SOUTH WEST WATER

WRMP Leakage Options Development

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Glossary of Terms

The following terms and abbreviations are used throughout this report.

- **AIC** Average Incremental Cost, a ratio of cost vs savings used to compare and rank multiple schemes from most cost effective to least cost effective.
- **ALC** Active Leakage Control, the process by which technicians actively search for leaks within an area, based on flow information that the leakage has risen. The alternative to this is passive leakage control, where no effort is made to find leaks proactively meaning they are often reported by customers.
- **AMI** Advanced Metering Infrastructure, an advanced smart metering system that is used to collect customer usage in real-time
- **AMR** Automatic Meter Reading, a smart metering device or technique that is used to collect customer usage more frequently than traditional meters
- **A-PM** Advanced Pressure Management
- **AR** Asset Renewal
- **AZNP** Average Zonal Night Pressure, the average pressure at night within an area such as a DMA. The night period is normally the same as the period that the minimum night flow assessment is made.
- **BABE**
- **BL** Background Leakage, the theoretical lowest leakage that can be achieved in an area. The background leakage is made up of very small leaks that cannot be located using currently available technologies.
- **CSP** Customer Supply Pipe
- **DMA** District Metered Area, a district area of the network where all the inflows and outflows are measured. From these measurements a balance of the area can be determined and from this an assessment of leakage can be made.
- **FMZ** Flow Monitoring Zone
- **FTE** Full Time Equivalent
- **GIS** Geographical Information System
- **HHNU** Household Night use
- **HTD** Hour to Day Factor, used to convert hourly night flow volumes to daily volumes. This conversion is required due to the differences in water pressure in the system during the night and is calculated for each DMA
- **I-ALC** Intensive Active Leakage Control
- **LRF** Leakage Rate and Flow
- **MAL** Minimum Achieved Leakage, a method for assessing the background leakage by viewing the lowest achieved leakage over an extended period in an area.
- **MCoW** Marginal Cost of Water, the cost to make an additional Ml of water to be used within an area.
- **MLE** Maximum Likelihood Estimate, a method that determines values for the parameters of a model. The parameters are found such that they maximise the likelihood that the process described by the model produced the data that was actually observed.
- **MNF** Minimum Night Flow, the DMA balance flow during the night hour. Leakage is normally assessed at this time as the amount of water used by households and non-households is at a minimum, so the leakage makes up a larger proportion of the total flow at this time.
- **NPV** Net Present Value, the estimation of the cost of a policy over a certain period of time, assuming that future costs are “discounted” by the interest accrued on any money set aside

- **NRR** Natural Rate of Rise, the rate at which leakage in an area would rise up, if no leaks were looked for or fixed. This if often deemed to be the "do nothing" or no reduction scenario in leakage management. It is calculated by adding all the drops in leakage due to repairs seen over a period of time in an area.
- **Ofwat** The Water Services Regulation Authority, responsible for economic regulation of the privatised water and sewerage industry in England and Wales.
- **PAL** Permanent Acoustic Logging
- **PIC** Public Interest Commitment
- **PMA** Pressure Managed Area, a defined area of network with specific pressure management controls
- **PM** Pressure Management, the monitoring and control of pressure in the network to avoid additional strain on the infrastructure. Managing the pressure of a system has been shown not only to improve leakage performance, but also reduce the number of failures that occur on the network
- **PML** Policy Minimum Leakage, interchangeable with minimum achieved leakage (MAL)
- **PV** Present Value
- **SELL** Sustainable Economic Level of Leakage, a methodology used in the UK to calculate the correct leakage level that a company should be operating at. The method looks at the incremental costs of reducing (or increasing) leakage against the cost to produce water (MCoW) as well as other social costs (i.e., impact on river flows, and increased traffic from repairs)
- **SoLow** Strategic Optimisation of Leakage Options for Water Resources
- **SWW** South West Water
- **TM** Trunk Main
- **TMA** Trunk Main Area
- **TMSR** Trunk Main and Service Reservoir
- **UDC** Unit Detection Cost
- **UKWIR** UK Water Industry Research
- **URC** Unit Repair Cost
- **WCWR** West Country Water Resource
- **WRMP** Water Resource Management Plan
- **WRZ** Water Resource Zone, a higher-level area, encompassing large numbers of DMAs each.
- **WWN** Waste Water Notices, a mechanism available to the water companies to prevent excessive wastage of water through legal solutions

1 EXECUTIVE SUMMARY

This report outlines how RPS assisted South West Water in possible leakage reduction options and scenarios, to inform the 2024 Water Resources Management Plan (WRMP) and PR24 Business Plan.

Through a process of workshop sessions and discussion a long list of all feasible leakage reduction options has been created and assessed. Following initial qualitative screening, options have been modelled using the RPS Strategic Optimisation of Leakage Options for Water Resources (SoLow) tool to find the most efficient mix of leakage reduction options to deliver a range of leakage reduction scenarios. All scenarios have been assessed against South West Water historic 2017/18 leakage performance of 128.3 Ml/d (re-baselined to be fully compliant with the consistent reporting method) and forecast end of AMP7 performance/target of 98.3 Ml/d in 2024/25.

A number of assumptions have been considered in this initial assessment; however, it is still fit to provide input data into the development of the wider South West Water WRMP option selection process. This assessment is an important step in understanding how the long term leakage reduction targets can be achieved.

A range of options and scenarios were considered (Table 1.1), and the conclusions can be summarised as follows:

- It is understood that the leakage management activities modelled here may take longer to implement, cost more, and achieve lower leakage reductions due to uncertainty and risk. However, this will be balanced by innovation within this sector over the coming years. As such a pragmatic approach has been taken in the development of each option and associated assumptions to address the uncertainty and to recognise optimism bias.
- The long term 50% reduction by 2049/50 target should be achievable but will require a significant amount of mains replacement, between 3,400 and 6,082 km, along with a significant increase in ALC activity. This equates to between 0.7% and 1.3% of the network been replaced each year to 2049/50 for leakage purposes.
- Achieving the 30% leakage reduction to 89.8 Ml/d by the year 2030, as set out in the Water UK Public Interest Commitment, would require significant investment with a particular weighting towards asset renewal and ALC.
- Investment in innovation leakage techniques for improving the cost efficiency of repair and mains renewal activities has been applied to reduce the long-term economic burden of these activities.
- A lower target scenario (scenario 7) was tested to demonstrate the difference in the order of magnitude of cost required to deliver various leakage reduction profiles by 2049/50.
- South West Water will account for potential leakage savings from AMR and AMI smart metering separately.

It is anticipated that this high-level assessment will be refined following stakeholder engagement and feedback and updated prior to final agreement of the preferred WRMP leakage options and in preparation for the South West Water PR24 business plan submission.

The information detailed in Table 1.1 has been provided for use within the WRMP optimiser and factors may undergo further adjustment through this finalisation and optimisation process. The target for scenario 3 was achieved within scenario 2 and was therefore excluded from the optimisations.

Table 1.1 Summary of Leakage Reduction Scenario Optimisations for the Period 2024/25 to 2049/50

Scenario	Target Leakage	Leakage Reduction (Ml/d)	Undiscounted Direct Leakage Related Costs (£m)	Cost of Water (£m)	Undiscounted Total Cost (£m)	Discounted Total Cost (£m)
1 – No Reduction	Start Leakage 98.3 Ml/d maintained to 2049/50	0	581.0	108.1	689.1	445.7
2 – Linear 50% by 2049/50	Start Leakage 98.3 Ml/d 2049/50: 64.2 Ml/d	34.15	1,287.5	82.5	1,370.1	874.3
3 – Front Loaded	Start Leakage 98.3 Ml/d 2029/30: 89.8 Ml/d 2049/50: 64.2 Ml/d	34.15	1,287.5	82.5	1,370.1	874.3
4 – Back Loaded	Start Leakage 98.3 Ml/d 2049/50: 64.2 Ml/d	34.15	1,428.1	86.9	1,515.0	929.4
5 – Linear 50% by 2044/45	Start Leakage 98.3 Ml/d 2044/45: 64.2 Ml/d, maintained to 2049/50	34.15	1,147.2	79.1	1,226.4	823.9
6 – Linear 50% by 2039/40	Start Leakage 98.3 Ml/d 2039/40: 64.2 Ml/d, maintained to 2049/50	34.15	1,275.2	75.2	1,350.4	931.7
7 – Linear 25% by 2049/50	Start Leakage 98.3 Ml/d 2049/50: 96.2 Ml/d	4.95	600.7	102.7	703.4	458.9

2 INTRODUCTION AND BACKGROUND

South West Water have requested RPS to support the Water Resources Management Plan (WRMP) work around leakage for WRMP 24 submission. This document outlines the collaborative development of a leakage plan that will deliver the leakage levels as indicated in the Public Interest Commitment (PIC)[1] to 2030 and National Infrastructure Commission's (NIC)[2] challenge to 2050, aligned with West Country Water Resource (WCWR) leakage reduction scenarios.

RPS has developed the Strategic Optimisation of Leakage Options for Water Resources (SoLow) tool based around the RPS developed SALT and FLO models. These models have been used to produce Sustainable Economic Level of Leakage (SELL) analysis and tactical leakage optioneering for the last decade. The use of SoLow allows for the efficient delivery of the leakage optioneering required as detailed in this report.

RPS have also used insight from the Water UK "A Leakage Routemap to 2050"[3] to assist South West Water in constructing their WRMP leakage options.

2.1 Scope of Work

The scope of this project is as laid out below:

- Compile a long list of leakage management options
- Short list the most appropriate options
- Model a small number of scenarios to look at the robustness of the leakage options in achieving the leakage target
- Support the wider WRMP activities as required
- Support the WCWR activities as required
- Produce a report that provides a transparent record of how the options required to meet the different leakage targets have been developed and highlight the key underlying assumptions

2.2 Leakage Reduction Scenarios

West Country Water Resource have published a leakage framework development report that outlines three leakage reduction scenarios. These scenarios consider the commitment water companies have made to deliver a 50% reduction in leakage from 2017/18 levels by 2050, and the Public Interest Commitment (PIC)[1,4] of tripling the rate of reduction by 2030.

Historic leakage performance for South West Water has been rebased using the fully compliant consistent reporting method. The 2017/18 reported leakage has been rebased to a total of 128.3 Ml/d, and this has been used to generate the target leakages of 96.2 Ml/d (25% reduction) and 64.2 Ml/d (50% reduction). In discussion with South West Water, they have stated that they will achieve leakage levels of 98.3 Ml/d by the end of AMP7. This has been used as the start position for all leakage scenarios.

Table 2.1 summarises the seven leakage reduction scenarios. Scenario 1 focuses on maintaining leakage levels at the 2024/25 level. Scenarios 2, 3, and 4 target a 50% reduction in leakage from 2017/18 levels by 2050, with scenario 3 also targeting a 30% reduction by 2030. Scenario 5 targets a 50% leakage reduction by

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[1] Public Interest Commitment, Water UK, April 2019, https://www.water.org.uk/publication/public-interest-commitment/

[2] National Infrastructure Assessment 1, National Infrastructure Commission, 2018, National Infrastructure Assessment 1 - NIC

[3] A Leakage Routemap to 2050, Water UK, March 2022, https://www.water.org.uk/wp-content/uploads/2022/03/Water-UK-A-leakage-Routemap-to-2050.pdf

[4] Public Interest Commitment Update, Water UK, October 2019, https://www.water.org.uk/publication/water-uk-public-interest-commitment-update/

2045, maintained to 2050 and scenario 6 targets a 50% leakage reduction by 2040, maintained to 2050. Scenario 7 targets a 25% reduction by 2050.

Table 2.1 Leakage Reduction Scenarios

Scenario	Description	Target Leakage
1	No Reduction	• Start Leakage 2024/25: 98.3 Ml/d maintained to 2049/50
2	Linear 50% by 2049/50	• Start Leakage 2024/25: 98.3 Ml/d • 2049/50: 64.2 Ml/d
3	Front Loaded	• Start Leakage 2024/25: 98.3 Ml/d • 2029/30: 77 Ml/d • 2049/50: 64.2 Ml/d
4	Back Loaded	• Start Leakage 2024/25: 98.3 Ml/d • 2049/50: 64.2 Ml/d
5	Linear 50% by 2044/45	• Start Leakage 2024/25: 98.3 Ml/d • 2044/45: 64.2 Ml/d, maintained to 2049/50
6	Linear 50% by 2039/40	• Start Leakage 2024/25: 98.3 Ml/d • 2039/40: 64.2 Ml/d, maintained to 2049/50
7	Linear 25% by 2049/50	• Start Leakage 2024/25: 98.3 Ml/d • 2049/50: 96.2 Ml/d

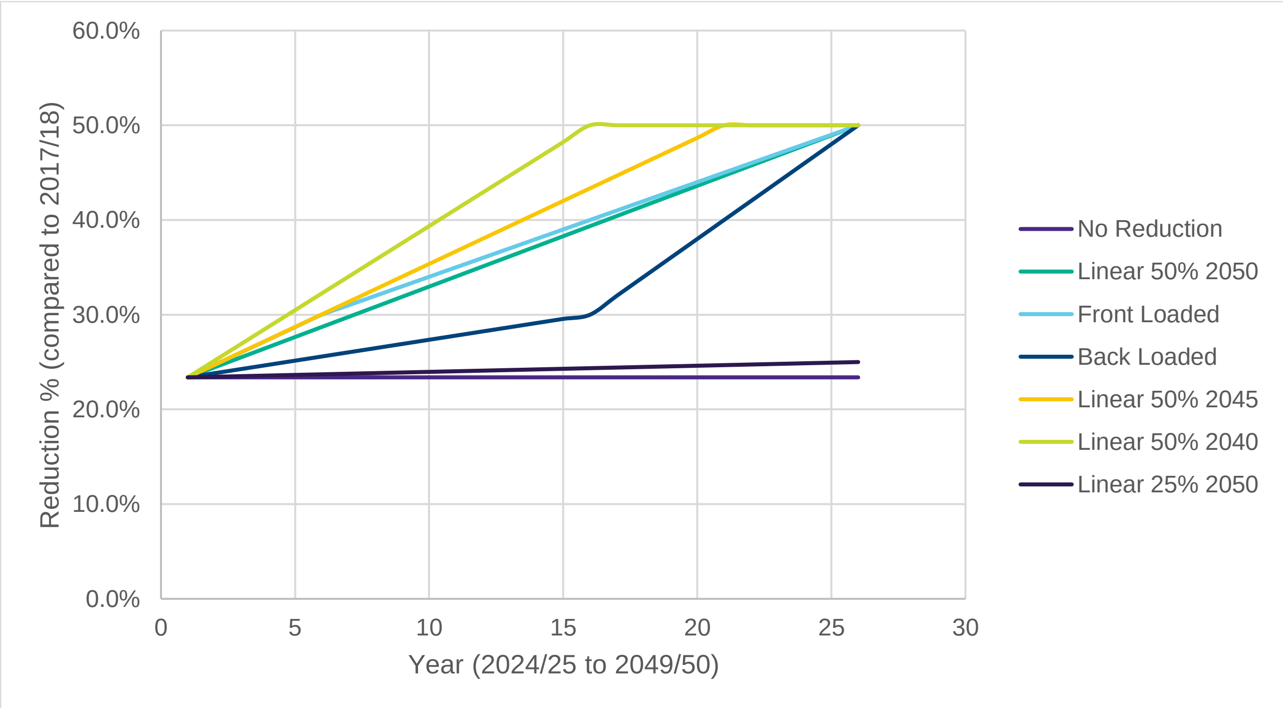

Figure 2.1 South West Water Leakage Reduction Scenarios

3 APPROACH

The approach taken for this assessment has involved South West Water at every stage of the process through open discussion and workshop.

Long list of feasible leakage management options

- Discussion and workshop with South West Water

Short list of appropriate options

- Feasibility and benefits criteria applied

Modelling of short-listed options

- Using current and historical South West Water data to understand the potential costs and leakage benefits for each leakage option

Optimisation of short-listed options against leakage reduction scenarios

- Identifying the most economical route to achieve target leakage from the available leakage options

Report

- A transparent record of how the options required to meet the different leakage targets have been developed and highlight the key underlying assumptions

3.1 Quality Checks

All data underwent quality checks, and a control process was used for checking the options, this conforms to the RPS IS09001 IMS and is there to ensure the quality of the output. Before analysis began, all data was checked to ensure that it was suitable for use within the options. This was done by comparing to previous SWW data and industry standards and checking for possible errors within the datasets. To ensure a high level of quality was achieved for each option, all documents have been both peer and senior reviewed by RPS. This process was repeated for updated versions of documents to ensure quality was maintained throughout.

Lessons learnt from previous work were also acted upon, these include work from SELL at the WRMP19 round as well as option work that RPS have done for a number of companies during the WRMP24 round.

3.2 Leakage Options Long List

Workshop discussions with South West Water considered current leakage management practices and potential feasible options that could be deployed in the future. Of the options discussed, the majority were considered feasible and were transferred from the long list to the short list of options.

Table 3.1 Leakage Options Long List

Option Name	Sub-Option	Description	Short Listed
Active Leakage Control	Standard ALC	Continuation of standard Active Leakage Control (ALC) practices. Provides a baseline maintenance of leakage that other options can enhance.	Yes
	Lift and Shift	Widespread implementation of lift and shift technology to improve the efficiency of standard detection activity.	No – forms part of current baseline activities
	Intensive ALC	Substantial temporary increase in standard ALC activity within target DMAs.	Yes
	Permanent Acoustic Logging	Installation of permanent acoustic loggers across network to create greater granularity of acoustic leakage detection data improving detection efficiency.	Yes
Asset Renewal	Mains and Comms Renewal	Renewal of mains and communication pipes for targeted materials across the network.	Yes
	Mains Only Renewal	Renewal of mains pipes for targeted materials across the network.	Yes
	Comms Only Renewal	Renewal of communication pipes for targeted materials across the network	Yes
Customer Supply Pipe Leakage	Customer Supply Pipe Repairs	Subsidised customer supply pipe repair to reduce repair times	No – not included due to lack of available data
Smart Metering	AMR metering	AMR smart metering policies to be considered through consumption policies	Yes – SWW to account for potential leakage savings separately
	AMI metering	AMR smart metering policies to be considered through consumption policies	Yes – SWW to account for potential leakage savings separately
Pressure Management	Advanced Pressure Management	Considers the installation and optimisation of PRVs, and where appropriate, the installation of new booster pumps to properties at higher elevations to allow pressure to be reduced in lower lying areas	Yes
	Pressure Transients	Programme of investment to reduce the occurrence of	Yes
Trunk Mains	Trunk Main Asset Renewal	Renewal of pipes within TMAs	Yes
	Trunk Main Additional ALC	Increasing standard ALC activity within TMAs to be on par with DMAs	Yes
	Trunk Main Flow Monitoring Zone	Setting up a FMZ with large diameter flow meter and logging equipment	Yes
	Trunk Main Logging	As FMZ policy, but with loggers	Yes
Innovation	ALC Innovation	Investment in ALC innovative research and development	Yes
	Asset Renewal Innovation	Investment in asset renewal innovative research and development	Yes

3.3 Short Listing Process

During the initial scoping of each leakage option on the long list with South West Water, it was determined that each leakage option was theoretically viable and should be progressed through to the short list. Lift & Shift was not taken through to the short list as it forms part of current baseline activities included within standard ALC. Customer Supply Pipe Repairs was also not taken through to the short list as there was a lack of data available for this option. Further discussion and initial analysis were undertaken to further develop these options. Consideration has been given to current South West Water policies and the size of potential benefits.

After discussion it was decided that South West Water would account for potential leakage savings from AMR and AMI Smart Metering separately, and therefore this option was not included in our analysis.

3.4 Leakage Options

RPS have good experience in developing models that describe the economic and leakage benefits from a range of leakage management techniques, having undertaken annual leakage performance and investment assessments for a number of UK water companies and are in the process of providing SELL estimations.

Where possible, data provided by South West Water has been used applying best practice techniques, as well as applying South West Water experience and industry-based assumptions to develop individual leakage options.

Leakage data and data relating to DMA and mains characteristics has been provided by South West Water, via Waternet, GIS and other South West Water systems. A base year of 2020/21 has been used as the most complete data sets are available from this year. The base year has been kept consistent throughout all leakage options.

Leakage options have been built at WRZ level. The Isles of Scilly have been excluded from all analysis due to the availability of data. It has been assumed that leakage levels are low for the Isles of Scilly and a maintenance cost will be required to keep them low. The WRZ's analysed are therefore Bournemouth, Colliford, Roadford and Wimbleball, and the leakage reductions required to achieve the scenario targets can be met from these WRZ's.

High-level base cost information for each of the leakage options has been provided by South West Water where available, alongside expected maintenance and asset replacement frequencies. Other costs have been derived from RPS industry experience. This information has been used to construct discounted and undiscounted whole life costs over the discount period.

A number of models use average incremental cost (AIC), taken from UKWIR guidance[5], to rank the order in which schemes should be undertaken within the optimisation to provide the greatest cost-benefit from the leakage option. AIC provides a cost per unit of leakage saving, and can be defined as shown in Equation 1, expressed as £ per Ml or pence per m^3 saved.

$$AIC = \frac{C - O - V}{W} \qquad Equation\ 1$$

Where: C = the present value (PV) of capital cost of renewal of targeted assets

O = the PV of leak detection and repair savings on targeted assets

V = the PV of water saved

W = the PV of volume of water saved

For the purposes of this initial assessment a scheme is assumed to be a whole single DMA. The AIC ranking process uses discounted costs applying a standard green book discount rates over an 80-year discount period[6]. The undiscounted costs for a scheme are carried through to SoLow.

[5] Atkinson, J., Buckland, M., Economics of Balancing Supply and Demand (EBSD) Guidelines NERA UKWIR 02/WR/27/4 (2002)

[6] The Green Book, HM Treasury (2020) The Green Book (publishing.service.gov.uk)

The SoLow optimisation process (as described in section 3.4) is used to determine the most economic mix of leakage options to achieve the specific leakage reduction scenarios (see section 2.2).

It should be noted that whilst £/Ml/d values have been provided to allow a degree of high-level comparison between leakage options, these figures do not fully articulate the range of schemes that have been entered into the optimisation.

3.4.1 Base Data

South West Water have provided a considerable volume of data, as detailed in Table 3.2. For the purposes of leakage options model development, a base year of 2020/21 has been used.

The majority of this data has been provided to DMA level, enabling detailed policy modelling. To align leakage and DMA data, annual averages for the base year are used. To ensure that this data aligned correctly, it was necessary to calculate the annual average DMA property count for the base year from Waternet® data. However, all leakage option models have been designed to be fully scalable to allow rebasing to the optimisation start year of 2024/25.

Material cohorts are defined in Table 3.3.

Leakage data as provided by SWW has been re-calculated as part of this project by adjusting household night use (HHNU) allowances, updating from approximately 3 l/p/hr to 4.5 l/p/hr, as provided by SWW.

Calculation and review of the Natural Rate of Rise in Leakage (NRR) has been undertaken to determine the appropriateness of the results for use within the leakage option model builds, and within the scenario optimisation. The base year NRR is found to be appropriate for use within the leakage option modelling. Further details of the NRR review can be found in section 3.4.1.1. Further details of planning NRR used within SoLow can be found in section 3.5.4.

The Minimum Achieved Leakage (MAL), often termed Policy Minimum Leakage (PML), has been used to define the background leakage for South West Water.

RPS calculated an indicative company level MCoW to SWW based on industry data and using network density as a scaling factor. SWW have rebased the company level estimate to WRZ level considering their WRZ characteristics. The final MCoW values used within this project are detailed in Table 3.4.

Table 3.2 Base Data and Source

Data Required	Year(s)	Source
Repair data complete with labelling of detected/reported, district metered area (DMA), Water Resource Zone (WRZ) and Area references, pipe type and repair start and completion dates.	2019/20	Waternet
DMA property count	2019/20	Waternet
Yearly NRR results complete with mains length, property counts and DMA cohort allocations.	2013/14 – 2020/21	Waternet
MAL	2019/20	Calculated by RPS
Reported MLE leakage	2018/19 – 2019/20	South West Water
Marginal Cost of Water (MCoW)	2019/20	South West Water
Distribution mains data	2019/20	South West Water
Daily leakage per DMA	2017/18 – 2019/20	Waternet
Daily Hour to Day Factor (HTD) and Average Zonal Night Pressure (AZNP)	2019/20	South West Water

Table 3.3 Material Cohort Definitions

Material Cohort	Definition
AC	Asbestos Cement
DI	Ductile Iron
FE	Galvanised, Spun and Cast Iron and Steel
PE	Polythene
PVC	Polyvinyl Chloride
BP	Black Polyethylene
Other	Not classified as any of the above

Table 3.4 MCoW Values provided by South West Water

WRZ	MCoW (£/Ml)
Bournemouth	£135.66
Colliford	£133.57
Roadford	£131.12
Wimbleball	£145.34

3.4.1.1 Natural Rate of Rise of Leakage

SWW NRR is calculated in Waternet® and the method used is consistent with UKWIR NRR Guidance documents[7,8]. Whilst a number of industry default settings have been used, the NRR is appropriate for use within the models and optimisation. Source data for calculation of the 2020/21 NRR was found to be more complete providing greater confidence in the final values. NRR for 2021/22 was also calculated within Waternet® to be considered in the planning NRR (section 3.5.4).

Table 3.5 NRR Zonal Summary 2020/21

WRZ	NRRt	NRRd	NRRd to NRRt Ratio
Bournemouth	28.79	13.19	0.46
Colliford	62.08	39.07	0.63
Roadford	98.71	56.97	0.58
Wimbleball	34.39	18.68	0.54
Company	251.68	147.95	0.57

3.4.1.2 Background Leakage

Background leakage (BL) has used re-calculated weekly leakage data as described in section 3.4.1. Consistent with UKWIR best practice guidance[9], 7-day average leakage values over a 5-year period (2017/18 – 2021/22) have been used to determine the minimum achieved leakage (MAL). The resulting MAL indicates the lowest level of leakage that has been observed over the period of assessment.

[7] Manning, C., Natural Rate of Rise of Leakage, UKWIR 05/WM/08/33 (2005)

[8] Butler, M., Grimshaw, D., Factors Affecting the Natural Rate of Rise of Leakage, UKWIR, 09/WM/08/40 (2009)

Observed DMA MAL results were used to calibrate the MAL explanatory factors within the UKWIR MAL estimation function. The calibrated functions for each cohort were used to estimate the MAL for DMAs where it was not possible to determine MAL directly from weekly leakage data.

For the purposes of this study Final DMA MAL has been used to describe BL and has been taken through to leakage option models and the scenario optimisation.

For consideration by SWW, further analysis has provided a BL Estimate, defined as the lowest level of achievable leakage as set by 'frontier' DMAs calibrated to a nationally representative data set[9]. The frontier assessment benchmarks BL estimation against national performance.

The frontier MAL values are plotted against observed MAL percentile values and used to determine the appropriate frontier MAL and observed MAL percentile values for BL estimation within each operational region.

It was found that targeting the MAL_{25} frontier was the most appropriate in estimating BL for SWW.

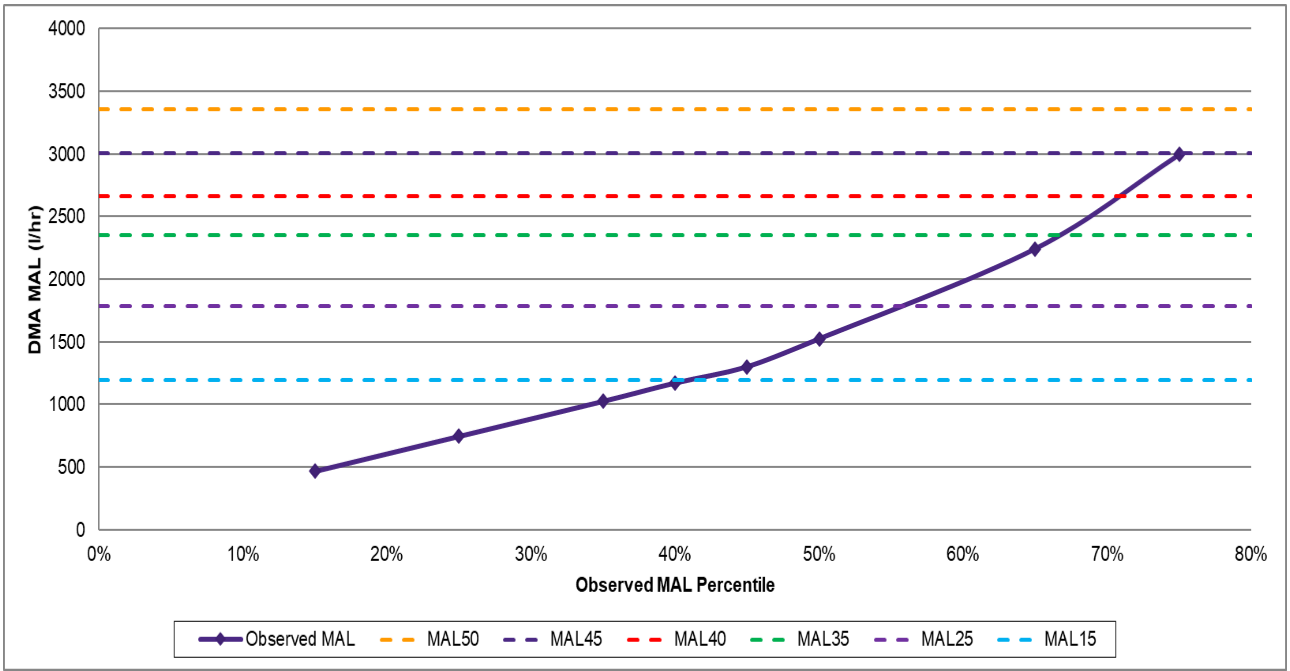

Figure 3.1 Frontier MAL Assessment

Table 3.6 Background Leakage Output Summary

WRZ	Final MAL (Ml/d)	Final MAL (l/p/d)	BL Estimate (Ml/d)	BL Estimate (l/p/d)
Colliford	15.92	59.21	10.59	39.39
Roadford	22.05	53.59	15.67	38.10
Wimbleball	8.94	53.26	6.35	37.83
Bournemouth	7.84	38.56	4.15	20.38
Company	54.76	52.07	36.50	34.71

3.4.1.3 DMA Size

In order to account for the variations in DMA network densities across South West Water the DMA data was normalised by the 'size' (kJ) of the DMAs using a function, that uses both the number of properties as well as the length of main in a DMA to calculate a sizing metric (see equation 2), developed as part of the UKWIR

[9] Butler, M., Farrelly, B., Factors Affecting Minimum Achieved Levels of Leakage, UKWIR 16/WM/08/58 (2016)

Factors affecting background leakage report[10]. This overcomes the need to normalise by property count or mains length, each of which have their inherent limitations due to network density factors. By normalising based on DMA size there is no requirement to model different network densities separately within the marginal ALC leakage~cost relationships which increases the DMA sample sizes available within the modelling leading to more statistically robust results. This is also allows for the impact of DMA size on leakage efficiency to be expressed robustly.

$$Size\ (kJ) = (7\,.N\ +\ L\ /\ 3)\ /\ 1000 \qquad Equation\ 2$$

Where:	N	= number of connections
	L	= length of the network in metres

3.4.2 Active Leakage Control

Active Leakage Control (ALC) cost functions were developed in accordance with the ‘method B’ approach, incorporating the latest recommendations from the UKWIR best practice[11]. The objective was to establish the relationship between the marginal cost of ALC (detected and repair) and leakage for each material cohort. This relationship is used within SoLow to describe transitional ALC savings and both transitional and maintenance ALC costs.

The general form of the ‘method B’ marginal equation given in the UKWIR best practice is as follows:

$$Marginal\ Cost\ of\ ALC = a * \ (L - BL)^{b} \qquad Equation\ 3$$

Where:	L	= the current leakage level of an area
	BL	= the current background leakage of an area
	The coefficient term a, and exponent term b are fit to South West Water data	

The average annual excess leakage was defined as the average annual distribution leakage minus background leakage (BL). The marginal unit detection cost (UDC) and unit repair cost (URC) were calculated for each DMA as the annual detection or repair costs divided by annual volume saving.

The coefficient “a” and exponent “b” were calculated by plotting the UDC and URC values against the DMA average leakage values above BL. The best-fit power law through each of the cohort plots then gave the coefficient values. DMA ALC costs and leakage levels were used to generate company level cost curves for detection and repairs. These were grouped into cohorts based on the predominant material at burst location, and the curves were smoothed by the size factor (kJ).

Assumptions:

The following key assumptions have been applied following UKWIR best practice:

- 50% ALC efficiency
- Cohort validity threshold of 50 data points. Any cohort below this threshold was mapped to the “Other” material cohort
- Lift and Shift activity is included as part of standard ALC practices

The model cost inputs were provided by South West Water and are summarised in Table 3.7.

[10] Butler M., Grimshaw D., Factors Affecting Background Leakage, UKWIR 13/WM/08/49 (2012)

[11] Cunningham, A., Rickard, J., Warren, R., Best Practice for the derivation of cost curves in economic level of leakage analysis, UKWIR 11/WM/08/46 (2011)

Table 3.7 ALC Input Costs Summary

Input	Cost
Ancillary Repair Cost (£/repair)	£492.90
Comms Repair Cost (£/repair)	£829.75
CSP Repair Cost (£/repair)	£465.74
Mains Repair Cost (£/repair)	£1,709.70
Observed Detection Cost (£m)	£5.80
Observed Repair Costs (£m)	£7.44

Table 3.8 ALC Output Summary

Output	Bournemouth	Colliford	Roadford	Wimbleball
Calibrated "c" Coefficient: Detection	699.92	528.23	420.56	127.66
Calibrated "d" Coefficient: Detection	0.52	0.63	0.66	0.72
Calibrated "c" Coefficient: Repair	307.77	340.31	195.93	191.34
Calibrated "d" Coefficient: Repair	0.67	0.70	0.73	0.72
Detection Cost Function "c" Coefficient	538.91	4,383.62	13,082.82	4,238.46
Detection Cost Function "d" Coefficient	0.52	0.63	0.66	0.72
Detected Repair Cost Function "c" Coefficient	347.57	271.37	215.24	227.68
Detected Repair Cost Function "d" Coefficient	0.67	0.70	0.73	0.72
£/Ml/d (Undiscounted)	£195,259	£220,660	£203,172	£187,990

3.4.3 Intensive ALC

Enhanced or Intensive ALC (I-ALC) can be defined as systematic and concentrated leakage detection effort in DMAs. This has typically been undertaken in DMAs with historically high leakage that has proven difficult to pinpoint and reduce. Concerted effort is made to significantly reduce leakage within a DMA and this new leakage level is then maintained, as described through the SoLow outputs.

Leakage savings and costs were calculated at DMA material cohort level (Table 3.9) using available industry trial data calibrated to South West Water standard ALC budget. Information on historic South West Water I-ALC activity was not available to fully calibrate this data to South West Water.

Leakage-cost relationships were used to predict policy cost and leakage savings in DMAs. Potential schemes were ranked according to their AIC as informed by UKWIR guidance[5]. The optimisation explored the best options from the ranked schemes at WRZ level.

It should be noted that whilst this leakage option may appear to be very effective in terms of whole life cost (Table 3.10) it does not account for ongoing maintenance costs as is the case with other leakage options. Ongoing maintenance costs are accounted for through additional standard ALC modelled within the SoLow optimisation.

Assumptions:

- Scheme costs and leakage savings are calculated at DMA level.
- All estimated leakage savings would be achievable.

- A 10% contingency has been added to the costs to account for any additional civil work and/or the installation of additional logging equipment to resolve long term leakage.
- No historic I-ALC data was provided by South West Water, and as such industry standard effectiveness and costs have been used, derived from available pooled national data, and calibrated to South West Water total ALC budget.

Table 3.9 Calibrated I-ALC Effectiveness and Cost Values

Cohort	Effectiveness	Cost (£/kJ)
AC	13.0%	£2,521.37
FE & DI	10.9%	£2,477.81
OTHER	22.5%	£2,759.29
PE & PVC	14.8%	£4,378.13
RELINED	14.1%	£2,749.07
POOLED	18.9%	£2,508.88

Table 3.10 I-ALC Output Summary

Output	Bournemouth	Colliford	Roadford	Wimbleball
Number of Schemes	152	265	373	72
Total Excess Leakage Savings (Ml/d)	2.28	3.80	3.85	0.74
Total Undiscounted Cost (£m)	£4.98	£7.89	£10.62	£2.90
Total Discounted Cost (£m)	£1.86	£2.78	£5.53	£1.82
£/Ml/d (Undiscounted)	£2,180,455	£2,073,570	£2,754,918	£3,916,204

3.4.4 Asset Renewal

The model considered three leakage-driven asset renewal (AR) policies (Table 3.11). For each policy, the cumulative costs and savings of renewing target assets in each DMA were assessed. A matrix of unit costs (£ per m) was calculated from data provided by South West Water and from this the DMA costs of target mains and comms renewal were calculated.

Table 3.11 Policy Breakdown

Policy	Pipe Types Included
1	Mains & Comms
2	Mains Only
3	Comms Only

To understand the potential benefits, the leakage associated with target assets was multiplied by an "effectiveness rate" and the percentage leakage reduced by asset renewal following UKWIR best practice[12]. Similarly, the effectiveness of reducing NRRt through AR was calculated using the UKWIR method. Final potential savings and costs for DMA level schemes were ranked within each WRZ according to their AIC, as informed by UKWIR guidance[5]. Outputs for the three policies have been summarised in Table 3.13.

Assumptions:

[12] Butler, M. Cathery, T. Mander, P. The Impact of Burst Driven Mains Renewal on Network Leakage Performance, UKWIR, 18/WM/08/67 (2018)

- Target mains materials were chosen due to their potential risk of failure and current burst rate. A recent UKWIR study[13] has shown that PE mains should have long asset life, so have been excluded from the assessment. However, mains classified as FE, DI, BP, AC and PVC have all been included.
- A 10% contingency cost has been added to renewal costs
- Leakage success rate was set to the tolerance cap of 60% and the NRR success rate was set to the tolerance cap of 50% as the default from UKWIR guidance[12]
- South West Water have provided renewal cost information in the form of an equation that is used for asset renewal, this uses the length of mains renewals and cost function based on size banding and urbanicity to calculate a cost per metre. To better fit the models used by RPS for mains renewals this was converted into a cost matrix by diameter band and surface type. Average renewal costs are summarised in Table 3.12.

Table 3.12 Asset Renewal Input Costs Summary

Input	Cost
Cost of Mains Renewal by Urban/Rural/Grassland and Diameter Band (£/m)	Values ranged from £62 - £1,399
Average Comms Connection Cost (£)	£314
Average Comms Pipe Renewal Cost (£)	£1,322
Average Mains Repair Cost (£)	£1,866
Average Comms Repair Cost (£)	£1,380
Detection Cost by DMA (£)	As per ALC analysis
MCoW	See Table 3.4

Table 3.13 Asset Renewal Output Summary

Output	Policy 1	Policy 2	Policy 3
Length of Mains Renewed (km)	12,702.64	12,702.64	12,702.64
Number of Connections Targeted	885,234	885,234	885,234
Potential Savings (Ml/d)	54.49	27.88	26.60
Costs (£/m)	£5,187.64	£3,992.67	£1,194.97
£/Ml/d	£95,205,374	£143,186,791	£44,916,010

3.4.5 Permanent Acoustic Logging

Permanent Acoustic Logging (PAL) is the permanent deployment of loggers within the network for the long-term monitoring of leakage. PAL deployment reduces routine manual surveying requirements and when a leak is suspected should help target ALC detection efforts.

For each DMA, the logger requirement is calculated from the mains length and the respective mains material cohort logger placement assumption. This is multiplied by the present value (PV) operational and capital costs for a logger to give the DMA level scheme cost. Transition ALC costs and maintenance ALC costs are calculated using standard ALC cost coefficients for each scheme implementation to help indicated the potential savings alongside direct leakage benefits. Schemes are generated at DMA level and are ranked by AIC for each WRZ.

[13] Long term performance of plastic (PE) pipes, UKWIR, 20/WM/03/22 (2020)

Assumptions:

- Detection cost savings were set at 30% based on best estimation from industry information to account for significant expected detection efficiencies from widespread acoustic logger placement.
- Excess leakage reduction was calculated from data provided by SWW, and was set at 25% for AC, PE & PVC, and Pooled, 20% for FE & DI, and 30% for Other.
- Distance between loggers was calculated from SWW data, and is set to 339 m for AC, PE & PVC, and Pooled, 319 m for Other, and 360 m for FE & DI.
- South West Water were not able to provide cost and maintenance information for loggers, and the costs used were therefore taken from available industry data, detailed in Table 3.14.

Table 3.14 PAL Input Costs Summary

Input	Cost	Activity Frequency (years)
Base Year Logger Cost (£)	£320	N/A
Replacement Logger Cost (£)	£320	10
Logger Repair Cost (£)	£80	3
Battery Replacement Cost (£)	£50	5
Maintenance Cost (£)	£21	1
Total PV Cost per Logger (£)	£2,448.41	N/A

Table 3.15 PAL Output Summary

Output	Bournemouth	Colliford	Roadford	Wimbleball
Number of Schemes	151	253	356	60
Total Excess Leakage Savings (Ml/d)	3.17	5.61	6.31	1.15
Total Undiscounted Cost (£m)	£17.43	£29.69	£39.45	£10.68
Total Discounted Cost (£m)	£12.58	£0.58	-£6.27	£4.90
£/Ml/d (Undiscounted)	£5,503,013	£5,293,069	£6,252,637	£9,279,082

3.4.6 DMA Sub-Division

South West Water have undertaken a process of sub-dividing DMAs into smaller areas and to date have 491 across 175 DMAs. Dividing DMAs into smaller areas helps to improve the efficiency of leakage detection. As advised by SWW, size (kJ) was used to determine the number of sub-divisions required within each DMA. One particular WRZ, Roadford, has had significant sub-division activity, and this was used to inform the policy. From this, it was calculated that no area should have a size greater than 5.64 kJ and the number of divisions required for each DMA to bring the size below 5.64 kJ was calculated. DMAs that did not require division were excluded from further analysis. The cost of implementing these divisions was calculated and the DMAs ranked by AIC ready for input into the SoLow optimiser.

Assumptions:

- Detection cost saving was set at 7%, taken from a calculated efficiency rate. This was based on the amount of detection time spent within each DMA from data provided by South West Water
- Excess leakage reduction was set at 8%, the industry average value
- For analysis purposes, properties have been split equally between sub-divisions
- The optimisation considered the cumulative scheme costs and benefits

Input costs were provided by South West Water and are summarised in Table 3.16 and a summary of the assessment outputs is provided in Table 3.17.

Table 3.16 DMA Sub-Division Input Costs Summary

Input	Cost	Activity Frequency (years)
Base Year Meter Cost (£)	£25,000	10
Flow/Pressure Logger Cost (£)	£2,100	10
Valve Cost (£)	£5,300	20
Washout (£)	£6,000	N/A
Battery Replacement (£)	£140	5
Meter Maintenance (£)	£180	5
Logger Maintenance (£)	£20	5
Discounted Total Cost (£)	£108,782	N/A
Undiscounted Total Cost (£)	£279,120	N/A

Table 3.17 DMA Sub-Division Output Summary

Output	Value
Number of Schemes	557
Total Savings (Ml/d)	3.79
Total Undiscounted Cost (£m)	£302.34
Total Discounted Cost (£m)	£105.54
£/Ml/d (Undiscounted)	£79,733,273

3.4.7 Advanced Pressure Management

To make further savings from pressure management, South West Water may need to reconfigure and reinforce the network to subdivide the system into smaller discrete pressure areas. Advanced Pressure Management accounts for both installing and optimising PRVS and the installation of booster pumps at properties situated at high elevations, allowing pressures to be reduced within the same DMA/PMA in lower lying areas to reduce leakage.

Advanced pressure management opportunities have been identified at DMA level rather than PMA due to the availability of data at this initial stage of analysis. The difference between the 98th percentile DMA property height and max DMA property height has been used for the initial screening process and to determine the proportion of a DMA that can be boosted and the proportion in which pressures can be reduced from booster pump installation. Pressure can be reduced with the installation of a PRV in DMAs that pass through the initial screening, and which are not currently pressure managed, whilst a DMA has an optimisation only scheme if the DMA passes through initial screening but already contains a PRV. Optimisation will also be carried out at new PRVs if the difference between the maximum property height and critical pressure (CP) is greater or equal to 5mH.

Leakage savings are only applicable to the areas in which pressures are reduced and are calculated using a standard leakage-pressure relationship and the NRR T3 function. Further assumptions and calculation inputs are as follows.

Assumptions:

- The threshold level as part of the initial screening for pressure management has been set to 20 mH minimum
- The threshold level for optimisation on top of a new PRV is set to 5mH for the minimum difference between the DMAs maximum property height and CP height
- N1 value for pressure/leakage relationship is 1.118 for the entire network

- The percentage of a DMA that can be reduced by booster pump installation is determined by the number of properties below the 98th percentile of height
- Pressure can be reduced for all properties in a DMA where PRVs are installed.

Table 3.18 Advanced Pressure Management Input Costs

Input	Cost	Activity Frequency (years)
Booster Pump Cost (£)	£20,000	20
PRV Cost (£)	£12,600	20
New Controller Optimisation Cost (£)	£5,000	10
New CP Logger Optimisation Cost (£)	£500	10

Table 3.19 Advanced Pressure Management Output Summary

Output	Value
Number of Schemes	469
Savings (Ml/d)	21.63
Total Undiscounted Cost (£m)	£36.93
Total Discounted Cost (£m)	£14.27
£/Ml/d (Undiscounted)	£1,707,681

3.4.8 Pressure Transients

The pressure transient policy considers the implementation of a network optimisation team, made up of 7 FTE technicians, and an external engagement team of 2.5 FTE technicians. This team would be involved in the identification and resolution of pressure transients within the network. Known sources of pressure transients include large water users, network repair activities, network pumping and valves. This option considers the optimisation of DMA booster pumps, PRVs and ALC repair activities alongside engaging with large consumption consumers through an additional external engagement team. Scheme costs are calculated at DMA level and ranked by AIC ready for input into the SoLow optimiser.

The relationship between pressure transients and consequent repairs/leakage is still under investigation, and there have been reports of varying success stories across the industry from undertaking pressure transient work[14]. So as not to over-estimate potential savings, low level savings have been attributed to individual pressure transient activities. However, where multiple sources of pressure transients have been identified within a DMA, the corresponding total potential savings will also increase.

Assumptions:

- Savings are 2% for external engagement per large consumer, 2.5% per asset for optimisation, 1.25% for upgrading a fixed pump to variable speed, and 5% from optimisation team activity.
- Pump replacement period is 20 years, pump optimisation every 10 years, and PRV optimisation every 10 years
- The optimisation team and external engagement costs are applied annually and spread across the relevant schemes
- Optimisation and engagement team costs are based on FTE technician costs provided by SWW

[14] The occurrence and causes of pressure transients in distribution networks, UKWIR, pre-publication (2022)

Table 3.20 Pressure Transients Input Costs Summary

Input	Cost
Replacement Pump Cost (£)	£25,000
Pump Optimisation Cost (£)	£10,000
Pump Maintenance Cost (£)	£5,000
PRV Optimisation Cost (£)	£5,000
Cost of Optimisation Team (£)	£361,361
Cost of External Engagement (£)	£129,058
Pump Costs NPV Cost (£)	£111,787
Pump Costs Undiscounted Cost (£)	£270,000
Pump Optimisation Costs NPV Cost (£)	£32,882
Pump Optimisation Costs Undiscounted Cost (£)	£90,000
PRV Optimisation Costs NPV Cost (£)	£16,441
PRV Optimisation Costs Undiscounted Cost (£)	£45,000
Optimisation Team Costs per DMA NPV Cost (£)	£23,625
Optimisation Team Costs per DMA Undiscounted Cost (£)	£68,871
External Engagement NPV Cost (£)	£12,033
External Engagement Undiscounted Cost (£)	£35,079

Table 3.21 Pressure Transients Output Summary

Output	Value
Savings (Ml/d)	7.25
Cost (£/m) (Undiscounted)	£170.4
£/Ml	£23,504,898

3.4.9 Trunk Mains

A total of four trunk main leakage reduction options have been assessed and are detailed below.

3.4.9.1 Trunk Main Asset Renewal

The trunk main (TM) renewal option has utilised an adapted standard DMA asset renewal method but applied to available TM data. This has used three asset renewal policies, summarised in Table 3.22. For Trunk Mains renewal the cumulative costs and savings of renewing target assets in each TMA were assessed utilising the matrix of unit costs (£ per m) by diameter band as used for DMA asset renewal could be applied to TMA target mains (Table 3.23).

Table 3.22 Policy Breakdown

Policy	Pipe Types Included
1	Mains & Comms
2	Mains Only
3	Comms Only

TMA level leakage was made available through assessment of provided leakage data, isolating those areas identified as using the BABE approach.

To understand the potential benefits, the leakage associated with target assets was multiplied by an "effectiveness rate" and the percentage leakage reduced by asset renewal following UKWIR best practice[12]. Similarly, the effectiveness of reducing NRRt through AR was calculated using the UKWIR method. Final potential savings and costs for DMA level schemes were ranked within each WRZ according to their AIC, as informed by UKWIR guidance[5]. Outputs for the three policies have been summarised in Table 3.24.

Assumptions:

- Materials to be renewed are consistent with standard asset renewal, and are AC, BP, DI, FE and PVC
- Leakage success rate was set to the UKWIR default of 50% for mains renewal
- Savings in NRR could not be applied due to lack of available data.

Table 3.23 Trunk Main Asset Renewal Input Costs

Input	Cost
Cost of Renewal by Urban/Rural and diameter band (£/m)	£62 - £1,399
MCoW (£/Ml)	See Table 3.4

Table 3.24 Trunk Main Asset Renewal Output Summary

Output	Policy 1	Policy 2	Policy 3
Length Renewed (km)	1,645.07	1,645.07	1,645.07
Savings (Ml/d)	4.14	2.32	1.82
Cost (£m)	805.02	772.14	32.88
£m/Ml/d	194.5	333.1	18.1

3.4.9.2 Trunk Main Additional ALC

This leakage option considers the creation of a dedicated trunk main ALC team to proactively identify leaks across the whole trunk main network. Current trunk main leak detection activity is undertaken by the wider distribution network ALC team who are primarily concerned with leak detection within DMAs. This translated into a significant uplift in hours dedicated to trunk main leakage detection, moving to approximately 57,674 additional hours per year. As a result of this, it has been assumed that the effectiveness of detection activity will be improved and so will the leak awareness time, with an assumed 25% improvement. An estimated 32 FTEs will be required to carry out this additional ALC activity.

Assumptions:

- A dedicated trunk main ALC team will improve the effectiveness of detection activity and provide a 25% improvement in trunk main leak awareness times
- Leakage benefits from a dedicated ALC team are realised in over the first 5 years, however annual costs for the team are ongoing to maintain the saving.

Table 3.25 Trunk Main Additional ALC Cost Inputs

Input	Cost
TM ALC Avg. Technician Cost (£/hr)	£24.82

Table 3.26 Trunk Main Additional ALC Output Summary

Output	TM Additional ALC
Savings (Ml/d)	3.56
Cost (£m)	1.36
£m/Ml/d)	0.38

3.4.9.3 Trunk Main Flow Monitoring Zone

This option considers the installation of large diameter flow meters on trunk mains to establish flow monitoring zones. Available guidance[15] suggests "*a smaller distance between meters and sensors is preferred, with as few meters as possible (approximately 0.5km and 6-7 meters)".* Following discussion with South West Water, size has been used to determine the number of FMZs required within a TM DMA. The size (kJ) limit has been set as 5.64, consistent with that used for DMA sub-division, and this has been used to determine FMZ numbers. In terms of leakage benefits an assumption has been made that there would be a 25% improvement in awareness time from the current trunk main leak position. However, the main benefit will be to enable flow balance leakage estimation.

Assumptions:

- The value of size used to determine FMZ numbers will be consistent with DMA sub-division at a value of 5.64
- FMZ creation will see a 25% improvement in leak detection awareness time
- Savings are one off
- The policy assumes full implementation but with a maximum number of 5 schemes per year per WRZ to spread costs and savings

Table 3.27 Trunk Main FMZ Input Costs

Input	Cost	Replacement Period
Meter Cost (£)	£25,000	10 years
Flow/Pressure Logger Cost (£)	£2,100	10 years
Valve Cost (£)	£5,300	20 years
Washout (£)	£6,000	N/A
Meter Maintenance (£)	£180	5 years
Logger Maintenance (£)	£20	5 years
Battery Replacement (£)	£140	5 years

Table 3.28 Trunk Mains FMZ Output Summary

Output	TM FMZ
Savings (Ml/d)	3.56
Cost (£m)	52.20
£m/Ml/d	14.67

[15] Best Practice for Upstream Flow Monitoring Zones, UKWIR, 20/WM/08/74 (2020)

3.4.9.4 Trunk Main Loggers

The trunk main logger leakage option follows similar principles to the flow monitoring zone option. However, rather than large diameter flow meters, pressure and flow monitoring probes and loggers are installed at a significantly reduced cost, and their placement has been determined using TM DMA size, consistent with the TM FMZ policy. A size value of 5.64 has been used as the limit, consistent with that used for DMA sub-division, and this has determined the number of loggers required within each TM DMA. This brings with it a reduced benefit, with an assumed 12.5% improvement in awareness time from the current trunk main leak position.

Assumptions:

- The value of size used to determine logger numbers will be consistent with DMA sub-division at a value of 5.64
- Widespread TM logger installation will see a 12.5% improvement in leak detection awareness time
- Savings are one off
- The policy assumes full implementation but with a maximum number of 10 schemes per year per WRZ to spread costs and savings

Table 3.29 Trunk Mains Input Costs Summary

Input	Cost	Replacement Period
Flow/Pressure Logger Cost (£)	£2,100	10 years
Logger Maintenance (£)	£20	5 years
Battery Replacement (£)	£140	5 years

Table 3.30 Trunk Mains Output Summary

Output	TM Loggers
Savings (Ml/d)	1.78
Cost (£m)	3.77
£m/Ml/d	2.12

3.4.10 ALC repair and Asset Renewal Innovation

To reach the challenging leakage reduction targets, innovative interventions need to be considered.

In recent years the focus has been on leakage detection with deployment of acoustic loggers and pressure loggers across distribution networks. Software and analytics of leakage data is also making good headway. Any gains within this realm are considered as risks or opportunities to those leakage options described above.

Two areas where there is further opportunity for considerable gains are with repairs and renewals. To assist in realising these opportunities there is a need to invest in innovative research and development. A recent UKIWR paper[16] discusses the need for innovation in this area and presents a roadmap to 2050.

Assumptions:

- Upfront innovation costs are required to initiate the policy
- There is a delay before efficiency savings are realised

[16] Transferring Minimal Excavation Methods to The Water Industry, UKWIR, 22/WM/12/1, 2022

Table 3.31 ALC and Asset Renewal Innovation Outputs

Output	ALC Repairs	Asset Renewal
Cost (£m)	0.5	0.5
Efficiency	10%	10%
Delay	10 years	10 years

3.5 SoLow Optimisation

To identify the most economical route to achieving the leakage reduction scenario targets (Table 2.1) an optimisation approach is required that moves beyond the Sustainable Economic Level of Leakage (SELL). RPS has developed the Strategic Optimisation of Leakage Options for Water Resources (SoLow) model to achieve this.

The SoLow model takes WRZ level network characteristics and policies, as well as company-level leakage targets, and optimises which policies need to be taken and when to achieve each target for the least cost.

SoLow allows for a large number of flexible policy options and leakage management techniques to be assessed. Relationships between policies, leakage, and network characteristics have been considered within SoLow.

SoLow is populated with data including the following:

- Property counts and mains lengths forecast over the period
  - Note that no property growth has been included past 2050 (see section 3.5.3)
- Start year leakage (2024/25)
- Functional planning NRR
- Background leakage
- Leakage reduction option cost functions, scheme costs, savings, and other network considerations
- MCoW profile over the period
- Glide path (years), period of which investment in leakage options is to be considered
- Discount period (80 years)
- Discount rate[6]

A limit has been set on the number of schemes that can be chosen within a year to prevent the optimiser from selecting all of an option within the first year of the glide path. The limit is based on the maximum number of schemes for each policy, divided by the number of years within the glide path. Testing has shown that optimisation runs have not approached the annual scheme cap.

3.5.1 Start Year Leakage

For optimisation purposes, the starting position for distribution leakage (i.e., 'base year' distribution leakage) has been defined by the estimated 2024/25 reported leakage for South West Water of 98.3 Ml/d. This is based on the MLE adjusted value of distribution leakage. Start year leakage has been distributed to WRZ level using base year background leakage.

The active leakage control (ALC) cost functions and other leakage management interventions are based on DMA marginal unit cost data and are only relevant to distribution leakage control. Inputs for SoLow therefore exclude TMSR losses from total distribution leakage estimates to arrive at base year DMA leakage. For the purposes of optimisation trunk main leakage has been held static for the optimisation period at 10.5 Ml/d.

3.5.2 Intervention Cost Functions

Cost curve coefficients from ALC are applied in SoLow. The cost curves describe the relationship between the level of excess leakage and the cost of reducing leakage. The SoLow model utilises the cost curves in order to optimise for ALC interventions throughout the planning period.

Individual scheme costs and benefits are implemented for the other leakage reduction options. The schemes are ranked using AIC for each intervention. SoLow models the costs and benefits of these schemes throughout the planning period.

As costs change according to the level of leakage, SoLow selects the most cost-effective interventions for each year of the planning period, considering the selected options for all the other years of the glide path.

A number of leakage options are also able to influence the cost functions of others such that if they are picked then additional benefits will be realised. These are as follows:

- ALC repair innovation – increases the cost efficiency of ALC repairs from 2035
- Asset renewal innovation – provides an asset renewal cost efficiency from 2040
- Pressure management – proportionally adjusts AZNP affecting NRR, background leakage, leakage and ALC costs
- Asset renewal – influences the age of the mains network affecting NRR and background leakage
- Permanent acoustic logging – improves ALC detection efficiency
- DMA-Subdivision – improves ALC detection efficiency

3.5.3 Background Leakage

Background leakage has been held static from base year to the start year position and within SoLow it is assumed that background leakage will rise with property growth.

Initial optimisations identified that with projected property growth beyond 2050 the estimated background leakage would exceed total leakage and as such would be impossible to maintain. Therefore property growth and the associated background leakage increase has not been modelled beyond 2050, and values are held static from 2050 for the rest of the 80 year discount period.

In real terms this means that South West Water need to ensure that new mains constructed over this time period, to manage property growth, have a minimal level of background leakage. No additional costs have been assigned to this assumption, as efforts to lay leak free new networks for mains renewals should ensure that this is the case.

3.5.4 Planning NRR

Table 3.32 details the available company-level annual NRR results from Waternet. Following discussions with South West Water it has been recommended that the "planning" NRR used within SoLow optimisation is generated from an average of 2 years, 2020/21to 2021/22 as this data is of a better quality and representative of the direction the region is taking.

The planning NRR is applied in order to best reflect and plan for a 'typical' leakage year over the next planning period, based on the range of climate possibilities and their impact on leakage.

NRR variations over the planning period are influenced largely by seasonal and annual weather effects of leak break-out rates. For example, for years in which there were extreme winters (such as occurred 2017/18) the calculated NRRt is substantially higher than for those in which the weather was much more benign. It is therefore expected that climate related differences will account for much of the variation in NRR between years. Other factors which will have an influence on NRR include asset renewal and pressure management activities over the period.

The NRR values have an influence on the resulting marginal cost of ALC in those years most affected by climate. It is therefore important that for forward planning purposes the SoLow is calculated using NRR values and cost relationships that strike a balance between extreme winter conditions and very benign years, so that appropriate leakage control budgets are established.

Table 3.32 Annual Natural Rate of Rise Results

	2018/19	2019/20	2020/21	2021/22	Planning NRR
NRRt	182.15	177.92	251.68	257.23	254.46
NRRd	105.02	111.31	147.95	144.37	146.16
Ratio	58%	63%	59%	56%	57%

4 ANALYSIS

Optimisation runs using the SoLow tool have been made against each leakage reduction scenario (Table 2.1) using a 25-year glide path from 2024/25 to 2049/50 and the outputs from each of these scenarios are presented in (Table 4.1).

Table 4.1 Summary of Leakage Reduction Scenario Optimisation for the Period 2024/25 to 2049/50

Scenario	Leakage Reduction (Ml/d)	Total Undiscounted Cost (£)
1 – No Reduction	0	689,103,223
2 – Linear 50% by 2049/50	34.15	1,370,067,073
3 – Front Loaded	N/A	N/A
4 – Back Loaded	34.15	1,514,959,469
5 – Linear 50% by 2044/45	34.15	1,226,360,398
6 – Linear 50% by 2039/40	34.15	1,350,390,917
7 – Linear 25% by 2049/50	4.95	703,421,870

4.1 Scenario 1 - No Reduction

The no reduction scenario considers the ALC maintenance costs over the glide path and discount period to ensure that the 2024/25 start leakage position can be maintained. This is the activity required to overcome NRR and effectively stand still and not reduce leakage further. It is a useful baseline to which other leakage reduction scenarios can be assessed against. This has generated a total leakage management cost of £689.1m over the 25-year glide path to 2050 as shown in Table 4.2. It should be noted that early test scenarios identified that with projected property growth beyond 2050 and the associated increase in background leakage would result in unmaintainable levels of leakage. Subsequently, for the purposes of optimisation and modelling, property growth has been held static from 2050 through to the end of the discount period.

For reference, the grand total discounted costs are provided in Table 4.3.

Table 4.2 Scenario 1 Undiscounted Policy Costs

Leakage Option	Undiscounted Cost over Glide Path (£m)
ALC Maintenance	581.0
Cost of Water	108.1
Grand Total	689.1

Table 4.3 Scenario 1 Discounted Costs

Period	Total Discounted Cost (£m)
Glide (2024/25 – 2049/50)	445.7
Total (2024/25 – 2104/05)	811.0

4.2 Scenario 2 - Linear 50% by 2049/50

From a start leakage position of 98.3 Ml/d (2024/25), this scenario targets a 34.1 Ml/d leakage reduction by 2049/50 to achieve the 50% reduction from 2017/18 levels.

The leakage reduction profile can be seen in Figure 4.1 with the undiscounted cost profile shown in Figure 4.2. Both are summarised in Table 4.4.

Optimisation runs targeting this have achieved a 13.31 Ml/d leakage reduction by 2030 and 30.59 Ml/d leakage reduction by 2050. This required a significant asset renewal programme, which is most beneficial if implemented early in the glide path as it delivers additional background leakage reduction and ALC efficiencies. To deliver these benefits it is estimated 3,400km of mains will require renewal over the 25-year period. The optimisation indicates that significant benefit may be gained through pressure management and trunk main ALC.

Significant leakage reductions have been found through ALC/Lift and Shift work along with investment in innovation to reduce the cost of ALC repairs.

ALC/Lift and Shift maintenance costs over the 25-year glide path total £646.2m, with a further £1,992.8m to the end of the discount period

Discounted grand total costs are shown in Table 4.5.

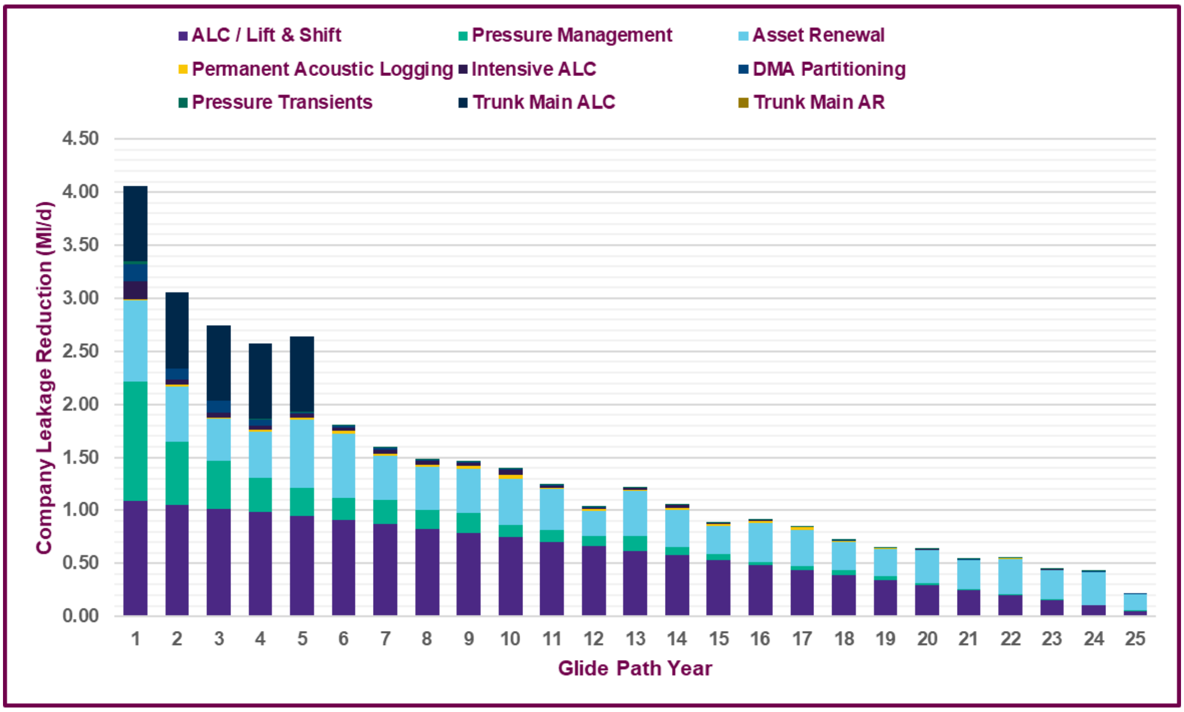

Figure 4.1 Scenario 2 Leakage Reductions by Year

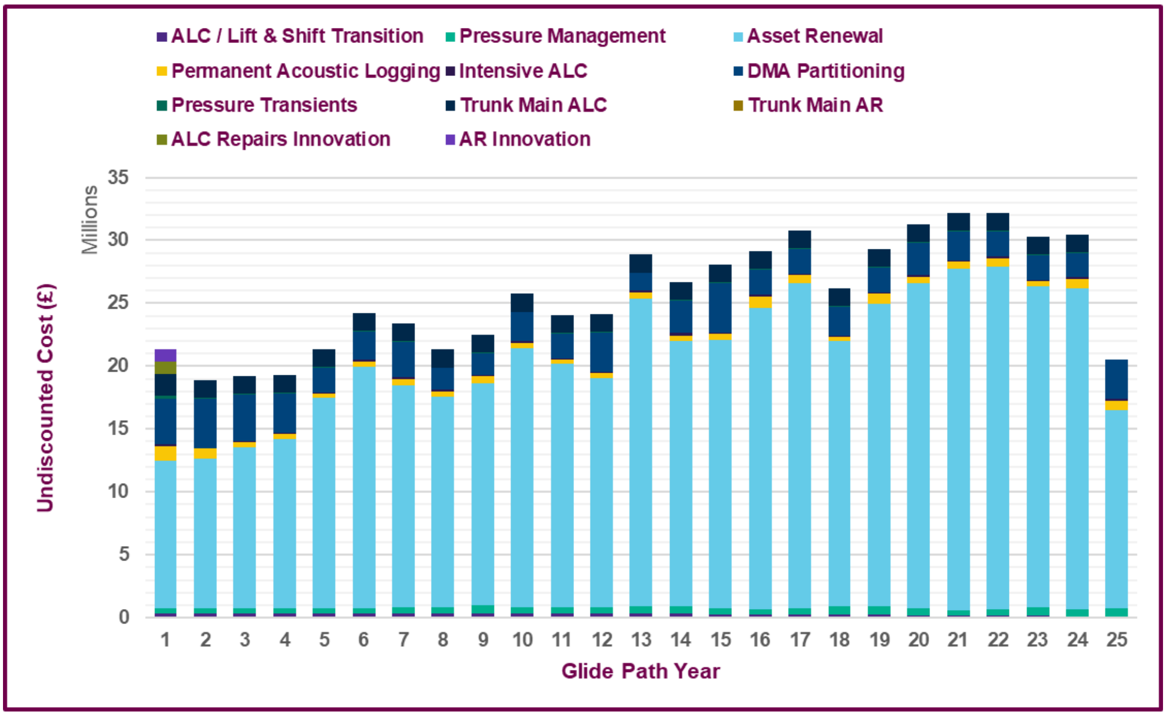

Figure 4.2 Scenario 2 Undiscounted Cost by Year

Table 4.4 Scenario 2 Cost and Reduction Summary

Leakage Option	Leakage Reduction (Ml/d)	Undiscounted Cost over Glide Path (£m)
ALC / Lift & Shift Transition	15.03	7.12
Pressure Management	4.36	12.69
Asset Renewal	9.59	504.55
Permanent Acoustic Logging	0.39	14.17
Intensive ALC	0.61	3.12
DMA Partitioning	0.55	61.77
Pressure Transients	0.06	1.80
Trunk Main ALC	3.56	34.11
Trunk Main AR		
ALC Repairs Innovation		1.00
AR Innovation		1.00
ALC / Lift & Shift Maintenance		646.20
Policy Subtotal	34.15	641.33
Cost of Water		82.54
ALC / Lift & Shift Total		**653.32**
Grand Total	**34.15**	**1,370.07**

Table 4.5 Scenario 2 Discounted Cost Summary

Period	Total Discounted Cost (£m)
Glide (2024/25 – 2049/50)	874.27
Total (2024/25 – 2104/05)	1,307.41

4.3 Scenario 3 - Front Loaded

From a start leakage position of 98.3 Ml/d in 2024/25, this scenario targets a leakage reduction of 8.5 Ml/d 2029/30, and a total leakage reduction of 34.1 by 2049/50 to achieve the PIC target of a 30% reduction from 2017/18 levels by 2030 and the target of a 50% reduction by 2050.

This 30% reduction by 2029/30 and 50% reduction by 2049/50 were achieved within Scenario 2. Efforts were made to hit the 30% 2029/30 target more closely within the optimisation runs, but as this scenario is a less optimal, the constraints required to shape the profile were judged to be too intrusive.

4.4 Scenario 4 - Back Loaded

From a start leakage position of 98.3 Ml/d (2024/25), this scenario targets a total leakage reduction of 34.1 Ml/d by 2049/50.

The leakage reduction profile can be seen in Figure 4.3, with the undiscounted cost profile shown in Figure 4.4**.** Both are summarised in Table 4.6.

For this scenario the optimisation delayed investment in asset renewal to year 9 of the glide path. After this time, it requires a significant asset renewal programme that delivers additional background leakage reduction and ALC efficiencies on top of its outwardly low leakage savings. To deliver these benefits it is estimated that 6,082 km of mains will require renewal over the period.

The optimisation indicates that benefits may be gained through trunk main ALC activities. Pressure management, intensive ALC and pressure transients also contribute to the leakage savings over the glide path.

Significant leakage reductions are projected to be achievable through ALC/Lift and Shift targeting along with investment in innovation to reduce the cost of ALC repairs.

ALC/Lift and Shift maintenance costs over the 25-year glide path total £631.5m, with a further £1,847.1m to the end of the discount period.

Discounted grand total costs are shown in Table 4.7.

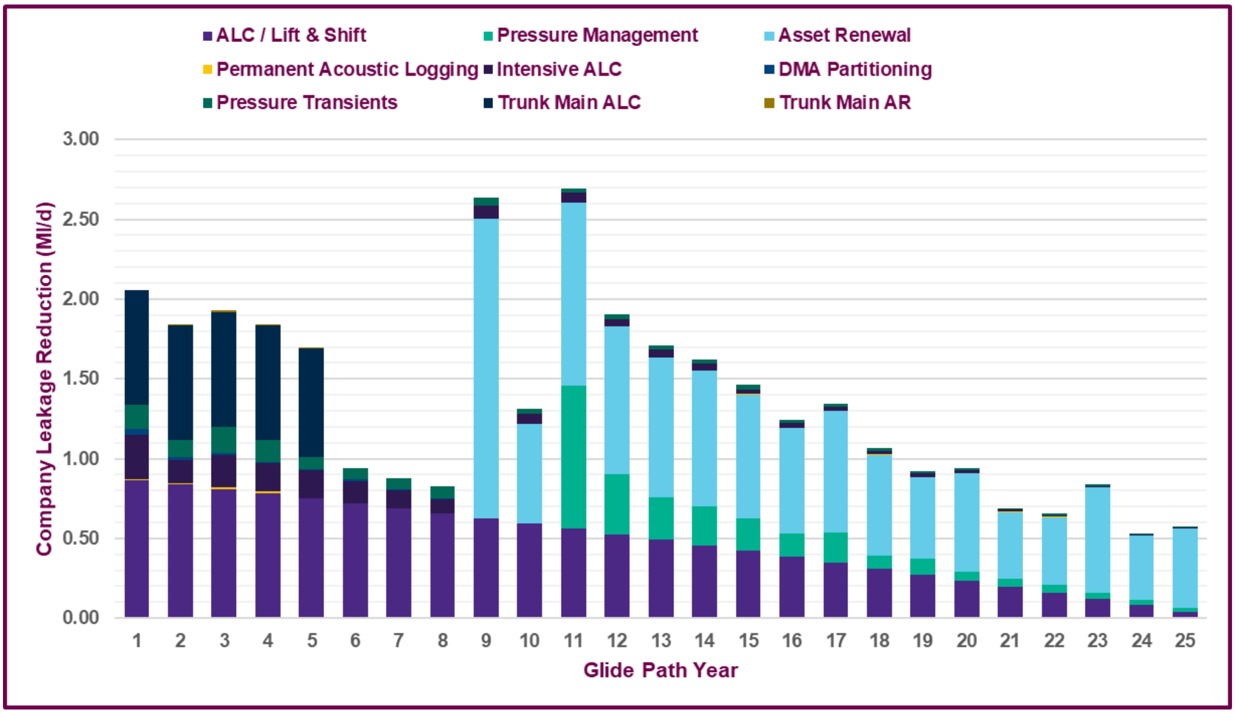

Figure 4.3 Scenario 4 Leakage Reduction by Year

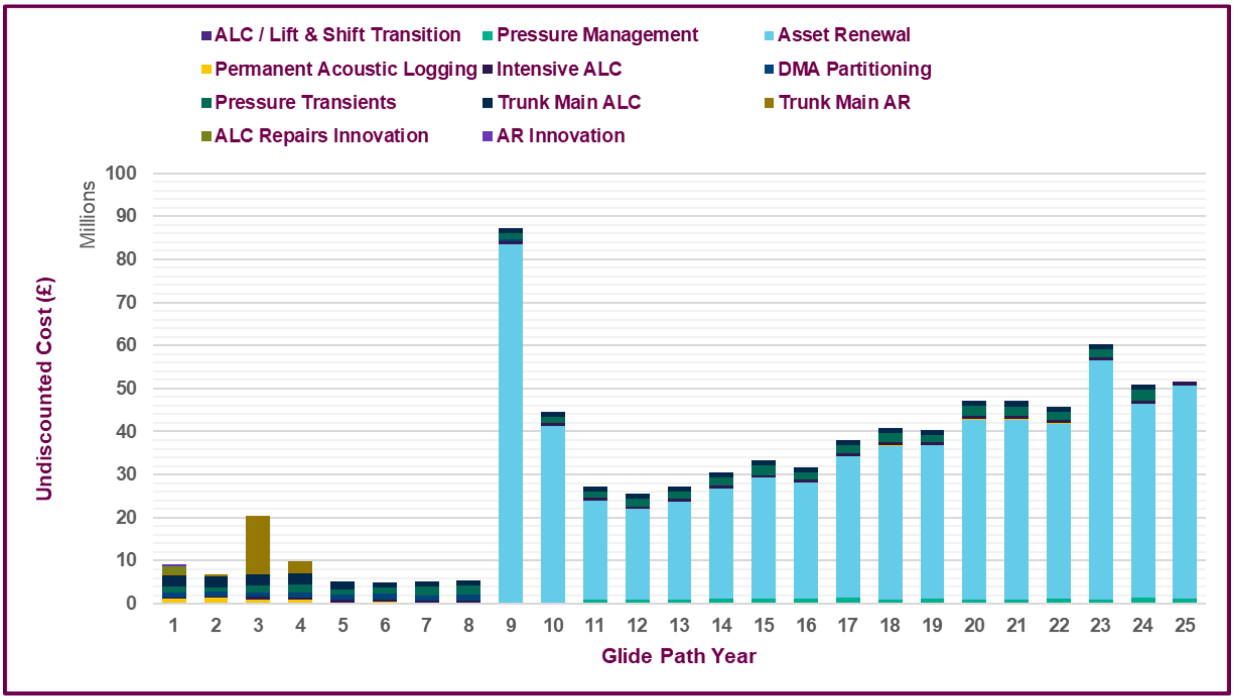

Figure 4.4 Scenario 4 Undiscounted Cost by Year

Table 4.6 Scenario 4 Cost and Reduction Summary

Leakage Option	Leakage Reduction (Ml/d)	Undiscounted Cost over Glide Path (£m)
ALC / Lift & Shift Transition	11.95	5.18
Pressure Management	2.74	14.57
Asset Renewal	12.68	649.48
Permanent Acoustic Logging	0.05	5.17
Intensive ALC	1.84	15.03
DMA Partitioning	0.11	10.14
Pressure Transients	1.20	42.70
Trunk Main ALC	3.56	34.90
Trunk Main AR	0.01	17.43
ALC Repairs Innovation		1.50
AR Innovation		0.50
ALC / Lift & Shift Maintenance		631.50
Policy Subtotal	34.15	796.58
Cost of Water		86.88
ALC / Lift & Shift Total		636.68
Grand Total	34.15	1,514.96

Table 4.7 Scenario 4 Discounted Cost Summary

Period	Total Discounted Cost (£m)
Glide (2024/25 – 2049/50)	929.39
Total (2024/25 – 2104/05)	1,332.96

4.5 Scenario 5 - Linear 50% by 2044/45

From a start leakage position of 98.3 Ml/d (2024/25), this scenario targets a total leakage reduction of 34.1 Ml/d by 2044/45, which is then maintained to 2049/50. The leakage reduction profile can be seen in Figure 4.5, with the undiscounted cost profile shown in Figure 4.6. Both are summarised in Table 4.8.

Optimisation runs targeting this have achieved a 30.88 Ml/d leakage reduction by 2045. This required a significant asset renewal programme, which is most beneficial if implemented early in the glide path as it delivers additional background leakage reduction and ALC efficiencies. To deliver these benefits it is estimated 4,593 km of mains will require renewal over the 25-year glide period. The optimisation indicates that significant benefit may be gained through pressure management and trunk main ALC.

Significant leakage reductions have been found through ALC/Lift and Shift work along with investment in innovation to reduce the cost of ALC repairs.

ALC/Lift and Shift maintenance costs over the 25-year glide path total £645.8m, with a further £1,911.1m to the end of the discount period.

Discounted grand total costs are shown in Table 4.9.

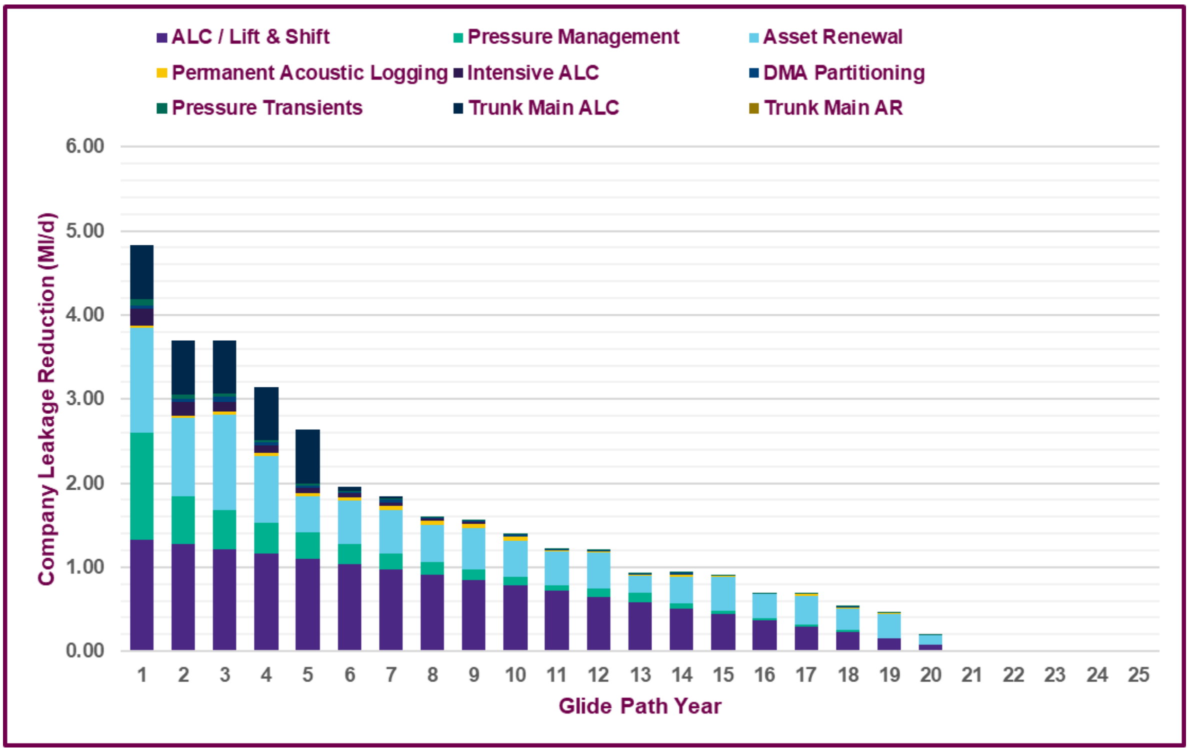

Figure 4.5 Scenario 5 Leakage Reduction by Year

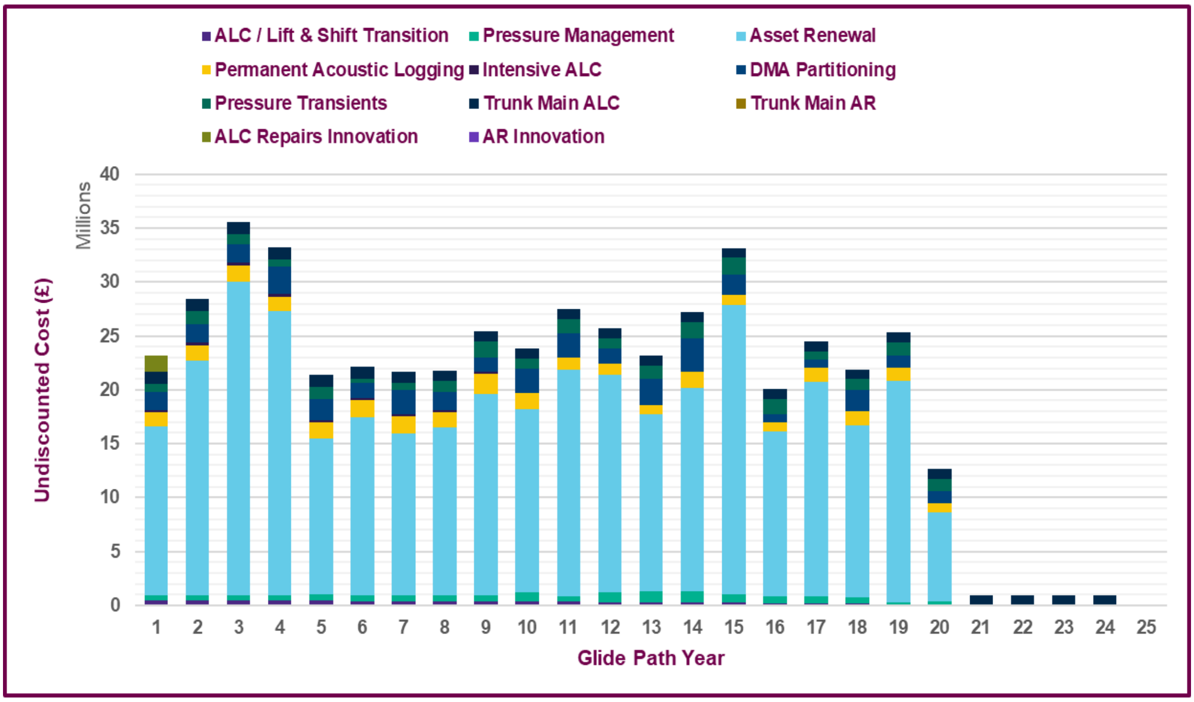

Figure 4.6 Scenario 5 Undiscounted Cost by Year

Table 4.8 Linear 50% by 2044/45 Scenario Cost and Reduction Summary

Leakage Option	Leakage Reduction (Ml/d)	Undiscounted Cost over Glide Path (£m)
ALC / Lift & Shift Transition	14.66	6.51
Pressure Management	4.29	12.17
Asset Renewal	9.90	373.36
Permanent Acoustic Logging	0.57	25.45
Intensive ALC	0.74	1.89
DMA Partitioning	0.42	35.65
Pressure Transients	0.31	21.43
Trunk Main ALC	3.26	23.48
Trunk Main AR		
ALC Repairs Innovation		1.50
AR Innovation		
ALC / Lift & Shift Maintenance		645.79
Policy Subtotal	34.15	501.45
Cost of Water		79.12
ALC / Lift & Shift Total		652.30
Grand Total	34.15	1,226.36

Table 4.9 Linear 50% by 2044/45 Scenario Discounted Cost Summary

Period	Total Discounted Cost (£m)
Glide (2024/25 – 2049/50)	823.90
Total (2024/25 – 2104/05)	1,240.36

4.6 Scenario 6 - Linear 50% by 2039/40

From a start leakage position of 98.3 Ml/d (2024/25), this scenario targets a total leakage reduction of 34.1 Ml/d by 2039/40, which is then maintained to 2049/50.

The leakage reduction profile can be seen in Figure 4.7, with the undiscounted cost profile shown in Figure 4.8. Both are summarised in Table 4.10.

Optimisation runs targeting this have achieved a 32.52 Ml/d leakage reduction by 2040. This required a significant asset renewal programme, which is most beneficial if implemented early in the glide path as it delivers additional background leakage reduction and ALC efficiencies. To deliver these benefits it is estimated 3,997.2 km of mains will require renewal over the 25-year glide period. The optimisation indicates that significant benefit may be gained through pressure management and trunk main ALC.

Significant leakage reductions have been found through ALC/Lift and Shift work along with investment in innovation to reduce the cost of ALC repairs.

ALC/Lift and Shift maintenance costs over the 25-year glide path total £643.3m, with a further £1,847.7m to the end of the discount period.

Discounted grand total costs are shown in Table 4.11.

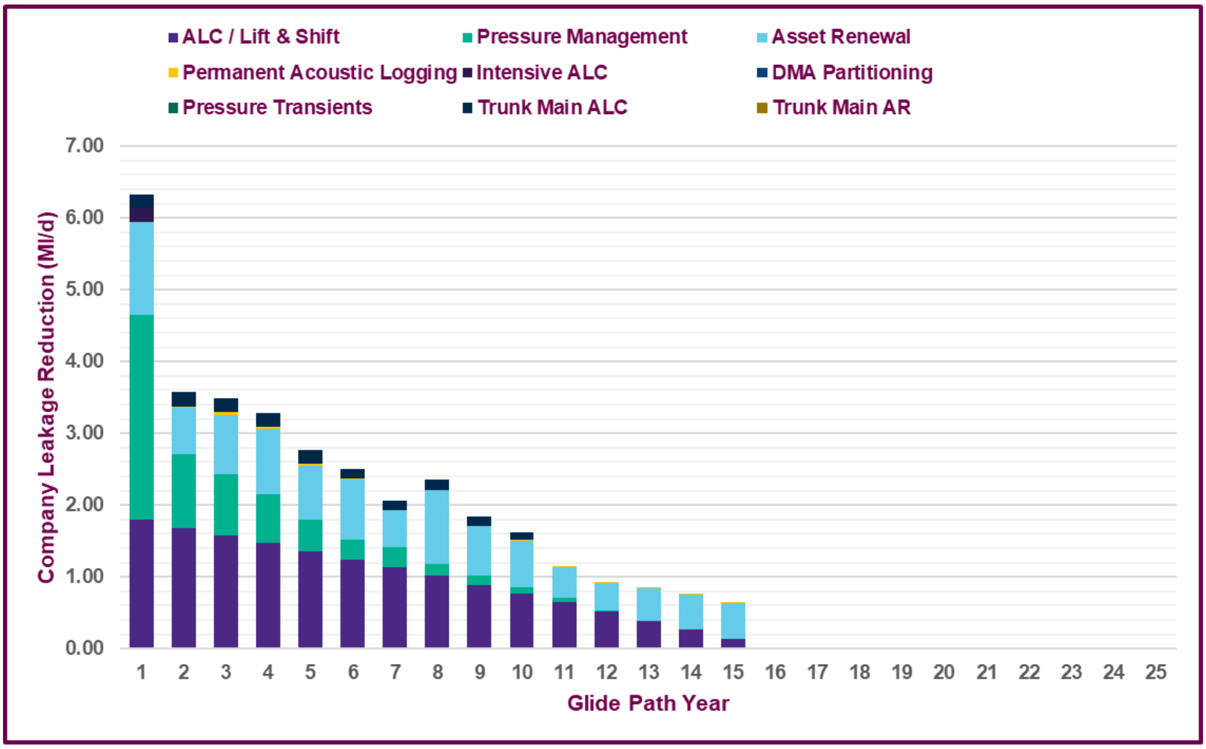

Figure 4.7 Scenario 6 Leakage Reduction by Year

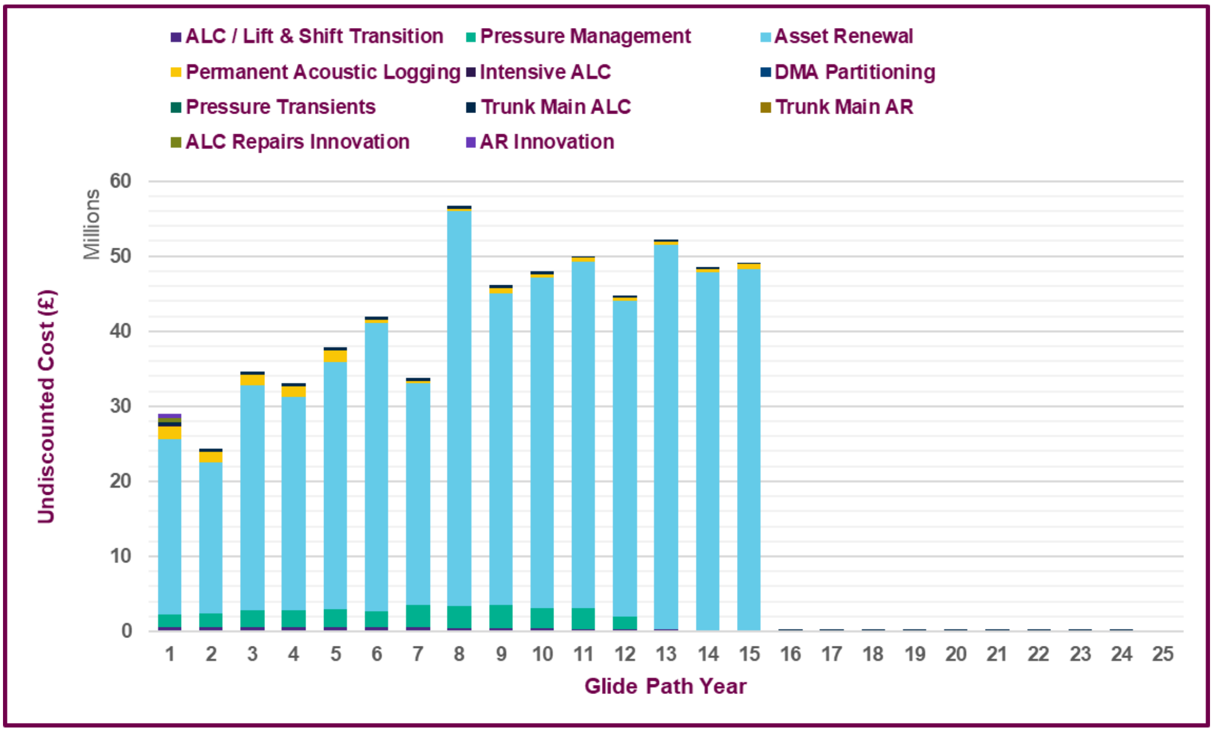

Figure 4.8 Scenario 6 Undiscounted Cost by Year

Table 4.10 Linear 50% by 2039/40 Scenario Cost and Reduction Summary

Leakage Option	Leakage Reduction (Ml/d)	Undiscounted Cost over Glide Path (£m)
ALC / Lift & Shift Transition	14.89	6.65
Pressure Management	6.88	28.39
Asset Renewal	10.38	576.27
Permanent Acoustic Logging	0.18	11.88
Intensive ALC	0.18	0.21
DMA Partitioning		
Pressure Transients		
Trunk Main ALC	1.64	7.52
Trunk Main AR		
ALC Repairs Innovation		0.5
AR Innovation		0.5
ALC / Lift & Shift Maintenance		643.30
Policy Subtotal	34.15	631.92
Cost of Water		75.16
ALC / Lift & Shift Total		649.96
Grand Total	34.15	1,350.39

Table 4.11 Linear 50% by 2039/40 Scenario Discounted Cost Summary

Period	Total Discounted Cost (£m)
Glide (2024/25 – 2049/50)	931.68
Total (2024/25 – 2104/05)	1,334.23

4.7 Scenario 7 - Linear 25% by 2049/50

From a start leakage position of 98.3 Ml/d (2024/25), this scenario targets a total leakage reduction of 2.1 Ml/d by 2049/50.

The leakage reduction profile can be seen in Figure 4.9, with the undiscounted cost profile shown in Figure 4.10. Both are summarised in Table 4.12.

Optimisation runs targeting this have achieved a 4.95 Ml/d leakage reduction by 2050. A significant proportion of this reduction has been achieved by pressure management, with a small amount of permanent acoustic logging also being required.

ALC/Lift and Shift maintenance costs over the 25-year glide path total £581m, with a further £1,572m to the end of the discount period.

Discounted grand total costs are shown in Table 4.13.

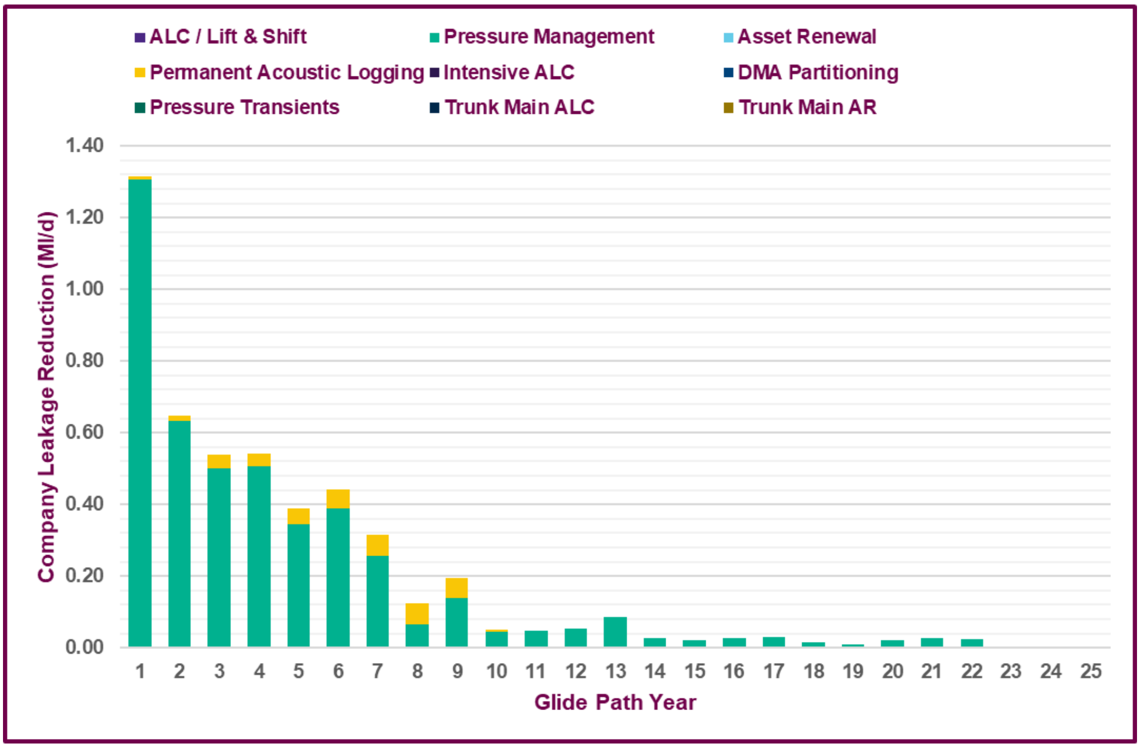

Figure 4.9 Scenario 7 Leakage Reduction by Year

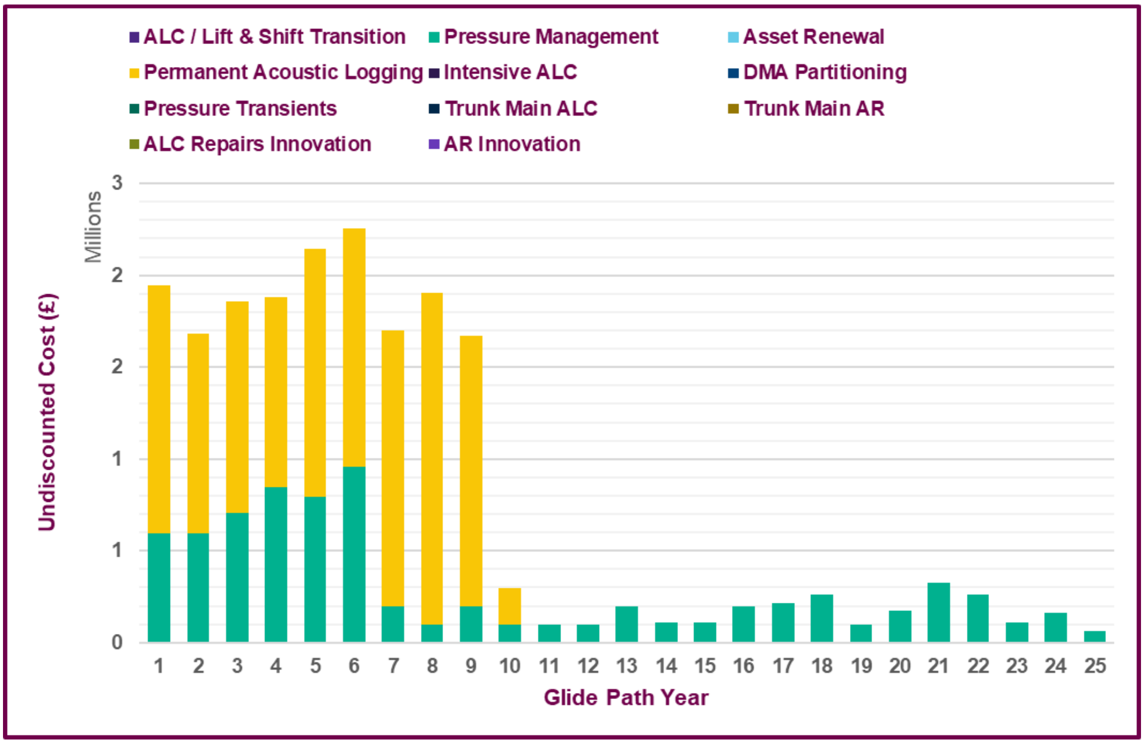

Figure 4.10 Scenario 7 Undiscounted Cost by Year

Table 4.12 Linear 25% by 2049/50 Scenario Cost and Reduction Summary

Leakage Option	Leakage Reduction (Ml/d)	Undiscounted Cost over Glide Path (£m)
ALC / Lift & Shift Transition		
Pressure Management	4.58	7.59
Asset Renewal		
Permanent Acoustic Logging	0.37	12.26
Intensive ALC		
DMA Partitioning		
Pressure Transients		
Trunk Main ALC		
Trunk Main AR		
ALC Repairs Innovation		
AR Innovation		
ALC Lift & Shift Maintenance		580.87
Policy Subtotal	4.95	19.85
Cost of Water		102.71
ALC / Lift & Shift Total		580.87
Grand Total	4.95	703.42

Table 4.13 Linear 25% by 2049/50 Scenario Discounted Cost Summary

Period	Total Discounted Cost (£m)
Glide (2024/25 – 2049/50)	458,903,488
Total (2024/25 – 2104/05)	820,415,109

5 DISCUSSION

Optimisations have been carried out against each leakage reduction scenario. This initial assessment has indicated that much of the required savings may be achievable through current leakage management techniques. It has been found that significant asset renewal will be required to achieve the 50% leakage reduction targets set by Ofwat for 2050, particularly given the projected property growth forecast for the region. It has also been indicated that early investment in asset renewal may be necessary to overcome background leakage and make the 50% leakage reduction target more achievable.

Ofwat have published further guidance on PR24 long term delivery strategies providing common reference scenarios to give a framework for water companies to use in the development of long-term plans. The common reference scenarios outlined by Ofwat are designed to alleviate some of the risk and uncertainty around investment requirements to meet future challenges. By providing “plausible variations in key assumptions” companies can test their long-term plans against eight common reference scenarios. Of particular relevance to the leakage reduction scenario design is the consideration of high and low technology scenarios.

Both scenarios refer to smart water supply networks that provide real time asset condition information and automatic detection of potential leaks. The high scenario has an expected implementation of smart networks by 2035, whilst the low scenario pushes this back 5 years to 2040. Alongside this, the high scenario expects 100% smart metering penetration by 2050.

The optimisation work carried out here has indicated that further investment in a permanent acoustic logging network and increased monitoring penetration through DMA sub-division would be beneficial. The earlier the investment and roll out of these technologies aligns with the journey towards smart water supply networks. Investment in innovation to drive efficiencies in ALC repair and Asset Renewal techniques has also been shown to beneficial.

South West Water are accounting for potential savings from AMR and AMI smart metering separately. The cost of smart metering is high and extensive implementation is required to realise the benefits. Initial modelling has indicated that due to the cost-leakage benefit ratio it is unlike to be chosen for leakage reduction in isolation, however further benefits such as a much better understanding of consumption should be considered.

5.1 Recommendations

Future considerations and recommendations related to the WRMP planning:

- A number of leakage options are considered to have some uncertainty with respect to costs and leakage saving assumptions, which would benefit from further validation, trials and refinement before finalisation of leakage options for WRMP 2024. For example, the evidence for leakage reduction from pressure transient reduction has bene largely anecdotal and would benefit from further investigation and refinement.
- An assessment of the cost uncertainties could be undertaken to provide upper and lower bounds given the leakage options chosen.
- A number of assumptions used within the optimisation may also benefit from further validation and refinement to ensure that they are truly representative of South West Water’s distribution network. For example, frontier background leakage estimates could be considered rather than using MAL.
- A full sensitivity analysis could be undertaken to understand the impact of input elements such as background leakage and NRR.
- Further detailed analysis of leakage option carbon externalities and development of net zero carbon scenarios should be considered for future iterations of the assessment and optimisation process to fully align with Ofwat common reference scenarios.