C5 B

Cost and Efficiency

C5B Technical Annex 15
Treatment Works Strategic Maintenance Investment Case:
Technical Approach and Business Case

NTPBP-INV-STR-0542

BRISTOL WATER

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1 Foreword

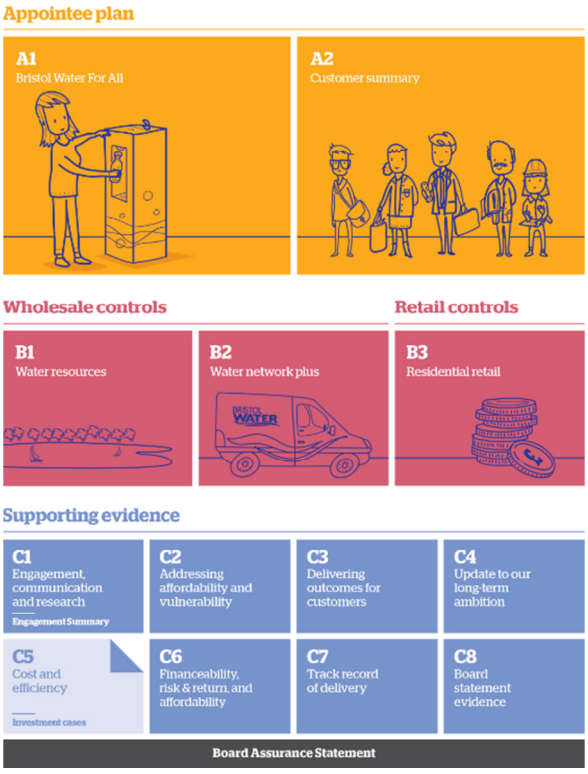
The Treatment Works Strategic Maintenance investment case will address specific site operational, maintenance or quality issues by implementing capital maintenance of obsolescent plant and water quality interventions which will contribute to a Safe and Reliable Supply to our customers.

We currently have seventeen water treatment works typically treating up to 277 Ml/d.

The purpose of this document is to set out Bristol Water's customer led, outcome focused plan which will mitigate risks posed by and associated with strategic maintenance

This investment case, one of twenty one, will summarise the facts, risks and investment requirements for treatment works strategic maintenance for the next review period for 2020 to 2025. This investment case will also summarise performance for strategic maintenance for the current review period from 2015 to 2020 and our methodology for determining and delivering the future strategic maintenance 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 seventeen water treatment works. We will achieve this by using our totex investment approach which includes investment of base maintenance and capital expenditure of £12.908m. We will deliver eight interventions that will contribute towards the water quality compliance, unplanned outages and unplanned maintenance - non-infrastructure performance commitments. We will challenge ourselves to deliver more efficiently and apply innovation to the process we adopt to treat water. When considering our efficient and innovative approach we plan to deliver our water treatment works capital programme for £11.875m.

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 specific site operational, maintenance or quality issues by utilising a totex approach to determine necessary capital maintenance investment to manage obsolescent plant and water quality commitments. It will also ensure continued compliance with the Water Supply (Water Quality) Regulations 2016 which are enforced by Drinking Water Inspectorate.

To deliver our customers' priorities and meet our compliance obligations 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 water treatment works strategic maintenance measures are the occurrence of unplanned maintenance events (target 3272), unplanned outages (target 1.74%) 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.

As at July 2018 we are achieving our AMP6 target for unplanned maintenance - non-infrastructure and forecast that we will continue to achieve it through the remainder of AMP6. 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 treatment works so that is sufficient to deliver our performance commitments and takes compensation for asset deterioration into account. This will ensure the continued performance of our treatment works and enable us to continue to deliver a safe, high quality, and reliable drinking water supply to our customers.

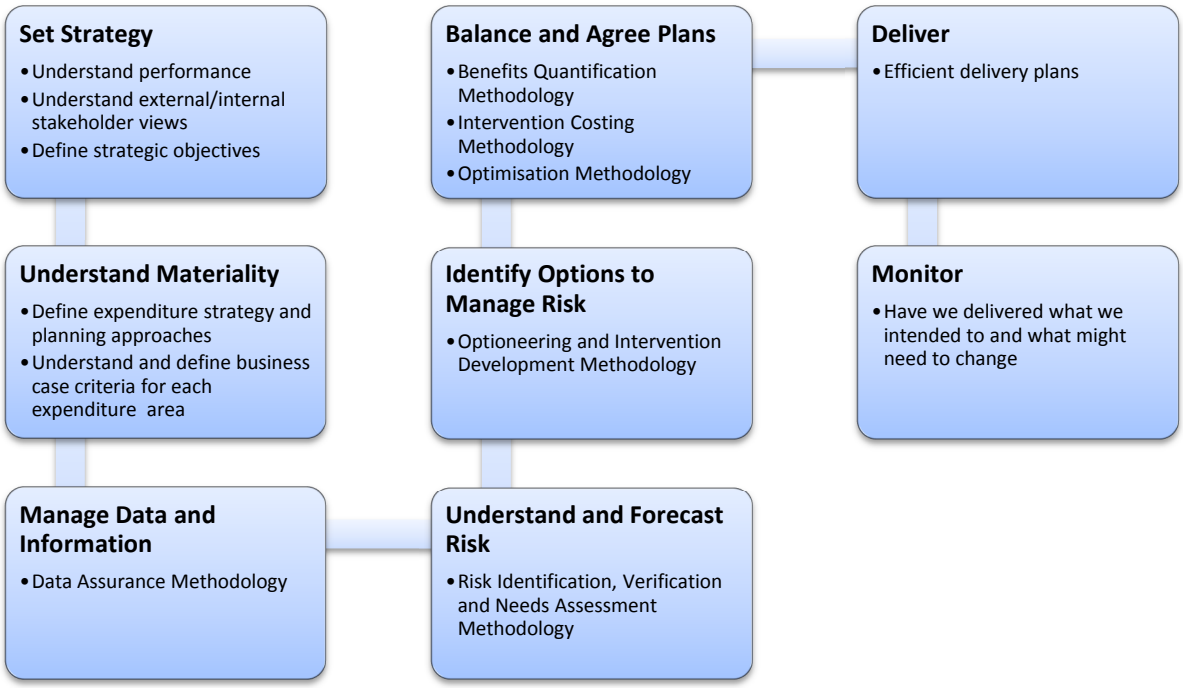
We will achieve this in a number of ways:

- By addressing a low incidence lead contamination at our customers' tap in one water supply zone by installing phosphate dosing at the treatment works;
- By selecting asset replacement and refurbishment to safeguard water quality and deliver operational efficiencies. Design improvements will further protect the safety of our operators;
- Strategic replacement of membranes at three of our water treatment works;
- Replacement of electrical switch gear and transformers to mitigate against loss of power to our sites; and
- By extending raw water deterioration trials at Cheddar water treatment works.

Should we fail to invest in water treatment works strategic maintenance or not achieve the associated performance improvements mentioned above, there is a risk that our water treatment works will fail leading to poor water quality and an unreliable supply of water. 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' priorities and mitigate the risks associated with water treatment works strategic maintenance 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 £12.908m 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 reducing our costs by 8% during AMP7. This will be achieved by delivery of our business transformation programme resulting in a post-efficiency investment of £11.875m.

Costs are allocated to the Water Treatment and Treated Water Distribution business units. Investment is all related to maintaining the long term capability of the -non infrastructure assets and is a mixture of maintenance and other capital expenditure.

87% of our investment for water treatment works strategic maintenance is associated with water treatment and 13% associated with treated water distribution business units. 96% is categorised as maintaining the long term capability of the assets – non infrastructure and 4% as other capital expenditure.

Table 1: Performance Commitment Targets and Percentage Contribution from Treatment Works Strategic Maintenance

Performance Commitment	Unit	2019/20 Baseline	2024/25 Target	Total Targeted Performance Commitment Improvement in AMP7	Water Treatment Works % Contribution to Performance Commitment Target
Water Quality Compliance (CRI)	Index	1.27	0.00	1.27	<0.01%
Unplanned Outage	%	1.74	1.74	0.00	n/a
Unplanned maintenance – non-infrastructure	Number of events	3976	3272	704	15.20%

Our AMP7 investment in treatment works strategic maintenance will help ensure our assets are being maintained appropriately to deliver resilient water services to current and future generations.

This investment case contributes 15.20% towards our AMP7 target for the unplanned maintenance – non-infrastructure performance commitment. Approximately a quarter of our performance improvement for this commitment will be achieved through investment case interventions. We will achieve the remaining performance improvement through our operational maintenance activities.

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

The purpose of a water treatment works is to remove contaminants and pathogens from raw water to produce water that is pure enough for human consumption. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, metals and minerals such as iron and manganese.

The processes involved in removing the contaminants include physical processes such as settling and filtration, chemical processes such as disinfection and coagulation and biological processes such as slow sand filtration.

A treatment works will typically contain the following sub systems; process plant, pumps, pipework, valves, tanks, structures and associated low voltage and high voltage electrical distribution systems.

Bristol Water has seventeen operational water treatment works providing supply to our customers; these are listed in Table 2. Axbridge Treatment Works provides seasonal pre-treatment of the River Axe water prior to discharge pumped into the Cheddar reservoir.

Our treatment works are designed to have some duty and standby assets in order to minimise the impact of any failures. Typically if there is a short duration plant failure, customers will still receive a reliable supply from the associated service reservoir, however if a repair cannot be undertaken quickly then in the worst case scenario that failure of our assets could lead to a loss of a reliable supply at the right quality to our customers.

Treatment works strategic maintenance comprises the asset interventions required as a result of specific risks at our treatment works relating to a possible failure to achieve regulatory compliance, safety obligations, water quality standards or required output levels.

The Treatment Works Strategic Maintenance investment case covers named schemes or programmes of work associated with the water treatment works and its sub systems. It will include the provision of new assets, or the replacement or refurbishment of existing assets.

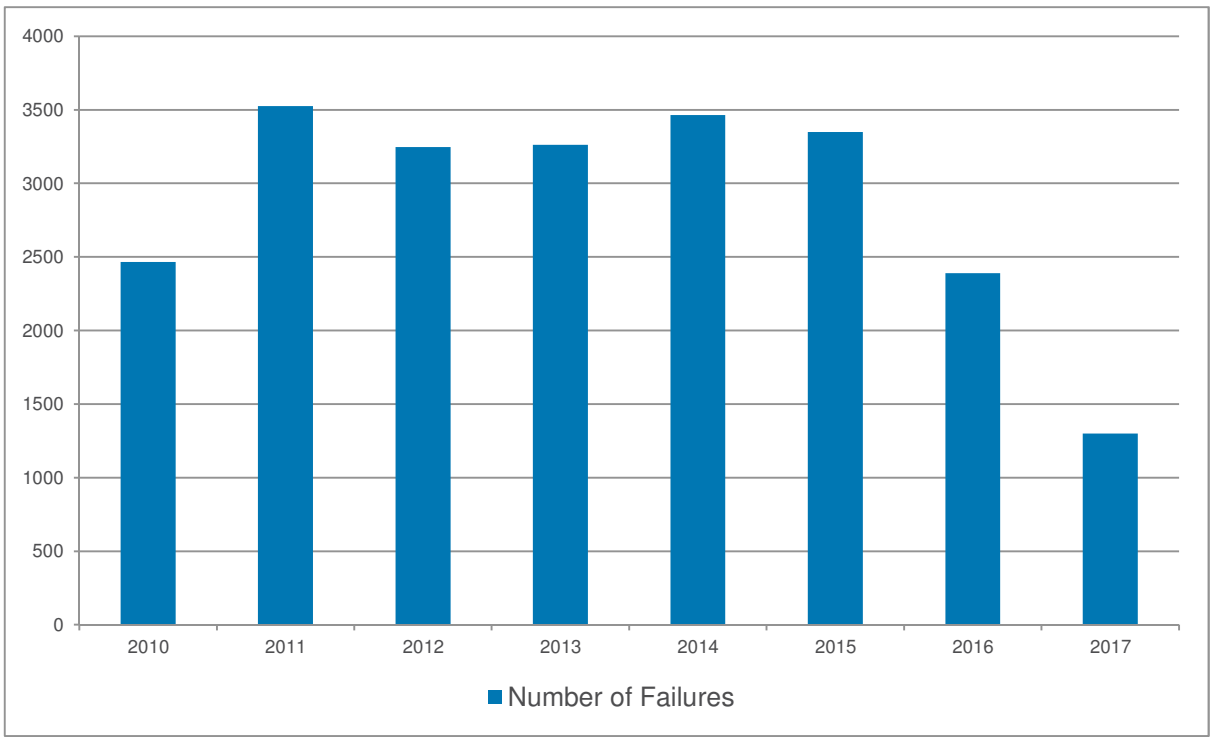
The primary objective of this investment case is to maintain a stable level of risk at treatment works and ensure an on-going and sustainable asset life of the plant. This will in turn enable us to deliver a Safe and Reliable Supply to our customers.

To monitor asset health at treatment works we have a risk based approach. Assets will be inspected and maintained at a set frequency. The frequency will be determined by the asset's attributes, its performance and its criticality. For example, the programme of planned maintenance ensures that pumps are inspected and maintained at a pre-determined frequency based on the criticality of the pump. Instruments, valves and other process plant is similarly inspected and maintained as appropriate. This includes procedures such as calibration, routine tasks such as flushing of tanks and

daily visual checks of the whole site. Any issues are logged internally and raised accordingly for planned maintenance.

As can be seen in Figure 2 below, recorded failures at our treatment works have generally been decreasing since 2011, demonstrating that are treatment works are becoming more reliable through our continued investment.

Figure 2: Treatment Works Asset Failures



This Treatment Works Strategic Maintenance investment case is aligned with the Water Resource Management Plan 2019, and typical deployable output from all sites is 277Ml/d. The balance between supply and demand ensures that there is sufficient deployable output in the event that one or more sites are out of service, due either to a planned maintenance event or through an unforeseen failure of the works. Therefore, proposed interventions are directed at delivering the full design capacity of each site. Investment into plant and equipment will maintain sustainable asset life for the duration of AMP7 and beyond to ensure a resilient water supply.

Within each treatment works, there is a vast number of individual assets of varying age including control panels, valves, chlorinators, transmitters, pumps, motors etc. Data relating to these assets is recorded internally in our company financial, operational and asset system. Table 2 provides an overview for the number of mechanical and electrical assets associated with each treatment works, along with the average asset age and maximum asset age. It should be noted that there are several assets without age data, due to historical data collation practices.

Table 2: Water Treatment Works Supplying Our Customers

Treatment Works Site Name	Actual output average 2010-16 (Ml/day)	Design output Ml/day	Number of Mechanical & Electrical Assets	Average Age (years)	Max Age (years)
Alderley Treatment Works	4.0	5	581	19	48
Axbridge Treatment Works	2.0	30	1567	11	14
Banwell Treatment Works	17.7	30	3515	13	44
Barrow Treatment Works	57.3	120	4665	13	67
Charterhouse Treatment Works	1.0	2	608	18	53
Cheddar Treatment Works	23.3	60	2056	18	34
Chelvey Treatment Works	7.9	20	1209	15	33
Clevedon Treatment Works	2.2	4.5	253	21	46
Forum Treatment Works	0.3	2	720	14	38
Frome Town Treatment Works	3.1	5	749	13	28
Littleton Treatment Works	27.6	60	3154	13	56
Oldford Treatment Works	13.5	18	780	16	47
Purton Treatment Works	95.4	165	7275	16	48
Sherborne Treatment Works	1.5	9	1141	5	46
Shipton Moyne Treatment Works	3.8	18	1249	7	50
Stowey Treatment Works	17.0	35	1866	17	59
Tetbury Treatment Works	1.7	3	348	15	63
Totals	**279.3**	**586.5**	**31736**	**14.4 average**	**45.5 average**

We have established minimum levels of expenditure in relation to the base maintenance of treatment works, as set out in the Non-Infrastructure Base Maintenance Investment Case. These minimum levels provide investment for routine and reactive maintenance, to ensure the continuation of 'business as usual'. The investment proposed through this Treatment Works Strategic Maintenance investment case will contribute towards these minimum levels, as it represents improvements to the performance of our treatment works assets above current levels. Investment for treatment work strategic maintenance in relation to non-infrastructure base maintenance is described in full in Section 5.6.

The following assets are related to, but are excluded from, the Treatment Works Strategic Maintenance investment case as they have been included in other investment cases:

- Raw water storage (see Water Resources)
- Raw Water transfer (see Raw Water Pumping Stations)
- Treated water (network) storage and transfer (see Service Reservoirs and Towers and Water Pumping Stations)
- Non-infrastructure Base Maintenance (see Non-infrastructure Base Maintenance)
- Instrument Control and Automation and Supervisory Control And Data Acquisition systems (see ICA and Telemetry)

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

- Network Ancillaries; shared target of water quality compliance (CRI).
- Water Pumping Stations; shared targets for unplanned maintenance - non-infrastructure and unplanned outage.
- Raw Water Pumping Stations; shared targets for unplanned maintenance - non-infrastructure and unplanned outage Interventions

3.2 Strategy

Developing the investment needs for our seventeen treatment works 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 treatments works 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 our assets are, and remain well 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 are specific outcomes (Safe and Reliable Supply and Local Community and Environmental Resilience) and specific performance commitments (unplanned outages, unplanned

maintenance – non-infrastructure, compliance risk index and waste disposal) that have strategic targets and incentives that will be directly influenced by our investment needs for water treatment works

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 short-term needs and the longer-term aims for Bristol Water and drive the capability development plan and asset planning activities. Delivery of the investment for our water treatment works 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 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 Bristol Water by stakeholders.

We need to ensure that investment is sufficient for the continuation of business as usual activities and routine and reactive maintenance, and the continued provision of high quality water to our customers.

This investment case articulates the bottom-up Asset Interventions that are required in AMP7 to achieve the outcomes that customers, regulators and other stakeholders have told us they expect.

3.3 Customer Preferences

Customer priorities relating to Bristol Water's 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 50 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 follows:

- 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
- 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 as follows:

- Excellent Customer Experiences
- Safe and Reliable Supply

- Local Community and Environmental Resilience
- 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 Treatment Works Strategic Miantenance and one of our outcomes – Safe and Reliable Supply.

We undertook more detailed discussions at phase 2 of our engagement process; gathering evidence (see section **C1 – Customer engagement, communication and research** appendix to our business plan) which gave us a wealth of information about how our customers' view Bristol Water, our services, and long term plans. 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[2]. Detailed analysis of customers' views on this area can be found in **section C3 – Delivering Outcomes for Customers.**

We consulted in three potential scenarios in relation to our Safe and Reliable Supply outcome:

Figure 3: 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 1,000 customers in three centres combined at risk

[2] A4g: Customer online panel March 2018

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.

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.

This investment case describes how we will achieve the suggested improvement plan and associated level of performance through our investment in Treatment Works Strategic Maintenance, specific details on our planned investment and associated performance can be found in Section 3.4.

3.4 AMP7 Performance Commitments & Outcome Delivery Incentives

The health of our assets is a key element in delivering resilient water services to our Customers. Our investment in treatment works strategic maintenance 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 treatment works strategic maintenance are unplanned maintenance events and unplanned outages. These performance commitments enable us to evaluate our long-term asset health performance

Additionally, our investment in treatment works strategic maintenance will support our AMP7 outcome ‘Safe and Reliable Supply’, by investing in our treatment works assets in order to provide high quality, reliable supplies for our Customers. Our Safe and Reliable Supply outcome will be measured through a set of associated performance commitments

Performance commitments associated with treatment works strategic maintenance are set out in Table 3.

Table 3: Performance Commitments Associated with Treatment Works Strategic Maintenance

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
Unplanned outage	%	1.74	1.74	1.74	1.74	1.74	1.74	0.00
Unplanned maintenance – non-infrastructure	Number of jobs	3976	3272	3272	3272	3272	3272	704

Unplanned outage is new performance commitment in AMP7, we have historical information for this measure and therefore we have set a target in line with our forecast of our 2019/20 performance. Treatment works strategic maintenance will support our ability to sustain this level of performance.

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 proposed investment for AMP7. Relevant legislation is detailed below.

We have a statutory obligation under the Water Supply (Water Quality) Regulations 2016 to ensure that all water supplied to our customers meets prescribed Water Quality Concentrations or Values. Our obligations are defined as undertakings for the Drinking Water Inspectorate.

Within this investment case there are specific risks that we are seeking to mitigate in order to ensure continued compliance with these regulations. They are explained in section 5.

3.6 AMP6 Investment and Performance

Our AMP6 investment in treatment works strategic maintenance supports our ability to meet our performance commitment for unplanned maintenance - non-infrastructure, and also supports the mean zonal compliance performance that we do achieve. Our investment in AMP6 will also underpin our performance commitments for water quality compliance (CRI) and unplanned outage in AMP7.

A summary of our AMP6 investment related to treatment works strategic maintenance is summarised in Table 4. 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 4: AMP6 capital investment

Year	Treatment works strategic maintenance investment capex (£m)
2015/16 actual	5.960
2016/17 actual	2.919
2017/18 actual	2.892
2018/19 forecast	6.231
2019/20 forecast	5.853
AMP6 forecast	**23.854**

Our AMP6 investment provides an extensive programme of refurbishment and upgrade works to a number of our treatment works. This includes electrochlorination systems across a number of sites, as well as schemes to upgrade mechanical and electrical assets.

The AMP6 performance commitments that are related to treatment works strategic maintenance investment, and our performance, is given in Table 5.

Table 5: Historic AMP6 performance related to treatment works strategic maintenance

Performance Commitment		2015/16	2016/17	2017/18	2018/19 (Forecast)	2019/20 (Forecast)
Mean Zonal Compliance (MZC) (%)						
Bristol Water	Target Performance	99.96	99.96	100	100	100
	Company Performance	99.93	99.97	99.93	99.96	99.96
Compliance Risk Index (CRI)						
Bristol Water	Target Performance	-	-	-	-	-
	Company Performance	3.17	1.53	0.03	1.27	1.27
Industry	Average	3.20	4.53	2.85	-	-
	Upper Quartile	0.96	2.34	1.30	-	-
	Frontier	0	0.27	0.03	-	-
Unplanned Outage (%)						
Bristol Water	Target Performance	-	-	-	-	-
	Company Performance	1.52	1.52	1.5	1.74	1.74

Performance Commitment		2015/16	2016/17	2017/18	2018/19 (Forecast)	2019/20 (Forecast)
Unplanned Maintenance - Non-Infrastructure						
Bristol Water	Target Performance	3976	3976	3976	3976	3976
	Company Performance	3353	2870	3279	3976	3976

Mean zonal compliance is included as it has been used throughout AMP6 to assess water quality. It will be replaced by water quality compliance (compliance risk index) in AMP7.

There are no targets in AMP6 for the compliance risk index and the unplanned outage performance commitments. However, we have undertaken an evaluation of our performance against these measures for the AMP6 period.

We have worked with Ofwat and the rest of the industry to align the reporting definition to help customers understand comparative performance in AMP6. See section C3 of our business plan for full details.

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

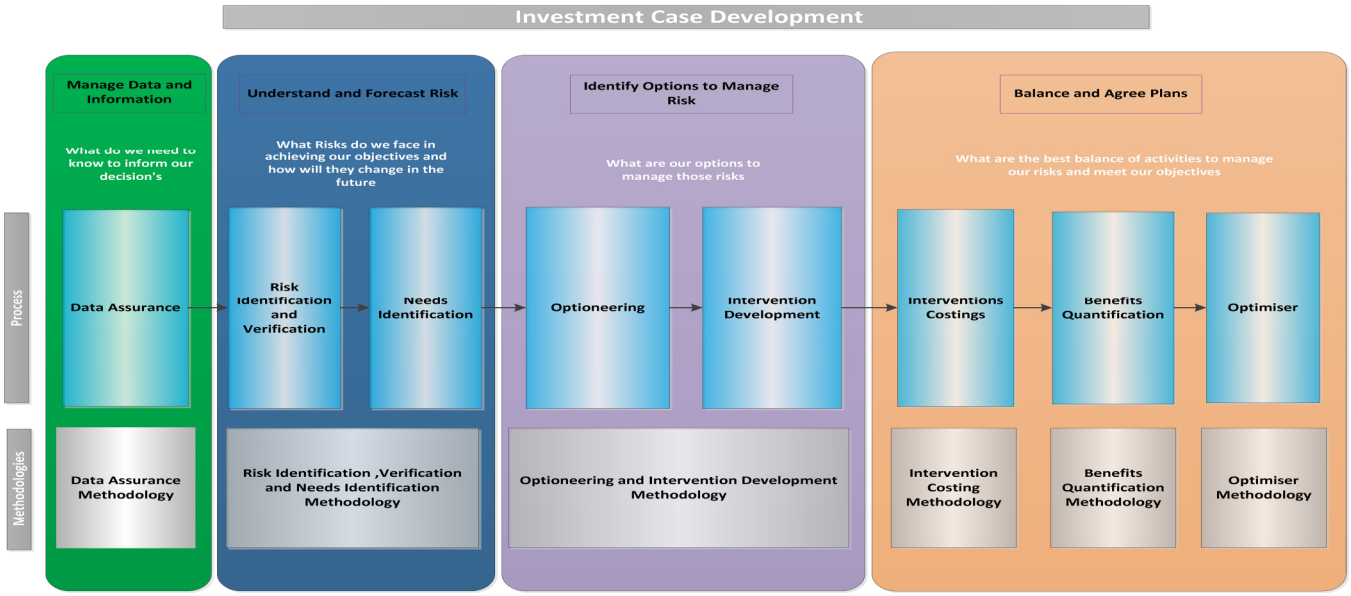
We have created and implemented a process that is supported by a set of six methodologies. When developing the methodologies, we wanted to ensure that they:

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

Figure 3: 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 the 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 eight 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

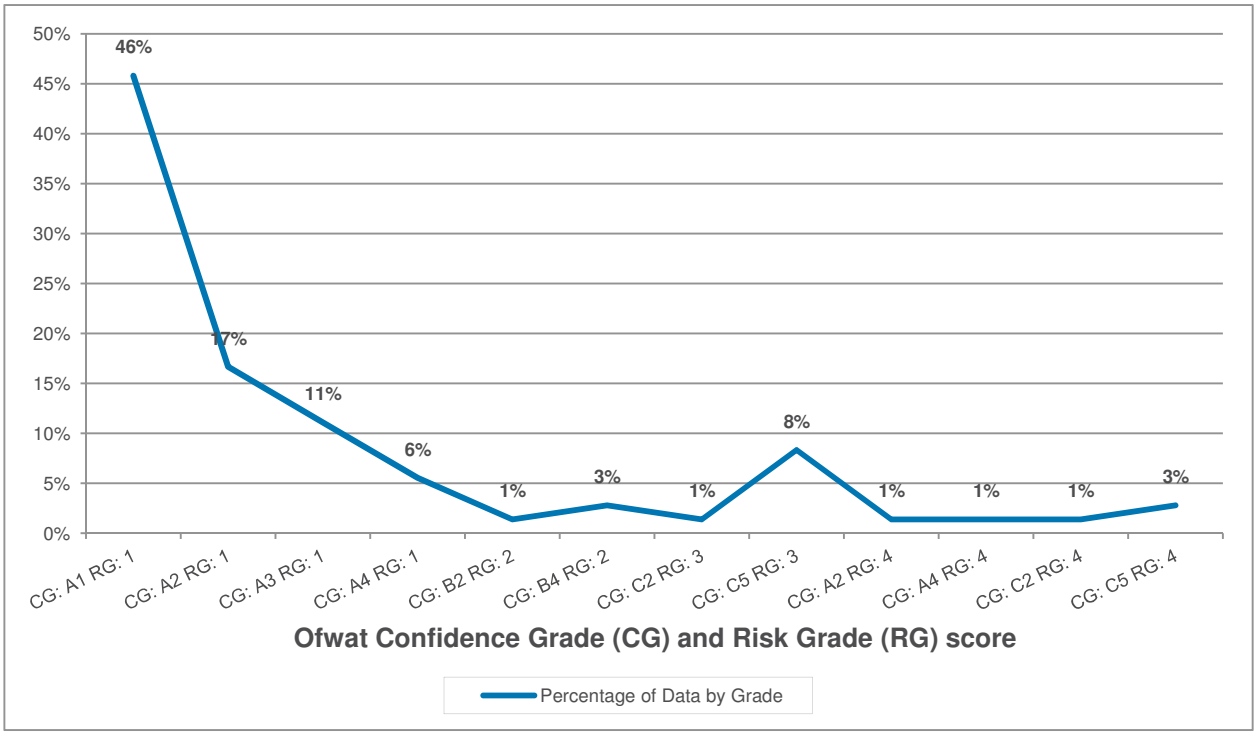
Each data point used in this investment case has been assured for completeness, accuracy and reliability, and has been given an overall score for quality in terms of a Risk Grade score between 1 and 5 (1 being good quality, 5 being poor quality). The risk grade has subsequently been aligned to the equivalent 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 seventy-two specific data types were identified, of which sixty (83%) have been assessed as being of good quality (Confidence Grade A1-B4 and Risk Grade 1-3).

Following a review, it was found that the remaining 17% of data were mainly text or qualitative assessments rather than quantitative assessments. This data will be included for enhancement as part of our business as usual approach to improve the quality of our data, which is outlined in our data and information strategy.

Figure 4 summarises the number of data types scored against Ofwat Confidence Grades and Risk Grades.

Figure 4: Percentage of Data Types by OFWAT Confidence Grade and Risk Grade



Annual Performance Report Assessment

The seventy-two 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.

Forty-four data types, 61% of 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 the 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 and where it was considered that mitigation of the risk will enhance our ability to meet our performance commitments, the risk was selected and developed into a needs statement.

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.

Unselected risks 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 have 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 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
- 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 Treatment Works Strategic Maintenance

Each of the following sections describes the specific details associated with the application of the investment case development process for treatment works strategic maintenance.

4.2.1 Risk Identification, Verification & Needs Assessment

There were one hundred and eight six risks identified in the Strategic Risk Register[3] 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.

Fifty 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.

Fifty one 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 6.

Table 6: Example of an Unselected Risk

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR274	Cheddar Treatment Works	If temporary generator is required, cannot run site on existing generator, then site is down (Cheddar-Area 3)	2	1	1	1	2	1	2	4

In the example above, it was determined that the generator was not likely to fail in AMP7 and therefore was allocated a likelihood score of two. Similarly, the impacts of such a failure were assessed to be small, primarily because of the availability of backup generators and the relatively small amount of work required for installation.

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 Treatment Works Strategic Maintenance Interventions Register[4].

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

4.2.2 Optioneering & Intervention Development

As described in Section 4.2.1, fifty 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 fifty seven needs statements. These options were peer reviewed and all options identified as not viable were discarded. Viable options are converted into interventions. Each intervention had its costs and benefits assessed.

For example, against the selected risk SRR168 regarding the failure of lead standards in Water Supply Zone 401, four options were identified, and one of these was developed into an intervention, as shown in Table 7.

[4] Bristol Water, 2018. *NTPBP-CAL-TW-0153 TW Strategic Maintenance IC Intervention Register.xlsx*

Table 7: Example of Options Selection for SRR168

Strategic Risk Register	Need Description	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Intervention Description
SRR168 IF failure of lead standards in Water Supply Zone 401 continue Then we will fail to meet DWI water quality standards and place our customers at risk in the long term (Risk Score = 25)	In 2013 the Drinking Water Inspectorate standard for lead in drinking water at customers' taps changed from 25 to 10µg/l. Between 2015 and 2017, 3 water quality tests exceeded this value in the Alderley Treatment Works water supply zone (WSZ) 401. Intervention is required to prevent further failure of lead samples which may harm the health of our customers and would impact on the company's CRI An intervention is required to improve water quality in the Alderley water supply zone 401 to mitigate risk of lead stand failures, ensure compliance with current legislation and long term customer health issues.	Do Nothing	Business as usual; no change, continue with current works operation and procedures and accept that lead failures may continue to occur with in WSZ401. Option Cost ; LOW	This option will not address the risk, the risk is listed as "unacceptable" in the DWSP and therefore this option has been discarded. Possible failure to meet CRI and therefore does not meet customer expectations of safe and reliable supply.	N/A		
		Replace lead pipework	Replacement of lead communication pipework in the Network Option Cost; HIGH	This option has been considered , there are approximately 8000 properties within the WSZ401 of which 40% have been identified with Pb or unknown CP/SP or both, it is feasible for replacement of lead pipe work to be completed within the AMP. However there is a substantial risk that agreement may not be reached with all effected customers within an acceptable timescale. It is accepted that phosphate dosing for Plumbosolvency control is not sustainable in the long term, but total lead pipework replacement in WSZ401 is not considered practical within the timescales required. Option not considered viable at treatment works (but is included as a mutually exclusive option in IC08 Network Ancillaries) Possible failure to meet CRI and therefore does not meet customer expectations of safe and reliable supply.	N/A		
		Provide additional treatment process at TW	Provide Orthophosphoric acid dosing and storage systems on site to control phosphate levels in treated water leaving the works to mitigate plumbo solvency in supply. Option Cost ; LOW	This is a viable option that has been used through out the water industry and equally applied at other sites by Bristol Water . Mitigates risk of CRI failures and therefore helps meet customer expectations of safe and reliable supply. Option Viability confirmed.	24.001.01	Alderley TW WSZ401 Plumbosolvency control - Orthophosphoric Acid Dosing	Provision of Orthophosphoric acid dosing and storage on site at Alderley TW
		Take Alderley TW out of supply	The failure rate is of a low frequency, therefore remove from supply when there is a risk of lead failure occurring (low phosphate in source water) and supply from Purton TW at such times. Option Cost ; LOW	This option is not viable as BW are unable to predict the risk of lead failure, and there for to enable the Alderley TW to be out of supply during periods of high risk. Limits available supply sources Option not Viable	N/A		

A total of fifty five 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 investment 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, costs for all interventions were calculated in collaboration with ChandlerKBS, based on activity schedules and sketches supplied by Bristol Water. 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.

As described in section 4.2.2, we have identified a total of fifty four interventions (including mutually exclusive options for the same risk) to be taken forward for scope development and cost estimation. For each of the fifty four interventions, high level scope documents were developed, including an activity schedule, and where appropriate, explanatory outline design drawings and annotated drawings. ChandlerKBS utilised a water industry unit cost database to complete cost estimation in accordance with their own assured methodology.

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. An example of this are the eight interventions developed to complete our strategy for company-wide replacement of chlorine gas with the installation of electrochlorination. A number of sites had already been completed in AMP6 and we were able to make this historical cost information available to ChandlerKBS to further inform their AMP7 cost estimations for the proposed electrochlorination interventions.

There were a number of electrical interventions where the ChandlerKBS unit cost database did not have an adequate dataset to provide reliable costs for some of the larger assets. These interventions were partially costed by Bristol Water using direct supplier quotations and previous tender costs for similar schemes (the electrical line items in the activity schedules) and partially costed by ChandlerKBS (the remaining line items in the activity schedule, overheads and the total intervention cost).

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: Stowey Ozone Plant Refurbishment

The ozone plant at Stowey Treatment Works accounts for an average of forty four unplanned maintenance events a year. The ozone contact tank was not designed for ozone contact, but adapted from its former use as a disinfection contact tank. The structure is in poor condition, and the roof in

particular is deteriorating due to corrosion by the ozone gas. There are typically ten alarm conditions arising from ozone leaks every year.

The need is to refurbish or replace the ozone plant to deliver compliance with our internal standard specification and improve the efficiency of the ozonation system.

We have established a cost of undertaking the works of £3.015m. 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 £0.489m for internal activities associated with the intervention, such as project management, land & compensation, legal, environmental costs, commissioning/handover, contract management, operations & system support, consultants and administration.

All of the direct costs above gave us an intervention cost of £3.504 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 implementation of the intervention in an un-programmed, accelerated manner. We have therefore used the implementation cost, and included a factor to account for non-competitive rates totalling £4.556m. 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 current and asset failure likely to occur in the next 12-36 months (i.e. a probability of 0.99), giving a reactive cost of £4.510m (£4.566m multiplied by 0.99).

We have established that if we undertook the above intervention in a planned way, there would be an increase of £0.012m 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

Fifty four water treatment works 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.

Unplanned Outages

The unplanned outage was assessed using operational data from our corporate financial and asset management system via routine asset performance reports. This information was cross-checked against operational treatment works flow data to establish the reduction in output (flow) during each outage and its duration. The information was recorded in the relevant benefits calculation and the impact was assessed. This process was undertaken in accordance with Ofwat guidance for measurement of unplanned outages.

Unplanned Maintenance - Non-Infrastructure Events

The unplanned maintenance - non-infrastructure contribution was also assessed using operational data from our corporate financial and asset management system via routine asset performance reports.

While a specific intervention would not be expected to fully eradicate unplanned maintenance events, a reduction of 80% was considered a reasonable assumption. The change in unplanned maintenance events before and after implementation of the intervention was recorded in the benefits calculation for input to the investment optimiser.

Compliance Risk Index

The compliance risk index performance commitment has a sole contributing intervention in the Treatment Works Strategic Maintenance investment case. This is related to the installation of orthophosphoric acid dosing at one site to control plumbosolvency in distribution (24.001.01 Alderley Treatment Works WSZ401 plumbosolvency control). As this is a water quality scheme driven by legislative requirements, for which we have received support from the Drinking Water Inspectorate (see letter of support included in Appendix G), this intervention was made mandatory.

The intervention Cheddar Treatment Works raw water deterioration trials extension relates to on-going investigational work. It will be used to inform an investment in AMP8/9 but will not deliver any recordable indirect benefits during AMP7.

Compliance with Environment Agency Discharge Consents

A small number of interventions (three in total) contribute to the waste disposal compliance performance commitment. To calculate the benefit, we used historical data taken from the last five years (2012-2017) to establish the current percentage failure of our effluent discharges to meet Environmental Agency consented discharge licences. The proposed interventions, in all cases, were assumed to deliver 100% future compliance for the relevant discharge. The benefit was expressed as the resultant percentage improvement in the company's total compliance.

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

5 Outcome

5.1 Selected Interventions

The fifty four interventions developed within the Treatment Works Strategic Maintenance investment case were assessed through the investment optimisation process. Of these fifty four interventions, eight were selected.

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 reducing our costs by 8% during AMP7. This will be achieved by delivery of our business transformation programme.

We see innovation as 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 specifically look for water treatment process innovations that mean we can contribute to our 8% efficiency challenge and keep our customers’ bills low into the future.

The eight selected interventions are set out in Table 8, along with details of the associated costs.

Table 8: Selected Interventions, Costs and % Performance Contribution

ID	Intervention Title	Total capex (£)	Change in opex per annum (£)	Water Quality Compliance (CRI)	Unplanned Outage	Unplanned maintenance – non-infrastructure
24.001.01	Alderley Treatment Works WSZ401 plumbosolvency control	£471,063	£9,690	<0.1%	-	-
24.001.10	Cheddar Treatment Works raw water deterioration trials extension	£500,000	£0	-	-	-
24.006.07	Stowey Ozone Plant	£3,504,637	£129	-	-	4.97%
24.008.01	Alderley Treatment Works membrane plant	£970,343	-£62,903	-	-	3.98%
24.008.04	Chelvey Treatment Works membrane plant	£1,675,289	-£1,475	-	-	3.84%
24.010.06	Banwell Treatment Works Slow Sand Filter Cryptosporidium Risk - Cover SSFs	£1,385,250	-£93,800	-	-	2.41%
24.010.08	Banwell Membrane Replacement	£2,700,065	-£22,341	-	-	-
24.012.02	Purton Treatment Works 11kV Supply System	£1,701,327	£0	-	-	-
Treatment works strategic maintenance capex investment (pre-efficiency)		**£12,907,974**	**-£170,700**	**<0.1%**	**-**	**15.20%**
Treatment works strategic maintenance capex investment with 8% capex efficiency		**£11,875,336**				

The intervention Alderley Treatment Works WSZ401 plumbosolvency control is selected because it is mandatory to meet Drinking Water Inspectorate obligations (see letter of support in Appendix G).

The intervention Cheddar Treatment Works raw water deterioration trials extension is selected because it is required in order to undertake a continued trial in relation to water deterioration at Cheddar Treatment Works, as support by the Drinking Water Inspectorate.

The remaining interventions are selected because they are all cost-beneficial, helping to offset future bill increases for our customers. Additionally, these interventions also provide contributions to achieving the unplanned maintenance - non-infrastructure performance commitment target.

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

5.1.1 Alderley Plumbo-Solvency Control

Alderley Plumbo-Solvency Control addresses water quality failures of the regulatory lead standard in the water quality zone supplied by Alderley Treatment Works. Our target for water quality is for zero failures. This intervention will install ortho-phosphoric acid dosing at Alderley Treatment Works to control plumbosolvency in supply and ensure future water quality compliance.

5.1.2 Cheddar Treatment Works Raw Water Deterioration Trials Extension

Historical evidence points to an increase in algae growth over recent years. The increase in algal loading at Cheddar Treatment Works is likely to be due in part to climatic changes, but may also be a result of changes in farming practice in the catchment[5].

The intervention will extend the current trial (commenced in 2017) of an enhanced treatment process to validate initial results and assess long term impacts of covering the slow sand filter at Cheddar.

5.1.3 Stowey Ozone Plant

Ozone gas is used at Stowey Treatment Works to treat algae in the raw water from Chew Valley Lake and ensure its effective removal by subsequent filtration technology.

The Ozone Contact Tank at Stowey Treatment Works is deteriorating due to corrosion by ozone. Historical data indicates that there is a record of confirmed ozone leaks initiating alarm conditions (typically 10 per annum); and ozone can frequently be smelt in the adjacent filter gallery. There are also issues with taking the ozone tank offline for inspection and/or maintenance, as the open by-pass channel can overspill into the adjacent ozone tank.

The data has identified there were an average of forty four unplanned maintenance events per annum directly related to the ozone plant.

[5] Bristol Water, 2017. *NTPBP_EXT_CHE_0269 PR19 Cheddar Algae DWI Report.docx*

5.1.4 Alderley & Chelvey Treatment Works Membrane Plant

We have a number of membrane plants installed principally for the treatment of cryptosporidium. In 2003 we installed membrane plants at six groundwater sites. Cryptosporidium in drinking water is a recognised and serious health risk.

These two interventions will replace pressurised membrane systems at Alderley and Chelvey Treatment Works.

The pressurised membrane units typically deteriorate over a seven year period and their replacement is due during AMP7/8. In addition, we need to replace the chemical and waste collection tanks at both Alderley and Chelvey Treatment Works. Replacing the tanks at the same time as the membranes themselves will generate programme efficiencies.

We have taken steps to minimise this risk of cryptosporidium to our customers, while maximising the remaining asset life of the six membrane plants affected. The interventions involve replacing the membrane units in both plants during AMP7, with replacement of the membrane units in the four remaining plants planned for AMP8.

5.1.5 Banwell Membrane Plant

The membranes at Banwell Treatment Works, while also installed for cryptosporidium removal, are ‘submerged’ membranes which use a vacuum pressure to draw the water through the membranes. This type of membrane is more robust than the pressurised systems and far better suited to the treatment of surface water abstracted from Blagdon and Cheddar Reservoirs.

The submerged membranes at Banwell Treatment Works provide general treatment of the raw water, including the removal of cryptosporidium. The membrane plant itself was installed in 2006; with the existing membranes installed in 2015/16. These membranes will reach the end of their asset life (seven years) in AMP7. If not replaced, outage will increase. This intervention will replace the existing membranes with a much more robust membrane.

5.1.6 Banwell Treatment Works Slow Sand Filter Cryptosporidium Risk

In 2014 there were two failures of the final water attributed to contamination of the slow sand filters by cryptosporidium (the slow sand filters are open to the atmosphere and contamination was attributed to wildlife).

The intervention will place covers over the three slow sand filters at Banwell Treatment Works to exclude wildlife and prevent contamination by cryptosporidium. Covering the slow sand filters will make the existing ultraviolet process redundant and removal will also obviate the requirement for interstage pumping. Filtrate from the slow sand filters will instead pass directly forward for chlorination disinfection.

5.1.7 Purton High Treatment Works 11kV System Supply

Purton Treatment Works accounts for approximately 30% of our maximum deployable output and is a key supply for Bristol, providing resilience for both Barrow Treatment Works and the southern area that we supply via the Southern Relief supply main.

In 2016 a preliminary feasibility report, P-2016-001[6] was planned, which discussed three risks and mitigating options associated with the pumping and electrical plant that supplies Purton Treatment Works (including the Purton High Lift pump station). The preferred option included upgrades of switchgear and starters to reduce transient fluctuations in power, to withstand fault levels, improved shrouding for internal components, together with replacement of the incoming high voltage assets in the main distribution system. The installation date of these assets is 1971/72.

This investment case is aligned to the Water Network Plus Wholesale Control category of our business plan. Costs are allocated to the Water Treatment and Treated Water Distribution Business Units. Investment is all related to non-infrastructure assets and is a mixture of maintenance and other capital expenditure. Water Service and Business Unit Allocation is summarised in Table 9.

Table 9: Water Services and Business Unit Allocation

Wholesale Control	**Water Network Plus**		**Total**
Business Unit Allocation	**03 Water Treatment**	**04 Treated Water Distribution**	
Treatment works strategic maintenance capex investment (%)	**86.8%**	**13.2%**	**100%**
Treatment works strategic maintenance capex investment	**£11.207m**	**£1.701m**	**£12.908m**
Maintaining the long term capability of the assets - non-infra	£10.707m (82.9)	£1.701m (13.2%)	£12.408m (96.1%)
Other capital expenditure - non-infra	£0.500m (3.9%)	£0m (0%)	£0.500m (3.9%)
Treatment works strategic maintenance capex investment with 8% capex efficiency			**£11.875m**

[6] Bristol Water, 2016. *P-2016-001 Purton High Lift pumping station.pdf*

5.2 Contribution to Performance Improvement

Table 10 set outs the percentage contribution to performance commitment improvement provided by the selected treatment works strategic maintenance interventions. These percentage contributions are discussed in the following sections.

Table 10: Contribution to Performance 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	Water treatment works contribution to performance improvement
Water quality compliance (CRI)	CRI Index Score	1.27	0	0	0	0	0	1.27	<0.1%
Unplanned outage	%	1.74	1.74	1.74	1.74	1.74	1.74	0.00	n/a
Unplanned maintenance – non-infrastructure	Number of jobs	3976	3272	3272	3272	3272	3272	704	15.20%

5.2.1 Asset Health

Our AMP7 investment in treatment works strategic maintenance will help ensure our assets are being maintained appropriately to deliver resilient water services to current and future generations.

5.2.2 Water Quality Compliance

This investment case contributes <0.1% towards our AMP7 target. Approximately half of our performance improvement will be achieved through investment case interventions. We will achieve the remaining performance improvement by enhancing management of our assets, reducing risk with proactive interventions (such as flushing mains), and improving operational procedures to quickly resolve problems.

5.2.3 Unplanned Outage

Our AMP7 target is to sustain our 2019/20 performance level of 1.74%. Our investment in treatment works strategic maintenance will support our ability to sustain this level of performance.

5.2.4 Unplanned Maintenance – Non-Infrastructure

This investment case contributes 15.20% towards our AMP7 target. Approximately a quarter of our performance improvement will be achieved through investment case interventions. We will achieve the remaining performance improvement through our operational maintenance activities.

5.3 Non-Selected Interventions

Of the fifty four interventions developed within this investment case, forty six were not selected because they did not provide the most cost beneficial way of meeting performance commitment targets compared to other interventions available. However, two of these 46 interventions (24.008.02 Alderly Treatment Works Crytosporidium Barrier Plant 5Ml/d and 24.010.05 Banwell Treatment Works Unvalidated UV Plant) were mutually exclusive with the two interventions selected by the investment optimiser.

The risks associated with the remaining 46 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 forty six non-selected interventions are given in Appendix F. An example is given in Table 11.

Table 11: Example Non Selected Intervention and Residual Risk

SSR ID	Risk & Need Statement	Non-Selected Intervention & Residual Risk
SRRN56	The Barrow Dissolved Air Floatation (DAF) was installed in 2003, it accounted for 40 unplanned maintenance events in 2016 and two unplanned outages. The flippers are old and require frequent replacement. There has been an average of 33 unplanned maintenance events (2010-2016). The Need is to refurbish the DAF at Barrow as there are associated risks with other DAF equipment (SRR106 DAF aeration valves; SRR127 DAF penstocks), which may potentially result in unplanned outage.	Non-Selected Intervention: 24.006.02 Barrow DAF Plant Refurbishment Residual Risk: If Barrow DAF fails, then stream(s) taken offline leading to reduced output. However this will be mitigated by using the other standby streams at Barrow.

5.4 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[7]. Assumptions specific to this investment case are discussed below.

In the calculation of benefits, it was assumed that the installation of new equipment will reduce the number of unplanned maintenance events by 80%, to account for a 'bathtub' failure profile. Therefore, it

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

was assumed that the average number of unplanned maintenance events will be reduced to 20% of the average number being experienced at the end of asset life.

5.5 AMP 8

We are not planning to change the number of water treatment works in our network and therefore there will still be seventeen as we proceed into AMP8.

We anticipate that the strategic replacement and renewal of our treatment works assets will follow a similar pattern in AMP8 as proposed for 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.

5.6 Base Maintenance

We have established minimum levels of investment in relation to the base maintenance of treatment works, as set out in the Non-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 mechanical and electrical assets within treatment works and pumping stations is £21m. 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 Non-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 treatment works assets above current levels.

In relation to this investment case, the non-infrastructure base maintenance investment case defines minimum levels of expenditure for mechanical and electrical assets in treatment works and pumping stations. The minimum investment levels are summarised in Table 12.

Table 12: Contribution to minimum non-infrastructure base maintenance investment

Non-Infrastructure Base Maintenance Asset Group	Minimum AMP7 investment to maintain asset health (£m)	AMP7 investment provided through Water Treatment Works interventions (£m)8	AMP7 investment provided through all interventions (£m)	Additional investment requirement as Base Maintenance (£m)
Treatment Works/Pumping Station Mechanical Electrical Assets	21.0	7.337	18.233	2.767

5.7 Historical & AMP7 Investment Comparison

A summary of historical treatment works strategic maintenance is provided in Table 13, along with our AMP7 investment in treatment works strategic maintenance 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 13: Historical & AMP7 capital investment

AMP	Capital investment values	Investment (£m)
AMP5	AMP5 actual	36.867
AMP6	2015/16 actual	5.960
	2016/17 actual	2.919
	2017/18 actual	2.892
	2018/19 forecast	6.231
	2019/20 forecast	5.853
	AMP6 forecast	23.854
AMP7	AMP7 pre-efficiency	12.908
	AMP7 8% capex efficiency applied	11.875

Our levels of treatment works strategic maintenance investment have decreased since AMP5. In AMP5 we made substantial investment to install ultraviolet disinfection at five of our sites. In AMP6 we are

[8] Only selected water treatment works interventions are considered in the assessment of contribution to base maintenance minimum spend. This assessment uses 70% of the 'capex before' (reactive cost) of these interventions, to recognise that the typical cost of a proactive intervention is 70% of a reactive intervention. Full details of this assessment methodology are provided in the Non-Infrastructure Base Maintenance Investment Case.

undertaking an extensive programme of refurbishment and upgrade works to a number of our treatment works, including electrochlorination systems across a number of sites, as well as schemes to upgrade mechanical and electrical assets. In AMP7, we are not proposing to undertake any such schemes, and instead will invest in targeted improvements to treatment works to meet statutory obligations, and to implement cost-beneficial solutions to identified risks.

6 Conclusions

In order to ensure our seventeen water treatment assets 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, the water treatment works strategic maintenance measures are the occurrence of unplanned maintenance - non-infrastructure events (target 3272), unplanned outages (target 1.74%) and water quality compliance which is measured against our target for the Compliance Risk Index (target 0).

An initial list of one hundred and eight four risks was narrowed down to a total of fifty four potential interventions. These interventions have been developed and assessed through our asset management totex focused and put forward for investment optimisation. Of these fifty four potential interventions, a total of eight interventions were selected on the basis that they were cost beneficial interventions and met our customer priorities and associated performance commitments.

We plan to invest a pre-efficiency total of £12.908m on two water quality and 6 capital maintenance interventions. We have set ourselves a challenging target of reducing our costs by 8% during AMP7. This will be achieved by delivery of our business transformation programme, resulting in a post-efficiency investment of £11.875m.

The interventions proposed are expected to contribute circa 15 % of the unplanned maintenance - non-infrastructure events target (3272), maintain our performance levels for unplanned outages at 1.74% and contribute towards water quality compliance. They also support compliance with our obligations in relation to the Water Supply (Water Quality) Regulations 2016.

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

Appendix G: Drinking Water Inspectorate Letter of Support

7.1 Appendix A: Line of Sight Diagram

Treatment Works Strategic Maintenance Line of Sight

Investment Case
NTPBP-INV-STR-0542

Customer Priorities

- Top Quality Water Supplies
- Best Experience
- Trust Beyond Water

Performance Commitments

Optimiser Input Form Reference

NTPBP-CAL-TW-0361

- Reliability
  - Safe and Reliable Supply of Water
    - Slower Plan
    - Suggested Plan
    - Faster Plan
    - Targets based on Lockdown >
  - Unplanned Outages — 1.74 | 1.74 | 1.74
    - Customer High Priority
    - ODI — Common Reward and Penalty
- Quality
  - Compliance Risk Index — 0 | 0 | 0
    - Customer High Priority
    - ODI — Common Penalty Only
- Carries Out Work Effectively
  - Unplanned non Infra Maintenance — 3272 | 3272 | 3272
    - Customer High Priority
    - ODI — Bespoke Reward and Penalty
  - Local Community Resilience
- Environment
  - Waste Disposal Compliance — 160 | 100 | 100
    - Customer High Priority
    - ODI — Bespoke Reputational
  - Other Monetised Benefit

Interventions

24.001.010, 24.002.01, 24.004.04, 24.005.04, 24.006.02-17, 24.008.01, 24.008.02, 24.008.04, 24.009.01, 24.010.05, 24.010.06, 24.10.08, 24.011.01-08, 24.012.02, 24.012.03, 24.013.01, 24.010.09, 24.010.07, 24.010.10

24.001.01

24.002.01, 24.004.04, 24.005.04, 24.006.02-17, 24.008.01, 24.008.02, 24.008.04, 24.009.01, 24.010.05, 24.010.06, 24.10.08, 24.011.01-08, 24.012.02, 24.012.03, 24.013.01, 24.010.09, 24.010.07, 24.010.10

24.002.01, 24.006.14, 24.009.01

24.004.010, 24.011.20, 24.011.21-27

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
- 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.
- 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

  — Business Planning

Performance Commitment Key

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

Document Number: NTPBPP-MET-PRO-0641

7.2 Appendix B: Datasets

This appendix show the data used in this investment case and where and how it has been applied.

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
NTPBP-STR-SIT-0086 Site Asset Age Analysis.xlsx	Latest asset inventory (including site, process, equipment number, equipment class, FL class, start up date etc.)	✓	-	-	✓
ADPW demand and TW capacity whole network_2016_2017 maximum transfer flows V1.0.pdf	Updating whole company TW zone current ADPW demand availability schematic for most recent data	✓	-	-	✓
NTPBP-CAL-MON-0085 Monthly Failure Data.xlsx	Maintenance Report examples. Repeat failure reports. Unscheduled maintenance reports back to 2010. Example of monthly report to OTMs	✓	-	-	✓
REQ-0061 P-2016-041 Solutions report -Alderley Pressurised Membranes share point 13-7-2017.docx	Membrane failure and replacement rate.	✓	-	-	-
REQ-0098 NTPBP-INT-SIT-0096 Site Design Output.xslx	Site design outputs and average flow data	✓	-	-	✓
REQ-0119 percent of lead in WSZs.xlsx	No. properties with Pb/unknown CP/SP or both	✓	-	-	✓
REQ-0125 Chemical Tank Data 2017.xlsx	Data showing BW Chemical tanks, age, condition and likely replacement year	-	-	-	✓
REQ-0126 Chemical Tank Summary and Totals(Atkins).xlsx	Chemical Tank Cost Summaries and Totals from Atkins Design Report	-	-	✓	-
REQ-0127 Chemical Tanks - Outline Design Report_FINAL 15092013 (2).docx	Atkins PR14 Chemical Tank Replacement Outline Design Report	✓	-	✓	-
REQ-0128 Written Scheme of Examination - Thermoplastic Atmospheric Storage Tanks Final draft.docx	Written Scheme of Examination for thermoplastic Tanks	✓	-	-	✓
REQ-0134 2017-11-09 Pinning Data frm M Davis.xlsx	Kalsep Membrane Pinning Data May to November 2017	-	-	✓	✓

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
REQ-0158 Production Structures Remedial Work Schedule.xlsx	Production Structures Remedial Works	✓	-	-	-
REQ-0168 WSZ 401_Pb and P.xlsx	WSZ 401_Pb and P	✓	-	-	✓
REQ-0171 Alderley Raw Turbidity.xlsx	Alderley Raw Water Turbidity	✓	-	-	-
REQ-0180 Trade Effluent October 2017.xls	Data showing the samples and failures to watercourse	✓	-	-	-
REQ-0186 NTPBP-INT-BAR-0430 Sludge Removal Barrow TW.docx	Barrow sludge removal costs	-	-	✓	✓
REQ-0187 16.01.2018 - Colin Medway - Shipton Moyne Chlorination.msg	Number of chlorine barrels stored onsite at Shipton Moyne TW	✓	-	-	✓
REQ-0191 Properties affected at BW sites due to Catastrophic Chlorine gas leak.xlsx	Number of properties within 180m of chlorination sites	✓	-	-	-
REQ-0193 Chlorine Costs for Sites Snapshot.xlsx	Average Cost of Chlorine on sites	-	-	✓	-
REQ-0195 NTPBP-SPE-SIT-0476 Site Chemical Capacities.pdf	Site Chlorine inventory	-	-	✓	✓
REQ-0202 REQ-0202 FW HYDRAcap Module Supply Bristol Water Sites.msg	Confirmation of stoppage of membrane manufacture	✓	-	-	-
REQ-0203 RE PR!9 Investment - Purton Intake screens. CM 30 01 2018.msg	Justification of Purton Inlet Band Screen Replacement	✓	-	-	-
REQ-0217 2017-09-05 - Schneider Transformer costs.pdf	Schneider costs for transformers.	-	-	✓	-
REQ-0218 Purton HV Cable repairs 55.0617.AM.130 Quote.pdf	Costs for repairing HV cables at Purton TW.	-	-	✓	-

Dataset File Name	Data Summary	Process In Which Data Has Been Used			
		Risk Identification, Verification and Needs Assessment	Optioneering	Intervention Costing	Benefits Quantification
REQ-0219 Q009060.pdf	Quote for various electrical instalments.	-	-	✓	-
REQ-0221 Quote Bridges 1.pdf	Oldford MCC and Electrical Changeover costs	-	-	✓	-
REQ-230 Purton Hire Transformer Quote extension 55 0218 AM 191.pdf	Details of cost to hire transformer to Purton	-	-	✓	-

7.3 Appendix C.1: Selected Risks

This appendix shows the 57 selected risks of the 108 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
SRR35	Almondsbury PS	IF the chlorination (gas) system Almondsbury TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	4	1	2	2	3	3	3	12
SRR62	Chelvey TW	IF the unused tanks left on site at Chelvey TW are not properly decommissioned THEN their condition will deteriorate and generate a potential H&S incident and/or surface water contamination (Chelvey TW).	3	3	2	2	5	1	5	15
SRR73	Banwell TW	IF the chlorination (gas) system at Banwell TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	3	4	2	1	1	1	4	12
SRR84	Banwell TW	IF pre treatment tank needs cleaning/maintenance THEN the site requires shutting down with consequence Unplanned Outage.	4	1	3	1	1	1	3	12
SRR95	Purton TW	IF the clarifiers for Littleton intake (located at Purton) mechanically fails THEN increased maintenance cost AND valve for Littleton intake	3	1	3	1	1	1	3	9
SRR100	Barrow TW	IF the Ozone Plant at Barrow TW is not refurbished and provided with full standby equipment THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	3	1	3	1	1	1	3	9
SRR107	Barrow TW	IF the flippers on the DAF desludge system fail (structurally), THEN the DAF stream will need to be taken offlin leading to reduced output from Barrow TW.	4	1	3	1	2	1	3	12
SRR114	Barrow TW	IF the single belt press at Barrow WTW fails (used for sludge dewatering) THEN the sludge (30 tonnes per day) would need to be tankered off site with rsulting increased operational cost.	4	1	3	1	2	1	3	12
SRR116	Banwell TW	IF the sodium hydroxide dosing static mixer and downstream pipework constricts/blocks THEN the flow through the mixer would be restricted and the works output would need to be reduced or the works shut down (Banwell - Area 3)	5	1	2	1	1	1	2	10
SRR118	Banwell TW	IF a structural failure of treated water tanks at Banwell TW occurs THEN there will be a reduced output from the site.	3	1	4	1	2	1	4	12

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR133	Banwell TW	IF the piers in the clear water tank at Banwell TW fail THEN then the output from the site would be lost and there would potential H&S safety risks to personnel in bring the site back online.	3	1	4	2	2	1	4	12
SRR134	Purton TW	IF one of the clariifers at Purtons fail THEN the site would have a reduced output and remedial repairs would be required.	3	1	4	1	2	1	4	12
SRR143	Charterhouse TW	IF the chlorination (gas) system at Charterhouse TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	4	1	2	1	1	3	3	12
SRR149	Purton TW	IF raw water quality in the Sharpness Canal deteriorates or Purton TW is required to operate at full capacity for a sustained period of time THEN the sludge production from the site will increase beyond the capacity of the existing sludge handling plant and there will be an increase in waste compliance failures , unplanned maintenance AND possible site shutdown	2	1	4	1	3	1	4	8
SRR150	Purton TW	IF the concrete walls of the ozone tank at Purton TW continue to deteriorate THEN water quality failure or long term structural failure could occur	5	2	4	1	4	1	4	20
SRR158	Littleton TW	IF the chlorination (gas) system at Littleton TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	4	1	2	1	1	3	3	12
SRR159	Cheddar TW	IF increased levels of algae are experienced in the source water for Cheddar TW THEN the slow sand filters will suffer increased blinding and output from works from the works will be further reduced.	5	1	5	1	5	1	5	25
SRR165	Banwell TW	IF the single contact tank at Banwell fails THEN output from the site is lost.	3	1	4	1	2	1	4	12
SRR166	Banwell TW	IF the open slow sand filters at Banwell TW are containated with Cryptosporidium THEN as the current UV system is not validated for treatment of crytosporidium there is a risk of a final water quality failure.	5	1	4	1	5	1	5	25
SRR168	Alderley TW	IF failure of lead standards in Water Supply Zone 401 continue Then we will fail to meet DWI water quality standards and place our customers at risk in the long term.	5	3	4	3	5	3	5	25
SRR175	Cheddar TW	IF the mains incoming control panel at Cheddar TW is not upgraded, THEN power supply to site may fail.							0	0

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR267	Charterhouse TW	IF spill occured during collection from the waste chemical collection tank at Charterhouse TW THEN contaimated liquid could be released into the enviroment	2	3	3	2	5	1	5	10
SRR269	Forum TW	IF spill occured during collection from the waste chemcial collection tank at Forum TW THEN contaminated liquid could be released into the enviroment	2	3	3	2	5	1	5	10
SRR270	Frome Town TW	IF spill during waste chemical collection THEN inadequate containment and possible surface water contamination (Frome Town TW)	2	3	3	2	5	1	5	10
SRR271	Barrow TW	IF the single mixer within the single sludge blend tank fails at Barrow THEN the sludge settles out within the tank (which has to be dug out) and produces poor performance within the sludge thickeners.	3	1	4	1	2	1	4	12
SRR272	Littleton TW	IF the High Voltage Transformer fails at Littleton TW THEN the electrical supply to Almondsbury PS would be lost (Based on site at Littleton TW).	4	1	3	1	1	1	3	12
SRR275	Clevedon TW	IF the control panel/ drives that feeds Clevedon's well and high lift pumps fails THEN the output from the site will be lost.	2	2	3	1	5	1	5	10
SRR276	Oldford TW	IF the power limitations at Oldford TW are exceeded THEN od the distribution board would be overloaded leading to site shut down and potential H&S issue (fire/electrical)	5	1	2	1	2	1	2	10
SRR628	Littleton TW	IF the condition of the GAC system at Littleton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant	4	1	3	1	1	1	3	12
SRR629	Purton TW	IF the condition of the GAC system at Purton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant	4	1	3	1	1	1	3	12
SRR650	Barrow TW	IF the chlorination (gas) system at Barrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	3	2	3	4	5	5	5	15
SRR651	Forum TW	IF the chlorination (gas) system at Forum TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	4	1	2	1	1	3	3	12

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR652	Shipton Moyne TW	IF the chlorination (gas) system at Shipton Moyne TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	3	5	2	2	5	5	5	15
SRR653	Rowberrow Chlorination	IF the chlorination (gas) system at Rowborrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	3	4	2	2	1	2	4	12
SRR654	Barrow NSS	IF the chemcial delivery system for the electro-chlorination plant at Barrow NSF is not upgraded THEN there is a risk to the H&S of the operators.	3	4	2	1	1	1	4	12
SRR658	Purton TW	IF a failure of the main High Voltage (HV) switchboard and/or 11/3.3kV transformers at Purton TW occurs THEN there will be an unplanned outage and a possible loss of supply to customers supplied by the Purton TW.	5	1	3	1	1	2	3	15
SRR659	Purton TW	IF the HV supply to Purton TW fails due to external factor THEN there would be a loss of output from the site.	3	1	3	4	4	5	5	15
SRR664	Sherborne TW	IF the source at Sherborne TW remains out of service for a extended period THEN the abstraction licence (and the deployable output) from the site may be permenently lost	3	2	4	2	2	3	4	12
SRR666	Purton TW	IF the ozone plant at Purton TW deteriorates further THEN there is an increased risk of water quality failure, unplanned outage and unplanned maintenance at the site.	3	3	3	1	1	1	3	9
SRR667	Purton TW	IF the band screen at Purton TW fails THEN the site would have a reduce output and additional cost would be required for resolution	3	1	4	1	1	1	4	12
SRR670	Stowey TW	IF further deterioration of the Ozone Plant at Stowey TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	4	3	4	1	1	1	4	16
SRR673	Purton TW	IF the RGFs at Purton TW fails THEN the output from the site would be reduced.	4	1	3	1	1	1	3	12
SRR674	Stowey TW	IF the roughing filters at Stowey TW fail THEN the output from the site would be reduced.	4	1	4	1	2	1	4	16
SRR675	Stowey TW	IF Slow Sand Filter no.2 is not repaired THEN may result in outage of filter and reduced output from Stowey TW.	4	1	4	1	2	1	4	16

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR679	Purton TW	IF ozone transformer No.1 fails at Purton TW THEN there is a risk of a reduced output from site.	3	1	3	1	1	1	3	9
SRR680	Purton TW	IF ozone transformer No 2 fails at Purton TW THEN there is a risk of reduced output from site	3	1	3	1	1	1	3	9
SRR681	Purton TW	IF the pre ozone tanks cannot be isolated at Purton TW THEN the radial defuser cannot not be maintained AND a loss of compartment would occur with reduction in site output.	3	1	3	1	1	1	3	9
SRR682	Non-Site Specific	IF a site High Voltage Transformer fails THEN would loose electrical supply to site (multiple sites at risk)	4	1	3	2	3	4	4	16
SRR704	All sites	IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment	2	3	2	1	5	1	5	10
SRR705	Littleton TW	IF either the coagulant dosing system or clarifiers at Littleton TW fail THEN the output from the site would be reduced or stopped	4	1	3	1	3	1	3	12
SRR706	Littleton TW	IF further deterioration of the Ozone Plant at Littleton TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	3	1	3	1	1	1	3	9
SRR709	Littleton TW	IF the waste water treatment system at Littleton TW fails THEN then there is a risk of failure of the EA discharge consent.	4	1	3	1	3	1	3	12
SRR710	Banwell TW	IF the membranes at Banwell TW are replaced at the correct time THEN output from the site will be reduced.	4	1	3	1	2	1	3	12
SRR711	Barrow TW	IF the sludge thickeners at Barrow do not operate efficiently THEN the poor quality supernatant can lead to a breach of the discharge consent of treated waste water returned to Barrow Reservoir 3	4	2	3	1	4	5	5	20
SRR781	Purton TW	IF a failure of the main High Voltage (HV) switchboard at Purton TW occurs during operation, maintenance or testing THEN there is a possibility of serious injury or death occurring leading to reputational damage and possible prosecution.	3	5	3	4	5	2	5	15

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR801	Alderley TW Charterhouse TW Chelvey TW Forum TW Frome TW Oldford TW	IF the supplier of the pressurised membrane filters at Alderley TW, Charterhouse TW, Chelvey TW, Forum TW, Frome TW and Oldford TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues.	3	4	4	4	5	3	5	15
SRR803	Alderley TW	IF the supplier of the pressurised membrane filters at Alderley TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues.	3	4	4	4	5	3	5	15

7.4 Appendix C.2: Non-Selected Risks

This appendix shows the 51 non-selected risks of the 108 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
SRR57	Alderley TW	IF stagnant water from deadlegs caused by removal of water quality instruments at Alderley TW enters supply THEN possible customer complaints, taste and odour, and water quality failures.	1	2	1	1	5	2	5	5
SRR58	Purton TW	IF stagnant water from deadlegs caused by removal of water quality instruments at Alderley TW enters supply THEN possible customer complaints, taste and odour, and water quality failures.	1	2	1	1	5	2	5	5
SRR59	Sherborne TW	IF stagnant water from deadlegs caused by removal of water quality instruments at Sherborne TW enters supply THEN possible customer complaints, taste and odour, and water quality failures.	1	2	1	1	5	2	5	5
SRR60	Stowey TW	IF stagnant water from deadlegs caused by removal of water quality instruments at Stowey TW enters supply THEN possible customer complaints, taste and odour, and water quality failures.	1	2	1	1	5	2	5	5
SRR61	Cheddar TW	IF the unused tanks at Cheddar TW leaks or fails catastrophically THEN chemical could be spilled causing and H&S hazard or environmental incident leading to prosecution (Cheddar TW)	1	1	1	1	1	1	1	1
SRR63	Clevedon TW	IF a chemcial spillage occurs above raw water source well at Clevedon TW and enters the well THEN possible contamination of well could occur with consequent loss of raw water supply and Unplanned Outage.	2	1	3	1	3	2	3	6
SRR64	Non Site Specific	Risk no longer in RIOR. Risk assumed to no longer exist	1	1	1	1	1	1	1	1
SRR65	Non Site Specific	Risk no longer in RIOR. Risk assumed to no longer exist	1	1	1	1	1	1	1	1
SRR66	Barrow TW	IF a fuel spill occurs during delivery at Barrow TW THEN the spilt fuel could contaminate the surface water system and cause an environmental incident. (Barrow TW)	1	1	1	1	5	1	5	5
SRR67	Barrow TW	If mixer on sludge blend tank fails THEN sludge settlement in blend tank (which has to be dug out) and poor performance of waste treatment plant results in reduced/loss of site output	1	1	1	1	1	1	1	1
SRR68	Banwell TW	IF the backwash water tank fails at Banwell TW THEN membrane backwashing cannot be carried out and output from the sitewill need to reduced as the membranes become blinded. (Banwell-Area 3)	1	1	2	1	1	1	2	2
SRR69	Banwell TW	IF the neutralisation tank at Banwell TW fails THEN membrane backwashing cannot be carried out and the output from the site will need to be reduced as the membranes become blinded. (Banwell-Area 3)	2	2	2	1	1	1	2	4
SRR70	Banwell TW	IF the backwash tank at Banwell TW fails THEN membrane backwashing cannot be carried out and the output from the site will need to be reduced as the membranes become blinded. (Banwell-Area 3)	2	2	2	1	1	1	2	4
SRR71	Banwell TW	IF the polyelectrolyte dosing system fgor the sludge treatment plant fails THEN membrane backwashing cannot be carried out and the output from the site will need to be reduced as the membranes become blinded. (Banwell-Area 3)	2	2	2	1	1	1	2	4
SRR72	Banwell TW	IF the low lift pumps at Banwell TW fail THEN water can not be lifted to the UV plant and the output from the site will be reduced. (Banwell-Area 3)	2	1	2	1	1	1	2	4
SRR74	Axbridge TW	IF the effluent & sludge thickener tanks fail THEN additional operational costs would be incured in tankering sludge off site. (Axbridge-Area 3)	2	2	2	1	2	1	2	4

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR75	Axbridge TW	IF the water tanks fail THEN then site would be out of service potentially losing a source of raw water for the Cheddar Reservoir.	2	1	2	1	1	1	2	4
SRR77	Purton TW	IF the sludge thickeners structurally fails at Purton THEN additional operational costs would be incured in tankering sludge off site.	2	1	3	1	2	1	3	6
SRR78	Purton TW	IF there is a requirement to clean the inlet channels to the RGF at Purton THEN unplanned outage of Purton WTW.	2	1	3	1	1	1	3	6
SRR79	Oldford TW	IF Oldford Treatment Works fails and output is lost THEN supply to the available supply to network is reduced and potion loss of supply or low pressures for customers.	2	1	3	1	2	4	4	8
SRR80	Sherborne TW	IF the failed membrane filters at Sherebourne can not be replaced THEN the output from the site would be reduced.	1	1	1	1	1	1	1	1
SRR81	Barrow TW	IF the backwash pumps fail at Barrow TW THEN the RGFs coulod not be backwashed and the output would initially be restricticted and ultimately the site shutdown.	3	1	1	1	1	1	1	3
SRR82	Barrow TW	IF causeway structurally fails at Barrow TW THEN access to site will be restricted and shortage of consumables would stop the treatment process and lead to unplanned outages.	2	2	4	1	1	1	4	8
SRR83	Barrow TW	IF Pump Hall electrical cabinets at Barrow TW fail THEN lack of spares availability could make them unrepeatable and lead to process failure and Unplanned Outages	1	1	2	1	2	1	2	2
SRR85	Banwell TW	IF solids passing through the boll filters damage or block the downstream cryptosporidium membranes THEN there will be Unplanned Outages or health risks to customers (Banwell-Area 3)	4	1	2	1	1	1	2	8
SRR86	Banwell TW	IF the valves fail on membrane inlet/outlet THEN output from the site would be reduced (Banwell-Area 3)	2	1	1	1	1	1	1	2
SRR87	Banwell TW	IF membrane pumps fail dueTHEN an Unplanned Outages could occur(Banwell-Area 3)	2	1	1	1	1	1	1	2
SRR88	Banwell TW	IF the potassium permanganate, KMn04, dosing plant fails at Banwell fails, due to loss of powder supply or equipment malfunction, THEN possible high manganese and water discolouration in network (Banwell-Area 3)	1	1	2	1	1	1	2	2
SRR89	Axbridge TW	IF a structural failure of the PACL tank occurs, THEN an Unplanned Outage would occur (Axbridge-Area 3)	2	2	2	1	2	1	2	4
SRR90	Axbridge TW	IF a structural failure of the sulphuric acid tank occurs, THEN an Unplanned Outage for the site could occur. (Axbridge-Area 3)	2	3	2	1	2	1	3	6
SRR91	Axbridge TW	IF structural failure of the coagulation tank occurs, THEN an Unplanned Outage for the site could occur. (Axbridge-Area 3)	2	3	2	1	2	1	3	6
SRR92	Axbridge TW	IF Actiflo re circulation Pump fails THEN an Unplanned Outage for the site could occur. (Axbridge-Area 3)	3	1	2	1	1	1	2	6
SRR93	Axbridge TW	IF the belt press fails THEN an Unplanned Outage for the site could occur. (Axbridge-Area 3)	3	1	2	1	1	1	2	6
SRR94	Stowey TW	IF the micro strainers fail THEN an Unplanned Outage for the site could occur. (Axbridge-Area 3)	3	1	1	1	2	1	2	6
SRR96	Purton TW	IF unacceptable levels of zooplankton devlop in the GAC absorbers THEN there is an increased risk of poor treated water quality and of zooplankton in the final water. (Purton TW)	2	1	2	1	4	1	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
SRR97	Forum TW	UCML from overload of Forum Treatment Works to Shepton Mallet power supply - This makes no sense but as no longer on RIOR not a problem	2	1	1	1	1	1	1	2
SRR98	Purton TW	IF the sludge thickeners mechanically fails at Purton THEN additional operational costs would be incured in tankering sludge off site.	3	1	2	1	2	1	2	6
SRR99	Banwell TW	IF hazardous waste (Dry sludge) is left on site THEN it may deteriarate and become non-compliant with waste management legislation (Banwell TW)	5	4	3	3	5	1	5	25
SRR101	Barrow TW	IF the Sulp[huric Acid dosing system fails THEN an Unplanned Outage for the site could occur. (Barrow - Area 2)	2	2	2	1	2	1	2	4
SRR102	Barrow TW	IF the DAF Recirculation Pumps fail THEN an Unplanned Outage for the site could occur. (Barrow - Area 2)	2	1	2	1	2	1	2	4
SRR103	Barrow TW	IF the motors for the DAF Recirculation Pumps fail THEN an Unplanned Outage for the site could occur. (Barrow -Area 2)	2	1	2	1	2	1	2	4
SRR104	Barrow TW	IF the coagulant flash mixers fail THEN the performance of down stream process may deteriorate and lead to an Unplanned Outage for the site. (Barrow -Area 2)	2	1	2	1	1	1	2	4
SRR105	Barrow TW	IF the PACL dosing system fails THEN an Unplanned Outage for the site could occur. (Barrow -Area 2)	2	2	2	1	2	1	2	4
SRR106	Barrow TW	IF DAF aeration common fail safe valve on saturator outlet or individual air inlet valves fail THEN there will be an Unplanned Outage whilst repair is effected	2	1	2	1	2	1	2	4
SRR108	Barrow TW	IF RGF water outlet valves fail THEN there will be an Unplanned Outage whilst repair is effected as this is a common chamber	3	1	2	1	2	1	2	6
SRR109	Barrow TW	IF RGF flow meter fails THEN there will be an Unplanned Outage as flow will have to be manually whilst repair is effected.	2	1	2	1	2	1	2	4
SRR110	Barrow TW	IF the effluent sewer fails/blocks, THEN it would be necessary to tanker off site the waste effluent. (Barrow-Area 2)	4	1	4	1	1	1	4	16
SRR111	Barrow TW	IF the offtake from main supply off site corrodes at the final joints,THEN no water could be transferred out of site. (Barrow-Area 2)	2	1	4	1	1	1	4	8
SRR112	Barrow TW	IF sludge thickener tanks fail due to age THEN additional operational costs would be incured as sludge would need tobe tankered off site.	2	1	1	1	2	1	2	4
SRR113	Barrow TW	IF the polyelectrolyte dosing plant fails THEN sludge drying process fails and sludge would need to be tanked off site increasing Unplanned Non-infrastructure maintenance and OPEX. (Barrow Area 2)	2	1	1	1	2	1	2	4
SRR115	Banwell TW	IF structural failure of the PACl tank occurs, THEN there would be an Unplanned Outage for the site (Banwell-Area 3)	2	2	2	1	1	1	2	4
SRR117	Banwell TW	If backwash chemicals for membranes run out, then lose site (membranes blind) (Banwell-Area 3)	5	1	2	1	2	1	2	10
SRR119	Axbridge TW	**IF** poly dosing plant fails **THEN** sludge thickening process fails and sludge would need to be tanked off site increasing Unplanned Non-infrastructure maintenance and OPEX. (Axbridge Area 3)	3	1	2	1	1	1	2	6
SRR120	Axbridge TW	If sludge transfer to STW (Wessex) off site fails, then works are down (Axbridge-Area 3)	5	1	3	1	1	1	3	15
SRR121	Cheddar TW	**IF** Microstrainers fail due to age and condition THEN Unplanned Outage from site (Cheddar-Area 3)	2	1	2	1	2	1	2	4
SRR122	Cheddar TW	**IF** control valves on SSF filters fail, **THEN** filter drain down/flow control will fail on differential pressure or turbidity leading to Unplanned Outage. (Cheddar-Area 3)	2	1	2	1	2	1	2	4

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR123	Axbridge TW	**IF** poly dosing plant fails **THEN** sludge thickening /dewatering process fails and sludge would need to be tanked off site increasing Unplanned Non-infrastructure maintenance and OPEX. (Cheddar Area 3)	3	1	2	1	2	1	2	6
SRR124	Charterhouse TW	**IF** Charterhouse effluent tanks fail due to age **THEN** additional operational costs as sludge would be tankered off site (Axbridge-Area 3) increasing unplanned non-infrastructure maintenance	2	2	3	1	2	1	3	6
SRR125	Stowey TW	**IF** baffles on inlet to Stowey RGFs fail **THEN** load will not be distributed evenly across the tanks reducing the effectiveness of the RGF and consequently the maximum output of the works (Unplanned Outage)	2	1	3	1	2	1	3	6
SRR126	Barrow TW	**IF** one of two DAF VS drives fail with age (installed 2004), **THEN** reduced resilience of Barrow TW (Barrow-Area 2)	2	1	2	2	2	1	2	4
SRR127	Barrow TW	**IF** a DAF inlet penstock needs replacing **THEN** entire inlet to DAF needs draining and output from Barrow TW is lost.	2	1	2	1	1	1	2	4
SRR128	Barrow TW	**IF** a Barrow RGF inlet penstock needs replacing **THEN** entire inlet channel to RGF needs draining and output from TW is lost.	2	1	2	1	1	1	2	4
SRR129	Barrow TW	**IF** Barrow slow sand filter side wall fails, **THEN** site access will be impeded and H&S risk	2	2	4	1	1	1	4	8
SRR130	Banwell TW	If sulphuric acid dosing pumps fail/block up, then require live work as pic pipework cannot be flushed(melt) (Banwell-Area 3)	4	3	2	1	2	1	3	12
SRR131	Banwell TW	IF Banwell blowers or backwash pumps fail, THEN cannot backwash RGFs and Unplanned Outage will occur	3	1	2	1	2	1	2	6
SRR132	Non Site Specific	**IF** the Oil Filled Circuit Breakers fail during operation or fault clearing conditions **THEN** the tank filled with oil in the switchgear can potentially explode from the arc-extinguishing reaction	2	5	2	3	2	1	5	10
SRR136	Purton TW	**IF** the removal of carbon from Purton densadeg tank is inefficient (sludge/carbon build ups in tank) **THEN** site shutdown AND significant maintenance	2	3	3	1	1	1	3	6
SRR137	Barrow TW	IF an alternative beneficial disposal route for the sludge produced at Barrow TW can be found THEN an opportunity exists to reduced cost for removal and disposal, and/or provide environmental benefits.	1	1	1	1	1	1	1	1
SRR138	~~Banwell TW~~	IF the sulphuric acid dosing pumps fail/block up, THEN require live work as pic pipework cannot be flushed(melt) (Banwell-Area 3)	1	1	1	1	1	1	1	1
SRR139	Banwell TW	IF the sulphuric acid dosing pumps fail/block up, THEN require live work as pic pipework cannot be flushed(melt) (Banwell-Area 3)	4	3	2	1	2	1	3	12
SRR140	Banwell TW	IF the sulphuric acid dosing pumps fail/block up, THEN require live work as pic pipework cannot be flushed(melt) (Axbridge-Area 3)	4	3	2	1	2	1	3	12
SRR141	Littleton TW	IF stagnant water from deadlegs caused by removal of water quality instruments at Littleton TW enters supply THEN possible customer complaints, taste and odour, and water quality failures.	1	2	1	1	5	2	5	5
SRR142	Stowey TW	**IF** Stowey TW chlorination system fails **THEN** works will shutdown on low Chlorine leading to Unplanned Outage.	4	1	2	1	1	4	4	16
SRR144	Littleton TW	IF it is not possible to clear supernatant basket filters at Littleton THEN there is a possibility of reduction of site output and increase in cost due to need for tankering supernatant.	4	4	3	1	2	1	4	16

SRR ID	Location/Zone	Revised Risk Description	Likelihood	Human Health / Environment	Ease to Resolve	Publicity & Reputation	Regulatory Impacts	Customers Impacted	Max Impact	Risk Score
SRR145	Chelvey TW	**IF** stagnant water from deadlegs caused by removal of water quality instruments at Chelvey TW enters supply **THEN** possible customer complaints, taste and odour, and water quality failures.	1	1	2	1	5	1	5	5
SRR146	Littleton TW	IF high level of bromide are pressent in the source water THEN increased risk of bromate formation from Ozonation (Littleton TW)	2	1	1	1	5	1	5	10
SRR147	Shipton Moyne TW	**IF** stagnant water from deadlegs caused by removal of water quality instruments at Shipton Moyne TW enters supply **THEN** possible customer complaints, taste and odour, and water quality failures.	1	2	1	1	5	2	5	5
SRR148	Cheddar TW	**IF** the phosphoric dosing line is not installed before SRS commissioning and validation **THEN** cannot meet SRS timescales for delivery	1	1	1	1	2	1	2	2
SRR151	Purton TW	IF the flow lines from Purton PAC tanks to dosing point are blocked THEN reduced output from site / site shutdown	5	2	1	1	2	1	2	10
SRR152	Purton TW	IF the cupscreen at Purton that feeds into the Littleton clarifiers fails THEN screen is bypassed and solids may enter clarifiers and inhibit operation leading to Unplanned Outage at Littleton TW.	3	1	1	1	2	1	2	6
SRR153	Sherborne TW	IF the chemical effluent tank and bund become overfilled THEN chemical tank detaches from mounts leading to structure failure ANJD potential flooding outside bund.	2	1	3	1	4	3	4	8
SRR154	Purton TW	IF the PACL system fails THEN unable to dose and the site will be shutdown leading to Unplanned Outages	5	1	1	1	1	3	3	15
SRR155	Barrow TW	If valve to empty inlet tanks does not work, then works are offline. (Barrow-Area 2)	5	1	2	1	2	1	2	10
SRR156	Banwell TW	IF delivery tankers cannot access site in a safe way, THEN there is a potential collision or lack of chemicals for dosing, leading to lack of supply. (Banwell-Area 3)	1	3	2	1	2	1	3	3
SRR157	Littleton TW	IF the loading valves are faulty or fails in the phosphoric acid dosing line THEN potential for Phosphoric acid to flow into the main water supply. (Littleton TW)	4	1	2	1	2	1	2	8
SRR160	Chelvey TW	Gross Alpha hazard from abstraction point (Chelvey TW)	3	1	1	1	1	1	1	3
SRR161	Clevedon TW	Gross Alpha hazard from abstraction point (Clevedon TW)	2	1	1	1	1	1	1	2
SRR162	Purton TW	If high bromide levels are pressent in the source water THEN there is an increased risk of bromate formation from Ozonation and potentail treated water quality issues. (Purton TW)	2	1	1	1	5	1	5	10
SRR164	Banwell TW	IF UV reactors fail when on Blagdon water then there is the potential to lose the site (when on blagdon) (Banwell-Area 3)	1	1	1	1	2	1	2	2
SRR167	Cheddar TW	Results of unrepresentative samples being used to assess the suitability of the options for the AMP 6 Cheddar scheme. This is due to the lack of appropriate sample points	5	1	2	1	5	1	5	25
SRR260	Charterhouse TW	IF there is high turbidity in the raw water from the springs, THEN site is shut down (Charterhouse-Area 3)	4	1	2	1	2	1	2	8
SRR262	Purton TW	IF the inlet valve post Bandscreen cannot be isolated THEN cannot work on or isolate the pumps	3	1	4	3	3	5	5	15
SRR263	Cheddar TW	IF contamination of water occurs when in open Slow Sand filters, THEN there is a risk that the outflow from filters carries cryptosporidium risk (Cheddar-Area 3)	1	1	1	1	1	1	1	1
SRR264	Non Site Specific	UCML following site failure due to aged and obsolescent Electrical Switch Gear	2	5	4	2	5	3	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
SRR265	Alderley TW	IF heavy rain at Alderley TW THEN possible surface flooding issues	3	2	2	1	1	1	2	6
SRR266	Alderley TW	IF there is a spill during waste chemical collection THEN there is possible surface water contamination (Alderley TW Well Pumps)	2	4	3	2	5	1	5	10
SRR268	Chelvey TW	IF there is a spill during waste chemical collection THEN there is possible surface water contamination (Chelvey TW).	2	3	3	2	5	1	5	10
SRR273	Cheddar TW	If mains incoming control panel is not upgraded, then power supply to site may fail (Cheddar-Area 3)	2	2	3	1	5	1	5	10
SRR274	Cheddar TW	If temporary generator is required, cannot run site on existing generator, then site is down (Cheddar-Area 3)	2	1	1	1	2	1	2	4
SRR277	Littleton TW	IF coliform failure in treated water THEN costly investigations and DWI notification (Littleton TW)	1	1	1	1	1	1	1	1
SRR279	Barrow TW	If electrical panel in ozone room is faulty then ozone treatment goes down and site stops (Barrow-Area 2)	2	1	2	1	2	1	2	4
SRR280	Barrow TW	IF pumps become outdated, THEN they will become obsolete and unserviceable on breakdown leading to reduced output/shut down (Barrow-Area 2)	3	1	3	1	2	1	3	9
SRR281	Charterhouse TW	IF unused tanks left on site at Charterhouse AND site floods THEN likely ground water contamination, potential loss of site	1	3	2	2	1	1	3	3
SRR284	Cheddar TW	If harmonic issue continues at Cheddar TW then we continue to breach G54 limits.	5	1	2	1	5	1	5	25
SRR355	Rowberrow PS	Main Incoming Switchboard original and could fail	2	1	3	3	3	4	4	8
SRR626	Barrow TW	If the 60" Contact Tank Outlet main failure due to deterioration, then causes loss of supply, water quality and bad publicity.	2	1	1	1	1	5	5	10
SRR627	Barrow TW	Study being carried out under AMP6 to look at impact of 60" main failure.	2	1	1	1	1	5	5	10

7.5 Appendix D: Options Considered

This appendix shows the 143 options considered from the 57 selected risks.

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR168	IF failure of lead standards in Water Supply Zone 401 continue Then we will fail to meet DWI water quality standards and place our customers at risk in the long term.	SRRN8	In 2013 the DWI standard for lead in drinking water at customers taps changed from 25 to 10µg/l. Between 2015 and 2017, 3 water quality tests exceeded this value in the Alderley TW water supply zone (WSZ) 401. Intervention is required to prevent further failure of lead samples which may harm the health of our customers and would impact on the company's CRI An intervention is required to improve water quality in the Alderley water supply zone 401 to mitigate risk of lead stand failures, ensure compliance with current legislation and long term customer health issues.	Do Nothing	Business as usual; no change, continue with current works operation and procedures and accept that lead failures may continue to occur with in WSZ401. Option Cost ; LOW	This option will not address the risk, the risk is listed as "unacceptable" in the DWSP and therefore this option has been discarded. Possible failure to meet CRI and therefore does not meet customer expectations of safe and reliable supply.
				Replace lead pipework	Replacement of lead communication pipework in the Network Option Cost; HIGH	This option has been considered , there are approximately 8000 properties within the WSZ401 of which 40% have been identified with Pb or unknown CP/SP or both, it is feasible for replacement of lead pipe work to be completed within the AMP. However there is a substantial risk that agreement may not be reached with all effected customers within an acceptable timescale. It is accepted that phosphate dosing for Plumbosolvency control is not sustainable in the long term, but total lead pipework replacement in WSZ401 is not considered practical within the timescales required. Option not considered viable at treatment works (but is included as a mutually exclusive option in IC08 Network Ancillaries) Possible failure to meet CRI and therefore does not meet customer expectations of safe and reliable supply.
				Provide additional treatment process at TW	Provide Orthophosphoric acid dosing and storage systems on site to control phosphate levels in treated water leaving the works to mitigate plumbo solvency in supply. Option Cost ; LOW	This is a viable option that has been used through out the water industry and equally applied at other sites by Bristol Water . Mitigates risk of CRI failures and therefore helps meet customer expectations of safe and reliable supply. Option Viability confirmed.
				Take Alderley TW out of supply	The failure rate is of a low frequency, therefore remove from supply when there is a risk of lead failure occurring (low phosphate in source water) and supply from Purton TW at such times. Option Cost ; LOW	This option is not viable as BW are unable to predict the risk of lead failure, and there for to enable the Alderley TW to be out of supply during periods of high risk. Limits available supply sources Option not Viable
SRR159	IF increased levels of algae are experienced in the source water for Cheddar TW THEN the slow sand filters will suffer increased blinding and output from works from the works will be further reduced.	SRRN9	Cheddar WTW is a key resource in the Southern Area providing up to 60 Ml/d output. The Slow Sand Filters experience elevated levels of algal blooms in some summers, which has caused the filters to blind and result in reduced output of the WTW and failure to meet the average daily demand (23 Ml/d). This in turn has led to depletions in supply in the network with Brent Knoll reservoir running dry for 1 day in 2010. Furthermore, reduced throughput in the SSFs can lead to anaerobic conditions developing increasing the risk of metals (aluminium, manganese, arsenic, iron and lead) adsorbed to the sand to be released in potentially high concentrations and causing water quality sample failures. Investment is required to reduce the risk of algal growth impacting on Plant Outage and Water Quality Compliance.	Cheddar robustness (raw water deterioration) - Do Nothing	Currently mitigated by monitoring dinobryon levels March to May. If trigger levels are exceeded an enhanced monitoring programme is undertaken. Relevant Production District Managers, Cheddar Operators and Ops Room kept informed of results. A bypass EOV, with flow meter, is in place at Winscombe which enables the transfer of water from Banwell TW to Cheddar TW for additional supply. Future support from SRS may be available.	
				Cheddar robustness (raw water deterioration) - Cover Slow Sand Filters Option 1	Cover the SSFs to limit the algal growth utilising low cost polythene covers replaced at regular intervals.	
				Cheddar robustness (raw water deterioration) - Cover Slow Sand Filters Option 2	Cover the SSFs to limit the algal growth utilising high quality enclosures with 25 year + life expectancy	Decision made not to take this forward in AMP7. Trials are not due to be completed until 2020 at which point results will be reviewed and a way forward decided upon. This approach is supported by DWI.
				Cheddar robustness (raw water deterioration) - Enhanced micro screens	Upgrading Cheddar micro screens using smaller mesh with improved efficiency	
				Cheddar robustness (raw water deterioration) - Enhanced reservoir management	Enhanced reservoir management	
				Do Nothing	Carry on "business as usual", increase frequency of skimming during algal blooms, emergency response in the event of reduced output	This option will not mitigate the risk.

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
				SSF Cover extended trial	An initial trial commenced in Spring 2017, and although BW have seen benefit from the covered slow sand filter there are concerns that during a prolonged period of hot weather the cover would lead to a significant increase in the temperature of the water above the filter potentially causing a detrimental impact on the Schmutzdecke with possible development of geosmin/methyl isoborneol related taste and odour in the filtrate. The only way to see if this risk is realised is by collecting further information as the trial progresses. Consequently, BW feel it is too early within the trial to commit to covering the slow sand filters as the most appropriate control measure to address the risks associated with the deteriorating raw water from Cheddar Reservoir and would prefer to continue an investigative period of trials though AMP7. This would significantly increase the likelihood of testing the effectiveness of the covers and ultrasonics both when there is a significant algal loading coming in from the reservoir and during extended periods of hot weather. There would then be much increased confidence that any treatment based solution proposed would be robust in maximising the benefits whilst minimising any possible adverse impacts.	Viable option, as infrastructure is in place.
SRR271 SRR711	IF the single mixer within the single sludge blend tank fails at Barrow THEN the sludge settles out within the tank (which has to be dug out) and produces poor performance within the sludge thickeners. IF the sludge thickeners at Barrow do not operate efficiently THEN the poor quality supernatant can lead to a breach of the discharge consent of treated waste water returned to Barrow Reservoir 3.	SRRN88	Barrow TW accounts for approximately 21% of BW's maximum deployable output. The TW produces waste water from the sand washing, rapid gravity filters and sludge form the dissolved air floatation process, these waste streams are blended in the waste water balance tanks and then passed forward for thickening prior to sludge dewatering by the sludge belt press. There is a record of unplanned maintenance events (average 66 per annum). The supernatant from the sludge settlement tanks is returned to Barrow Reservoir 3. There is a history of failures against the Res 3 EA Licensed Discharge Consent conditions (high aluminium), with 4 failures in 2016. An intervention is required at Barrow TW to ensure to improve the operation of the waste treatment works, this includes the mixing in the sludge blending tank and the thickening processes to reduce sample failures on the return to reservoir 3, and to reduce to the unplanned maintenance events.	Do nothing	The option to do Nothing will continue the current "Fix on Fail" strategy.	This option does not address the Need which is to improve the operation of the sludge blending and thickening processes to reduce sample failures on the return to reservoir 3, and to reduce to the unplanned maintenance events. Option not Viable Does not meet customer preferences regarding environment resilience as waste compliance issues likely to continue.
				Improve performance of existing plant	Install second balancing tank, and provide improved mixing in the blend tanks to allow better management of the sludge blending. Refurbish existing plant and ensure full duty/standby capability of streams	A second balance tank will provide a buffer to accommodate rapid increase in plant flows (algal conditions in reservoirs) allowing changes in settlement rate to be minimised/ made gradually. Will provide improved blending and thickening to help settlement of solids and reduce sample failures on return to reservoir 3. 2 streams will allow comprehensive study work to be implemented; (could be used to allow different polyelectrolytes to be used to optimise performance); increase resilience and enable one stream to be taken off line for maintenance without impact to works and greater flexibility in the event of a plant failure. Intervention will address unplanned maintenance and sample failures to meet customer requirements regarding environmental resilience. Option confirmed Viable
				Revoke EA discharge licence to Reservoir 3	Discussions are in place with the EA to revoke the requirement of a discharge license to Reservoir 3 as the receiving body does not discharge to a water course. Option cost evaluation ; LOW	This option does address the repeated sample failures but not the number of unplanned maintenance events. There is a risk that returning supernatant with high solids/aluminium concentrations to Res 3 will result in recirculation through the works. It has therefore not been considered as a sole solution as the outcome of these discussions is still awaited, but it should be pursued as it will significantly contribute to any implemented solution for Barrow waste. Option not Currently Viable
SRR704: SRR267: SRR269; SRR270:	IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment IF spill occured during collection from the waste chemical	SRRN100: SRRN101: SRRN102: SRRN103	**SRRN100** The Need is to replace all chemical tanks which will become life expired in AMP7 in accordance with BW WSE. The BW Written Scheme of Examination Thermoplastic Atmospheric Storage Tanks is in accordance with BW's general legal	Do Nothing	The Do Nothing Option would require that where the determined operational life of the tank has reached the 'notional' asset life, 'Thorough' inspections will be suspended and asset specific control measures (ASCM) will be put in place.	This option is not viable as it will not fully meet the Intervention Needs , TG indicated that BW practice is not to operate tanks beyond their asset life. This option can only be considered an interim measure pending full intervention to replace tanks / environmental containment facilities.
				Replacement of life expired chemical tanks and delivery management / spill containment improvements	Replace polypropylene tanks that will be life expired in AMP7 upgrade delivery management and spill containment improvements at identified sites.	This option will meet the requirements to replace life expired tanks and SERA as identified.

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
	collection tank at Charterhouse TW THEN contaimated liquid could be released into the enviroment IF spill occured during collection from the waste chemcial collection tank at Forum TW THEN contaminated liquid could be released into the enviroment IF spill occured during collection from the waste chemcial collection tank at Frome Town TW THEN contaminated liquid could be released into the enviroment		obligations set out in the Health and Safety at Work Act (1974) and the specific requirements of the Provision and Use of Work Equipment Regulations 1998 (PUWER). **SRRN101** The risk is identified; Relevant document: SERA053 - Charterhouse Treatment Works risk assessment." There is currently no tertiary containment for the chemical waste tank during its discharge. The absence of containment means that any liquids would be released onto the surface water drainage network or go into the Cheddar Yeo. The Need is to reduce unplanned maintenance and provide spill containment during waste collection by road tanker to prevent environmental contamination and comply with current legislation **SRRN102** The risk is identified; Relevant document: SERA132 - Forum Treatment Works. The chemical waste tank currently has no bunded area or drip tray under the abstraction points. Chemical waste could contain sodium hydroxide, hydrochloric acid or hydrogen peroxide waste chemicals. The Need is to unplanned maintenance and provide chemical containment during road tanker collection of waste o prevent environmental contamination and comply with current legislation **SRRN103** Relevant document: SERA130 - Frome Town Treatment Works. The chemical waste tank is not discharged in line with any discharge consents. The chemical waste is discharged directly into the roadway and road drains. This is not Best Practice. Chemical waste may also be extracted from the chemical waste tank, but there is no bunded extraction area or drip tray under the extraction points. Chemical waste could contain chemicals damaging to the environment. The Need is to unplanned maintenance and provide provision for containment during tanker collection of chemical waste and to include the connection point within the bunded area .	Revised specification replacement of life expired chemical tanks and delivery management / spill containment improvements	Replace polypropylene tanks that will be life expired in AMP7 upgrade delivery management and spill containment improvements at identified sites. Revised scope following review of CKBS cost estimate.	This option will meet the requirements to replace life expired tanks and SERA where identified.

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Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR95 SRR150 SRR134	IF the clarifiers for Littleton intake (located at Purton) mechanically fails THEN increased maintenance cost AND valve for Littleton intake IF the concrete walls of the ozone tank at Purton TW continue to deteriorate THEN water quality failure or long term structural failure could occur IF one of the clariifers at Purtons fail THEN the site would have a reduced output and remedial repairs would be required.	SRRN43 SRRN112 SRRN113	Purton Post-Ozone tanks are a key process element of Bristol Water's largest WTW. Reduced pH in the waters and the presence of ozone accelerates the rates of deterioration of the concrete matrix, leading to a significantly increased rate of failure of the structure above normal water retaining structures. Furthermore, the common outlet channel would require an entire plant shutdown to undertake any remedial. Investment is required to prevent further deterioration of the structure which may ultimately lead to increased remedial costs. The Littleton clarifiers (located at Purton) are part of "Old Purton" (circa 1970), there are 3 no. tanks on the raw water inlet and all show evidence of carbonation penetration on concrete sections above ground and water level, with spalling of concrete on number 2 tank. Routine inspections are carried out, the Need is to carry out remedial work to the tanks and apply WRAS approved lining to halt further deterioration and ensure there on-going asset life. The Purton TW clarifiers all show evidence of carbonation penetration on concrete sections above ground and water level with spalling of concrete. Routine inspections show that there is a Need is to carry out remedial work to the tanks and apply WRAS approved lining to halt further deterioration and ensure there on-going asset life.	Do Nothing	Continue to monitor concrete deterioration.	In the long term the concrete deterioration could lead to water quality issues and ultimately risks to the structurally integrity of the tanks. Timely repairs will prevent loss of tanks and allow planned maintenance of common channels to be carried out at times when works through put is low giving the option of bypassing the tanks.
				Refurbish and Reline tanks and common channels	Refurbish concrete structures and re-line with WRAS approved urethane or similar tank lining	Urethane coatings have been used to line ozone tanks and have demonstrated mixed results, with corrosion in areas above the water line exposed to ozone gas. Some investigation of appropriate coatings may be required to confirm lining method. Shutting down ozone process/works may be required to complete works.. Littleton and Purton clarifiers can be taken off line one at a time for refurbishment to minimise works disruption
				Refurbish and Reline tanks and common channels excluding Purton Clarifiers	Reduced scope removes the requirement for intervention relating to Purton clarifiers (addressed in AMP 6). Refurbish concrete structures and re-line with WRAS approved urethane or similar tank lining	Urethane coatings have been used to line ozone tanks and have demonstrated mixed results, with corrosion in areas above the water line exposed to ozone gas. Some investigation of appropriate coatings may be required to confirm lining method. Shutting down ozone process/works may be required to complete works. Littleton clarifiers can be taken off line one at a time for refurbishment to minimise works disruption
SRR114	IF the single belt press at Barrow WTW fails (used for sludge dewatering) THEN the sludge (30 tonnes per day) would need to be tankered off site with rsulting increased operational cost.	SRRN58	The majority of equipment at Barrow belt press is 14 years old, and the age of the equipment has led to an increased number of unplanned maintenance events in recent years (120 in the last 4 years). There is currently no backup system if the belt press fails. A catastrophic failure of the belt press would lead to site shut down and tankering offsite being required. Without a backup system in place the cost of applying a fix-on-fail policy to the belt press would amount to a large cost for a tanker to be used until the belt press is repaired, as well as the cost of repairing the belt press itself. Investment is required to increase resilience of the belt press system at Barrow TW, and reduce the amount of unplanned maintenance events.	Do Nothing	"Continue Fix on fail"	This option is not considered viable as a long term solution as it does not fully mitigate risk or meet need.
				Alternative mechanical sludge dewatering	Fit a different form of sludge pressing such as a centrifuge or sludge pressing plates.	This Option likely to generate the highest cost as the write off value of existing equipment must be considered. Further study work required to justify equipment selection and to determine benefits of alternative dewatering systems.
				Additional standby belt press	Installation of second belt press in new extension of existing building, limited feed pumping capability (D/D /S).	Reduced scope option extends the existing building and maximises use of existing systems. Will reduce CAPEX whilst delivering greater system resilience.
				Duplicate existing Press facility to provide full standby operation	Install additional pressing facility at TW. This can be used as a duty/standby system, or both can be run parallel. For this intervention a second belt press will be installed in a new purpose built build and full duty standby pumping for each of the duplicate sludge feed systems	Option considered to viable but likely be high cost (taken forward for costing)
SRR107	IF the flippers on the DAF desludge system fail (structurally), THEN the DAF stream will need	SRRN56	The DAF was installed in 2003 , it accounted for 40 unplanned maintenance events in 2016 and two	Refurbish DAF	Carry out refurbishment of DAF mechanical and ICA.	A full refurbishment of the mechanical and ICA items within the DAF plant. Taken forward as new equipment will help to reduce unplanned outages and maintenance events.

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	to be taken offlin leading to reduced output from Barrow TW.		unplanned outages. The flippers are old and require frequent replacement. There has been an average of 33 unplanned maintenance events (2010-2016). The Need is to refurbish the DAF at Barrow as there are associated risks with other DAF equipment (SRR106 DAF aeration valves; SRR127 DAF penstocks), which may potentially result in unplanned outage.	Do Nothing	Continue to current practice of Fix on Fail	If the DAF plant were to be left as a fix-on-fail operation, the amount of Ops maintenance likely to increase as the with increasing age and deteriorating condition of the equipment . This would not satisfy the intervention need as there will be no reduction in unplanned maintenance and outage .
SRR667	IF the band screen at Purton TW fails THEN the site would have a reduce output and additional cost would be required for resolution	SRRN87	There are two band screens on the Purton intake, one has already been replaced. The need is to replace the second screen.	Replace band screen and penstocks.	Carry out like for like replacement of the band screen and all actuated penstocks.	Taken forward as new equipment will reduce unplanned outages and maintenance events.
				Replace band screen and refurbish penstocks.	Carry out like for like replacement of the band screen and refurbish all penstocks.	This option reduces the CAPEX by refurbishing rather than the replacement of penstocks.
				Refurbish	Refurbish band screen and penstocks.	20K has already been spent on the repair of the band screen , however correspondence with CM indicates this is not adequate to return full functionality.
				Do Nothing	Continue current Fix On Fail	Does not need Intervention requirements
SRR100	IF the Ozone Plant at Barrow TW is not refurbished and provided with full standby equipment THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	SRRN86	Barrow TW accounts for approximately 21% of BW's day to day and maximum deployable output. The TW utilises ozone for the pre-oxidation of raw water to facilitate the removal of organic material and prevent water quality failures. Ozone is hazardous to health and can impact on respiratory systems. The Barrow Ozone Plant was installed in 2004 and there is no record of any significant refurbishment work since installation. The deterioration model for the Ozone Plant at Barrow recommends a replacement year of 2019. The Ozone Plant was designed to operate with duty/standby ozone generators. Whilst one ozone generator can operate the works for a significant part of a day it was not designed for 24 hour operation and the failure of a generator could lead to a failure to remove organic material and consequently a water quality failure. An average of 22 unplanned maintenance events were recorded for the Barrow Ozone Plant between 2010 and 2016. An intervention is required at Barrow TW to ensure the long term safety and operation of the Ozone Plant to prevent risk to operators, ensure that organic removal from the water sources is carried out effectively and reduce the number of unplanned maintenance events.	Refurbish ozone plant	Carry out replacement/ refurbishment of existing ozone plant see intervention description	This option will prolong asset life and reduce unplanned maintenance events.
				Do Nothing	Continue current Fix On Fail	There is a high likelihood that the frequency of unplanned maintenance events will increase as the ozone system continues to deteriorate with age. This presents an increasing risk to water quality and of unplanned outage.
SRR666 SRR679 SRR680	IF the ozone plant at Purton TW deteriorates further THEN there is an increased risk of water quality	SRRN84 SRRN106 SRRN107	Purton Post-Ozone tank is a key process element of Bristol Water's largest WTW in supplying Bristol.	Do Nothing	Continue current Fix On Fail	There is a high likelihood that the frequency of unplanned maintenance events will increase as the ozone system continues to deteriorate with age, which presents an increasing risk to water quality.
				Replace Ozone plant	Carry out a full replacement of the Ozonation system	This option has been discarded as the plant is fit for purpose, and due to the high cost of replacement.

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SRR681	failure, unplanned outage and unplanned maintenance at the site. IF ozone transformer No.1 fails at Purton TW THEN there is a risk of a reduced output from site. IF ozone transformer No 2 fails at Purton TW THEN there is a risk of reduced output from site IF the pre ozone tanks cannot be isolated at Purton TW THEN the radial defuser cannot not be maintained AND a loss of compartment would occur with reduction in site output.	SRRN110	The Pre and Post Ozone was installed at Purton in 1993 and then underwent partial refurbishment in 2008. There is no subsequent evidence for further refurbishment. The TW utilises ozone to facilitate the removal of organic material and prevent water quality failures, notably pesticides and also assists with the flocculation and coagulation processes. Ozone is hazardous to health and can impact on respiratory systems. Ozonation failure is likely to result in full or partial loss of out put from the site. An average of 49 unplanned maintenance events per annum recorded for the Purton Ozone plant between 2010 and 2016 and 2 unplanned outages resulting in significant reduction of works output. An intervention is required at Purton TW to ensure the long term safety and operation of the Ozone Plant to prevent risk to operators, ensure that organic removal from the water sources is carried out effectively and reduce the number of unplanned maintenance events.	Purton Ozone Refurbishment	Carry out refurbishment of existing ozone plant.	This option will prolong asset life and reduce unplanned maintenance events.
SRR706	IF further deterioration of the Ozone Plant at Littleton TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	SRRN108	The TW utilises ozone to facilitate the removal of organic material and prevent water quality failures, notably pesticides and also assists with the flocculation and coagulation processes. Ozone is hazardous to health and can impact on respiratory systems. Failure of the transformer will therefore likely to result in partial loss of out put from the site.	Refurbishment	Carry out refurbishment of existing ozone plant see intervention description	This option will prolong asset life and reduce unplanned maintenance events.
				Replace Ozone plant	Carry out a full replacement of the Ozonation system and relocate pre-ozone to upstream of the clarifiers	This option was proposed and discarded at PR14, the site is currently considering decommissioning the post ozone, as a result it may prove more beneficial to retain the pre-ozone upstream of the GAC filtration. The option is high cost. For these reasons the option has been discarded..
				Do Nothing	Continue to operate Fix on Fail	There is a high likelihood that the frequency of unplanned maintenance events will increase as the ozone system continues to deteriorate with age. This presents an increasing risk to water quality.
SRR670	IF further deterioration of the Ozone Plant at Stowey TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	SRRN93	The Stowey Ozone Plant was installed in 2004 and is some 13 years old. There is no record of any refurbishment having been carried out. The Ozone Contact Tank is some 60 years old, it was not designed for ozone contact, but adapted from its former use as a disinfection contact tank,. It is in the tank the structure is in poor condition, the roof in particular is deteriorating due to the corrosion by the ozone gas. Ozone can frequently be smelt in the adjacent filter gallery. There were an average 44 unplanned maintenance events at Stowey between 2010-2016. This has to be reduced. The need is to provide a replace with a new facility, which will comply with internal BW standard specification and improve the efficiency of the Ozonation system.	Do Nothing	Continue to operate Fix on Fail	High incidence of unplanned outages averaging 44 over the last 6 years.
				Replace existing Ozonation treatment plant	Drain down and decommission existing pre ozone tanks at Stowey TW including removal of redundant Ozonation plant; Develop green field site within the site boundary , including access roads, security, all services and diversion of existing services (2 no. 18 " mains) Construction of new Ozonation Plant including mixing chamber, dual cell contact tank Ozone Generation and injection; Liquid Oxygen Storage Compound; Sulphuric Acid Tank and Bund; Acid Dosing System (for bromide control); Transfer pumping station	Available foot print for development with in site boundary, will require transfer pumping back up to RGFs. This is a viable long term solution.
				Refurbish existing Ozonation plant	Carry out mechanical and electrical refurbish to all ozone equipment, including instrumentation and PLCs (detailed condition assessment required). Drain down contact tank and inlet chamber, replace diffusers. Survey and carry out structural repairs as required, reline tank with WRAS approved ozone resistant coating.	The option to refurbish has been considered but issues with the 70 year old concrete contact tank and the corrosive effect of ozone give cause for concern. The tank cannot be drained down with out taking the works off line. The contact tank is below the works access road , the severity of the roof cracking is unclassified as the external rook is covered with tarmac. The existing structure does not conform to BW standard specification for ozone contact tanks. This solution is likely to provide a short term solution due to the condition./age of the contact tank.
SRR673	IF the RGFs at Purton TW fails THEN the output from the site	SRRN92	Purton TW is BWs largest treatment works and contributes approximately	Do Nothing	Continue current practice of Fix on Fail	This option will not meet the intervention need as the number of unplanned maintenance events/ / unplanned outages is likely to increase as asset continues to deteriorate with age.

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Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
	would be reduced.		30% of BWs deployable output. The RGFs at Purton TW were installed in 1994/1995, there is no evidence of any significant refurbishment having been carried out. The number of unplanned maintenance events appears to have been increasing in recent years (zero it in 2010 ; 8 no. in 2015. One event in 2016 caused the plant to stop output. Investment is required at Purton RGFs to reduce the number of unplanned maintenance events and prevent unplanned outages.	Replace (Construct new RGF block)	Build new RGF block and bypass current system.	Comparison with refurbishment options suggests refurbishment of existing RGFs would give similar benefit at a much lower cost. Not a viable option due to expense compared to benefit.
				Replace/Refurbish	Carry out civils, mechanical and ICA refurbishment of the RGFs at Purton TW	Option is a lower cost than a new build RGF block and is likely to achieve comparative improvement in performance. No structural issues identified for existing RGF block Most viable option.
SRR674	IF the roughing filters at Stowey TW fail THEN the output from the site would be reduced.	SRRN94	Stowey TW makes up approximately roughly 7% of BW's deployable output. There are 8 no. RGFs at Stowey acting as roughing filters receiving ozonated raw water prior to treatment by the slow sand filters. The RGFs were originally installed in the early 1950's (drawings date to 1951), making the concrete structures some 66 years old. There is no record of maintenance. Investment is required at Stowey RGFs to reduce the number of unplanned maintenance events and ensure the on-going reliability of the RGF plant. The RGFs at Stowey suffer an average of 12 unplanned maintenance events a year (2010-2016) .	Refurbish existing RGF	Carry out civils, mechanical and ICA refurbishment of the 8no. RGFs at Stowey TW	Option is a lower cost than a new build RGF block and is likely to achieve comparative improvement in performance. Most viable option.
				Do Nothing	Continue current practice of Fix on Fail	This option will not meet the intervention need as the number of unplanned maintenance events/ / unplanned outages is likely to increase as asset continues to deteriorate with age.
				Replace (new construction)	Construct new RGF block	Comparison with refurbishment options suggests refurbishment of existing RGFs would give similar benefit at a much lower cost. Not a viable option due to expense compared to benefit.
SRR628	IF the condition of the GAC system at Littleton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant.	SRRN10	Littleton TW provides approximately 11% of Bristol Waters deployable output. The RGF system was converted to GAC in the 1980s and is suffering from an increasing number of unplanned maintenance events due to the age of the equipment at the TW, with some equipment being over 25 years old (original installation date 1963). The plant suffers from an average of 20 non-infrastructure maintenance events per year (2010-2016). Without investment the system will continue to deteriorate and the number of unplanned non-infrastructure maintenance events will continue to rise. Investment is required to reduce the amount of unplanned maintenance events and extend the asset life of the plant.	Do Nothing	Continue to fix on fail, typically 20 times a year.	Option considered not viable as a long term intervention as it does not mitigate the risk or meet the intervention need.
				Refurbish existing GAC filters	FOR 10 No. GAC filters and common channels; Replace /refurbish all MEICA and refurbish civils structures as required,	This is considered a viable option . Comparison with refurbishment options suggests refurbishment of existing plant would give similar benefit at a much lower cost. Not a viable option due to expense compared to benefit.
				Replace with new GAC filters	Construct new GAC filters and refurbish down stream of existing filters; return current GAC filters to original status as RGFs (post clarification).	This option was considered during PR14, however the high cost of this option and the requirement for upgrading the waste plant, refurbishment of the RGFs and additional pumping makes its inclusion in the business plan unfavourable.
SRR629	IF the condition of the GAC system at Purton TW continues to	SRRN11	Purton TW is Bristol Waters largest WTW, providing approximately 30% of	Do Nothing	Continue to fix on fail.	The occurrence of unplanned maintenance events is likely to increase as the condition of the plant continues to deteriorate with age. This intervention has been discarded as it does not mitigate the risk.

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	deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant		Bristol Waters deployable output. The GAC system at Purton TW is suffering from an increasing amount of unplanned maintenance events due to the age of the equipment at the TW, with the plant suffering 23 events in 2016 compared to 5 events in 2010. The majority of the GAC systems assets are 22/23 years of age or have an unknown age. Without investment the system will continue to deteriorate and the amount of unplanned maintenance events will continue to rise and will increase the risk of unplanned outage of one or more of the filters.	Refurbish	Refurbish/replace all electrically actuated valves and controls.	This option has been taken forward for costing as a viable option.
SRR705	IF either the coagulant dosing system or clarifiers at Littleton TW fail THEN the output from the site would be reduced or stopped	SRRN109	The Littleton Clarification was installed at least 23 years ago although there is no clear definitive date. There is no evidence of major refurbishment. There were 10 unplanned outages in 2016 and unplanned maintenance events average some 45 events per annum (2010-16). The Intervention Need is to carry out refurbishment of the clarifiers and chemical dosing systems to significantly reduce unplanned outage and unplanned maintenance events and to maintain and/ or extend asset life.	Do Nothing	Continue to fix on fail.	This option will continue the current strategy of fix on fail, however the clarification process plant is aging (no data with actual installation date, but circa 30 years old by the end of AMP7) and an increased maintenance requirement is entirely likely if the age related deterioration condition is not addressed. Therefore this option has been discarded as it is not seen to fully implement the need requirements and does not mitigate the risk.
				New build	New build clarification process , most likely small footprint unitised package plant (e.g. DAF, Actiflo)	This is a viable option for Littleton TW. Comparison with refurbishment option suggests refurbishment of existing plant would give similar benefit at a much lower cost. Not a viable option due to expense compared to benefit.
				Refurbish existing coagulation clarification plant.	Refurbish / replace MEICA elements and carry out refurbishment to civils structures .	This option has been selected for optimisation as it will provide significant contribution to customer derived benefits and will extend the asset life of the plant.
SRR709	IF the waste water treatment system at Littleton TW fails THEN then there is a risk of failure of the EA discharge consent.	SRRN111	Littleton TW accounts for approximately 21% of BW's day to day and maximum deployable output. The TW produces waste water from the process treatment which is treated onsite prior to discharge to the environment.. Littleton has a history of low EA discharge failure . The waste plant n averages 30 unplanned maintenance events per annum and 2 recorded unplanned outages in 2016. An intervention is required at Littleton TW to eliminate sample failures in accordance with BWs performance commitment of 100%, and reduce unplanned maintenance and unplanned outage events and extend the asset life of the plant.	Do Nothing	Continue to fix on fail.	This option will continue the current strategy of fix on fail, however the effluent treatment plant is aging (24 years old) by the end of AMP7) and an increased maintenance requirement is entirely likely if deterioration is not addressed. Therefore this option has been discarded as it is not seen to fully implement the need requirements and does not mitigate the risk.
				Refurbish plant	Carry out full refurbishment of Littleton Effluent treatment plant.	This option has been selected for optimisation as it will provide significant contribution to customer derived benefits and will extend the asset life of the plant.
SRR664	IF the source at Sherborne TW remains out of service for a extended period THEN the abstraction licence (and the deployable output) from the site may be permenently lost	SRRN44	The site has been out of service since 2012. The Environment Agency are due to conduct a review of water abstraction licences by 2020/2025 for all water companies, with the view to reduce abstraction and evaluate sustainable practices. Any sources not being utilised are expected to come under scrutiny with a potential reduction in allowable abstraction limits. The source may be required in future as demand in the BW network grows.	Abandon Works	Abandon the works and surrender the licence.	Not beneficial due to difficulty in obtaining new licences for future demand
				Move Abstraction licence to Chew Valley Lakes	Abandon the works and attempt to move the abstraction licence to Chew Valley Lake.	Not viable as the Environment Agency were not willing to accommodate the transfer of the licence to Chew Valley Lake.
				UV	Replacing the arrangement with cartridge filters and UV, and subsequently blending with water from Stowey.	Viable solution, though rejected due to the complex issues regarding water quality (presence of soluble lead), sources blending and reduced output when dependant on other works.
				Containerised unit	Replace the works with a containerised filtration unit.	Viable solution, to buy a containerised unit with low commissioning costs. Rejected due to high Capex costs reduced CBA ratio.
				Rehabilitate abandoned 21" raw pipeline	Rehabilitation of an abandoned 21” pipeline to allow treatment at a Stowey.	Viable and most cost beneficial solution, to use the old 21” main that linked the site to Stowey, advance to next design stage.
				New 6" pipeline	Install a new 6” pipeline to transfer the water to Stowey	Viable, but rejected due to high Capex for a new pipeline near existing mains, routes constrained by local geography.

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			The draft Water Resource Management Plan has been produced in line with a statutory 25-year WRMP planning process and includes the output of Sherborne spring. The Sherborne licence is an issue separate from the abstraction at Chew Valley Lake and provides water that is additional to the abstraction licence from Chew Valley Lake. If the Sherborne spring licence were revoked, this would reduce the deployable output of our sources by 3.7 Ml/day (this figure is lower than the licensed volume and is a calculation based on anticipated yield during a period of extreme drought). Investment is required to ensure that the deployable out put from Sherborne remains available to BW in a drought event.	Carry out modifications to works	Modify and recommission TW to provide reduced 4.5M/d output works to include relocate chemical rigs and dosing lines to improve access, install HVAC to reduce condensation, improve chemical bunding, improve low lift pump access and restore floating chemical tank.	Viable option. Significant effort required to redesign and rectify existing works within the current constraints,
SRR272 SRR276 SRR682	IF the High Voltage Transformer fails at Littleton TW THEN the electrical supply to Almondsbury PS would be lost (Based on site at Littleton TW). IF the power limitations at Oldford TW are exceeded THEN the distribution board would be overloaded leading to site shut down and potential H&S issue (fire/electrical) IF a site High Voltage Transformer fails THEN would lose electrical supply to site (multiple sites at risk): Rowberrow PS; Axbridge; Littleton; Oldford; Chew Stoke; Stowey TW; Purton Intake; Cheddar.	SRRN82	The age analysis records (derived from SAP) show that BW owns and operates 21 items of HV electrical equipment that will be beyond 40 years of age and life expired at the end of AMP 7. Much of this equipment is a single point of failure which will shutdown the TW in its entirety causing an unplanned outage which could prevent BW from achieve customer commitments of safe and reliable supply. An intervention is required to begin the process of replacing some of this equipment to improve the overall reliability of the BW TWs and maintain the average asset age of the equipment.	Do Nothing	Continue "fix on fail" .	With age of equipment a rolling programme of asset renewal is required if significant expenditure is to be avoided in AMP8/9.
				Refurbish replace transformers and HV switchgear	Replace aging transformers and HV switchgear at Littleton, Purton, Chew Valley and Axbridge etc.	Option is viable and managed electrical asset renewal plan is considered to be a sensible approach to the issue of the average age of the plant.
SRR175 SRR275	IF the mains incoming control panel at Cheddar TW is not upgraded, THEN power supply to site may fail. IF the control panel/ drives that feeds Clevedon's well and high lift pumps fails THEN the output from the site will be lost.	SRRN83	The age analysis records (derived from SAP) show that BW owns and operates 5 motor control centres that will be beyond 40 years of age and life expired at the end of AMP 7. Much of this equipment is a single point of failure which will shutdown the TW in its entirety causing an unplanned outage which could prevent BW from achieve customer commitments of safe and reliable supply. An intervention is required to begin the process of replacing some of this equipment to improve the overall reliability of the BW TWs and maintain the average asset age of the equipment.	Do Nothing	Continue "fix on fail" .	With age of equipment a rolling programme of asset renewal is required if significant expenditure is to be avoided in AMP8/9.
				Refurbish/replace control panels	Replace aging electrical equipment in rolling programme	Option is viable and managed electrical asset renewal plan is considered to be a sensible approach to the issue of the average age of the plant.
SRR801 SRR803 SRR704	IF the supplier of the pressurised membrane filters at Alderley TW, Charterhouse TW, Chelvey TW, Forum TW, Frome TW and	SRRN50	Kalsep have ceased to supply KALMEM membranes, BW have 6 sites currently using these membranes for removal of Crypto. In order to	Replace membranes and upgrade Membrane Plant to 7 Ml/d	Modify and replace existing with new supplier membranes, replace chemical and waste storage tanks and upgrade to utilise full abstraction licence. Option Cost Evaluation: MEDIUM	This has been identified as a viable option and will taken forward for costing and Optimisation

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
	Oldford TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues. IF the supplier of the pressurised membrane filters at Alderley TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues. IF chemical tanks/bunds at Alderley TW fail THEN discharge of contents present a risk to H&S and the environmental .		continue production at these sites all membranes rigs must be modified to enable them to accept membranes from an alternative supplier. The Intervention will replace the obsolete membranes with either alternative supplier membrane or alternative process to ensure removal of cryptosporidium and turbidity at Alderley TW. Investment is required to reduce the unplanned maintenance and secure future operation of the site. This Option includes a site upgrade from current 5 Ml/d to 7 Ml/d (licenced abstraction), as the current short fall (2.2 Ml/d at maximum demand) in supply is made up from Purton TW. This will generate OPEX savings on treatment and transfer of water from Purton.	Replace Excising Membranes at current capacity 5 Ml/d	Modify manifolds and replace existing with new supplier membranes (5 Ml/d), replace chemical and waste storage tanks.	This has been identified as a viable option and will taken forward for costing and Optimisation
				Replace Membranes with UV System	Replace membranes with UV system	Increased occurrence of turbidity in the source during the winter months makes this option unviable with out additional installation of a filtration plant. Option Discarded
				Do Nothing	Continue to operate on existing membranes and then decommission site when membranes fail and supply from Purton	Fix on Fail - continue to use membrane stock pile - limited availability (likely to run out in AMP7. Alderley is a been identified as a key source supplying WSZ401, supported by transfer from Purton.) This option has been discarded as this solution would reduce resilience of the zone and place our customers at risk of infection by Cryptosporidium. I Option Discarded
				Replace Membrane plant with combined UV and Cartridge Filter system	This option would decommission and remove the membrane plant and replace it with a UV system and cartridge filter plant approved for removal of Cryptosporidium and turbidity.	The solids loading capability of the filter cartridges is questionable and the associated impact on OPEX still has to be established by pilot trials, given the known presence of turbidity in the raw water. This option is likely to have the highest CAPEX. For these reasons this option has therefore been discarded.
				Replace Membrane plant with New Packaged Membrane System	Decommission the existing membrane plant and replace it with a package membrane system.	This is a viable solution for Alderley TW, however a detailed cost benefit analysis will need to be conducted for both sites taking into account the net write off value of existing plant and buildings. Even without the latter cost, the initial cost estimate for a package system (estimated £1.3 M for Alderley TW) indicates that this solution will have a higher CAPEX than the preferred solution. This option has been discarded
				Replace Membrane plant with Cartridge Filters	This option would decommission and remove the membrane plant and replace it with a cartridge filter plant approved for removal of Cryptosporidium	The solids loading capability of the filter cartridges is questionable and the associated impact on OPEX still have to be established given the known presence of turbidity in the raw water at Alderley. This option has therefore been discarded pending further investigation.
SRR801 SRR704 SRR62	IF the supplier of the pressurised membrane filters at Alderley TW, Charterhouse TW, Chelvey TW, Forum TW, Frome TW and Oldford TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues.water quality issues. IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment IF the unused tanks left on site at Chelvey TW are not properly decommissioned THEN their condition will deteriorate and generate a potential H&S incident and/or surface water contamination (Chelvey TW).	SRRN49 SRRN51 SRRN100	Kalsep have ceased to supply KALMEM membranes, BW have 6 sites currently using these membranes for removal of Crypto. IN order to continue production at these sites all membrane rigs must be modified to enable them to accept membranes from an alternative supplier. The Intervention at Chelvey TW cryptosporidium barrier plant will replace and fit new membranes for existing 20Ml/d capacity with either alternative supplier membrane or alternative process to ensure removal of cryptosporidium and turbidity, reduce the risk of unplanned outage and unplanned maintenance. Intervention is required to prevent further deterioration of the un-used chemical (softener) tanks, which could potentially result in a pollution or a Health & Safety incident. Investment is required to replace all chemical tanks which will become life expired in AMP7 (multiple sites). The WSE is required under the BW Written Scheme of Examination Thermoplastic Atmospheric Storage Tanks in accordance with BW's general legal obligations set out in the Health and Safety at Work Act (1974) and the specific requirements of the Provision and Use of Work Equipment Regulations 1998 (PUWER).	Replace Excising Membranes at current capacity 20 Ml/d	Modify manifolds and replace existing with new supplier membranes (20 Ml/d), replace chemical and waste storage tanks.	Replace existing membranes with same capacity system.
				UV Replacement of membranes	Replace membranes with UV system	Occurrence of turbidity in the source makes this option unviable with out additional installation of a filtration plant.
				Do Nothing	Continue to operate on existing membranes and then decommission site	Limited membrane stockpile. Chelvey is a key source for supply to the zone
				Replace Membrane plant with combined UV and Cartridge Filter system	This option would decommission and remove the membrane plant and replace it with a UV system and cartridge filter plant approved for removal of Cryptosporidium and turbidity.	The solids loading capability of the filter cartridges is questionable and the associated impact on OPEX still has to be established by pilot trials, given the known presence of turbidity in the raw water. This option is likely to have the highest CAPEX. For these reasons this option has therefore been discarded.
				Replace Membrane plant with New Packaged Membrane System	Decommission the existing membrane plant and replace it with a package membrane system.	This is a viable solution for Chelvey TW, however a detailed cost benefit analysis will need to be conducted for both sites taking into account the net write off value of existing plant and buildings. Even without the latter cost, the initial cost estimate for a package system is anticipated to have a significantly higher CAPEX than the preferred solution. This option has been discarded
				Replace Membrane plant with Cartridge Filters	This option would decommission and remove the membrane plant and replace it with a cartridge filter plant approved for removal of Cryptosporidium	The solids loading capability of the filter cartridges is questionable and the associated impact on OPEX still have to be established given the known presence of turbidity in the raw water at Chelvey TW. This option has therefore been discarded pending further investigation.

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	**SRR Revised Risk Description**	**SRR Need ID**	**Need Description (from SRR)**	**Proposed Option Name**	**Proposed Option Description**	**Option Viability?**
SRR149	IF raw water quality in the Sharpness Canal deteriorates or Purton TW is required to operate at full capacity for a sustained period of time THEN the sludge production from the site will increase beyond the capacity of the existing sludge handling plant and there will be an increase in waste compliance failures , unplanned maintenance AND possible site shutdown	SRRN67	The Need is to carry out a refurbishment of the waste treatment to reduce unplanned maintenance, unplanned outage and achieve the zero waste compliance failures target demanded by BW Performance Commitments on environmental discharges (2 no. EA discharge failures in 2017). The Densadeg was installed in 1992 for treatment of wash water, while the "Old" plant (coagulant sludge settlement) pre dates this. The sludge storage tank has a volume of settled sludge which remains in the base of tank, however to take the tank off line for cleaning entails shutting the DENSADEG down with knock on implications to the works. There are substantial unplanned maintenance events occurring on an annual basis. Studies are on-going (BW Solutions team) to develop solutions in AMP6 potentially for implementation in AMP7/8.	Refurbish existing densedeg plant.	Option will improve reliability of the existing sludge handling plant (Densedeg) by refurbishing the existing system on a like for like basis. This will improve the reliability of the sludge pumping station and ensure the existing plant is performing at an optimal level.	
				Provision of second Densedeg plant and refurbish the existing plant.	Option will improve reliability of the existing sludge handling plant (Densedeg) by refurbishing the existing system on a like for like basis and provide additional capacity should the TW need to run at full output for a sustained period. . This will improve the reliability of the sludge pumping station and ensure the existing plant is performing at	
				Tankering of sludge off site	Tank surplus waste sludge off site for disposal at a licenced tip.	
				Do nothing	Continue with poorly performing sludge plant repair broken plant and increased maintenance costs associated with tank cleaning	
SRR166	IF the open slow sand filters at Banwell TW are containated with Cryptosporidium THEN as the current UV system is not validated for treatment of crytosporidium there is a risk of a final water quality failure.	SRRN77	The UV was installed for general disinfection and does not carry DWI validation for attenuation of cryptosporidium In 2014 there were two failures of the final water attributed to contamination of the SSFs by Crypto. Crypto is harmful to health and WQ failure must be notified to the DWI. Realisation of the risk will impact on Customer Health & Safety and on unplanned outage and unplanned maintenance. Bristol Water have informed the DWI that the Need will be addressed in AMP7, therefore an intervention is required to either remove potential for contamination of the SSFs or ensure that a DWI approved process for treatment of Crypto is in place.	Replace with new validated UV system	Provision of new fully validated UV plant system This solution would replace the existing UV with a new validated UV system, including replacement of existing electrical system and controls, and decommissioning existing plant. The capacity to be sized for maximum output (30 Ml/d) when treating all raw water sources (i.e. including operation on Blagdon Reservoir water). A new building to house the new plant to be included.	This solution will provided UV disinfection validated in compliance with DWI guidance for the selected target organism(s). In this case the requirement would be to provide a UV system validated for 4 log attenuation of Cryptosporidium and general disinfection.
				Banwell Unvalidiated UV; Cover SFFs	Provision of new covers for the Banwell TW SSFs to exclude light, wildlife and other sources of potential contamination. Decommission low lift pumping station and UV.	This option will remove the requirement for UV attenuation of Cryptosporidium. The membrane filtration stage provide protection against Crypto in the raw water , covering the SSFs will exclude potential sources for re-contamination in the SSFs. There is an additional OPEX saving in that by removing the UV , interstage pumping between the SSFs and the contact tank will no longer be required.
				Remove SSFs and UV	This option will remove both the SSFs (Source of Crypto contamination) and the UV (disinfection) from the treatment process, as the membrane filtration will remove Crypto from the raw water. Additional treatment will be required to ensure water quality (MIB & geosmin). in the form of GAC or PAC	There is an additional OPEX saving as LL pumping between SSFs and contact tank will no longer be required. The SSFs perform an important function in removing organic material (principally methylisoborneol and geosmin) which could otherwise cause significant issues with taste and odours in supply. An additional stage would be required to remove these substances, solutions for which include the following; - Addition of PAC (powered activated carbon) to the raw water discarded due to the potential damage to membranes potentially reducing membrane life to 6 months. - Provision of GAC absorbers - discarded due to consequential impact on the Banwell waste treatment plant. Considerable additional investment would be required to enhance the current waste system.
				Do Nothing	Continue Operational practice of Fix on Fail	Discarded as does not address the Intervention Need
SRR84	IF pre treatment tank needs cleaning/maintenance THEN the site requires shutting down with consequence Unplanned Outage.	SRRN89	If the pretreatment tank fails then site is down. It was constructed in 1973 and the last major refurbishment was in 2007 when baffle walls, a mixing chamber and GRP roof was added. The pre-treatment tank is hydraulically undersized and does not provide sufficient driving head to achieve maximum flow through the downstream Boll Filters. The control band is therefore restricted providing minimal tolerance to any change in level. As a result the pretreatment tank I s the cause of numerous works outages and unplanned maintenance events.	Replace pretreatment tank	Construct new twin celled pretreatment tank to provide correct mixing and chemical coagulation contact requirements	Option considered viable but will require significant CAPEX, also need to consider implication of potential future site re-design.
				Do Nothing	Continue with current practice of Fix on Fail	This option will not meet the Intervention requirements.(Need)
				Refurbish	Refurbish tank including concrete structure, replace GRP roof , secure suspended mixers and replace instrumentation	It is not possible to take the tank of line with out removing the works from Production. Refurbishing the tank will not meet BW specification requiring a twin celled duty/standby structure to permit one cell to be taken out of service whilst maintaining the works in service. However this solution would provide a viable short term solution.
SRR710	IF the membranes at Banwell TW are replaced at the correct time	SRRN115	The membranes at Banwell provide treatment including removal of Crypto,	Replace Membranes with more robust S10N membranes	Replace Membranes with more robust S10N membranes	Initial replacement likely to be carried out in AMP6 of a small number of membranes. Option is considered fully viable

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	THEN output from the site will be reduced.		the existing membranes are likely to deteriorate and require replacement in AMP7, (asset life 7years last replaced 2015). The membrane system experiences an exceptionally high rate of pinning - 2 men are employed for 2 days a week pinning broken membrane fibres. There is an opportunity to replace the existing membranes with a more robust membrane from the same membrane supplier which could significantly reduce pinning as the membranes reach the end of their asset life inthe next AMP Investment is required to forestall unplanned outage (reduced site out put) and reduce site OPEX .	Replace membranes like for like	Replace with current membranes	Viable solution , but the comparative OPEX savings likely to be generated by the S10N membranes result in this solution being discarded.
				Do Nothing	Continue fix on fail	This option is not viable as it will result in significant unplanned outage of the site.
SRR118 SRR165 SRR133	IF a structural failure of treated water tanks at Banwell TW occurs THEN there will be a reduced output from the site. IF the single contact tank at Banwell fails THEN output from the site is lost. IF the piers in the clear water tank at Banwell TW fail THEN then the output from the site would be lost and there would potential H&S safety risks to personnel in bring the site back online.	SRRN61 SRRN76 SRRN90	There are structural concerns regarding the condition of the Treated Water storage tanks. An AECOM site survey 2017: recently inspected and found concrete cancer in both cells A&B. Loss of either cell will place will result in significant cost of bringing back on line. The need is to carry out a refurbish the TWT to eliminate the risk of structural failure and potential for water quality failure. There is a single contact tank at Banwell, if it were to fail then the site will be out. The tank cannot be taken out of service for inspection or maintenance with out taking the works off line. The Need is to provide a standby arrangement to allow the contact tank to be taken out of service without disruption to supply (tank inspection including drain down, may take up to a week), The Need entails providing an alternative arrangement for super and dechlorination, and will include provision of baffles in cells A&B of the clear water tank. The tank was originally constructed in 1958. Visual inspection of the structure (16/11/16) has highlighted visible cracks in 3 off piers at the top where they brace the roof load. An AECOM site survey 2017: recently inspected and found concrete cancer in both cells A&B. Loss of either cell will result in significant cost of bringing back on line. The need is to carry out a refurbish the TWT to eliminate the risk of structural failure and potential for water quality failure.	Refurbish	Refurbish existing tanks; carry out structural repairs and carry out relining. Installation of baffles in TWT and provision of new chlorination dose point and monitoring.	Taken forward for costing
				Do Nothing	Continue current practice of Fix on Fail	This option is not considered feasible due to the risk of final water contamination if structural repairs are not implemented
				Replace	Land purchase and construction of new twin celled TWTs and twin celled contact tanks	Likely to be high CAPEX, potential for long term development plan for Banwell TW. However the long term plan for Banwell has still to be formulated therefore this option has been discarded for construction in AMP7
SRR116	IF the sodium hydroxide dosing static mixer and downstream	SRRN59	The existing caustic mixing arrangement at Banwell relies on	New twin celled mixing chamber	Replace existing static mixer with twin celled mixing tank for introduction of caustic	Taken forward - meets BW standard specification for dosing sodium hydroxide

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	pipework constricts/blocks THEN the flow through the mixer would be restricted and the works output would need to be reduced or the works shut down (Banwell - Area 3).		injection of caustic into a static mixer. The mixer and pipework immediately downstream of the mixer experience heavy deposition of scale resulting in significant reduction in the diameter of the pipe and blockage of the mixer itself. An operational shut down of the site is required to carry out CCTV inspection and maintenance. The blockage is cleared by removing the affected pipe sections and the mixer itself and either cleaning in acid or alternatively, in the case of irretrievable fouling, replacement with a new pipe connection and mixer. This impacts the PCs as unplanned outage and unplanned maintenance. An intervention is required to ensure that the caustic mixing arrangement fully meets with Bristol Water Standard Specifications.	Do Nothing	Continue with existing arrangement (injection of caustic into static mixer) of Fix on Fail / preventative maintenance	This option does not meet the Intervention Need, it does not meet BW standard specifications for dosing arrangements for caustic.
SRR650	IF the chlorination (gas) system at Barrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN36	Barrow Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There is 1 property within 180m of the site. The system suffers from regular failures (52 failures occurred in the chlorination system in 2016, 9 of which led to plant shutdown). Barrow provides 23% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this strategic production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Barrow Electro-chlorination Plant	Installation of electro-chlorination system at Barrow TW to replace existing chlorine gas system	Yes this option will replicate work already completed at other large BW sites , notably Cheddar & Purton
				Do Nothing	Continue to operate the works using chlorine gas disinfection and fix on fail of aging chlorine plant.	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7
				Barrow Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Barrow TW to replace existing chlorine gas system	Yes this option will replicate work already completed at other large BW sites , notably Cheddar & Purton
SRR143	IF the chlorination (gas) system at Charterhouse TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN34	Charterhouse Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There is 1 property within 180m of the site. The system is old and suffers from regular failures (22 failures occurred in the chlorination system in 2016) and is due for replacement in 2017. Furthermore, the system utilises Portacel equipment, which is no longer supported by the supplier and there are no spares available. Charterhouse provides 0.4% of Bristol Water's output. Investment is required to reduce the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Charterhouse TW Electro-chlorination Plant	Installation of electro chlorination system a Charterhouse TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage .
				Charterhouse TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Charterhouse TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.02

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
SRR651	IF the chlorination (gas) system at Forum TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN37	Forum Disinfection is currently a chlorine gas system with bulk gas storage on site. There are 7 properties within 180m of the site. The system is old and suffers from regular failures (13 failures occurred in the chlorination system in 2016, 3 of which led to plant shutdown) and is due for replacement in 2021. Forum provides 0.4% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Forum TW Electro-chlorination Plant	Installation of electro-chlorination system a Forum TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7
				Forum TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Forum TW to replace existing chlorine gas system	Yes this option will replicate work already completed at other smaller BW sites , notably Alderley and Tetbury
SRR158	IF the chlorination (gas) system at Littleton TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN35	Littleton Disinfection is currently a chlorine gas system with bulk gas storage on site. The system is old and suffers from regular failures (38 failures occurred in the chlorination system in 2016 ("Performance Benefits" C109) , 5 of which led to plant shutdown and 3 leading to reduced site output), often leading to plant shutdown, and was due for replacement in 2003. Furthermore, the system utilises Portacel equipment, which is no longer supported by the supplier and there are no spares available. Littleton provides approximately 11% of Bristol Water's maximum deployable output. Investment is required to reduce the risk of plant unplanned outage at this strategic production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Littleton TW Electro-chlorination Plant	Installation of electro-chlorination system a Littleton TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7
				Littleton TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Littleton TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.04
SRR652	IF the chlorination (gas) system at Shipton Moyne TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN38	Shipton Moyne Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There are 4 properties	Shipton Moyne Electro-chlorination Plant	Installation of electro-chlorination system a Shipton Moyne TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
			within 90m of the site. The system is old and suffers from regular failures (38 failures occurred in the chlorination system in 2016, 2 of which led to plant shutdown), and is due for replacement in 2027. Shipton Moyne provides 2.3% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Shipton Moyne Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Shipton Moyne TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.05
SRR35	IF the chlorination (gas) system Almondsbury TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN32	Almondsbury Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There are 7 properties within 180m of the site. The system is old and suffers from regular failures (31 failures occurred in the chlorination system in 2016), and was due for replacement in 2009. Investment is required to reduce the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Almondsbury PS Electro-chlorination Plant	Installation of electro-chlorination system a Almondsbury PS to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7
				Almondsbury PS Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Almondsbury PS to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.06
SRR73	IF the chlorination (gas) system at Banwell TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN33	Banwell Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There are 7 properties within 180m of the site. The system is old and suffers from regular failures (22 failures occurred in the chlorination system in 2016, 1 of which led to plant shutdown and 1 leading to reduced output), and is due for replacement in 2027. Banwell provides 5.7% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Banwell TW Electro-chlorination Plant	Installation of electro-chlorination system a Banwell TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7
				Banwell TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Banwell TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.07

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	**SRR Revised Risk Description**	**SRR Need ID**	**Need Description (from SRR)**	**Proposed Option Name**	**Proposed Option Description**	**Option Viability?**
SRR653	IF the chlorination (gas) system at Rowborrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN39	Rowberrow Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There is 1 property within 90m of the site a further 6 within 180m of the site. The system is old and suffers from regular failures (12 failures occurred in the chlorination system in 2016), and was due for replacement in 2010. Investment is required to reduce the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Rowberrow PW Electro-chlorination Plant	Installation of electro-chlorination system a Rowberrow TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6
				Do Nothing	Continue to operate the works using chlorine gas disinfection	This option does not meet the Investment Need BW strategy to replace with EC.
				Use of bulk sodium hypochlorite	Replace gas chlorination with bulk storage of sodium hypochlorite for chlorination disinfection	This option is not considered viable given the 30 day storage capacity required, and the propensity of hypochlorite to deteriorate on prolonged storage . BW is carrying out strategic replacement of all chlorination sites in AMP6/7
				Rowberrow PW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Rowberrow TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.08
SRR654	IF the chemcial delivery system for the electro-chlorination plant at Barrow NSF is not upgraded THEN there is a risk to the H&S of the operators.	SRRN85	BARROW NSF Standard duty/standby 1.8kg/h electro-chlorination system including duty standby electro-chlorinators, 2 No 20 tonne salt saturators, 2No 5cu.m capacity bulk hypochlorite storage tanks, 2No,1 cu.m capacity intermediate tanks, duty/standby brine transfer pump skid, duty standby dosing pump skid, 18 x 8m SR3 rated kiosk, 50sq.m x 0.5m high concrete bund, 16x8 concrete slab for kiosk, 800m of double skinned dosing pipe, pipework trace heating and lagging, electrical installation and controls	Do Nothing	Continue to operate site as it is	As chlorine is still transferred by hand there is still risk of health and safety event.
				Chlorine dosing from Barrow TW		
				Full Electro-chlorination	Build full electro-chlorination dosing system at Barrow NSS PS	Removes Health and Safety risk, however very expensive compared to the benefits.
SRR658 SRR781	IF a failure of the main High Voltage (HV) switchboard and/or 11/3.3kV transformers at Purton	SRRN82	Purton TW accounts for approximately 30% of BW's maximum deployable output. The TW is supplied electrically	Do Nothing	Business as usual including annual inspection and monitoring.	Not a long term viable solution. Risk to reliable supply and operator health still on-going.
				Refurbish existing switchboard and replace transformer.	Replace oil filled circuit breakers with vacuum circuit breakers.	Short term fix. In longer term AMP8/9 will be necessary to replace switchgear.

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
	TW occurs THEN there will be an unplanned outage and a possible loss of supply to customers supplied by the Purton TW. If a failure of the main High Voltage (HV) switchboard at Purton TW occurs during operation, maintenance or testing THEN there is a possibility of serious injury or death occurring leading to reputational damage and possible prosecution.		at 11,000volts (11kV) by the local District Network Operator (DNO). The main site 11kV switchboard was installed in 1974 and is jointly owned by BW and the DNO. The switchboard no longer meets current design and safety standards mainly due to the use of obsolete oil filled switchgear. Obtaining spare parts and carrying out maintenance is difficult. The age and condition of the switchboard creates a fire/explosion health and safety risk for operators, and an operational risk which could cause a significant unplanned outages event. The 11kV switchboard feeds 2No 5MVA, ONAN cooled, 11kV/3.3kV transformers. A transformer has failed during AMP6 and is being replaced. The 2nd transformer is of a similar age and similarly requires replacement if unplanned outages are to be avoided. An intervention is required to replace the obsolete switchboard and transformer at Purton TW to manage the health and safety risk to operation all staff and mitigate the risk of unplanned outages.	Replace 11kV switchboard and transformer	Replace switchboard and transformers with new equipment and possibly building. Separate DNO equipment from BW owned equipment	Fully viable short term planned reduction in output.
SRR659	IF the HV supply to Purton TW fails due to external factor THEN there would be a loss of output from the site.	SRRN83	Purton TW accounts for approximately 30% of BW's day to day and maximum deployable output. The TW is supplied electrically at 11kV by 2No overhead powers lines from Berkley Primary Substation. The site electricity supplies were designed in 1974 to provide a 100% standby in the event of a single point of failure on the electrical system. A study carried out in 2014 shows that as the TW process have been modified to provide enhanced treatment the electrical power supplies have not been reinforced and as consequence the standby capacity is no longer available, and the TW would be unable to deliver its reported 165Ml/d design output without a significant risk of overloading the supply network and causing an unplanned outage. An intervention is required to reinforce the power supply at Purton TW to ensure that the reported design output could be delivered without risk of a system overload and an unplanned outage.	Do Nothing	Maintain power supplies as is. Ensure existing supplies are maintained at high availability. Provide additional generation or supplemental supplies in the event of failure of works	Viable but there is risk involved regarding generator availability.
				Provide additional supply for treatment works	Provide new power supply to treatment works that enables full works output to be achieved consistently.	Viable but only provides limited resilience and unlikely to cope if complete loss of supply from Berkley.
				Provide full power supplies from and alternative part of DNOs network.	Provide new and separate power supply to treatment works and pumping station to provided full system redundancy	Option is viable but cost would be disproportionate to the value provided. Not considered to be worth further consideration
SRR675	IF Slow Sand Filter no.2 is not repaired THEN may result in outage of filter and reduced output from Stowey TW.	SRRN95	Stowey TW is one of Bristol Waters supplies approximately 7% of BW's deployable output. The SSFs at Stowey suffer an average of 25	Refurbish	Carry out structural and mechanical refurbishment of SSF2	Refurbishment of SSF2 will work to reduce unplanned outage and maintenance as newer equipment will have a lower failure rate. This in turn will meet the outlined performance commitment. For the above reasons this options has been taken forward for costing.

		Risk Need		Identification & Viability of Options		
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?
			unplanned maintenance events a year (2010-2016) and 1 event in 2016 that led to site shutdown. SSF 1 under went full refurbishment in 2012, SSF2 has been identified by Jas currently leaking and requiring civils refurbishment. Concerns have also been raised around the poor condition of the inlet, outlet and drain valves. Investment is required at Stowey SSFs to reduce the number of unplanned maintenance, unplanned outage events and restore the asset life of SSF2.	Do Nothing	Continue current practice of Fix on Fail	Leaving the SSFs to be fixed on fail will start to become more expensive over the course of the AMP cycle. SSF2 will continue to deteriorate, causing a negative impact on both performance commitments. This option does not meet the Intervention Need or future resilience of the site, so will not be taken forward for costing.

7.6 Appendix E: Interventions Developed

This appendix shows the 55 interventions developed from the 143 options.

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR168	IF failure of lead standards in Water Supply Zone 401 continue Then we will fail to meet DWI water quality standards and place our customers at risk in the long term.	SRRN8	In 2013 the DWI standard for lead in drinking water at customers taps changed from 25 to 10µg/l. Between 2015 and 2017, 3 water quality tests exceeded this value in the Alderley TW water supply zone (WSZ) 401. Intervention is required to prevent further failure of lead samples which may harm the health of our customers and would impact on the company's CRI An intervention is required to improve water quality in the Alderley water supply zone 401 to mitigate risk of lead stand failures, ensure compliance with current legislation and long term customer health issues.	Provide additional treatment process at TW	Provide Orthophosphoric acid dosing and storage systems on site to control phosphate levels in treated water leaving the works to mitigate plumbo solvency in supply. Option Cost ; LOW	This is a viable option that has been used through out the water industry and equally applied at other sites by Bristol Water . Mitigates risk of CRI failures and therefore helps meet customer expectations of safe and reliable supply. Option Viability confirmed.	24.001.01	Alderley TW WSZ401 plumbosolvency control - Orthophosphoric Acid Dosing	£471,063	£9,690	0.000	0.00	0.00	0.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR159	IF increased levels of algae are experienced in the source water for Cheddar TW THEN the slow sand filters will suffer increased blinding and output from works from the works will be further reduced.	SRRN9	Cheddar WTW is a key resource in the Southern Area providing up to 60 Ml/d output. The Slow Sand Filters experience elevated levels of algal blooms in some summers, which has caused the filters to blind and result in reduced output of the WTW and failure to meet the average daily demand (23 Ml/d). This in turn has led to depletions in supply in the network with Brent Knoll reservoir running dry for 1 day in 2010. Furthermore, reduced throughput in the SSFs can lead to anaerobic conditions developing increasing the risk of metals (aluminium, manganese, arsenic, iron and lead) adsorbed to the sand to be released in potentially high concentrations and causing water quality sample failures. Investment is required to reduce the risk of algal growth impacting on Plant Outage and Water Quality Compliance.	SSF Cover extended trial	An initial trial commenced in Spring 2017, and although BW have seen benefit from the covered slow sand filter there are concerns that during a prolonged period of hot weather the cover would lead to a significant increase in the temperature of the water above the filter potentially causing a detrimental impact on the Schmutzdecke with possible development of geosmin/methyl isoborneol related taste and odour in the filtrate. The only way to see if this risk is realised is by collecting further information as the trial progresses. Consequently, BW feel it is too early within the trial to commit to covering the slow sand filters as the most appropriate control measure to address the risks associated with the deteriorating raw water from Cheddar Reservoir and would prefer to continue an investigative period of trials though AMP7. This would significantly increase the likelihood of testing the effectiveness of the covers and ultrasonics both when there is a significant algal loading coming in from the reservoir and during extended periods of hot weather. There would then be much increased confidence that any treatment based solution proposed would be robust in maximising the benefits whilst minimising any possible adverse impacts.	Viable option , as infrastructure is in place.	24.001.10	Cheddar Tw raw water deterioration trials extension	£500,000	£0	0.000	0.00	0.00	0.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR271 SRR711	IF the single mixer within the single sludge blend tank fails at Barrow THEN the sludge settles out within the tank (which has to be dug out) and produces poor performance within the sludge thickeners. IF the sludge thickeners at Barrow do not operate efficiently THEN the poor quality supernatant can lead to a breach of the discharge consent of treated waste water returned to Barrow Reservoir 3	SRRN88	Barrow TW accounts for approximately 21% of BW's maximum deployable output. The TW produces waste water from the sand washing, rapid gravity filters and sludge form the dissolved air floatation process, these waste streams are blended in the waste water balance tanks and then passed forward for thickening prior to sludge dewatering by the sludge belt press. There is a record of unplanned maintenance events (average 66 per annum). The supernatant from the sludge settlement tanks is returned to Barrow Reservoir 3. There is a history of failures against the Res 3 EA Licensed Discharge Consent conditions (high aluminium), with 4 failures in 2016. An intervention is required at Barrow TW to ensure to improve the operation of the waste treatment works, this includes the mixing in the sludge blending tank and the thickening processes to reduce sample failures on the return to reservoir 3, and to reduce to the unplanned maintenance events.	Improve performance of existing plant	Install second balancing tank, and provide improved mixing in the blend tanks to allow better management of the sludge blending. Refurbish existing plant and ensure full duty/standby capability of streams	A second balance tank will provide a buffer to accommodate rapid increase in plant flows (algal conditions in reservoirs) allowing changes in settlement rate to be minimised/ made gradually. Will provide improved blending and thickening to help settlement of solids and reduce sample failures on return to reservoir 3. 2 streams will allow comprehensive study work to be implemented; (could be used to allow different polyelectrolytes to be used to optimise performance); increase resilience and enable one stream to be taken off line for maintenance without impact to works and greater flexibility in the event of a plant failure. Intervention will address unplanned maintenance and sample failures to meet customer requirements regarding environmental resilience. Option confirmed Viable	24.002.01	Barrow Waste System Improvements	£583,939	£10,322	0.000	0.00	52.80	0.00
SRR704 SRR267 SRR269 SRR270	IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment. IF spill occured during	SRRN100: SRRN101: SRRN102: SRRN103	SRRN100 The Need is to replace all chemical tanks which will become life expired in AMP7 in accordance with BW WSE. The BW Written Scheme of Examination Thermoplastic Atmospheric Storage Tanks is in accordance with BW's general	Replacement of life expired chemical tanks and delivery management / spill containment improvements	Replace polypropylene tanks that will be life expired in AMP7 upgrade delivery management and spill containment improvements at identified sites.	This option will meet the requirements to replace life expired tanks and SERA as identified.	24.004.04	Replacement of life expired chemical tanks and delivery management and spill containment improvements	£3,998,443	£0	0.000	0.00	8.00	5.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
	collection from the waste chemical collection tank at Charterhouse TW THEN contaimated liquid could be released into the enviroment IF spill occured during collection from the waste chemcial collection tank at Forum TW THEN contaminated liquid could be released into the enviroment. IF spill occured during collection from the waste chemcial collection tank at Frome Town TW THEN contaminated liquid could be released into the enviroment		legal obligations set out in the Health and Safety at Work Act (1974) and the specific requirements of the Provision and Use of Work Equipment Regulations 1998 (PUWER). SRRN101 The risk is identified; Relevant document: SERA053 - Charterhouse Treatment Works risk assessment." There is currently no tertiary containment for the chemical waste tank during its discharge. The absence of containment means that any liquids would be released onto the surface water drainage network or go into the Cheddar Yeo. The Need is to reduce unplanned maintenance and provide spill containment during waste collection by road tanker to prevent environmental contamination and comply with current legislation SRRN102 The risk is identified; Relevant document: SERA132 - Forum Treatment Works. The chemical waste tank currently has no bunded area or drip tray under the abstraction points. Chemical waste could contain sodium hydroxide, hydrochloric acid or hydrogen peroxide waste chemicals. The Need is to unplanned maintenance and provide chemical containment during road tanker collection of waste o prevent environmental contamination and comply with current legislation SRRN103 Relevant document: SERA130 - Frome Town Treatment Works. The chemical waste tank is not discharged in line with any discharge consents. The chemical waste is discharged directly into the roadway and road drains. This is not Best Practice. Chemical waste may also be extracted from the chemical waste tank, but there is no bunded extraction area or drip tray under the extraction points. Chemical waste could contain chemicals damaging to the environment. The Need is to unplanned maintenance and provide provision for containment during tanker collection of chemical waste and to include the connection point within the bunded area .	Revised specification replacement of life expired chemical tanks and delivery management / spill containment improvements	Replace polypropylene tanks that will be life expired in AMP7 upgrade delivery management and spill containment improvements at identified sites. Revised scope following review of CKBS cost estimate.	This option will meet the requirements to replace life expired tanks and SERA where identified.	24.004.10	Replacement of life expired chemical tanks and delivery management and spill containment improvements Option 2	£3,682,369	-£18,000	0.000	0.00	8.00	5.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR95 SRR150 SRR134	IF the clarifiers for Littleton intake (located at Purton) mechanically fails THEN increased maintenance cost. IF the concrete walls of the ozone tank at Purton TW continue to deteriorate THEN water quality failure or long term structural failure could occur IF one of the clariifers at Purtons fail THEN the site would have a reduced output and remedial repairs would be required.	SRRN43 SRRN112 SRRN113	Purton Post-Ozone tanks are a key process element of Bristol Water's largest WTW. Reduced pH in the waters and the presence of ozone accelerates the rates of deterioration of the concrete matrix, leading to a significantly increased rate of failure of the structure above normal water retaining structures. Furthermore, the common outlet channel would require an entire plant shutdown to undertake any remedial. Investment is required to prevent further deterioration of the structure which may ultimately lead to increased remedial costs. The Littleton clarifiers (located at Purton) are part of "Old Purton" (circa 1970), there are 3 no. tanks on the raw water inlet and all show evidence of carbonation penetration on concrete sections above ground and water level, with spalling of concrete on number 2 tank. Routine inspections are carried out, the Need is to carry out remedial work to the tanks and apply WRAS approved lining to halt further deterioration and ensure there on-going asset life. The Purton TW clarifiers all show evidence of carbonation penetration on concrete sections above ground and water level with spalling of concrete. Routine inspections show that there is a Need is to carry out remedial work to the tanks and apply WRAS approved lining to halt further deterioration and ensure there on-going asset life.	Refurbish and Reline tanks and common channels	Refurbish concrete structures and re-line with WRAS approved urethane or similar tank lining	Urethane coatings have been used to line ozone tanks and have demonstrated mixed results, with corrosion in areas above the water line exposed to ozone gas. Some investigation of appropriate coatings may be required to confirm lining method. Shutting down ozone process/works may be required to complete works.. Littleton and Purton clarifiers can be taken off line one at a time for refurbishment to minimise works disruption	24.004.05	Purton Tank Remedial Works and Lining	£502,028	£0	0.000	0.00	0.00	0.00
				Refurbish and Reline tanks and common channels excluding Purton Clarifiers	Reduced scope removes the requirement for intervention relating to Purton clarifiers (addressed in AMP 6). Refurbish concrete structures and re-line with WRAS approved urethane or similar tank lining	Urethane coatings have been used to line ozone tanks and have demonstrated mixed results, with corrosion in areas above the water line exposed to ozone gas. Some investigation of appropriate coatings may be required to confirm lining method. Shutting down ozone process/works may be required to complete works. Littleton clarifiers can be taken off line one at a time for refurbishment to minimise works disruption	24.004.11	Purton Tank Remedial Works and Lining	£284,314	£0	0.000	0.00	0.00	0.00
SRR114	IF the single belt press at Barrow WTW fails (used for sludge dewatering) THEN the sludge (30 tonnes per day) would need to be tankered off site with rsulting increased	SRRN58	The majority of equipment at Barrow belt press is 14 years old, and the age of the equipment has led to an increased number of unplanned maintenance events in recent years (120 in the last 4 years). There is currently no backup	Additional standby belt press	Installation of second belt press in new extension of existing building, limited feed pumping capability (D/D /S).	Reduced scope option extends the existing building and maximises use of existing systems. Will reduce CAPEX whilst delivering greater system resilience.	24.006.20	Barrow Belt Press Resilience - Option 2 (Reduced scope)	£1,157,303	£4,691	0.000	0.00	24.00	0.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
	operational cost.		system if the belt press fails. A catastrophic failure of the belt press would lead to site shut down and tankering offsite being required. Without a backup system in place the cost of applying a fix-on-fail policy to the belt press would amount to a large cost for a tanker to be used until the belt press is repaired, as well as the cost of repairing the belt press itself. Investment is required to increase resilience of the belt press system at Barrow TW, and reduce the amount of unplanned maintenance events.	Duplicate existing Press facility to provide full standby operation	Install additional pressing facility at TW. This can be used as a duty/standby system, or both can be run parallel. For this intervention a second belt press will be installed in a new purpose built build and full duty standby pumping for each of the duplicate sludge feed systems	Option considered to viable but likely be high cost (taken forward for costing)	24.006.01	Barrow Belt Press Resilience	£1,350,760	£11,004	0.000	0.00	24.00	0.00
SRR107	IF the flippers on the DAF desludge system fail (structurally), THEN the DAF stream will need to be taken offlin leading to reduced output from Barrow TW.	SRRN56	The DAF was installed in 2003 , it accounted for 40 unplanned maintenance events in 2016 and two unplanned outages. The flippers are old and require frequent replacement. There has been an average of 33 unplanned maintenance events (2010-2016). The Need is to refurbish the DAF at Barrow as there are associated risks with other DAF equipment (SRR106 DAF aeration valves; SRR127 DAF penstocks), which may potentially result in unplanned outage.	Replace band screen and penstocks.	Carry out like for like replacement of the band screen and all actuated penstocks.	Taken forward as new equipment will reduce unplanned outages and maintenance events.	24.006.02	Barrow DAF Plant Refurbishment	£1,091,624	£0	0.000	0.00	26.00	0.00
SRR667	IF the band screen at Purton TW fails THEN the site would have a reduce output and additional cost would be required for resolution	SRRN87	There are two band screens on the Purton intake, one has already been replaced. The need is to replace the second screen.	Replace band screen and refurbish penstocks.	Carry out like for like replacement of the band screen and refurbish all penstocks.	This option reduces the CAPEX by refurbishing rather than the replacement of penstocks.	24.006.03	Purton Inlet Band Screen Refurbishment	£1,790,475	£0	0.000	0.00	3.00	0.00
				Purton Ozone Refurbishment	Carry out refurbishment of existing ozone plant.	This option will prolong asset life and reduce unplanned maintenance events.	24.006.21	Purton Inlet Band Screen Refurbishment Option 2 Descoped	£539,192	£0	0.000	0.01	3.00	0.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR666 SRR679 SRR680 SRR681	IF the ozone plant at Purton TW deteriorates further THEN there is an increased risk of water quality failure, unplanned outage and unplanned maintenance at the site. IF ozone transformer No.1 fails at Purton TW THEN there is a risk of a reduced output from site. IF ozone transformer No 2 fails at Purton TW THEN there is a risk of reduced output from site IF the pre ozone tanks cannot be isolated at Purton TW THEN the radial defuser cannot not be maintained AND a loss of compartment would occur with reduction in site output.	SRRN84 SRRN106 SRRN107 SRRN110	Purton Post-Ozone tank is a key process element of Bristol Water's largest WTW in supplying Bristol. The Pre and Post Ozone was installed at Purton in 1993 and then underwent partial refurbishment in 2008. There is no subsequent evidence for further refurbishment. The TW utilises ozone to facilitate the removal of organic material and prevent water quality failures, notably pesticides and also assists with the flocculation and coagulation processes. Ozone is hazardous to health and can impact on respiratory systems. Ozonation failure is likely to result in full or partial loss of out put from the site. An average of 49 unplanned maintenance events per annum recorded for the Purton Ozone plant between 2010 and 2016 and 2 unplanned outages resulting in significant reduction of works output. An intervention is required at Purton TW to ensure the long term safety and operation of the Ozone Plant to prevent risk to operators, ensure that organic removal from the water sources is carried out effectively and reduce the number of unplanned maintenance events.	Purton Ozone Refurbishment	Carry out refurbishment of existing ozone plant.	This option will prolong asset life and reduce unplanned maintenance events.	24.006.05	Purton Ozone Plant Refurbishment	£7,186,512	£0	0.000	0.00	39.00	0.00
SRR706	IF further deterioration of the Ozone Plant at Littleton TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	SRRN108	The TW utilises ozone to facilitate the removal of organic material and prevent water quality failures, notably pesticides and also assists with the flocculation and coagulation processes. Ozone is hazardous to health and can impact on respiratory systems. Failure of the transformer will therefore likely to result in partial loss of out put from the site.	Refurbishment	Carry out refurbishment of existing ozone plant see intervention description	This option will prolong asset life and reduce unplanned maintenance events.	24.006.06	Littleton Ozone Plant Refurbishment	£3,202,393	£0	0.000	0.00	25.00	0.00

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR670	IF further deterioration of the Ozone Plant at Stowey TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.	SRRN93	The Stowey Ozone Plant was installed in 2004 and is some 13 years old. There is no record of any refurbishment having been carried out. The Ozone Contact Tank is some 60 years old, it was not designed for ozone contact, but adapted from its former use as a disinfection contact tank,. It is in the tank the structure is in poor condition, the roof in particular is deteriorating due to the corrosion by the ozone gas. Ozone can frequently be smelt in the adjacent filter gallery. There were an average 44 unplanned maintenance events at Stowey between 2010-2016. This has to be reduced. The need is to provide a replace with a new facility, which will comply with internal BW standard specification and improve the efficiency of the Ozonation system.	Replace existing Ozonation treatment plant	Drain down and decommission existing pre ozone tanks at Stowey TW including removal of redundant Ozonation plant; Develop green field site within the site boundary , including access roads, security, all services and diversion of existing services (2 no. 18 " mains) Construction of new Ozonation Plant including mixing chamber, dual cell contact tank Ozone Generation and injection; Liquid Oxygen Storage Compound; Sulphuric Acid Tank and Bund; Acid Dosing System (for bromide control); Transfer pumping station	Available foot print for development with in site boundary, will require transfer pumping back up to RGFs. This is a viable long term solution.	24.006.07	Stowey Ozone Plant Refurbishment	£3,504,637	£129	0.000	0.00	35.00	0.00
SRR673	IF the RGFs at Purton TW fails THEN the output from the site would be reduced.	SRRN92	Purton TW is BWs largest treatment works and contributes approximately 30% of BWs deployable output. The RGFs at Purton TW were installed in 1994/1995, there is no evidence of any significant refurbishment having been carried out. The number of unplanned maintenance events appears to have been increasing in recent years (zero it in 2010 ; 8 no. in 2015. One event in 2016 caused the plant to stop output. Investment is required at Purton RGFs to reduce the number of unplanned maintenance events and prevent unplanned outages.	Replace/Refurbish	Carry out civils, mechanical and ICA refurbishment of the RGFs at Purton TW	Option is a lower cost than a new build RGF block and is likely to achieve comparative improvement in performance. No structural issues identified for existing RGF block Most viable option.	24.006.08	Purton RGF Plant Refurbishment	£6,123,632	£0	0.000	0.00	2.00	0.00
SRR674	IF the roughing filters at Stowey TW fail THEN the output from the site would be reduced.	SRRN94	Stowey TW makes up approximately roughly 7% of BW's deployable output. There are 8 no. RGFs at Stowey acting as roughing filters receiving ozonated raw water prior to treatment by the slow sand filters. The RGFs were originally installed in the early 1950's (drawings date to 1951), making the concrete structures some 66 years old. There is no record of maintenance. Investment is required at Stowey RGFs to reduce the number of unplanned maintenance events and ensure the on-going reliability of the RGF plant. The RGFs at Stowey suffer an average of 12 unplanned maintenance events a year (2010-2016) .	Refurbish existing RGF	Carry out civils, mechanical and ICA refurbishment of the 8no. RGFs at Stowey TW	Option is a lower cost than a new build RGF block and is likely to achieve comparative improvement in performance. Most viable option.	24.006.10	Stowey RGF Plant Refurbishment	£1,781,865	£0	0.000	0.00	10.00	0.00

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SRR628	IF the condition of the GAC system at Littleton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant.	SRRN10	Littleton TW provides approximately 11% of Bristol Waters deployable output. The RGF system was converted to GAC in the 1980s and is suffering from an increasing number of unplanned maintenance events due to the age of the equipment at the TW, with some equipment being over 25 years old (original installation date 1963). The plant suffers from an average of 20 non-infrastructure maintenance events per year (2010-2016). Without investment the system will continue to deteriorate and the number of unplanned non-infrastructure maintenance events will continue to rise. Investment is required to reduce the amount of unplanned maintenance events and extend the asset life of the plant.	Refurbish existing GAC filters	FOR 10 No. GAC filters and common channels; Replace /refurbish all MEICA and refurbish civils structures as required,	This is considered a viable option . Comparison with refurbishment options suggests refurbishment of existing plant would give similar benefit at a much lower cost. Not a viable option due to expense compared to benefit.	24.006.11	Littleton RGF (GAC)Plant Refurbishment	£923,893	£0	0.000	0.00	16.00	0.00
SRR629	IF the condition of the GAC system at Purton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant	SRRN11	Purton TW is Bristol Waters largest WTW, providing approximately 30% of Bristol Waters deployable output. The GAC system at Purton TW is suffering from an increasing amount of unplanned maintenance events due to the age of the equipment at the TW, with the plant suffering 23 events in 2016 compared to 5 events in 2010. The majority of the GAC systems assets are 22/23 years of age or have an unknown age. Without investment the system will continue to deteriorate and the amount of unplanned maintenance events will continue to rise and will increase the risk of unplanned outage of one or more of the filters.	Refurbish	Refurbish/replace all electrically actuated valves and controls.	This option has been taken forward for costing as a viable option.	24.006.12	Purton GAC Plant Refurbishment	£1,687,444	£0	0.000	0.00	13.00	0.00
SRR705	IF either the coagulant dosing system or clarifiers at Littleton TW fail THEN the output from the site would be reduced or stopped	SRRN109	The Littleton Clarification was installed at least 23 years ago although there is no clear definitive date. There is no evidence of major refurbishment. There were 10 unplanned outages in 2016 and unplanned maintenance events average some 45 events per annum (2010-16). The Intervention Need is to carry out refurbishment of the clarifiers and chemical dosing systems to significantly reduce unplanned outage and unplanned maintenance events and to maintain and/ or extend asset life.	Refurbish existing coagulation clarification plant.	Refurbish / replace MEICA elements and carry out refurbishment to civils structures .	This option has been selected for optimisation as it will provide significant contribution to customer derived benefits and will extend the asset life of the plant.	24.006.13	Littleton Clarification Refurbishment	£480,306	£0	0.000	0.00	36.00	0.00

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SRR709	IF the waste water treatment system at Littleton TW fails THEN there is a risk of failure of the EA discharge consent.	SRRN111	Littleton TW accounts for approximately 21% of BW's day to day and maximum deployable output. The TW produces waste water from the process treatment which is treated onsite prior to discharge to the environment.. Littleton has a history of low EA discharge failure . The waste plant n averages 30 unplanned maintenance events per annum and 2 recorded unplanned outages in 2016. An intervention is required at Littleton TW to eliminate sample failures in accordance with BWs performance commitment of 100%, and reduce unplanned maintenance and unplanned outage events and extend the asset life of the plant.	Do Nothing	Continue to fix on fail.	This option will continue the current strategy of fix on fail, however the effluent treatment plant is aging (24 years old) by the end of AMP7) and an increased maintenance requirement is entirely likely if deterioration is not addressed. Therefore this option has been discarded as it is not seen to fully implement the need requirements and does not mitigate the risk.	24.006.14	Littleton Effluent Refurbishment	£991,418	£0	0.000	0.00	24.00	0.00
SRR664	IF the source at Sherborne TW remains out of service for a extended period THEN the abstraction licence (and the deployable output) from the site may be permenently lost.	SRRN44	The site has been out of service since 2012. The Environment Agency are due to conduct a review of water abstraction licences by 2020/2025 for all water companies, with the view to reduce abstraction and evaluate sustainable practices. Any sources not being utilised are expected to come under scrutiny with a potential reduction in allowable abstraction limits. The source may be required in future as demand in the BW network grows. The draft Water Resource Management Plan has been produced in line with a statutory 25-year WRMP planning process and includes the output of Sherborne spring. The Sherborne licence is an issue separate from the abstraction at Chew Valley Lake and provides water that is additional to the abstraction licence from Chew Valley Lake. If the Sherborne spring licence were revoked, this would reduce the deployable output of our sources by 3.7 Ml/day (this figure is lower than the licensed volume and is a calculation based on anticipated yield during a period of extreme drought). Investment is required to ensure that the deployable out put from Sherborne remains available to BW in a drought event.	Abandon Works	Abandon the works and surrender the licence.	Not beneficial due to difficulty in obtaining new licences for future demand	24.006.15	Sherborne TW Drought Resilience	£688,527	£114,400	0.000	0.00	0.00	13.72
				Carry out modifications to works	Modify and recommission TW to provide reduced 4.5M/d output works to include relocate chemical rigs and dosing lines to improve access, install HVAC to reduce condensation, improve chemical bunding, improve low lift pump access and restore floating chemical tank.	Viable option. Significant effort required to redesign and rectify existing works within the current constraints,	24.006.15	Sherborne TW Drought Resilience	£688,527	£114,400	0.000	0.00	0.00	13.72

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SRR272 SRR276 SRR682	IF The High Voltage Transformer fails at Littleton TW THEN the electrical supply to Almondsbury PS would be lost (Based on site at Littleton TW). IF the power limitations at Oldford TW are exceeded THEN od the distribution board would be overloaded leading to site shut down and potential H&S issue (fire/electrical) IF a site High Voltage Transformer fails THEN would lose electrical supply to site (multiple sites at risk): Rowberrow PS; Axbridge; Littleton; Oldford; Chew Stoke; Stowey TW; Purton Intake; Cheddar.	SRRN82	The age analysis records (derived from SAP) show that BW owns and operates 21 items of HV electrical equipment that will be beyond 40 years of age and life expired at the end of AMP 7. Much of this equipment is a single point of failure which will shutdown the TW in its entirety causing an unplanned outage which could prevent BW from achieve customer commitments of safe and reliable supply. An intervention is required to begin the process of replacing some of this equipment to improve the overall reliability of the BW TWs and maintain the average asset age of the equipment.	Refurbish replace transformers and HV switchgear	Replace aging transformers and HV switchgear at Littleton, Purton, Chew Valley and Axbridge etc.	Option is viable and managed electrical asset renewal plan is considered to be a sensible approach to the issue of the average age of the plant.	24.006.16	TW HV Resilience and Refurbishment	£2,215,302	£0	0.000	0.01	0.20	0.00
SRR175 SRR275	IF the mains incoming control panel at Cheddar TW is not upgraded, THEN power supply to site may fail. IF the control panel/ drives that feeds Clevedon's well and high lift pumps fails THEN the output from the site will be lost.	SRRN83	The age analysis records (derived from SAP) show that BW owns and operates 5 motor control centres that will be beyond 40 years of age and life expired at the end of AMP 7. Much of this equipment is a single point of failure which will shutdown the TW in its entirety causing an unplanned outage which could prevent BW from achieve customer commitments of safe and reliable supply. An intervention is required to begin the process of replacing some of this equipment to improve the overall reliability of the BW TWs and maintain the average asset age of the equipment.	Refurbish/replace control panels	Replace aging electrical equipment in rolling programme	Option is viable and managed electrical asset renewal plan is considered to be a sensible approach to the issue of the average age of the plant.	24.006.17	TW LV Resilience and Refurbishment	£3,033,716	£0	0.000	0.00	7.00	0.00
SRR801 SRR803 SRR704	IF the supplier of the pressurised membrane filters at Alderley TW, Charterhouse TW, Chelvey TW, Forum TW, Frome TW and Oldford TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues.	SRRN50	Kalsep have ceased to supply KALMEM membranes, BW have 6 sites currently using these membranes for removal of Crypto. In order to continue production at these sites all membranes rigs must be modified to enable them to accept membranes from an alternative supplier. The Intervention will replace the obsolete membranes with either alternative supplier membrane or alternative process to ensure removal of cryptosporidium and turbidity at Alderley TW.	Replace membranes and upgrade Membrane Plant to 7 Ml/d	Modify and replace existing with new supplier membranes, replace chemical and waste storage tanks and upgrade to utilise full abstraction licence. Option Cost Evaluation: MEDIUM	This has been identified as a viable option and will taken forward for costing and Optimisation	24.008.01	Alderley TW cryptosporidium barrier plant - fit new membranes and increase capacity to 7Ml/d	£970,343	-£62,903	0.000	0.00	28.00	186.00
				Replace Excising Membranes at current capacity 5 Ml/d	Modify manifolds and replace existing with new supplier membranes (5 Ml/d), replace chemical and waste storage tanks.	This has been identified as a viable option and will taken forward for costing and Optimisation	24.008.02	Alderley TW cryptosporidium barrier plant - fit new membranes for existing 5Ml/d capacity	£561,420	-£2,173	0.000	0.00	28.00	186.00

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	IF the supplier of the pressurised membrane filters at Alderley TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues. IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment		Investment is required to reduce the unplanned maintenance and secure future operation of the site. This Option includes a site upgrade from current 5 Ml/d to 7 Ml/d (licenced abstraction), as the current short fall (2.2 Ml/d at maximum demand) in supply is made up from Purton TW. This will generate OPEX savings on treatment and transfer of water from Purton.	Replace Membranes with UV System	Replace membranes with UV system	Increased occurrence of turbidity in the source during the winter months makes this option unviable with out additional installation of a filtration plant. Option Discarded	24.008.03	#N/A	£0	£0	#N/A	#N/A	#N/A	#N/A
SRR801 SRR704 SRR62	IF the supplier of the pressurised membrane filters at Alderley TW, Charterhouse TW, Chelvey TW, Forum TW, Frome TW and Oldford TW can not provide direct replacements THEN the long term deterioration of the membrames would result in a reduced output from the site and potential water quality issues. IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment IF the unused tanks left on site at Chelvey TW are not properly decommissioned THEN their condition will deteriorate and generate a potential H&S incident and/or surface water contamination (Chelvey TW).	SRRN49 SRRN51 SRRN100	Kalsep have ceased to supply KALMEM membranes, BW have 6 sites currently using these membranes for removal of Crypto. IN order to continue production at these sites all membrane rigs must be modified to enable them to accept membranes from an alternative supplier. The Intervention at Chelvey TW cryptosporidium barrier plant will replace and fit new membranes for existing 20Ml/d capacity with either alternative supplier membrane or alternative process to ensure removal of cryptosporidium and turbidity, reduce the risk of unplanned outage and unplanned maintenance. Intervention is required to prevent further deterioration of the un-used chemical (softener) tanks, which could potentially result in a pollution or a Health & Safety incident. Investment is required to replace all chemical tanks which will become life expired in AMP7 (multiple sites). The WSE is required under the BW Written Scheme of Examination Thermoplastic Atmospheric Storage Tanks in accordance with BW's general legal obligations set out in the Health and Safety at Work Act (1974) and the specific requirements of the Provision and Use of Work Equipment Regulations 1998 (PUWER).	Replace Excising Membranes at current capacity 20 Ml/d	Modify manifolds and replace existing with new supplier membranes (20 Ml/d), replace chemical and waste storage tanks.	Replace existing membranes with same capacity system.	24.008.04	Chelvey TW cryptosporidium barrier plant - fit new membranes for existing 20Ml/d capacity;, Chemical tank replacement, softener tank removal & waste collection containment.	£1,675,289	-£1,475	0.000	0.00	27.00	333.97

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SRR149	IF raw water quality in the Sharpness Canal deteriorates or Purton TW is required to operate at full capacity for a sustained period of time THEN the sludge production from the site will increase beyond the capacity of the existing sludge handling plant and there will be an increase in waste compliance failures , unplanned maintenance AND possible site shutdown	SRRN67	The Need is to carry out a refurbishment of the waste treatment to reduce unplanned maintenance, unplanned outage and achieve the zero waste compliance failures target demanded by BW Performance Commitments on environmental discharges (2 no. EA discharge failures in 2017). The Densadeg was installed in 1992 for treatment of wash water, while the "Old" plant (coagulant sludge settlement) pre dates this. The sludge storage tank has a volume of settled sludge which remains in the base of tank, however to take the tank off line for cleaning entails shutting the DENSADEG down with knock on implications to the works. There are substantial unplanned maintenance events occurring on an annual basis. Studies are on-going (BW Solutions team) to develop solutions in AMP6 potentially for implementation in AMP7/8.	Refurbish existing densedeg plant.	Option will improve reliability of the existing sludge handling plant (Densedeg) by refurbishing the existing system on a like for like basis. This will improve the reliability of the sludge pumping station and ensure the existing plant is performing at an optimal level.		24.009.01	Purton Waste Refurbishment	£2,262,267	£0	0.000	0.00	29.00	0.00
SRR166	IF the open slow sand filters at Banwell TW are containated with Cryptosporidium THEN as the current UV system is not validated for treatment of crytosporidium there is a risk of a final water quality failure.	SRRN77	The UV was installed for general disinfection and does not carry DWI validation for attenuation of cryptosporidium In 2014 there were two failures of the final water attributed to contamination of the SSFs by Crypto. Crypto is harmful to health and WQ failure must be notified to the DWI. Realisation of the risk will impact on Customer Health & Safety and on unplanned outage and unplanned maintenance. Bristol Water have informed the DWI that the Need will be addressed in AMP7, therefore an intervention is required to either remove potential for contamination of the SSFs or ensure that a DWI approved process for treatment of Crypto is in place.	Replace with new validated UV system	Provision of new fully validated UV plant system This solution would replace the existing UV with a new validated UV system, including replacement of existing electrical system and controls, and decommissioning existing plant. The capacity to be sized for maximum output (30 Ml/d) when treating all raw water sources (i.e. including operation on Blagdon Reservoir water). A new building to house the new plant to be included.	This solution will provided UV disinfection validated in compliance with DWI guidance for the selected target organism(s). In this case the requirement would be to provide a UV system validated for 4 log attenuation of Cryptosporidium and general disinfection.	24.010.05	Banwell TW Unvalidiated UV Plant - Replace existing UV treatment with validated UV Plant.	£1,859,560	-£31,848	0.000	0.00	11.77	195.96
				Banwell Unvalidiated UV; Cover SFFs	Provision of new covers for the Banwell TW SSFs to exclude light, wildlife and other sources of potential contamination. Decommission low lift pumping station and UV.	This option will remove the requirement for UV attenuation of Cryptosporidium. The membrane filtration stage provide protection against Crypto in the raw water , covering the SSFs will exclude potential sources for re-contamination in the SSFs. There is an additional OPEX saving in that by removing the UV , interstage pumping between the SSFs and the contact tank will no longer be required.	24.010.06	Banwell TW Unvalidiated UV Plant - Cover SSFs and decommission LL pumping station and UV treatment.	£1,385,250	-£93,800	0.000	0.00	17.00	195.96

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SRR84	IF pre treatment tank needs cleaning/maintenance THEN the site requires shutting down with consequence Unplanned Outage.	SRRN89	If the pretreatment tank fails then site is down. It was constructed in 1973 and the last major refurbishment was in 2007 when baffle walls, a mixing chamber and GRP roof was added. The pre-treatment tank is hydraulically undersized and does not provide sufficient driving head to achieve maximum flow through the downstream Boll Filters. The control band is therefore restricted providing minimal tolerance to any change in level. As a result the pretreatment tank I s the cause of numerous works outages and unplanned maintenance events.	Replace pretreatment tank	Construct new twin celled pretreatment tank to provide correct mixing and chemical coagulation contact requirements	Option considered viable but will require significant CAPEX, also need to consider implication of potential future site re-design.	24.010.07	Banwell TW Pretreatment Tank Resilience	£1,728,281	£14,364	0.000	0.01	24.00	0.00
SRR710	IF the membranes at Banwell TW are replaced at the correct time THEN output from the site will be reduced.	SRRN115	The membranes at Banwell provide treatment including removal of Crypto, the existing membranes are likely to deteriorate and require replacement in AMP7, (asset life 7years last replaced 2015). The membrane system experiences an exceptionally high rate of pinning - 2 men are employed for 2 days a week pinning broken membrane fibres. There is an opportunity to replace the existing membranes with a more robust membrane from the same membrane supplier which could significantly reduce pinning as the membranes reach the end of their asset life inthe next AMP Investment is required to forestall unplanned outage (reduced site out put) and reduce site OPEX .	Replace Membranes with more robust S10N membranes	Replace Membranes with more robust S10N membranes	Initial replacement likely to be carried out in AMP6 of a small number of membranes. Option is considered fully viable	24.010.08	Banwell Membrane Replacement	£2,700,065	-£22,341	0.000	0.01	0.00	0.00

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SRR118 SRR165 SRR133	IF a structural failure of treated water tanks at Banwell TW occurs THEN there will be a reduced output from the site. IF the single contact tank at Banwell fails THEN output from the site is lost. IF the piers in the clear water tank at Banwell TW fail THEN then the output from the site would be lost and there would potential H&S safety risks to personnel in bring the site back online.	SRRN61 SRRN76 SRRN90	There are structural concerns regarding the condition of the Treated Water storage tanks. An AECOM site survey 2017: recently inspected and found concrete cancer in both cells A&B. Loss of either cell will place will result in significant cost of bringing back on line. The need is to carry out a refurbish the TWT to eliminate the risk of structural failure and potential for water quality failure. There is a single contact tank at Banwell, if it were to fail then the site will be out. The tank cannot be taken out of service for inspection or maintenance with out taking the works off line. The Need is to provide a standby arrangement to allow the contact tank to be taken out of service without disruption to supply (tank inspection including drain down, may take up to a week), The Need entails providing an alternative arrangement for super and dechlorination, and will include provision of baffles in cells A&B of the clear water tank. The tank was originally constructed in 1958. Visual inspection of the structure (16/11/16) has highlighted visible cracks in 3 off piers at the top where they brace the roof load. An AECOM site survey 2017: recently inspected and found concrete cancer in both cells A&B. Loss of either cell will result in significant cost of bringing back on line. The need is to carry out a refurbish the TWT to eliminate the risk of structural failure and potential for water quality failure.	Refurbish	Refurbish existing tanks; carry out structural repairs and carry out relining. Installation of baffles in TWT and provision of new chlorination dose point and monitoring.	Taken forward for costing	24.010.09	Banwell TW Contact Tank and Treated Water Tank Rehabilitation and Resiliance	£1,326,543	£3,540	0.000	0.00	1.00	0.00

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SRR116	IF the sodium hydroxide dosing static mixer and downstream pipework constricts/blocks THEN the flow through the mixer would be restricted and the works output would need to be reduced or the works shut down (Banwell - Area 3).	SRRN59	The existing caustic mixing arrangement at Banwell relies on injection of caustic into a static mixer. The mixer and pipework immediately downstream of the mixer experience heavy deposition of scale resulting in significant reduction in the diameter of the pipe and blockage of the mixer itself. An operational shut down of the site is required to carry out CCTV inspection and maintenance. The blockage is cleared by removing the affected pipe sections and the mixer itself and either cleaning in acid or alternatively, in the case of irretrievable fouling, replacement with a new pipe connection and mixer. This impacts the PCs as unplanned outage and unplanned maintenance. An intervention is required to ensure that the caustic mixing arrangement fully meets with Bristol Water Standard Specifications.	New twin celled mixing chamber	Replace existing static mixer with twin celled mixing tank for introduction of caustic	Taken forward - meets BW standard specification for dosing sodium hydroxide	24.010.10	Banwell TW NaOH mixer pipeline calcification	£863,081	£8,915	0.000	0.00	3.00	0.00
SRR650	IF the chlorination (gas) system at Barrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN36	Barrow Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There is 1 property within 180m of the site. The system suffers from regular failures (52 failures occurred in the chlorination system in 2016, 9 of which led to plant shutdown). Barrow provides 23% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this strategic production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Barrow Electro-chlorination Plant	Installation of electro-chlorination system at Barrow TW to replace existing chlorine gas system	Yes this option will replicate work already completed at other large BW sites , notably Cheddar & Purton	24.011.01	Barrow Electro-chlorination Plant	£1,522,039	£22,218	0.000	0.00	28.00	0.14
				Barrow Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Barrow TW to replace existing chlorine gas system	Yes this option will replicate work already completed at other large BW sites , notably Cheddar & Purton	24.011.20	Barrow Electro-chlorination Plant Option 2	£1,506,194	£22,218	0.000	0.00	28.00	0.14
SRR143	IF the chlorination (gas) system at Charterhouse TW fails THEN there is a potential H&S risk to operators and customers	SRRN34	Charterhouse Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would	Charterhouse TW Electro-chlorination Plant	Installation of electro chlorination system a Charterhouse TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.02	Charterhouse Electro-chlorination Plant	£984,306	£153	0.000	0.00	24.00	0.12

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
	and works will shutdown leading to an Unplanned Outage.		move away from the use of highly toxic chlorine gas on site. There is 1 property within 180m of the site. The system is old and suffers from regular failures (22 failures occurred in the chlorination system in 2016) and is due for replacement in 2017. Furthermore, the system utilises Portacel equipment, which is no longer supported by the supplier and there are no spares available. Charterhouse provides 0.4% of Bristol Water's output. Investment is required to reduce the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Charterhouse TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Charterhouse TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.02	24.011.21	Charterhouse Electro-chlorination Plant Option 2	£630,982	£153	0.000	0.00	24.00	0.12
SRR651	IF the chlorination (gas) system at Forum TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN37	Forum Disinfection is currently a chlorine gas system with bulk gas storage on site. There are 7 properties within 180m of the site. The system is old and suffers from regular failures (13 failures occurred in the chlorination system in 2016, 3 of which led to plant shutdown) and is due for replacement in 2021. Forum provides 0.4% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Forum TW Electro-chlorination Plant	Installation of electro-chlorination system a Forum TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.03	Forum Electro-chlorination Plant	£984,306	£74	0.000	0.00	20.00	0.21
				Forum TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Forum TW to replace existing chlorine gas system	Yes this option will replicate work already completed at other smaller BW sites , notably Alderley and Tetbury	24.011.22	Forum Electro-chlorination Plant Option 2	£630,982	£74	0.000	0.00	20.00	0.21
SRR158	IF the chlorination (gas) system at Littleton TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN35	Littleton Disinfection is currently a chlorine gas system with bulk gas storage on site. The system is old and suffers from regular failures (38 failures occurred in the chlorination system in 2016 ("Performance Benefits" C109) , 5 of which led to plant shutdown and 3 leading to reduced site output), often leading to plant shutdown, and was due for replacement in 2003. Furthermore, the system utilises Portacel equipment, which is no longer supported by the supplier and there are no spares available. Littleton provides approximately 11% of Bristol Water's maximum deployable output. Investment is required to reduce the risk of plant unplanned outage at this strategic production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Littleton TW Electro-chlorination Plant	Installation of electro-chlorination system a Littleton TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.04	Littleton Electro-chlorination Plant	£1,065,480	£4,497	0.000	0.00	30.00	0.09
				Littleton TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Littleton TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.04	24.011.23	Littleton Electro-chlorination Plant Option 2	£870,013	£4,497	0.000	0.00	30.00	0.09

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR652	IF the chlorination (gas) system at Shipton Moyne TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN38	Shipton Moyne Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There are 4 properties within 90m of the site. The system is old and suffers from regular failures (38 failures occurred in the chlorination system in 2016, 2 of which led to plant shutdown), and is due for replacement in 2027. Shipton Moyne provides 2.3% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Shipton Moyne Electro-chlorination Plant	Installation of electro-chlorination system a Shipton Moyne TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.05	Shipton Moyne Electro-chlorination Plant	£1,065,480	£668	0.000	0.00	29.00	0.06
				Shipton Moyne Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Shipton Moyne TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.05	24.011.24	Shipton Moyne Electro-chlorination Plant Option 2	£870,013	£668	0.000	0.00	29.00	0.06
SRR35	IF the chlorination (gas) system Almondsbury TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN32	Almondsbury Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There are 7 properties within 180m of the site. The system is old and suffers from regular failures (31 failures occurred in the chlorination system in 2016), and was due for replacement in 2009. Investment is required to reduce the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Almondsbury PS Electro-chlorination Plant	Installation of electro-chlorination system a Almondsbury PS to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.06	Almondsbury PS Electro-chlorination	£1,065,480	£153	0.000	0.00	5.00	0.08
				Almondsbury PS Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Almondsbury PS to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.06	24.011.26	Almondsbury PS Electro-chlorination Plant Option 2	£870,013	£153	0.000	0.00	4.86	0.08
SRR73	IF the chlorination (gas) system at Banwell TW fails THEN there is a potential H&S risk to operators and customers	SRRN33	Banwell Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away	Banwell TW Electro-chlorination Plant	Installation of electro-chlorination system a Banwell TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.07	Banwell TW Electro-chlorination	£1,065,480	£2,730	0.000	0.00	26.00	1.54

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
	and works will shutdown leading to an Unplanned Outage.		from the use of highly toxic chlorine gas on site. There are 7 properties within 180m of the site. The system is old and suffers from regular failures (22 failures occurred in the chlorination system in 2016, 1 of which led to plant shutdown and 1 leading to reduced output), and is due for replacement in 2027. Banwell provides 5.7% of Bristol Water's output. Investment is required to reduce the risk of plant unplanned outage at this production site, the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Banwell TW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Banwell TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.07	24.011.25	Banwell Electro-Chlorination Plant Option 2	£870,013	£2,703	0.000	0.00	26.00	1.54
SRR653	IF the chlorination (gas) system at Rowborrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.	SRRN39	Rowberrow Disinfection is currently a chlorine gas system with bulk gas storage on site. In 2012 BWs board agreed that for health and safety reasons they would move away from the use of highly toxic chlorine gas on site. There is 1 property within 90m of the site a further 6 within 180m of the site. The system is old and suffers from regular failures (12 failures occurred in the chlorination system in 2016), and was due for replacement in 2010. Investment is required to reduce the number of unplanned maintenance events, and the risk to health and safety of our operations staff and customers in nearby properties.	Rowberrow PW Electro-chlorination Plant	Installation of electro-chlorination system a Rowberrow TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6	24.011.08	Rowberrow PS Electro-chlorination	£1,065,480	£153	0.000	0.00	15.00	0.33
				Rowberrow PW Electro-chlorination Plant Phase 1 (descoped)	Installation of electro-chlorination system at Rowberrow TW to replace existing chlorine gas system	Yes this intervention will mirror similar installations of electro-chlorination at BW sites in AMP6 and can be delivered at a lower CAPEX compared with 24.010.08	24.011.27	Rowberrow PS Electro-chlorination Plant Option 2	£870,013	£153	0.000	0.00	15.00	0.33

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR658 SRR781	IF a failure of the main High Voltage (HV) switchboard and/or 11/3.3kV transformers at Purton TW occurs THEN there will be an unplanned outage and a possible loss of supply to customers supplied by the Purton TW. IF a failure of the main High Voltage (HV) switchboard at Purton TW occurs during operation, maintenance or testing THEN there is a possibility of serious injury or death occurring leading to reputational damage and possible prosecution.	SRRN82	Purton TW accounts for approximately 30% of BW's maximum deployable output. The TW is supplied electrically at 11,000volts (11kV) by the local District Network Operator (DNO). The main site 11kV switchboard was installed in 1974 and is jointly owned by BW and the DNO. The switchboard no longer meets current design and safety standards mainly due to the use of obsolete oil filled switchgear. Obtaining spare parts and carrying out maintenance is difficult. The age and condition of the switchboard creates a fire/explosion health and safety risk for operators, and an operational risk which could cause a significant unplanned outages event. The 11kV switchboard feeds 2No 5MVA, ONAN cooled, 11kV/3.3kV transformers. A transformer has failed during AMP6 and is being replaced. The 2nd transformer is of a similar age and similarly requires replacement if unplanned outages are to be avoided. An intervention is required to replace the obsolete switchboard and transformer at Purton TW to manage the health and safety risk to operation all staff and mitigate the risk of unplanned outages.	Replace 11kV switchboard and transformer	Replace switchboard and transformers with new equipment and possibly building. Separate DNO equipment from BW owned equipment	Fully viable short term planned reduction in output.	24.012.02	Purton High Lift PS 11kV System Safety and Refurbishment	£1,701,327	£0	0.000	0.07	0.00	1.13

		Risk Need		Identification & Viability of Options			Proposed Interventions		Costs	Benefits				
Strategic Risk Register (SRR) Reference	SRR Revised Risk Description	SRR Need ID	Need Description (from SRR)	Proposed Option Name	Proposed Option Description	Option Viability?	Ref No	Intervention Title	Capex After (£)	Change in Opex (£)	Compliance risk index	Unplanned Outage	Unplanned maintenance (non-infra)	Other monetised benefits
SRR659	IF the HV supply to Purton TW fails due to external factor THEN there would be a loss of output from the site.	SRRN83	Purton TW accounts for approximately 30% of BW's day to day and maximum deployable output. The TW is supplied electrically at 11kV by 2No overhead powers lines from Berkley Primary Substation. The site electricity supplies were designed in 1974 to provide a 100% standby in the event of a single point of failure on the electrical system. A study carried out in 2014 shows that as the TW process have been modified to provide enhanced treatment the electrical power supplies have not been reinforced and as consequence the standby capacity is no longer available, and the TW would be unable to deliver its reported 165Ml/d design output without a significant risk of overloading the supply network and causing an unplanned outage. An intervention is required to reinforce the power supply at Purton TW to ensure that the reported design output could be delivered without risk of a system overload and an unplanned outage.	Provide additional supply for treatment works	Provide new power supply to treatment works that enables full works output to be achieved consistently.	Viable but only provides limited resilience and unlikely to cope if complete loss of supply from Berkley.	24.012.03	Purton Power Resilience	£4,066,650	£0	0.000	0.04	0.00	0.00
SRR675	IF Slow Sand Filter no.2 at Stowey WTW is not repaired/refurbished THEN the number of unplanned maintainace tasks and plant outages will increase and reduce the output from the site.	SRRN95	Stowey TW is one of Bristol Waters supplies approximately 7% of BW's deployable output. The SSFs at Stowey suffer an average of 25 unplanned maintenance events a year (2010-2016) and 1 event in 2016 that led to site shutdown. SSF 1 under went full refurbishment in 2012, SSF2 has been identified by Jas currently leaking and requiring civils refurbishment. Concerns have also been raised around the poor condition of the inlet, outlet and drain valves. Investment is required at Stowey SSFs to reduce the number of unplanned maintenance, unplanned outage events and restore the asset life of SSF2.	Refurbish	Carry out structural and mechanical refurbishment of SSF2	Refurbishment of SSF2 will work to reduce unplanned outage and maintenance as newer equipment will have a lower failure rate. This in turn will meet the outlined performance commitment. For the above reasons this options has been taken forward for costing.	24.013.01	Stowey TW Slow Sand Filter Refurbishment	£936,395	£0	0.000	0.00	20.00	0.00

7.7 Appendix F: Non-Selected Interventions

This appendix shows the 48 non-selected interventions. See Appendix D for costs or performance commitments.

Ref No	Intervention Title	Expected Capex after (£)	Change in Opex (£)	Residual Risk
24.001.10	Cheddar Tw raw water deterioration trials extension	£500,000	£0	IF increased levels of algae are experienced in the source water for Cheddar TW THEN the slow sand filters will suffer increased blinding and output from works from the works will be further reduced.
24.002.01	Barrow Waste System Improvements	£583,939	£10,322	IF the single mixer within the single sludge blend tank fails at Barrow THEN the sludge settles out within the tank (which has to be dug out) and produces poor performance within the sludge thickeners. IF the sludge thickeners at Barrow do not operate efficiently THEN the poor quality supernatant can lead to a breach of the discharge consent of treated waste water returned to Barrow Reservoir 3
24.004.04	Replacement of life expired chemical tanks and delivery management and spill containment improvements	£3,998,443	£0	IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment. IF spill occured during collection from the waste chemical collection tank at Charterhouse TW THEN contaimated liquid could be released into the enviroment IF spill occured during collection from the waste chemcial collection tank at Forum TW THEN contaminated liquid could be released into the enviroment. IF spill occured during collection from the waste chemcial collection tank at Frome Town TW THEN contaminated liquid could be released into the enviroment
24.004.10	Replacement of life expired chemical tanks and delivery management and spill containment improvements Option 2	£3,682,369	-£18,000	IF chemical tanks/bunds fail THEN discharge of contents present a risk to H&S and the environment. IF spill occured during collection from the waste chemical collection tank at Charterhouse TW THEN contaimated liquid could be released into the enviroment IF spill occured during collection from the waste chemcial collection tank at Forum TW THEN contaminated liquid could be released into the enviroment. IF spill occured during collection from the waste chemcial collection tank at Frome Town TW THEN contaminated liquid could be released into the enviroment
24.004.05	Purton Tank Remedial Works and Lining	£502,028	£0	IF the clarifiers for Littleton intake (located at Purton) mechanically fails THEN increased maintenance cost. IF the concrete walls of the ozone tank at Purton TW continue to deteriorate THEN water quality failure or long term structural failure could occur IF one of the clariifers at Purtons fail THEN the site would have a reduced output and remedial repairs would be required.
24.004.11	Purton Tank Remedial Works and Lining	£284,314	£0	IF the clarifiers for Littleton intake (located at Purton) mechanically fails THEN increased maintenance cost. IF the concrete walls of the ozone tank at Purton TW continue to deteriorate THEN water quality failure or long term structural failure could occur IF one of the clariifers at Purtons fail THEN the site would have a reduced output and remedial repairs would be required.
24.006.20	Barrow Belt Press Resilience -Option 2 (Reduced scope)	£1,157,303	£4,691	IF the single belt press at Barrow WTW fails (used for sludge dewatering) THEN the sludge (30 tonnes per day) would need to be tankered off site with rsulting increased operational cost.

Ref No	Intervention Title	Expected Capex after (£)	Change in Opex (£)	Residual Risk
24.006.01	Barrow Belt Press Resilience	£1,350,760	£11,004	IF the single belt press at Barrow WTW fails (used for sludge dewatering) THEN the sludge (30 tonnes per day) would need to be tankered off site with rsulting increased operational cost.
24.006.02	Barrow DAF Plant Refurbishment	£1,091,624	£0	IF the flippers on the DAF desludge system fail (structurally), THEN the DAF stream will need to be taken offlin leading to reduced output from Barrow TW.
24.006.03	Purton Inlet Band Screen Refurbishment	£1,790,475	£0	IF the band screen at Purton TW fails THEN the site would have a reduce output and additional cost would be required for resolution
24.006.21	Purton Inlet Band Screen Refurbishment Option 2 Descoped	£539,192	£0	IF the band screen at Purton TW fails THEN the site would have a reduce output and additional cost would be required for resolution
24.006.05	Purton Ozone Plant Refurbishment	£7,186,512	£0	IF the ozone plant at Purton TW deteriorates further THEN there is an increased risk of water quality failure, unplanned outage and unplanned maintenance at the site. IF ozone transformer No.1 fails at Purton TW THEN there is a risk of a reduced output from site. IF ozone transformer No 2 fails at Purton TW THEN there is a risk of reduced output from site IF the pre ozone tanks cannot be isolated at Purton TW THEN the radial defuser cannot not be maintained AND a loss of compartment would occur with reduction in site output.
24.006.06	Littleton Ozone Plant Refurbishment	£3,202,393	£0	IF further deterioration of the Ozone Plant at Littleton TW occurs THEN a failure treated water quality, an increase in unplanned maintenance activities and a failure of appropriate safety standards could occur.
24.006.08	Purton RGF Plant Refurbishment	£6,123,632	£0	IF the RGFs at Purton TW fails THEN the output from the site would be reduced.
24.006.10	Stowey RGF Plant Refurbishment	£1,781,865	£0	IF the roughing filters at Stowey TW fail THEN the output from the site would be reduced.
24.006.11	Littleton RGF (GAC)Plant Refurbishment	£923,893	£0	IF the condition of the GAC system at Littleton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant.
24.006.12	Purton GAC Plant Refurbishment	£1,687,444	£0	IF the condition of the GAC system at Purton TW continues to deteriorate THEN the there will be an increase in the number of unplanned maintenance events associated with the plant
24.006.13	Littleton Clarification Refurbishment	£480,306	£0	IF either the coagulant dosing system or clarifiers at Littleton TW fail THEN the output from the site would be reduced or stopped
24.006.14	Littleton Effluent Refurbishment	£991,418	£0	IF the waste water treatment system at Littleton TW fails THEN then there is a risk of failure of the EA discharge consent.
24.006.15	Sherborne TW Drought Resilience	£688,527	£114,400	IF the source at Sherborne TW remains out of service for a extended period THEN the abstraction licence (and the deployable output) from the site may be permenently lost.
24.006.15	Sherborne TW Drought Resilience	£688,527	£114,400	IF the source at Sherborne TW remains out of service for a extended period THEN the abstraction licence (and the deployable output) from the site may be permenently lost.
24.006.16	TW HV Resilience and Refurbishment	£2,215,302	£0	IF The High Voltage Transformer fails at Littleton TW THEN the electrical supply to Almondsbury PS would be lost (Based on site at Littleton TW). IF the power limitations at Oldford TW are exceeded THEN od the distribution board would be overloaded leading to site shut down and potential H&S issue (fire/electrical) IF a site High Voltage Transformer fails THEN would lose electrical supply to site (multiple sites at risk): Rowberrow PS; Axbridge; Littleton; Oldford; Chew Stoke; Stowey TW; Purton Intake; Cheddar.

Ref No	Intervention Title	Expected Capex after (£)	Change in Opex (£)	Residual Risk
24.006.17	TW LV Resilience and Refurbishment	£3,033,716	£0	IF the mains incoming control panel at Cheddar TW is not upgraded, THEN power supply to site may fail. IF the control panel/ drives that feeds Clevedon's well and high lift pumps fails THEN the output from the site will be lost.
24.008.02	Alderley TW cryptosporidium barrier plant - fit new membranes for existing 5Ml/d capacity	£561,420	-£2,173	IF the mains incoming control panel at Cheddar TW is not upgraded, THEN power supply to site may fail. IF the control panel/ drives that feeds Clevedon's well and high lift pumps fails THEN the output from the site will be lost.
24.008.03	#N/A	£0	£0	IF the mains incoming control panel at Cheddar TW is not upgraded, THEN power supply to site may fail. IF the control panel/ drives that feeds Clevedon's well and high lift pumps fails THEN the output from the site will be lost.
24.009.01	Purton Waste Refurbishment	£2,262,267	£0	IF raw water quality in the Sharpness Canal deteriorates or Purton TW is required to operate at full capacity for a sustained period of time THEN the sludge production from the site will increase beyond the capacity of the existing sludge handling plant and there will be an increase in waste compliance failures , unplanned maintenance AND possible site shutdown
24.010.05	Banwell TW Unvalidiated UV Plant - Replace existing UV treatment with validated UV Plant.	£1,859,560	-£31,848	IF the open slow sand filters at Banwell TW are containated with Cryptosporidium THEN as the current UV system is not validated for treatment of crytosporidium there is a risk of a final water quality failure.
24.010.07	Banwell TW Pretreatment Tank Resilience	£1,728,281	£14,364	IF pre treatment tank needs cleaning/maintenance THEN the site requires shutting down with consequence Unplanned Outage.
24.010.09	Banwell TW Contact Tank and Treated Water Tank Rehabilitation and Resiliance	£1,326,543	£3,540	IF a structural failure of treated water tanks at Banwell TW occurs THEN there will be a reduced output from the site. IF the single contact tank at Banwell fails THEN output from the site is lost. IF the piers in the clear water tank at Banwell TW fail THEN then the output from the site would be lost and there would potential H&S safety risks to personnel in bring the site back online.
24.010.10	Banwell TW NaOH mixer pipeline calcification	£863,081	£8,915	IF the sodium hydroxide dosing static mixer and downstream pipework constricts/blocks THEN the flow through the mixer would be restricted and the works output would need to be reduced or the works shut down (Banwell - Area 3).
24.011.01	Barrow Electro-chlorination Plant	£1,522,039	£22,218	IF the chlorination (gas) system at Barrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.20	Barrow Electro-chlorination Plant Option 2	£1,506,194	£22,218	IF the chlorination (gas) system at Barrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.02	Charterhouse Electro-chlorination Plant	£984,306	£153	IF the chlorination (gas) system at Charterhouse TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.21	Charterhouse Electro-chlorination Plant Option 2	£630,982	£153	IF the chlorination (gas) system at Charterhouse TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.03	Forum Electro-chlorination Plant	£984,306	£74	IF the chlorination (gas) system at Forum TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.22	Forum Electro-chlorination Plant Option 2	£630,982	£74	IF the chlorination (gas) system at Forum TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.

Ref No	Intervention Title	Expected Capex after (£)	Change in Opex (£)	Residual Risk
24.011.04	Littleton Electro-chlorination Plant	£1,065,480	£4,497	IF the chlorination (gas) system at Littleton TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.23	Littleton Electro-chlorination Plant Option 2	£870,013	£4,497	IF the chlorination (gas) system at Littleton TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.05	Shipton Moyne Electro-chlorination Plant	£1,065,480	£668	IF the chlorination (gas) system at Shipton Moyne TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.24	Shipton Moyne Electro-chlorination Plant Option 2	£870,013	£668	IF the chlorination (gas) system at Shipton Moyne TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.06	Almondsbury PS Electro-chlorination	£1,065,480	£153	IF the chlorination (gas) system Almondsbury TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.26	Almondsbury PS Electro-chlorination Plant Option 2	£870,013	£153	IF the chlorination (gas) system Almondsbury TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.07	Banwell TW Electro-chlorination	£1,065,480	£2,730	IF the chlorination (gas) system at Banwell TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.25	Banwell Electro-Chlorination Plant Option 2	£870,013	£2,703	IF the chlorination (gas) system at Banwell TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.08	Rowberrow PS Electro-chlorination	£1,065,480	£153	IF the chlorination (gas) system at Rowborrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.011.27	Rowberrow PS Electro-chlorination Plant Option 2	£870,013	£153	IF the chlorination (gas) system at Rowborrow TW fails THEN there is a potential H&S risk to operators and customers and works will shutdown leading to an Unplanned Outage.
24.012.03	Purton Power Resilience	£4,066,650	£0	IF the HV supply to Purton TW fails due to external factor THEN there would be a loss of output from the site.
24.013.01	Stowey TW Slow Sand Filter Refurbishment	£936,395	£0	IF Slow Sand Filter no.2 at Stowey WTW is not repaired/refurbished THEN the number of unplanned maintainace tasks and plant outages will increase and reduce the output from the site.

7.8 Appendix G: Drinking Water Inspectorate Letter of Support

Letter of support from the Drinking Water Inspectorate in relation to Alderley Plumbosolvency Control.

DRINKING WATER INSPECTORATE
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30 May 2018

Mr Graham Williams
Director of Water Quality
Bristol Water Plc
PO Box 218
Bridgwater Road
Bristol
BS99 7AU

Dear Mr Williams

PERIODIC REVIEW 2019: Bristol Water Plc
DWI Scheme reference: BRL 1 – *Alderley WTW – Plumbosolvency Control - lead*

FINAL DECISION LETTER

The Inspectorate has completed its detailed assessment of the scheme proposed by Bristol Water Plc to provide plumbosolvency dosing at Alderley WTW to secure or facilitate compliance with the lead standard for drinking water quality reasons in Water Supply Zone 401 (Z401).

The detailed assessment also took into consideration the outcome of the risk assessment report submitted to the Inspectorate as required by regulation 28(1) of the Water Supply (Water Quality) Regulations 2016 for Z401 and Alderley Water Treatment Works.

A summary of the outcome of our assessment of this scheme is attached. Based on the information submitted by the Company, the Inspectorate supports the need for a scheme to reduce lead concentrations in treated water for water quality reasons, and the supported scheme shall be included by the Company in its Final Business Plan, subject to the caveats listed in the attachment.

In this instance the Inspectorate intends to issue a Notice under Regulation 28(4) of the Water Supply (Water Quality) Regulations 2016, as amended, that requires the Company to mitigate the risk of lead that has been identified as a potential danger to human health from the water supplied from Alderley treatment works to water supply zone Z401.

It is expected that the Company will continue to monitor treated water lead concentrations, and that it will take all reasonable steps to prevent contraventions of the lead standard.

I am copying this letter to:

- Jon Ashley and Kevin Ridout at Ofwat;

- Elinor Smith and John Collins at the Environment Agency;
- David Heath (CCW Chair, Western)
- Peaches Golding (Chair of Water Challenge Panel)

Please contact Sue Pennison (Sue.Pennison@defra.gsi.gov.uk) with any queries relating to this letter.

Yours sincerely

Milo Purcell
Deputy Chief Inspector

PERIODIC REVIEW 2019

SUMMARY OF DWI ASSESSMENT – LETTER OF SUPPORT

<table>
<tr><th colspan="2">Comment</th></tr>
<tr><td><u>Water company:</u></td><td>Bristol Water Plc</td></tr>
<tr><td><u>DWI scheme reference(s):</u></td><td>BRL 1</td></tr>
<tr><td><u>Scheme name:</u></td><td>Alderley WTW – Plumbosolvency Control - lead</td></tr>
<tr><td><u>Proposal:</u></td><td>Installation of phosphate dosing at Alderley Treatment Works, and optimisation thereof, to secure or facilitate compliance with the lead standard for drinking water quality reasons in Z401 (Water Supply Zone 401 (Falfield, Charfield, Wickwar and Hawkesbury Upton)).</td></tr>
<tr><td><u>Supporting evidence:</u></td><td>- Risk assessment report submitted on 22 December 2017 as follows:
<table>
<tr><th>File Ref</th><th>DWSP Ref</th><th>Version</th><th>Asset name & ref</th><th>Version Date</th></tr>
<tr><td>Alderley Treatment Works DWSP Version 3 7 PR19</td><td>WSP0010</td><td>3.7</td><td>T01 - Alderley Treated</td><td>30/11/2017</td></tr>
<tr><td>WSZ 401 DWSP Version 3 9 PR19</td><td>WSP0173</td><td>3.9</td><td>Z401 - Falfield, Charfield, Wickwar and Hawkesbury Upton</td><td>30/11/2017</td></tr>
</table>
- Letter dated 22 December 2017 from Iain McGuffog to Milo Purcell.
- Email correspondence from Graham Williams dated 20/02/2018 responding to question raised by the Inspectorate (dated 15/01/2018) about the proposal.
- Email correspondences from Graham Williams dated 22/02/2018 responding to questions raised by the Inspectorate (dated 22/01/2018) about the proposal.</td></tr>
<tr><td><u>Conclusion:</u></td><td>Subject to the caveats listed below, the Inspectorate supports the need for the following scheme:

Installation of phosphate dosing at Alderley Treatment Works, and optimisation thereof, to secure or facilitate compliance with the lead standard for drinking water quality reasons. The company will also continue to pursue other measures to mitigate the risk of lead across the company's area (under their Lead</td></tr>
</table>

	Strategy) in the long term but it is recognised that dosing is required in the interim to protect human health. Proposal aligns with the Inspectorate's Long Term Planning Guidance.
Timescale:	Completion date: 2021/2022
Estimated cost:	Estimated capital costs: £ 471, 714 Estimated net additional operating costs: £9,688 per annum
Legal Instrument Required:	Notice under Regulation 28 (4)
Caveats:	1. Continued optimisation of lead dosing at Alderley treatment works. Consideration should be given to the optimum dose with regard to water aggressivity parameters and management of alkalinity and organic carbon to reduce potential for plumbosolvency. 2. Continuation and continuous development of the Company's Lead Strategy in line with the Inspectorate's guidance.
Comment:	DWI has no role in determining proportional allocation of expenditure. Where DWI technical support is given, this should not be taken by the company to imply that the scheme will be partially or wholly funded as a Quality item. Schemes that require a legal instrument are considered necessary to meet statutory drinking water quality requirements. These schemes will be transposed to formal programmes of work by DWI as soon as possible and their implementation and completion will be monitored, audited and closure confirmed by DWI.