4	4	16	Y
SRR386	1 Bedminster Down Road (In Bridge)	Interruptions and disruptions to supply-critical main near /over Railway Lines burst - Bedminster Down Road (In Bridge)	4	4	3	3	4	4	4	16	Y
SRR392	7 Whiteladies Road, Clifton	Interruptions and disruptions to critical main near /over Railway Lines burst - Whiteladies Road, Clifton, Bristol	3	5	3	4	4	4	5	15	Y
SRR395	11 Luckington Road, Acton Turville	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Luckington Road, Acton Turville	3	3	3	2	4	4	4	12	Y
SRR397	13 Dodington Road, Chipping Sodbury	12" AC main crosses over railway in road bridge. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	4	5	3	4	4	4	5	20	Y
SRR398	14 Nr Broadmead Lane, Keynsham	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Broadmead Lane, Keynsham, Bristol	3	2	2	2	4	4	4	12	Y
SRR400	16 Nr Burton Row, Brent Knoll	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Burton Row, Brent Knoll.	4	5	3	4	4	4	5	20	Y
SRR401	17 Nr Chelvey Road	Interruptions and disruptions to supply critical main near /over Railway Lines burst - Nr Burton Row, Brent Knoll. No, mains ID is Chelvey Road, Backwell	5	5	3	4	4	4	5	25	Y
SRR408	24 Jacks Lane, Spring Gardens, Frome	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Jacks Lane, Spring Gardens, Frome	3	5	3	4	4	4	5	15	Y
SRR409	25 Gloucester Road, Patchway,	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Gloucester Road, Patchway, Bristol	3	3	3	2	4	4	4	12	Y
SRR411	28 St John's Road, Clifton, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - St John's Road, Clifton, Bristol	3	5	3	4	4	4	5	15	Y

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score	Risk Confirmed?
SRR412	29 Temple Gate to Bath Road, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Temple Gate to Bath Road, Bristol	3	5	3	4	4	4	5	15	Y
SRR413	30 Severn Road, Chittening	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Severn Road, Chittening	3	5	3	4	4	4	5	15	Y
SRR414	32 Pembroke Road, Clifton, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Pembroke Road, Clifton, Bristol	3	2	2	2	3	3	3	9	N
SRR415	33 Cambridge Batch, Flax Bourton	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Cambridge Batch, Flax	3	4	3	3	4	4	4	12	Y
SRR420	37 Nr Moorhouse Lane, Avonmouth, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Moorhouse Lane, Avonmouth, Bristol	3	5	3	4	4	4	5	15	Y
SRR421	38 Diamond Batch, Weston-Super-Mare	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Diamond Batch, Weston-Super-Mare	3	5	3	4	4	4	5	15	Y
SRR424	41 Portway, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Portway, Bristol	4	4	2	3	4	4	4	16	Y
SRR425	42 (part) Clanage Road, Ashton, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Clanage Road, Ashton, Bristol	3	4	3	3	4	4	4	12	Y
SRR426	42 (part) Rownham Hill Bridge Road, Ashton, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Rownham Hill Bridge Road, Ashton, Bristol	3	4	3	3	4	4	4	12	Y
SRR427	43 Nr Rose Meadow View, Ashton Vale, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Rose Meadow View, Ashton Vale, Bristol	4	3	3	2	4	4	4	16	Y
SRR428	44 Durley Land, Keynsham, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Durley Land, Keynsham, Bristol	3	5	3	4	4	4	5	15	Y

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score	Risk Confirmed?
SRR429	45 Over Lane, Almondsbury, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Over Lane, Almondsbury, Bristol	3	5	3	4	4	4	5	15	Y
SRR432	48 Nr Nibley Lane, Iron Acton	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Nibley Lane, Iron Acton	3	5	3	4	4	5	5	15	Y
SRR459	Purton to Pucklechurch Trunk Main	UCML of larger scope from inability to operate Purton to Pucklechurch isolation valves	3	2	3	2	3	5	5	15	Y
SRR460	Pucklechurch to Barrow Trunk Main	UCML of larger scope from inability to operate Pucklechurch to Barrow (south Bristol ring main) isolation valves	3	2	3	2	3	5	5	15	Y
SRR598	31 Severn Road, Chittening	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Severn Road, Chittening	3	4	3	3	4	4	4	12	Y
SRR599	Hotwells Tunnel	Hotwells Tunnel culvert risk of a burst main adjacent to Portway shaft	4	3	4	3	4	3	4	16	Y
SRR622	All supply area	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	3	4	3	4	4	1	4	12	Y
SRR623	All supply area	Risk of discoloured water or water with high iron content supplied to customer.	3	2	4	3	5	3	5	15	Y
SRR1000	Non Site Specific	IF a strategic main critical, THEN further information on its integrity can target future investment and reduce the likelihood of failure. Leaks will be fix on find and should also reduce bursts.	4	2	2	3	4	5	5	20	Y
SRR1001	Non Site Specific	IF a strategic main was to fail under pressure, THEN it may cause a health and safety incident leading to serious injury or death.	3	5	2	4	5	5	5	15	Y
SRR1002	Non Site Specific	IF a strategic valve is not maintained, THEN it may lead to a delay in response to an interruption to supply to significant numbers of the population	3	2	2	1	2	5	5	15	Y
SRR1003	Non Site Specific	IF wayleaves are not maintained, THEN any duration to respond and recover during an incident is increased	3	2	1	1	1	5	5	15	Y

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score	Risk Confirmed?
SRR1004	Non Site Specific	IF unknown critical risks are identified via the Asset Criticality Profiling project or by other means in AMP6, THEN they must be mitigated where possible.	4	2	2	4	5	5	5	20	Y
SRR1005	Non Site Specific	IF strategic air valves are not maintained, THEN they may pose a risk to pressurised mains and lead to a burst	3	2	2	2	2	5	5	15	Y
SRR1006	Non Site Specific	IF strategic loose jumper hydrants are not swapped out for through bore hydrants, THEN hydrants cannot be used to supply water during an interruption to supply	3	2	2	2	3	5	5	15	Y

7.4 Appendix C.2: Non-Selected Risks

This appendix shows the 35 non-selected risks of the 72 relevant risks.

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR1	Barrow TW	If Yanley Lane valve fails, then cannot control a main flow to the city (Barrow-Area 2) and either Victoria reservoir overflows or Victoria reservoir starts dropping out.	3	2	1	1	1	1	2	6
SRR259	Cheddar TW	If main between cheddar cliffs res and Cheddar fails, then reduced output from site (Cheddar-Area 3)	2	1	1	2	3	3	3	6
SRR387	2 Wild Country Lane, Long Ashton, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Wild Country Lane, Long Ashton, Bristol	2	4	3	3	4	4	4	8
SRR388	3 Maesdown Road, Shepton Mallet	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Mesdown Road, Shepton Mallet	2	5	3	3	4	4	5	10
SRR389	5 Stapleton Road, Easton	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Stapleton Road, Easton, Bristol	2	2	2	2	4	4	4	8
SRR390	4 Nr Church Street, Radstock	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Church Street, Radstock	2	0	0	0	0	0	0	0
SRR391	6 Little Stoke - Clay Lane	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Clay Lane, Little Stoke, Bristol - assumed to be 300 main in A38 in Little Stoke - Clay Lane does not cross the railway.	2	5	3	4	4	4	5	10
SRR393	9 Nr Westerleigh Road, Yate	Interruptions and disruptions to critical main near /over Railway Lines burst - Nr Westerleigh Road, Yate	3	2	2	2	3	3	3	9
SRR394	10 Goose Greenway, Yate	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Goose Greenway, Yate	2	5	3	4	4	4	5	10
SRR396	12 St Marks Road, Easton	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Weston Road, Cambridge Batch, Backwell. No, mains ID is for St Marks Road , Easton. Cambridge Batch is covered in RR1300 below.	1	2	2	2	4	4	4	4
SRR399	15 Nr West End, Wickwar	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr West End, Wickwar.	2	3	3	3	3	3	3	6

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR402	18 Church Road, Lawrence Hill	Interruptions and disruptions to critical main near /over Railway Lines burst - Church Road, Lawrence Hill, Bristol	2	5	3	4	4	4	5	10
SRR403	19 Silverthorne Lane, St. Phillips Marsh	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Silverthorne Lane, St. Phillips Marsh	2	2	2	2	4	4	4	8
SRR404	20 Ram Hill, Coalpit Heath	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Ram Hill, Coalpit Heath	3	2	2	2	3	3	3	9
SRR405	21 Shepherds Way, St Georges	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Shepherds Way, St Georges	2	5	3	4	4	4	5	10
SRR406	22 Cheltenham Road, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Cheltenham Road, Bristol	3	2	2	2	3	3	3	9
SRR407	23 Station Road, Filton	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Station Road, Filton, Bristol	2	2	2	2	4	4	4	8
SRR410	26 Avonmouth Industrial Centre, Avonmouth	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Avonmouth Industrial Centre, Avonmouth	1	3	3	2	4	4	4	4
SRR416	Non Site Specific	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Elevated Road M5 near Pill	2	4	3	3	4	4	4	8
SRR417	34 Smoke Lane, Avonmouth, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Smoke Lane, Avonmouth, Bristol	2	3	3	2	3	3	3	6
SRR418	35 Hutton Moor Lane, Weston-Super-Mare	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Hutton Moor Lane, Weston-Super-Mare	2	5	3	4	4	4	5	10

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR419	36 Nr Moorhouse Lane, Avonmouth, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Moorhouse Lane, Avonmouth, Bristol	2	5	3	4	4	4	5	10
SRR422	39 Nr Wotton Road, Rangeworthy	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Wotton Road, Rangeworthy	2	5	3	4	4	4	5	10
SRR423	40 Gloucester Road, Filton, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Gloucester Road, Filton, Bristol	1	5	3	4	4	4	5	5
SRR430	46 Bath Road, Willsbridge, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Bath Road, Willsbridge, Bristol	2	4	2	3	4	4	4	8
SRR431	47 Nr B4066, Berkeley Heath, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr B4066, Berkeley Heath, Bristol	1	5	3	4	4	5	5	5
SRR433	49 Nr Box Hedge Lane, Coalpit Heath, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Nr Box Hedge Lane, Coalpit Heath, Bristol	2	5	3	4	4	5	5	10
SRR434	50 Cattle Market Road, Temple Meads, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Cattle Market Road, Temple Meads, Bristol	1	2	2	2	4	4	4	4
SRR435	51 Muller Road, Horfield, Bristol	Interruptions and disruptions to supply - critical main near /over Railway Lines burst - Muller Road, Horfield, Bristol	2	2	2	2	4	4	4	8
SRR436	52 Nr Kendall Close, Yate	If the 355mm polyethylene main under a railway bursts then this may cause Interruptions to supply for our Customers and disruptions to the railway.	1	3	3	2	4	4	4	4
SRR457	Barton Hill	UCML of larger scope from lack of valves in Barton Hill	2	2	1	3	3	3	3	6
SRR458	Bradley Stoke TM	UCML of larger scope from lack of valves on Bradley Stoke TM	2	2	1	3	3	3	3	6
SRR597	Brent Knowle to Cheddar TM	If main between Brent Knoll res and Cheddar fails, then reduced output from site to Brent Knoll (Cheddar-Area 3)	2	2	1	2	4	4	4	8

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR608	Brent Knoll to Burnham 12"	Brent Knoll Service Reservoir to Burnham 12 inch main risk of loss of supply to customers	2	2	2	3	3	4	4	8
SRR618	Pucklechurch to Barrow	Unable to maximise Pucklechurch to Barrow transfer							0	0
SRR624	Various	Risk of failure of cathodic protection system	2	2	3	2	3	4	4	8
SRR625	All supply area	Risk of Customer Minuets Lost (Supply Interruptions)	3	2	4	3	5	3	5	15
SRR660	Hotwells Tunnel	Hotwells Tunnel condition	2	4	5	3	2	3	5	10

7.5 Appendix D: Options Considered

This appendix shows the 85 options considered from the 37 selected risks.

Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	Risk Need		Identification & Viability of Options		
		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR385	IF the pipeline under the River Avon at Willsbridge burst THEN this will cause supply interruptions to a large population.	SRRN117	800mm diam Steel main crosses beneath the River Avon at Willsbridge, Bristol. Failure of the main under the river will be very difficult to repair and will cause a supply interruption to a large population and a pollution incident. Investment is required to minimise the risk of this main failing.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR385	IF the pipeline under the River Avon at Willsbridge burst THEN this will cause supply interruptions to a large population.	SRRN117	800mm diam Steel main crosses beneath the River Avon at Willsbridge, Bristol. Failure of the main under the river will be very difficult to repair and will cause a supply interruption to a large population and a pollution incident. Investment is required to minimise the risk of this main failing.	Install Leakage Monitors on the length of main beneath the river	Install Leakage Monitors on the length of main crossing the river to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR386	IF any of the pipelines crossing over the railway fail THEN this will cause supply interruptions and potential injury.	SRRN118	1 Bedminster Down Road: A 27"CI , 20" CI and 200 AC cross over a railway in a bridge deck. The 27" and 20" are slip lined. Only 200 AC is not slip lined. Host pipe acts as a sleeve and mitigates some of the impacts. Failure of any main may flood the railway and cause disruption and potential injury and supply interruptions. Investment is needed to minimise the risk of a burst.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR386	IF any of the pipelines crossing over the railway fail THEN this will cause supply interruptions and potential injury.	SRRN118	1 Bedminster Down Road: A 27"CI , 20" CI and 200 AC cross over a railway in a bridge deck. The 27" and 20" are slip lined. Only 200 AC is not slip lined. Host pipe acts as a sleeve and mitigates some of the impacts. Failure of any main may flood the railway and cause disruption and potential injury and supply interruptions. Investment is needed to minimise the risk of a burst.	Install Leakage Monitors on the length of main at the high risk crossing	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR392	7 Whiteladies Road, Clifton: Three mains cross over railway in a bridge - 6" CI, 10" CI and 15" CI. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN119	7 Whiteladies Road, Clifton: Three mains cross over railway in a bridge - 6" CI, 10" CI and 15" CI. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR392	7 Whiteladies Road, Clifton: Three mains cross over railway in a bridge - 6" CI, 10" CI and 15" CI. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN119	7 Whiteladies Road, Clifton: Three mains cross over railway in a bridge - 6" CI, 10" CI and 15" CI. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR395	11 Luckington Road, Acton Turville: The main is located in the bridge in steel sleeve which reduces impacts of a burst main. IF the main burst water would flood onto the tracks causing potential delays, damage to reputation and expensive claims.	SRRN126	A 450 PE main is laid in a steel duct over the railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR395	11 Luckington Road, Acton Turville: The main is located in the bridge in steel sleeve which reduces impacts of a burst main. IF the main burst water would flood onto the tracks causing potential delays, damage to reputation and expensive claims.	SRRN126	A 450 PE main is laid in a steel duct over the railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices

Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	Risk Need		Identification & Viability of Options		
		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR397	13 Dodington Road, Chipping Sodbury: 12" AC main crosses over railway in road bridge. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN127	A 12" AC main crosses over railway in road bridge.Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR397	13 Dodington Road, Chipping Sodbury: 12" AC main crosses over railway in road bridge. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN127	A 12" AC main crosses over railway in road bridge.Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR398	14 Nr Broadmead Lane: Interruptions and disruptions to supply - critical main near /over Railway Lines burst. 12" CI main crosses under railway in road. Railway is on bridge over road. The railway bridge results in an area of restricted access, which would make a burst more challenging to fix than a main in the adjacent sections of road.	SRRN128	12" CI main crosses under railway in road. Railway is on bridge over road. Investment is needed to minimise the risk of a mains burst under the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR398	14 Nr Broadmead Lane: Interruptions and disruptions to supply - critical main near /over Railway Lines burst. 12" CI main crosses under railway in road. Railway is on bridge over road. The railway bridge results in an area of restricted access, which would make a burst more challenging to fix than a main in the adjacent sections of road.	SRRN128	12" CI main crosses under railway in road. Railway is on bridge over road. Investment is needed to minimise the risk of a mains burst under the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR400	16 Nr Burton Row, Brent Knoll: 355mm HDPE main buried in ground crossing under railway tracks. The main is located under the track. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN129	355mm HDPE main buried in ground crossing under railway tracks. Investment is needed to minimise the risk of this main failing and causing supply interruptions, bursts, danger to the public and third party damage.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR400	16 Nr Burton Row, Brent Knoll: 355mm HDPE main buried in ground crossing under railway tracks. The main is located under the track. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN129	355mm HDPE main buried in ground crossing under railway tracks. Investment is needed to minimise the risk of this main failing and causing supply interruptions, bursts, danger to the public and third party damage.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR401	17 Nr Chelvey Road: 300mm DI crossing track, laid directly underneath. 20" SI crossing track, laid directly underneath. 300mm DI crossing is joined either side to 450mm AC main. 20" SI is joined either side to 18" SI main. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN130	300mm DI crossing track, laid directly underneath. 20" SI crossing track, laid directly underneath. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high

Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	Risk Need		Identification & Viability of Options		
		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR401	17 Nr Chelvey Road: 300mm DI crossing track, laid directly underneath. 20" SI crossing track, laid directly underneath. 300mm DI crossing is joined either side to 450mm AC main. 20" SI is joined either side to 18" SI main. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN130	300mm DI crossing track, laid directly underneath. 20" SI crossing track, laid directly underneath. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR408	`	SRRN131	18" AC main crossing railway, buried directly beneath track. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR408	24 Jacks Lane, Spring Gardens, Frome: 18" AC main crossing railway, buried directly beneath track. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN131	18" AC main crossing railway, buried directly beneath track. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR409	25 Gloucester Road, Patchway: 250 HDPE in 300 duct and 355 HDPE in 400 duct, both in western bridge. 300mm unknown material in eastern bridge. Road bridges with buried pipes cross over railway line. Failure here would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN132	250 HDPE in 300 duct and 355 HDPE in 400 duct, both in western bridge. 300mm unknown material in eastern bridge. Road bridges with buried pipes cross over railway line. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR409	25 Gloucester Road, Patchway: 250 HDPE in 300 duct and 355 HDPE in 400 duct, both in western bridge. 300mm unknown material in eastern bridge. Road bridges with buried pipes cross over railway line. Failure here would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN132	250 HDPE in 300 duct and 355 HDPE in 400 duct, both in western bridge. 300mm unknown material in eastern bridge. Road bridges with buried pipes cross over railway line. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR411	28 St John's Road, Clifton, Bristol: 18" CI main in road bridge crossing over railway. Line from Bristol TM to Avonmouth/Severn Beach. The main is located in the bridge. Failure here would flood immediately down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN133	18" CI main in road bridge crossing over railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high

Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	Risk Need		Identification & Viability of Options		
		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR411	28 St John's Road, Clifton, Bristol: 18" CI main in road bridge crossing over railway. Line from Bristol TM to Avonmouth/Severn Beach. The main is located in the bridge. Failure here would flood immediately down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN133	18" CI main in road bridge crossing over railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR412	29 Temple Gate to Bath Road,Bristol: 18" CI main. Bath Road Bridge. Main attached to road bridge which passes over main line railways close to Temple Meads station. Failure here would flood immediately down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN134	18" CI main. Bath Road Bridge. Main attached to road bridge which passes over main line railways close to Temple Meads station. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR412	29 Temple Gate to Bath Road,Bristol: 18" CI main. Bath Road Bridge. Main attached to road bridge which passes over main line railways close to Temple Meads station. Failure here would flood immediately down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	SRRN134	18" CI main. Bath Road Bridge. Main attached to road bridge which passes over main line railways close to Temple Meads station. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR413	30 Severn Road, Chittening: 20" SI main crossing directly underneath railway tracks. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN135	20" SI main crossing directly underneath railway tracks. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR413	30 Severn Road, Chittening: 20" SI main crossing directly underneath railway tracks. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN135	20" SI main crossing directly underneath railway tracks. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR414	32 Pembroke Road, Clifton, Bristol: 700 DI and 21" CI mains. The railway is in tunnel 30m below the mains separated by limestone. If the main burst it may be possible that water could migrate down to the railway but this seems remote.	N/A	N/A	N/A	N/A	N/A
SRR414	32 Pembroke Road, Clifton, Bristol: 700 DI and 21" CI mains. The railway is in tunnel 30m below the mains separated by limestone. If the main burst it may be possible that water could migrate down to the railway but this seems remote.	N/A	N/A	N/A	N/A	N/A
SRR415	33 Cambridge Batch, Flax Bourton: 500mm PE slipline inside 21" CI host pipe. In road bridge over railway. Failure here would flood down onto the tracks causing potential delays, damage to reputation and expensive claims.	SRRN136	500mm PE slipline inside 21" CI host pipe. In road bridge over railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high

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		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR415	33 Cambridge Batch, Flax Bourton: 500mm PE slipline inside 21" CI host pipe. In road bridge over railway. Failure here would flood down onto the tracks causing potential delays, damage to reputation and expensive claims.	SRRN136	500mm PE slipline inside 21" CI host pipe. In road bridge over railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR420	37 Nr Moorhouse Lane, Avonmouth, Bristol: 600mm AC main laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN137	600mm AC main laid beneath railway. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR420	37 Nr Moorhouse Lane, Avonmouth, Bristol: 600mm AC main laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN137	600mm AC main laid beneath railway. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR421	38 Diamond Batch, Weston-Supre-Mare: 600mm AC main laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN138	600mm AC main laid beneath railway. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR421	38 Diamond Batch, Weston-Supre-Mare: 600mm AC main laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN138	600mm AC main laid beneath railway. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR424	41 Portway, Bristol: 27" main is parallel to railway but so 50m offset. Railway is slightly raised. Any burst on the 27" is unlikely to disrupt railway but flood surrounding ground.	SRRN139	27" main is parallel to railway but so 50m offset. Railway is slightly raised. Any burst on the 27" is unlikely to disrupt railway but flood surrounding ground. Investment is needed to reduce third party damage and supply interruptions and bursts.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR424	41 Portway, Bristol: 27" main is parallel to railway but so 50m offset. Railway is slightly raised. Any burst on the 27" is unlikely to disrupt railway but flood surrounding ground.	SRRN139	27" main is parallel to railway but so 50m offset. Railway is slightly raised. Any burst on the 27" is unlikely to disrupt railway but flood surrounding ground. Investment is needed to reduce third party damage and supply interruptions and bursts.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR425	42 (part) Clanage Road, Ashton, Bristol: 30" CI under railway. Railway is not a passenger route and is only open for freight. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN140	30" CI under railway. Railway is not a passenger route and is only open for freight. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high

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SRR425	42 (part) Clanage Road, Ashton, Bristol: 30" CI under railway. Railway is not a passenger route and is only open for freight. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN140	30" CI under railway. Railway is not a passenger route and is only open for freight. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR426	42 (part) Rownham Hill Bridge Road, Ashton, Bristol: 30" PSC laid under railway. Railway is not a passenger route and is only open for freight. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN141	30" PSC laid under railway. Railway is not a passenger route and is only open for freight. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR426	42 (part) Rownham Hill Bridge Road, Ashton, Bristol: 30" PSC laid under railway. Railway is not a passenger route and is only open for freight. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN141	30" PSC laid under railway. Railway is not a passenger route and is only open for freight. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR427	43 Nr Rose Meadow View, Ashton Vale, Bristol: 800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel.	SRRN142	800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR427	43 Nr Rose Meadow View, Ashton Vale, Bristol: 800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel.	SRRN142	800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR427	43 Nr Rose Meadow View, Ashton Vale, Bristol: 800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel.	SRRN142	800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install isolation valve	The main is twinned where it crosses beneath the railway line, and branches just downstream. With the current isolation valve arrangement, a burst on the eastern twin main would result in the eastern branch (which connects Barrow with Victoria Res) being out of service whilst a repair was carried out. One additional isolation valve would allow both branches to be kept in service if either of the twin mains failed.	Due to additional twinning downstream of this rail crossing, a burst on either section under the railway could be isolated with water continuing to gravitate to Victoria Res from Barrow. Therefore this option is not needed.
SRR428	44 Durley Land, Keynsham, Bristol: 800 PSC is laid in road in tunnel beneath the railway. Tunnel is very narrow (one vehicle width). PSC pipes are known to explode if they burst therefore burst could damage tunnel.	SRRN143	800 PSC is laid in road in tunnel beneath the railway. Tunnel is very narrow (one vehicle width). PSC pipes are known to explode if they burst therefore burst could damage tunnel. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high

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SRR428	44 Durley Land, Keynsham, Bristol: 800 PSC is laid in road in tunnel beneath the railway. Tunnel is very narrow (one vehicle width). PSC pipes are known to explode if they burst therefore burst could damage tunnel.	SRRN143	800 PSC is laid in road in tunnel beneath the railway. Tunnel is very narrow (one vehicle width). PSC pipes are known to explode if they burst therefore burst could damage tunnel. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR429	45 Over Lane, Almondsbury, Bristol: 36" PSC laid in road over railway. Railway is some 10m below but burst main could flood railway.	SRRN144	36" PSC laid in road over railway. Railway is some 10m below but burst main could flood railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR429	45 Over Lane, Almondsbury, Bristol: 36" PSC laid in road over railway. Railway is some 10m below but burst main could flood railway.	SRRN144	36" PSC laid in road over railway. Railway is some 10m below but burst main could flood railway. Investment is needed to minimise the risk of a mains burst over the railway and thereby reduce the risk of supply interruptions, bursts or other indirect cost caused by flooding the railway.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR432	48 Nr Nibley Lane, Iron Acton: 46" steel laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN145	46" steel laid beneath railway. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR432	48 Nr Nibley Lane, Iron Acton: 46" steel laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	SRRN145	46" steel laid beneath railway. Investment is needed to reduce risk of failure of the main and thereby reduce risk of supply interruption, danger to the public or third party damages.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices
SRR459	The Purton to Pucklechurch main has one 36" and two 24" butterfly valves which were installed when the main was built in 1973. IF a valve failed shut during a burst incident (as happened in 2007/8 on the Pucklechurch to Barrow section) THEN customers will be at risk of losing their supply because flows to Pucklechurch serving the north and east Bristol area will be prevented.	SRRN4	The Purton-Pucklechurch Main has one 36" butterfly valve and two 24" butterfly valves which were installed when the main was built in 1973. A 36" valve of the same mechanism, and roughly the same age, failed shut during a burst incident in 2002. Purton-Pucklechurch is a key trunk main serving the strategic Pucklechurch service reservoir which feeds the Bristol area. The deterioration model predicts at least one burst on the main in both AMPs 7 and 8. To prevent customers losing their supply investment is needed to replace the butterfly valve.	Do nothing with Purton - Pucklechurch butterfly valves	Leave existing 1 No 36" and 2 No 24" butterfly valves in situ and do not carry out maintenance, accepting risk of valve failure which may lead to supply interruptions	Not viable. Action must be taken to reduce supply interruptions in line with AMP7 performance commitments.
SRR459	The Purton to Pucklechurch main has one 36" and two 24" butterfly valves which were installed when the main was built in 1973. IF a valve failed shut during a burst incident (as happened in 2007/8 on the Pucklechurch to Barrow section) THEN customers will be at risk of losing their supply because flows to Pucklechurch serving the north and east Bristol area will be prevented.	SRRN4	The Purton-Pucklechurch Main has one 36" butterfly valve and two 24" butterfly valves which were installed when the main was built in 1973. A 36" valve of the same mechanism, and roughly the same age, failed shut during a burst incident in 2002. Purton-Pucklechurch is a key trunk main serving the strategic Pucklechurch service reservoir which feeds the Bristol area. The deterioration model predicts at least one burst on the main in both AMPs 7 and 8. To prevent customers losing their supply investment is needed to replace the butterfly valve.	Refurbish Purton - Pucklechurch butterfly valves	Refurbishment of 1 No 36" and 2 No 24" existing butterfly valves on strategic 46" dia. trunk main	Not viable…? Refurbishment would require each valve to be taken off-site for inspection and maintenance, then reinstalled. The main would have to be out of service for this period of time. Purton-Pucklechurch is a key strategic main and this is not an option.

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SRR459	The Purton to Pucklechurch main has one 36" and two 24" butterfly valves which were installed when the main was built in 1973. IF a valve failed shut during a burst incident (as happened in 2007/8 on the Pucklechurch to Barrow section) THEN customers will be at risk of losing their supply because flows to Pucklechurch serving the north and east Bristol area will be prevented.	SRRN4	The Purton-Pucklechurch Main has one 36" butterfly valve and two 24" butterfly valves which were installed when the main was built in 1973. A 36" valve of the same mechanism, and roughly the same age, failed shut during a burst incident in 2002. Purton-Pucklechurch is a key trunk main serving the strategic Pucklechurch service reservoir which feeds the Bristol area. The deterioration model predicts at least one burst on the main in both AMPs 7 and 8. To prevent customers losing their supply investment is needed to replace the butterfly valve.	Replace Purton - Pucklechurch butterfly valves	Installation of 1 No 36" and 2 No 24" replacement butterfly valves on strategic 46" dia. trunk main	Viable. Replacement of the valves is the most efficient way to carry out maintenance, without taking the main out of service for long periods of time.
SRR460	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. IF a valve failed shut during a burst incident (as happened in 2007/8) THEN flows in the SBRM serving the east of Bristol area will be prevented.	SRRN5	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. One valve failed shut during a burst incident in 2007/8(?). SBRM is a key trunk main serving the east of Bristol area. The deterioration model predicts at least one burst on the SBRM in both AMPs 7 and 8. Investment is needed to replace the butterfly valves in order to: - meet the performance commitment for Supply Interruptions.	Do nothing with Pucklechurch - Willsbridge (SBRM) butterfly valves	Leave existing 6 No 36" butterfly valves in situ and do not carry out maintenance, accepting risk of valve failure which may lead to supply interruptions	Not viable. Action must be taken to reduce supply interruptions in line with AMP7 performance commitments.
SRR460	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. IF a valve failed shut during a burst incident (as happened in 2007/8) THEN flows in the SBRM serving the east of Bristol area will be prevented.	SRRN5	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. One valve failed shut during a burst incident in 2007/8(?). SBRM is a key trunk main serving the east of Bristol area. The deterioration model predicts at least one burst on the SBRM in both AMPs 7 and 8. Investment is needed to replace the butterfly valves in order to: - meet the performance commitment for Supply Interruptions.	Refurbish Pucklechurch - Willsbridge (SBRM) butterfly valves	Refurbishment of 6 No 36" existing butterfly valves on strategic 1100mm dia. trunk main	Not viable…? Refurbishment would require each valve to be taken off-site for inspection and maintenance, then reinstalled. The main would have to be out of service for this period of time. The South Bristol Ring Main is a key strategic main which supplies several DMAs and therefore this is not a preferable option.
SRR460	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. IF a valve failed shut during a burst incident (as happened in 2007/8) THEN flows in the SBRM serving the east of Bristol area will be prevented.	SRRN5	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. One valve failed shut during a burst incident in 2007/8(?). SBRM is a key trunk main serving the east of Bristol area. The deterioration model predicts at least one burst on the SBRM in both AMPs 7 and 8. Investment is needed to replace the butterfly valves in order to: - meet the performance commitment for Supply Interruptions.	Replace Pucklechurch - Willsbridge (SBRM)butterfly valves	Installation of 6 No 36" replacement butterfly valves on strategic 1100mm dia. trunk main	Viable. Replacement of the valves is the most efficient way to carry out maintenance, without taking the main out of service for long periods of time.
SRR598	31 Severn Road, Chittening: 20" SI parallel to railway line. The main is located in the parralel road. Failure here would flood onto the tracks causing potential delays, damage to reputation and expensive claims.	SRRN182	20" SI parallel to railway line. Investment is needed to reduce the risk of failure which coud cause third party claims, supply interruptions and mains bursts.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR598	31 Severn Road, Chittening: 20" SI parallel to railway line. The main is located in the parralel road. Failure here would flood onto the tracks causing potential delays, damage to reputation and expensive claims.	SRRN182	20" SI parallel to railway line. Investment is needed to reduce the risk of failure which coud cause third party claims, supply interruptions and mains bursts.	Install Leakage Monitors on the length of main crossing the railway	Install Leakage Monitors on the length of main crossing the railway to monitor the pipes for any leakage occuring and get early warning of a potential burst.	Viable - BW has experience of installing these devices

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		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR599	The 20m deep vertical shafts of the Hotwells tunnel each house a 36" cast iron main installed in 1930. The main connects Barrow Treatment Works and Victoria Reservoir, serving central Bristol. The main is known to be leaking at the top of eastern shaft, located on the Portway (A4), a key transport route into central Bristol. IF the main in the Hotwells Tunnel fails THEN the supply to Victoria and Avonmouth will be interrupted and the performance committments against Supply Interruptions and Mains Bursts will be compromised and third party damage to the highway or elsewhere may result.	SRRN3	The 20m deep vertical shafts of the Hotwells tunnel each house a 36" cast iron main installed in 1930. The main connects Barrow Treatment Works and Victoria Reservoir, serving central Bristol. The main is known to be leaking at the top of eastern shaft, located on the Portway (A4), a key transport route into central Bristol. Investment is needed to carry out repair works on the leaking main and associated thrust restraint in order to: - help meet the performance commitment for Supply Interruptions; - help meet the performance commitment for Mains Bursts; - help meet the performance commitment for Leakage; - avoid the potential cost of third party damage as experienced following a burst in a nearby location in 2001.	Do nothing	Take no action and accept risk of failure	Not viable - risk is too high
SRR599	The 20m deep vertical shafts of the Hotwells tunnel each house a 36" cast iron main installed in 1930. The main connects Barrow Treatment Works and Victoria Reservoir, serving central Bristol. The main is known to be leaking at the top of eastern shaft, located on the Portway (A4), a key transport route into central Bristol. IF the main in the Hotwells Tunnel fails THEN the supply to Victoria and Avonmouth will be interrupted and the performance committments against Supply Interruptions and Mains Bursts will be compromised and third party damage to the highway or elsewhere may result.	SRRN3	The 20m deep vertical shafts of the Hotwells tunnel each house a 36" cast iron main installed in 1930. The main connects Barrow Treatment Works and Victoria Reservoir, serving central Bristol. The main is known to be leaking at the top of eastern shaft, located on the Portway (A4), a key transport route into central Bristol. Investment is needed to carry out repair works on the leaking main and associated thrust restraint in order to: - help meet the performance commitment for Supply Interruptions; - help meet the performance commitment for Mains Bursts; - help meet the performance commitment for Leakage; - avoid the potential cost of third party damage as experienced following a burst in a nearby location in 2001.	Hotwells tunnels pipework and thrust restraint improvement works	Replace the pipework at the top of the eastern tunnel shaft and make good the thrust restraint.	Viable
SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Install security measures at 50 randomly selected locations	Randomly select 50 pipe bridge and pipe crossing locations. At these locations, install deterrents or security fencing on pipe bridges and crossings to reduce the likelihood of members of the public climbing on and walking over these assets.	By making improvements at 50 random locations the benefit will be limited. See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'.

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SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Accept risk and do nothing	Take no action to reduce the risk presented by pipe bridges and crossings in the Bristol Water network. Accept the possibility that members of the public could come to harm if accessing BW assets and take liability if and when this occurs.	See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'
SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Install security measures	Install deterrents or security fencing on pipe bridges and crossings to reduce the likelihood of members of the public climbing on and walking over these assets.	See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'

Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	Risk Need		Identification & Viability of Options		
		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Carry out risk assessments and install security measures at 50 high-risk locations	Programme of risk assessments and surveys of circa 330 pipe bridges and production of an asset inventory for these assets. Identify the 50 most high risk locations of pipe bridges and crossings by identifying those close to children's playgrounds, public footpaths and commonly used routes around schools. At these locations, install deterrents or security fencing on pipe bridges and crossings to reduce the likelihood of members of the public climbing on and walking over these assets.	By targeting the highest risk-locations for improvements, the maximum possible benefits will be derived from the intervention. See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'
SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Turn pipe crossings into footbridges	Build a footbridge over every pipe crossing. This makes every location safe without obstructing access.	See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'

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SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Bury pipes under watercourses	Replace overground pipe crossings with buried pipework. Open cut through the watercourse, fluming the flow.	See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'
SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	SRRN1	Bristol Water's supply network includes a number of known pipe bridges and crossings, as well as pipes fixed to the side of bridges. Over 600 locations were identified on GIS where mains cross water courses. There is no register of pipe bridges or crossing and it is not known how many pipe bridges or crossings BW have. The Water UK document published in 2007 highlighted the need to protect the public from injury by falling from a pipe bridge or crossing. Bristol Water have a duty to protect the safety of the public. Investment is needed to survey Bristol Water's supply area, identify pipe bridges and crossings and make safe all locations, in order to: - ensure no assets pose a risk to the public; - ensure industry best practice is followed; - meet obligations under the Health and Safety at Work Act 1974 and the Corporate Manslaughter and Corporate Homicide Act 2007; - avoid liability and reputational damage in the event of accident or injury resulting from an unsafe asset.	Bury pipe crossings at high-risk locations under watercourses	Identify the 50 most high risk locations of pipe bridges and crossings by identifying those close to children's playgrounds, public footpaths and commonly used routes around schools. At these locations, replace overground pipe crossings with buried pipework. Open cut through the watercourse, fluming the flow.	See document 'NTPBP-CAL-TRU-0137 Pipe bridge interventions option comparison'

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		SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Do nothing	Do nothing and accept the deterioration of ferrous mains and the increased risk of water quality compliance failures and discoloured water contacts. As a result, risk not meeting the Performance Commitment for discolouration.	All risk remains. Performance commitment for discoloured water requires improvements.
SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Increased flushing of downstream distribution mains	Increase the regularity at which the downstream distribution mains are flushed to remove iron particulate.	This option treats the sympton rather than the cause, and is therefore not a viable long term solution.
SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Slipline with structural pipe	Insert a regular polyethelene (PE) pipe inside the existing main. This results in a decrease in hydraulic capacity. Reduces the area of exposed ferrous pipe in the network leaching dissolved iron into the water supply. Long term benefit of reducing iron particulate build up in mains. Allows mains to be cleaned in the future, through swabbing, jetting or ice-pigging.	Hydraulic capacity is compromised more than other relining options due to thickness of pipe wall and annulus between host pipe and liner.

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SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	PU lining	Line the inside of the main with a spray-application polyurethane (PU) lining. Reduces the area of exposed ferrous pipe in the network leaching dissolved iron into the water supply. Long term benefit of reducing iron particulate build up in mains. BW has previously experienced problems with the quality of PU spray lining.	Where mains have a significant number of lateral ferrules PU lining is likely to block the laterals which then need reopening. Where mains have leaking joints groundwater will ingress and PU will not bond onto wet pipe.
SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Swabbing	Swab the inside of the main to remove the build up of particulate material. This material causes discoloured water when dislodged by changes in velocity. This method is considered aggressive to unlined ferrous mains, as the swabbing action can break off nodules of corroded iron, exposing fresh corrosion sites which then leach soluble iron into the water at a high rate.	Exposed ferrous main remains, with fresh corrosion sites releasing soluble iron into water

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SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Ice-pigging	Pig the inside of the main using a pumped ice slurry to remove the build up of particulate material. This material causes discoloured water when dislodged by changes in velocity. This method is considered aggressive to unlined ferrous mains, as the movement of the slurry can break off nodules of corroded iron, exposing fresh corrosion sites which then leach soluble iron into the water at a high rate.	Exposed ferrous main remains, with fresh corrosion sites releasing soluble iron into water
SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Mains conditioning	Condition the main to cope with increases in velocity and change in flow direction. A programme of controlled velocity increases and/or flow reversals removes material from the mains and conditions the remaining material to resist the imposed conditions. As a result, mains can withstand changes to normal flow, during for example a burst event, without risk of causing discoloured water downstream. Conditioning is an ongoing programme of work and so the solution is effective for as long as this programme continues.	This option is more of a resilience measure as it allows mains to be used in ways that they are not currently, for fear of causing downstream discolouration. Mains conditioning has no effect on everyday conditions. Further, discoloured contacts associated with a burst event do not count against the performance committment for discoloured water.

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SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	SRRN2	Bristol Water's supply network has 2832km of unlined ferrous mains that are more than 30 years old. Bristol Water received 6181 discoloured water contacts in the last five years (April 2012-March 2017), equating to 51/10,000 population, and has taken, in the period April 2012-March 2017, 279 samples as part of the ZNC sampling programme which had levels of iron over the water quality regulations compliance limit of 200micrograms/litre. Investment is needed for replacement or rehabilitation of aging, unlined ferrous mains, in order to: - help meet the performance commitment for Water quality - discolouration customer contacts; - help meet the performance commitment for Water Quality Compliance (Compliance Risk Index); - avoid Notices served by the DWI; - avoid being fined by the DWI.	Abandonment	Abandon the mains. Accept the potential decrease in network resilience. Identify alternative supplies for the WWMDs downstream of the mains.	Abandoning mains is generally not practical from a network and resilience point of view. Other remedial works would be required to facilitate, incurring additional costs. This can be examined on a case by case basis.
SRR1000	IF a strategic main critical, THEN further information on its integrity can target future investment and reduce the likelihood of failure. Leaks will be fix on find and should also reduce bursts.	N/A				
SRR1001	IF a strategic main was to fail under pressure, THEN it may cause a health and safety incident leading to serious injury or death.	N/A				
SRR1002	IF a strategic valve is not maintained, THEN it may lead to a delay in response to an interruption to supply to significant numbers of the population	N/A				

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SRR1003	IF wayleaves are not maintained, THEN any duration to respond and recover during an incident is increased	N/A				
SRR1004	IF unknown critical risks are identified via the Asset Criticality Profiling project or by other means in AMP6, THEN they must be mitigated where possible.	N/A				
SRR1005	IF strategic air valves are not maintained, THEN they may pose a risk to pressurised mains and lead to a burst	N/A				
SRR1006	IF strategic loose jumper hydrants are not swapped out for through bore hydrants, THEN hydrants cannot be used to supply water during an interruption to supply	N/A				

7.6 Appendix E: Interventions Developed

This appendix shows the 26 interventions developed from the 85 options

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR385	IF the pipeline under the River Avon at Willsbridge burst THEN this will cause supply interruptions to a large population.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR386	IF any of the pipelines crossing over the railway fail THEN this will cause supply interruptions and potential injury.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR392	7 Whiteladies Road, Clifton: Three mains cross over railway in a bridge - 6" CI, 10" CI and 15" CI. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR395	11 Luckington Road, Acton Turville: The main is located in the bridge in steel sleeve which reduces impacts of a burst main. IF the main burst water would flood onto the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR397	13 Dodington Road, Chipping Sodbury: 12" AC main crosses over railway in road bridge. If a main fails water would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR398	14 Nr Broadmead Lane: Interruptions and disruptions to supply - critical main near /over Railway Lines burst. 12” CI main crosses under railway in road. Railway is on bridge over road. The railway bridge results in an area of restricted access, which would make a burst more challenging to fix than a main in the adjacent sections of road.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR400	16 Nr Burton Row, Brent Knoll: 355mm HDPE main buried in ground crossing under railway tracks. The main is located under the track. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR401	17 Nr Chelvey Road: 300mm DI crossing track, laid directly underneath. 20" SI crossing track, laid directly underneath. 300mm DI crossing is joined either side to 450mm AC main. 20" SI is joined either side to 18" SI main. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR408	24 Jacks Lane, Spring Gardens, Frome: 18" AC main crossing railway, buried directly beneath track. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR409	25 Gloucester Road, Patchway: 250 HDPE in 300 duct and 355 HDPE in 400 duct, both in western bridge. 300mm unknown material in eastern bridge. Road bridges with buried pipes cross over railway line. Failure here would flood down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR411	28 St John's Road, Clifton, Bristol: 18" CI main in road bridge crossing over railway. Line from Bristol TM to Avonmouth/Severn Beach. The main is located in the bridge. Failure here would flood immediately down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0

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		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR412	29 Temple Gate to Bath Road,Bristol: 18" CI main. Bath Road Bridge. Main attached to road bridge which passes over main line railways close to Temple Meads station. Failure here would flood immediately down onto the roads, tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR413	30 Severn Road, Chittening: 20" SI main crossing directly underneath railway tracks. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR415	33 Cambridge Batch, Flax Bourton: 500mm PE slipline inside 21" CI host pipe. In road bridge over railway. Failure here would flood down onto the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR420	37 Nr Moorhouse Lane, Avonmouth, Bristol: 600mm AC main laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR421	38 Diamond Batch, Weston-Supre-Mare: 600mm AC main laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR424	41 Portway, Bristol: 27" main is parallel to railway but so 50m offset. Railway is slightly raised. Any burst on the 27" is unlikely to disrupt railway but flood surrounding ground.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR425	42 (part) Clanage Road, Ashton, Bristol: 30" CI under railway. Railway is not a passenger route and is only open for freight. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR426	42 (part) Rownham Hill Bridge Road, Ashton, Bristol: 30" PSC laid under railway. Railway is not a passenger route and is only open for freight. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR427	43 Nr Rose Meadow View, Ashton Vale, Bristol: 800mm DI laid in 1200mm sleeve. And 30" CI laid in tunnel under railway. Impact of any burst is therefore mitigated to some extent by the sleeve and the tunnel.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR428	44 Durley Land, Keynsham, Bristol: 800 PSC is laid in road in tunnel beneath the railway. Tunnel is very narrow (one vehicle width). PSC pipes are known to explode if they burst therefore burst could damage tunnel.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR429	45 Over Lane, Almondsbury, Bristol: 36" PSC laid in road over railway. Railway is some 10m below but burst main could flood railway.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR432	48 Nr Nibley Lane, Iron Acton: 46" steel laid beneath railway. Failure here would damage the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR459	The Purton to Pucklechurch main has one 36" and two 24" butterfly valves which were installed when the main was built in 1973. IF a valve failed shut during a burst incident (as happened in 2007/8 on the Pucklechurch to Barrow section) THEN customers will be at risk of losing their supply because flows to Pucklechurch serving the north and east Bristol area will be prevented.	01.001.21	Isolation valve replacement on Purton-Pucklechurch main	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR459	The Purton to Pucklechurch main has one 36" and two 24" butterfly valves which were installed when the main was built in 1973. IF a valve failed shut during a burst incident (as happened in 2007/8 on the Pucklechurch to Barrow section) THEN customers will be at risk of losing their supply because flows to Pucklechurch serving the north and east Bristol area will be prevented.	01.001.04	Isolation valve replacement on Purton-Pucklechurch main	£399,082	£0	0	0.358680568	0	0	0
SRR460	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. IF a valve failed shut during a burst incident (as happened in 2007/8) THEN flows in the SBRM serving the east of Bristol area will be prevented.	01.001.21	Isolation valve replacement on Pucklechurch-Willsbridge main	£892,288	£25,000	0	0.73998973	0	0.0293	0
SRR460	The Pucklechurch-Willsbridge section of the South Bristol Ring Main has six 36" butterfly valves which were installed when the main was built in 1972. IF a valve failed shut during a burst incident (as happened in 2007/8) THEN flows in the SBRM serving the east of Bristol area will be prevented.	01.001.03	Isolation valve replacement on Pucklechurch-Willsbridge	£798,165	£0	0	1.076219337	0	0	0
SRR598	31 Severn Road, Chittening: 20” SI parallel to railway line. The main is located in the parralel road. Failure here would flood onto the tracks causing potential delays, damage to reputation and expensive claims.	01.001.21	Install Leakage Monitors at 25 locations where trunk mains cross railway lines and rivers	£892,288	£25,000	0	0.73998973	0	0.0293	0

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR599	The 20m deep vertical shafts of the Hotwells tunnel each house a 36" cast iron main installed in 1930. The main connects Barrow Treatment Works and Victoria Reservoir, serving central Bristol. The main is known to be leaking at the top of eastern shaft, located on the Portway (A4), a key transport route into central Bristol. IF the main in the Hotwells Tunnel fails THEN the supply to Victoria and Avonmouth will be interrupted and the performance committments against Supply Interruptions and Mains Bursts will be compromised and third party damage to the highway or elsewhere may result.	01.001.20	Hotwells tunnels pipework and thrust restraint improvement works	£252,738	£0	0	0	0	0	0
SRR622	IF a member of the public climbs on a pipe bridge THEN they may fall and injure themselves.	01.001.02	Pipe Bridge H&S Improvements	£454,530	£0	0	0	0	0	0
SRR623	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts	01.001.05	Slipline 9" Durdham Down to Cedar Park	£1,627,470	£0	0.002528419	0	0.003744	0.032803461	0.032020877
		01.001.06	Slipline 8" Shirehampton Road	£2,094,680	£0	0.001359384	0.00257057	0.005328	0.031985797	0.07393688
		01.001.07	Slipline 8" Arley Hill to Hawkesbury Road	£2,604,190	£0	0.033608397	4.48087E-05	0.006624	0.049885377	0.113117895
		01.001.08	Slipline 7" Ashley Road Roundabout to Greenbank Cemetery	£911,370	£0	0.013883408	0	0.002592	0.024191785	0.138362761
		01.001.09	Slipline 10" Ashley Road to Lower Ashley Road	£1,051,060	£0	0.005293653	0	0.00144	0.024546543	0
		01.001.10	Slipline 9" Stapleton Road to Freemantle gardens	£813,720	£0	0.010343532	0	0.001872	0.016133126	0
		01.001.11	Slipline 7" Robertson Road to Greenbank Road	£303,790	£0	0.004237975	0	0.000864	0.0060362	0
		01.001.12	Slipline 10" Abbots Leigh	£280,280	£0	0.000138722	0	0.000576	0.003243499	0.005562168
		01.001.13	Slipline 16" Victoria Reservoir to Ralph Road	£4,488,670	£0	0.099368166	0	0.039552	0.0218	0.131387004

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
		01.001.14	Slipline 24" Chase reservoir to Lodge Road	£681,020	£0	0.301068839	0	0.00192	0.00070789	0.081419686
		01.001.15	Slipline 300mm Bath Road	£426,510	£0	0.001641991	0	0.00264	0.002437204	0
		01.001.16	Slipline 10" Speedwell Road to Rose Green Road	£658,660	£0	0.133323369	0	0.0013536	0.00461052	0.206046044
		01.001.17	Slipline 15" Speedwell Road to Rose Green Road	£1,154,850	£0	0.160041916	0	0.010176	0.005949764	0.146798203
		01.001.18	Slipline 7", 8" & 9 " Lawrence Hill to Church Road and Greenbank Road	£1,844,340	£0	0.02009716	0	0.0031488	0.038657358	0.036507487
SRR1000	IF a strategic main critical, THEN further information on its integrity can target future investment and reduce the likelihood of failure. Leaks will be fix on find and should also reduce bursts.	01.002.01	Inspection and Testing Programme	£3,984,967	£0	0	0.989218053	0	0	0
SRR1001	IF a strategic main was to fail under pressure, THEN it may cause a health and safety incident leading to serious injury or death.	01.002.02	Proximity Risk Management	£6,021,092	£0	0	0	0	0	0
SRR1002	IF a strategic valve is not maintained, THEN it may lead to a delay in response to an interruption to supply to significant numbers of the population	01.002.03	Strategic Valve Maintenance	£5,956,582	£0	0	4.021972881	0	0	0
SRR1003	IF wayleaves are not maintained, THEN any duration to respond and recover during an incident is increased	01.002.04	Wayleave Management	£363,787	£0	0	0.267188507	0	0	0
SRR1004	IF unknown critical risks are identified via the Asset Criticality Profiling project or by other means in AMP6, THEN they must be mitigated where possible.	01.002.05	Exceptional Sites	£885,500	£0	0	1.287225314	0	0	0

Strategic Risk Register Reference	SRR Revised Risk Description	Proposed Interventions		Costs		Benefits				
		Ref. No.	Intervention Title	Capex After (£)	Change in Opex (£)	Water Quality Compliance	Supply Interruptions	Leakage	Mains Bursts	Discoloured Contacts
SRR1005	IF strategic air valves are not maintained, THEN they may pose a risk to pressurised mains and lead to a burst	01.002.06	Air Valve Maintenance	£1,893,812	£0	0	1.458	0	0	0
SRR1006	IF strategic loose jumper hydrants are not swapped out for through bore hydrants, THEN hydrants cannot be used to supply water during an interruption to supply	01.002.07	Hydrant Replacement	£3,279,765	£0	0	1.958283735	0	0	0

7.7 Appendix F: Non-Selected Interventions

This appendix shows the 14 non-selected interventions. See appendix D for costs or performance commitments.

Ref. No.	Intervention Title	Expected Capex After (£m)	Change in Opex (£k)	Residual Risk
01.001.05	Slipline 9" Durdham Down to Cedar Park	£1,627,470	£0	IF ferrous pipes corrode THEN there is a risk of negative water quality contacts
01.001.06	Slipline 8" Shirehampton Road	£2,094,680	£0	
01.001.07	Slipline 8" Arley Hill to Hawkesbury Road	£2,604,190	£0	
01.001.09	Slipline 10" Ashley Road to Lower Ashley Road	£1,051,060	£0	
01.001.10	Slipline 9" Stapleton Road to Freemantle gardens	£813,720	£0	
01.001.11	Slipline 7" Robertson Road to Greenbank Road	£303,790	£0	
01.001.12	Slipline 10" Abbots Leigh	£280,280	£0	
01.001.13	Slipline 16" Victoria Reservoir to Ralph Road	£4,488,670	£0	
01.001.15	Slipline 300mm Bath Road	£426,510	£0	
01.001.18	Slipline 7", 8" & 9 " Lawrence Hill to Church Road and Greenbank Road	£1,844,340	£0	
01.002.01	Inspection and Testing Programme	£3,984,967	£0	IF a strategic main critical, THEN further information on its integrity can target future investment and reduce the likelihood of failure. Leaks will be fix on find and should also reduce bursts.
01.002.02	Proximity Risk Management	£6,021,092	£0	IF a strategic main was to fail under pressure, THEN it may cause a health and safety incident leading to serious injury or death.

Ref. No.	Intervention Title	Expected Capex After (£m)	Change in Opex (£k)	Residual Risk
01.002.03	Strategic Valve Maintenance	£5,956,582	£0	IF a strategic valve is not maintained, THEN it may lead to a delay in response to an interruption to supply to significant numbers of the population
01.002.06	Air Valve Maintenance	£1,893,812	£0	IF strategic air valves are not maintained, THEN they may pose a risk to pressurised mains and lead to a burst