DD Supporting Evidence: EJP09

Cost Beneficial Mains Replacement

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1 Introduction

This document should be read in conjunction with the Engineering Justification Paper EJP09 - Cost Beneficial Mains Replacement.

This document contains additional supporting evidence, aligned with Ofgem's requirements. (RIIO-3 Business Plan Guidance – Annex 1 – IDP Guidance v3)

This document contains the following additional information:

Content	Annex	Commentary
Equipment Summaries	Annex A	Analysis of historical asset data across four regions, highlighting the shift to polyethylene (PE) pipes and the reduction of iron mains and steel services. Includes RIIO1 and RIIO2 RRP sources for reference.
Diameter Band Breakdown of Chosen Option	Annex B	Details of the diameter bands of decommissioned assets in our chosen option, by year, for each regulatory network.
How We Have Selected the Right Programme	Annex C	Details of how we have selected the programme of work and the assumptions made in our modelling approach.
Deliverability Considerations	Annex D	Details of how we have assessed the deliverability of our chosen option.
Enhanced Emissions Assessment	Annex E	Analysis of our enhanced emissions data and assessments, and how we will use advanced leakage management and leak detection to target proactive mains replacement in-period.
CBA Costs and Benefits Explanation	Annex F	Details of the assumptions made in building our cost benefit analysis.
Robust and Efficient Unit Costs	Annex G	Details of how we have calculated our unit costs, and how they are efficient.
Detailed Options-Level Data	Annex H	Detailed data of each of our options, including volume of replacement, volume of robotic intervention (where applicable), volume of service, and costs.

2 Annex A: Equipment Summaries

The following document section sets out details of the below 7 bar distribution mains across our four networks (East of England, North London, North West, and West Midlands). It highlights trends in material usage, such as the adoption of Polyethylene (PE) pipes to replace iron mains in line with the IMRRP. This annex provides data sources and tables from the RIIO1 and RIIO2 Regulatory Reporting Packs (RRPs) for accurate reference.

Table 1 shows the total distribution mains population by material and network in kilometres. In the time period shown the volume of iron assets has reduced from 23% of the network to 15%, with PE increasing from 71% to 80%.

	km	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
EE	PE	36,349	37,048	37,775	38,434	39,069	39,814	40,562
	Steel	3,030	3,011	2,968	2,932	2,932	2,916	2,906
	Cast Iron	3,800	3,585	3,320	3,104	2,918	2,697	2,508
	Spun Iron	3,773	3,396	3,073	2,788	2,596	2,378	2,159
	Ductile Iron	2,330	2,303	2,259	2,188	2,030	1,860	1,653
	Other Materials	1	1	1	-	2	2	2
NL	PE	13,335	13,716	14,059	14,322	14,669	15,031	15,395
	Steel	982	978	961	955	942	899	884
	Cast Iron	2,600	2,410	2,257	2,138	2,021	1,919	1,803
	Spun Iron	2,175	2,057	1,933	1,846	1,737	1,606	1,482
	Ductile Iron	1,170	1,137	1,107	1,076	994	933	880
	Other Materials	-	-	-	-	-	-	-
NW	PE	24,543	24,929	25,408	25,893	26,373	26,855	27,298
	Steel	1,421	1,414	1,379	1,354	1,332	1,286	1,274
	Cast Iron	3,945	3,734	3,548	3,301	3,073	2,864	2,675

	km	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
	Spun Iron	2,028	1,897	1,706	1,542	1,426	1,288	1,168
	Ductile Iron	1,238	1,227	1,184	1,137	1,042	973	896
	Other Materials	77	68	60	58	56	54	50
WM	**PE**	15,830	16,140	16,475	16,891	17,250	17,672	18,016
	Steel	1,513	1,500	1,492	1,487	1,489	1,489	1,488
	Cast Iron	3,267	3,089	2,887	2,657	2,508	2,306	2,096
	Spun Iron	1,695	1,594	1,500	1,370	1,267	1,185	1,110
	Ductile Iron	1,022	1,014	1,006	970	925	886	849
	Other Materials	-	-	-	-	-	-	-

Table 1: Distribution Mains by Material and Network

3 Annex B: Diameter Band Breakdown of Chosen Option

Diameter Band Breakdown, Option 1, East of England (Km)						
Diameter Band Decommissioned	2026/27	2027/28	2028/29	2029/30	2030/31	Total
Band A	1.02	1.16	4.68	4.94	8.82	**20.61**
Band B	1.80	3.82	9.30	7.66	7.26	**29.85**
Band C	4.07	8.29	10.10	5.87	5.71	**34.04**
Band D	3.61	2.58	2.75	7.99	4.73	**21.65**
Band E	0.19	0.14	3.65	4.93	0.76	**9.66**
Band F	10.43	13.27	20.46	18.56	15.87	**78.59**
Band G	1.68	4.02	4.65	1.87	1.01	**13.23**
Band H	1.85	2.99	3.61	4.73	4.73	**17.92**
Band I	0.09	-	1.23	-	-	**1.32**
Total	**24.74**	**36.27**	**60.45**	**56.53**	**48.89**	**226.88**

Table 2: Diameter band of decommissioned assets in East of England for Option 1.

Diameter Band Breakdown, Option 1, North London (Km)						
Diameter Band Decommissioned	2026/27	2027/28	2028/29	2029/30	2030/31	Total
Band A	0.90	1.10	1.28	1.09	2.44	**6.81**
Band B	2.85	5.59	9.90	10.03	7.66	**36.02**
Band C	1.29	0.65	1.22	1.77	3.40	**8.32**
Band D	1.02	1.26	2.61	2.12	1.00	**8.00**
Band E	0.78	-	-	-	-	**0.78**
Band F	1.78	1.73	0.46	0.22	0.34	**4.53**
Band G	0.54	0.06	0.83	0.09	0.03	**1.55**
Band H	0.69	1.08	1.79	1.40	1.24	**6.20**
Band I	-	-	-	0.36	-	**0.36**
Total	**9.84**	**11.46**	**18.08**	**17.08**	**16.11**	**72.57**

Table 3: Diameter band of decommissioned assets in North London for Option 1.

Diameter Band Breakdown, Option 1, Northwest (Km)						
Diameter Band Decommissioned	**2026/27**	**2027/28**	**2028/29**	**2029/30**	**2030/31**	**Total**
Band A	2.18	3.54	4.05	4.91	7.63	**22.30**
Band B	2.24	3.92	7.82	5.36	2.22	**21.56**
Band C	1.43	2.17	2.98	4.47	3.54	**14.59**
Band D	0.94	0.14	1.15	2.07	1.01	**5.30**
Band E	1.61	1.32	3.24	7.21	2.51	**15.88**
Band F	7.97	10.58	18.46	15.55	9.11	**61.67**

Diameter Band Breakdown, Option 1, Northwest (Km)						
Diameter Band Decommissioned	**2026/27**	**2027/28**	**2028/29**	**2029/30**	**2030/31**	**Total**
Band G	0.16	2.44	2.26	0.91	1.83	**7.60**
Band H	0.79	1.20	1.89	1.90	1.88	**7.67**
Band I	-	-	-	-	-	**-**
Total	**17.31**	**25.29**	**41.84**	**42.37**	**29.75**	**156.57**

Table 4: Diameter band of decommissioned assets in Northwest for Option 1

Diameter Band Breakdown, Option 1, West Midlands (Km)						
Diameter Band Decommissioned	**2026/27**	**2027/28**	**2028/29**	**2029/30**	**2030/31**	**Total**
Band A	0.02	1.00	2.05	1.42	4.03	**8.52**
Band B	1.72	5.09	8.84	7.72	7.01	**30.38**
Band C	5.14	4.55	5.06	8.02	6.95	**29.72**
Band D	1.99	3.14	6.15	6.05	4.91	**22.24**
Band E	0.13	0.63	1.06	0.13	0.19	**2.14**
Band F	5.24	5.27	9.74	10.84	4.24	**35.34**
Band G	0.40	1.74	2.89	1.84	1.56	**8.43**
Band H	0.18	0.81	1.38	1.47	1.31	**5.15**
Band I	0.26	0.08	0.09	-	0.01	**0.43**
Total	**15.07**	**22.31**	**37.25**	**37.49**	**30.21**	**142.34**

Table 5: Diameter band of decommissioned assets in West Midlands for Option 1

4 Annex C: How We Have Selected the Right Programme

This section builds on the information contained in **Section 3: Introduction** within **EJP09**, which sets out our investment methodology.

The Network Asset Risk Measures developed with Ofgem is an approach that allows us to understand risk on our assets and the benefit that investment will have. The reporting approach covers several asset categories including distribution mains. The distribution model is the most robust within the NARMs reporting suit.

In RIIO-1 and RIIO-2 we have invested in advanced software to allow us to build asset management capability using the NARMs approach. We have included an optimisation capability which allows us to model different investment scenarios, produce optimised plans and test their cost-benefit.

The diagram below shows how the NARMs model has been enhanced to enable CBA to be carried out for the RIIO-3 plan and how the models are used to populate the various data templates Ofgem requires as part of the submission.

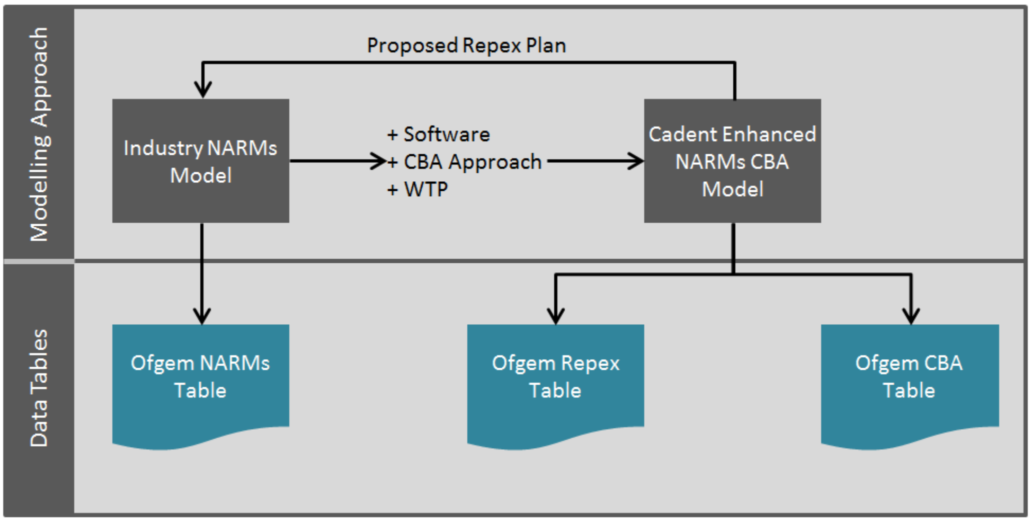

Figure 1: Schematic Showing Model Development and Sources of Data for Data Tables

The CBA capability within our software can find the solution to a problem with many restrictions and millions of viable, individual investment decisions.

The model contains a copy of the mains assets operated by Cadent and can forecast how the asset base will perform into the future in terms of asset failure, customer impact and cost. The model we have used for RIIO-3 planning is at an asset level, this allows each individual pipe and its performance to be modelled and results in a very precise output for the plan.

The model can be configured so that an optimised solution can be found for either a set of intervention constraints or a set of specific performance targets.

Below are the central elements of the modelling approach we have used for RIIO-3 planning. They are essential in driving the investment choices and finding the most efficient plan for our customers.

CBA Approach: Cost-benefit analysis is widely recognised as an essential input into the business case for any investment proposal. The purpose of doing CBA is to assess the economic case for investment. It determines if the benefits of any given investment outweigh the costs. If they do, the investment is considered 'value for money'. Our formalised approach to CBA allows us to understand for each option costs in RIIO-3 and beyond, NPV, payback, and the NPV/Spend ratio – which we consider and balance alongside stakeholder and customer views in assessing and developing our plans.

An important element of a CBA approach is the discounting of investments over time. Ofgem recommends the Spackman method for discounting. This method has been embedded in our modelling approach.

Asset Failure and Deterioration: To determine how assets perform a number of statistical models have been developed to predict the probability of failure given a set of asset attributes such as age, material, location, diameter, and length. These predictors generate a cohort approach which treats like pipes (same material/age/diameter etc) as equals.

The following failure types have been modelled:

- Corrosion
- Joint failure
- Fracture
- Interference
- Capacity

To allow the modelling approach to understand the differences between individual assets, we apply a tuner to the results of the final pipe level model. This model is applied to consider all the variation that is not explained by the fixed predictors as well as any random variation between individual assets.

Model results are shown in the figure below. A perfect fit would lie along the diagonal dashed line, and it can be seen the effect of the Bayesian Tuner (green) is to significantly improve the model predictions at individual pipe level as compared to the un-tuned predictions (red). It should be noted that most of the data is clustered in the bottom left corners of each plot. We only apply the tuner to the last 3 years of failures so that the model reflects the assets as observed over recent history. This model is used for the starting positions in the model.

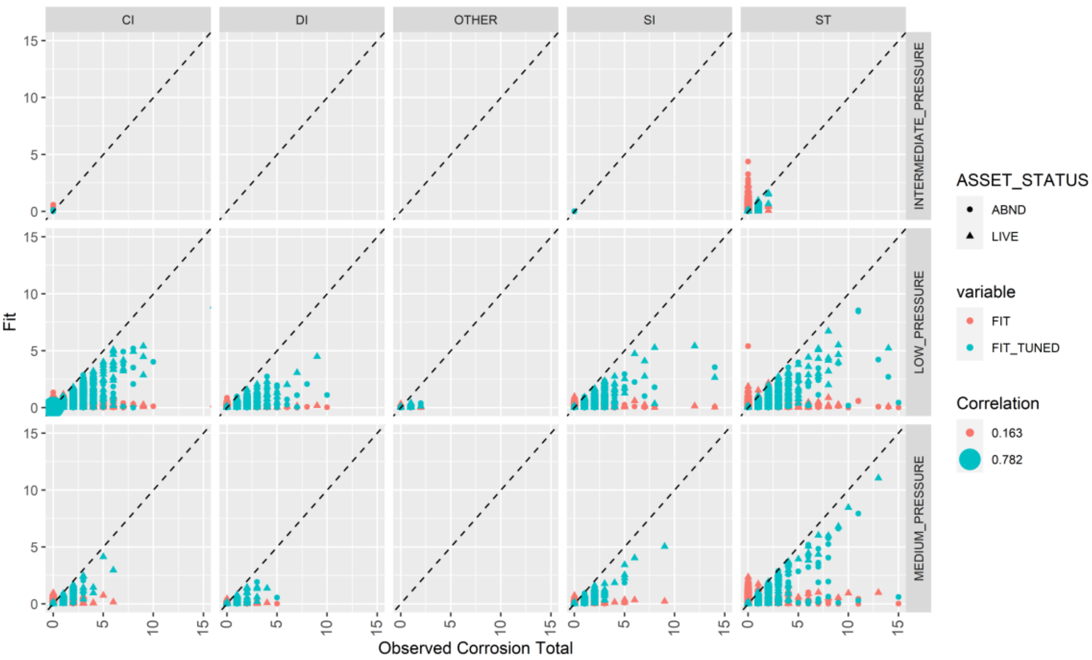

Figure 2: Corrosion - pipe-level model - observed versus fitted/tuned

Deterioration is calculated by adding asset age into the existing failure model as a continuous predictor. Adding age into the model like this allows us to quantify the effect of asset age while normalising out all other pipe attributes. The result is the quantifying of the percentage change in failure rates between pipes as age increases. This had been done as an industry-wide project as part of the Long Term Risk (LTR) Network Asset Risk Metric (NARM) update, and currently in review status by OFGEM (240405 GDN NARM Reporting Methodology 2024 v6 Final).

We have used the NARMS model update for the mains with deterioration coefficients shown in the table and plot the below (Table 66 and Figure 33) For corrosion and joint failure, 'material' was chosen as that has the biggest impact on pipe failure rates as assets age. For fracture, capacity and interference, a constant deterioration is applied.

	Cast Iron	Ductile Iron	Spun Iron	Steel	Asbestos
Corrosion	2.15%	3.00%	2.10%	3.71%	1.89%
Joint Failure	2.90%	2.09%	3.03%	1.39%	2.14%
Fracture	5.10%	5.10%	5.10%	5.10%	5.10%

Table 6: Deterioration Rate by Material

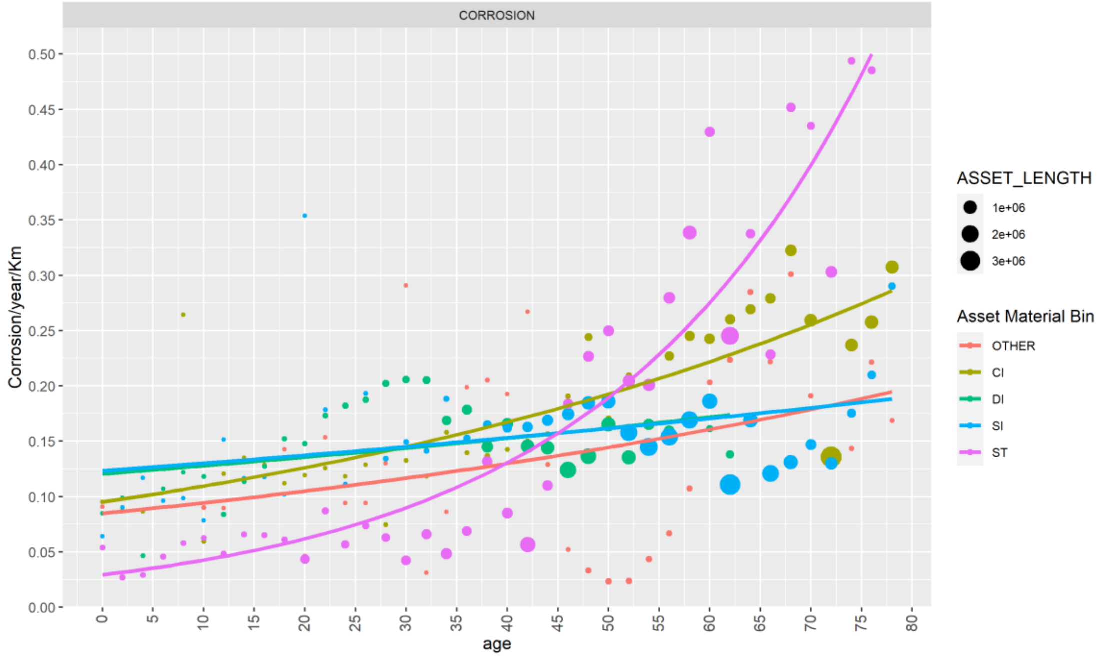

Figure 3: Deterioration Rate by Material

Repex Unit Costs: Our 2018/19 unit costs form the base of our plan. We have developed detailed cost models using our delivery experience over the start of the RIIO-1 period, considering the diameter, location, service density, insertion rate and length of scheme. Using these unit costs, the model can accurately assign unit costs to individual pipes within the network. For further detail see EJP09-SE-Cost Beneficial Mains Replacement, Annex G.

Super Strings: Amongst various cost drivers, the Repex unit cost is dependent on scheme length. So that the improved cost-benefit of longer length schemes can be captured and included within the RIIO-3 plan, the modelling approach we are using has the concept of 'super strings'. These are sections of connected pipes that are understood by the model, so it has the choice of either renewing individual sections of mains or grouping neighbouring mains into a longer scheme where it makes economic sense to do so.

The diagram below shows how the model understands the assets; the green shading indicates a CBA-positive asset and red a CBA-negative asset. The model can 'see' and invest in an individual asset, or the same assets can be 'seen' as a continuous length. Investment in the longer length 'super string' may be more CBA-positive than investment in the three shorter individual cost beneficial sticks as there is efficiency in cost for delivering longer-length schemes (mobilisation and design costs per metre are reduced). The super string does not hide non-cost-beneficial work within a cost-beneficial scheme but rather understands that with reduced mobilisation costs an NPV positive scheme will become more NPV positive and an otherwise NPV-negative scheme will become less negative or in fact NPV-positive. For further discussion on the CBA approach see EJP09-SE-Cost Beneficial Mains Replacement, Annex F.

The superstring approach is both advanced and innovative; it brings some of the efficiencies that would previously be identified at the detailed design stage (or which might be missed altogether) forward to the beginning of the pipeline selection processes. This produces better schemes and reduces costs for customers. It also addresses feedback we have had from customers about dealing with issues on a single visit rather than leaving sections of pipe to be picked up later.

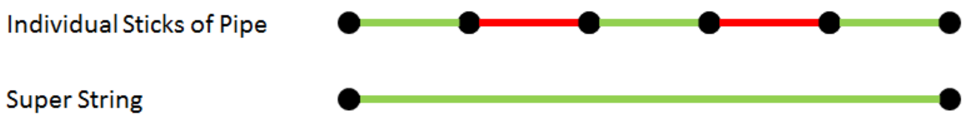

Figure 4: Super String Example

Other Assumptions applied within our decision-making approach:

- **Dynamic Growth:** no dynamic growth has been assumed as part of the safety or CBA business cases.
- **Stubs:** Where tier 2 and 3 mains are being replaced as part of our ongoing renewal programme and these mains have stubs attached, the stub will be replaced as part of the work making the IMRRP more efficient (see EJP08-Mains IMRRP (Including Associated=2" Steel)). The cost is assumed to be carried out with no impact on the Tier 2 or Tier 3 unit costs.
- **Services:** Our forecast of service volumes has been done using advanced spatial analysis, mapping meter points to the mains most likely to feed this meter via the service. This analysis has given us an estimated volume of services associated with each main.

5 Annex D: Deliverability Considerations

As part of optimising our preferred mains replacement programme we have undertaken a comprehensive deliverability review in the following areas, considering what skills and capacity are needed from both our delivery partners, suppliers and Cadent staff:

- **Design and planning of pre-construction** activities including early stakeholder engagement with Highways and Local Authorities
- **Logistics and Supply chain management:** We are considering our options to secure appropriate volumes of pipe materials to site, whilst driving cost reductions through central procurement and managing the logistics of national and local distribution centres.
- **Commercial and Procurement Strategy**: Engagement with pipe, flow-stop, and pipe fitting suppliers has demonstrated that with adequate notice, there is sufficient manufacturing capacity to supply Cadent’s needs, without impacting on supply-costs.
- **Streetworks coordination and collaboration**: Due to the additional complexity of Tier 2 and 3 works, additional time for pre-planning and collaborative Streetworks approaches are an important consideration.
- **Delivery Operations and Competency**: Cadent is utilising the skills and knowledge gained through delivery of the London Medium Pressure Scheme (in central London). This will form the basis for ongoing mentoring and training on deep excavations, hot works, and lifting techniques.

We utilised input from Subject Matter Experts across each discipline within the business to inform the constraints feeding into the modelled scenarios and then further reviewed the outputs of each scenario relative to each network, including the requirement to scale up on delivery.

A key factor to consider against this is the external contract labour (Local Delivery Partners) utilised to deliver this workload. We regularly review their skillsets, tools, plant and equipment available to them. Our latest review has shown that our LDPs would only require ~9% increase in available teams to deliver the most ambitious of the proposed scenarios.

This in-depth review of LDP and individual competencies has proven that there are adequate skilled resources available to lead teams to deliver both the tier 2 and tier 3 workload volumes which is where the greatest skills gap is deemed to exist. We intend to build and develop this further throughout our mains-replacement programme through mentoring and support with training across these disciplines.

Finally, to ensure that these resources continue to be available to us, we are progressing to renew our LDP framework agreement, to secure these resources throughout the RIIO-3 period.

6 Annex E: Enhanced Emissions Assessment

6.1 Cadent's Evolution in Leakage Management

Cadent is pioneering a shift towards a leakage management strategy driven by observed emissions data, moving beyond the limitations of traditional industry models like the Shrinkage and Leakage Model (SLM). While the SLM has historically been used to estimate shrinkage based on a limited set of asset characteristics, such as pipe diameter, material, and pressure, to identify 'cohorts' of assets with potentially higher emissions, it does not account for asset condition or the impact of interventions. Consequently, it cannot accurately estimate actual leaks on specific assets within these cohorts.

Although the SLM has supported significant shrinkage reductions during RIIO-2, its capacity to inform a proactive intervention programme for specific assets to systematically reduce network leakage is inherently limited.

6.2 Advancing Leakage Detection

This situation is now changing significantly due to the large-scale collection of empirical emissions data and the availability of digital tools that enhance our understanding of the network and its leakage. Cadent is at the forefront of this transition, adopting an approach centred on addressing observed leakage rather than relying solely on modelled estimations. This is facilitated by a suite of tools that provide a granular view of our emissions and the impact of interventions.

Cadent is actively surveying its network to measure actual emissions. We have partnered with a provider of vehicle mounted Advance Leak Detection (ALD) technology, which offers a digitalised method for monitoring the gas network for leaks – even smaller ones. This technology is notably more sensitive and cost-effective than legacy approaches, offering a significantly larger detection range compared to vehicles following underground pipes. Furthermore, we are trialling other emerging leakage detection technologies, including acoustics and ultrasonics-based sensors, handheld and bolt-on sensors, fixed sensors, and satellite imaging.

6.3 The Hybrid Leakage Model (HLM)

Cadent's Asset information Management (AIM) tool uses the most up-to-date information on our mains assets (e.g. age, location) to forecast long-term performance. This enables us to target mains with the highest risks for proactive intervention. The AIM tool incorporates observed leakage data from the Hybrid Leakage Model (HLM). We integrate the 'observed' emissions data (which gives us emissions occurring in an area) into AIM to estimate which pipes may be leakiest based on asset condition and calculate the 'net benefit' of interventions. We then run an optimisation model that enables us to target interventions that will deliver the greatest value in terms of emission reductions and safety benefits, with a minimal impact on our customers' bills.

Our observed leakage data indicates that some pipes leak more than assumed in the SLM, while others leak less. While there is only a very small overall increase in emissions between the two approaches, our HLM directs interventions to different pipes compared to the SLM. This means the HLM enables us to target pipes with the highest risk of failure – and thus the greatest safety and leakage risk – more accurately than the theoretical SLM.

For example, initial survey data from North London indicates that under the SLM, 2.5% of network length accounts for 40% of emissions, whereas based on observed data, only 1.6% of network length accounts for the same emission level (figure 5). Furthermore, observations suggest that Tier 2 and 3 Cast Iron pipes and Steel pipes tend to leak less than estimated by SLM, while Ductile Iron pipes tend to leak more, confirming that interventions planned based on SLM would differ significantly from those based on observed emissions data.

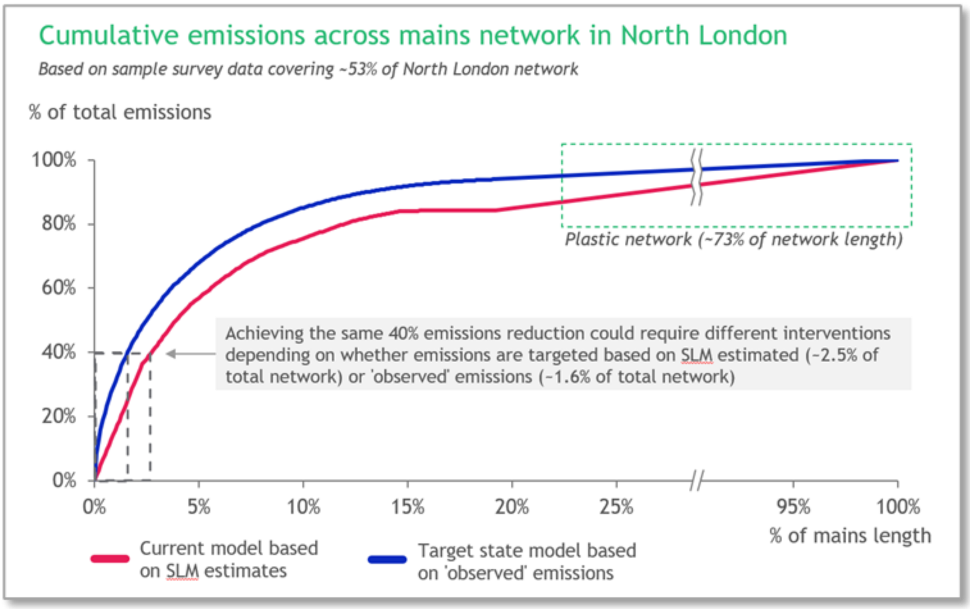

Figure 5: Cumulative emissions in North London

6.4 Strategic Investment and Programme Delivery

Cadent's approach to non-mandatory mains replacement is determined by evaluating the net present value of various scenarios. This process prioritises key benefits: environmental improvements by avoiding gas emissions, cost savings achieved through reduced reactive repairs, and enhanced safety by preventing fatalities from gas ignitions. This investment framework underpins our 5-year Advanced Leakage Intervention Programme (ALIP) strategy.

This strategy is delivered through our Advanced Leakage Management Approach (Figure 6), which integrates ALD and the Digital Platform for Leakage Analytics (DPLA).

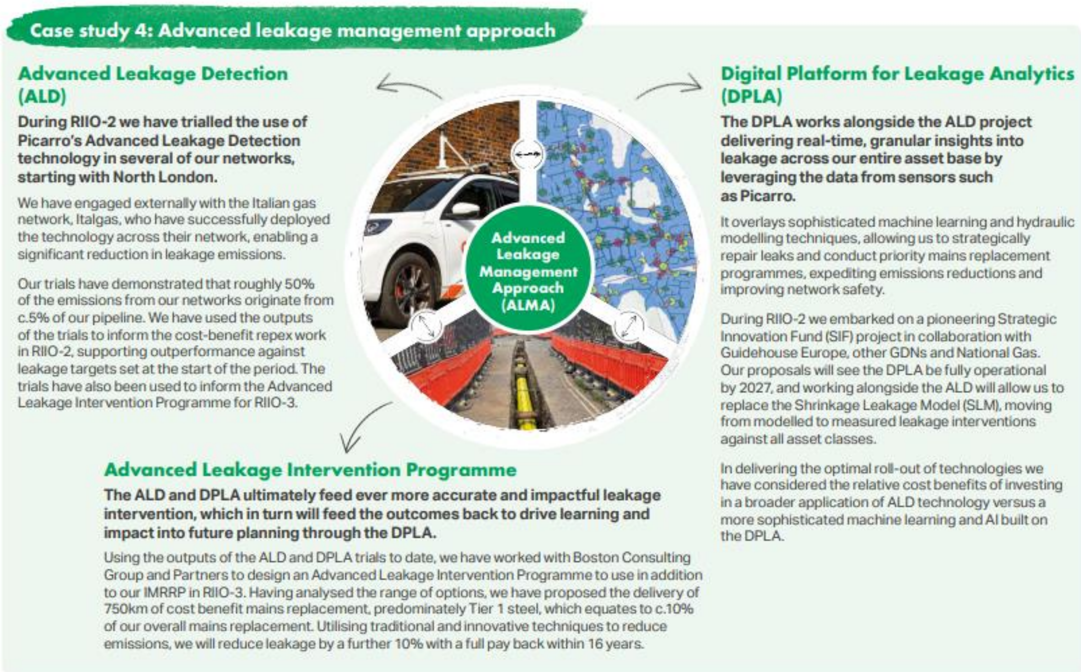

Figure 6: The three components of the Advanced Leakage Management Approach

Day-to-day operations involve a continuous rolling programme of leak detection using vehicle-mounted monitoring. When we identify a leak in the field, we respond by repairing it, provided it exceeds the Environmental Action Threshold or Safety Action Threshold. This is a reactive repair following a failure which stops the immediate leak on a temporary basis only (see 'Intervention Mode 0', section 8.2.1 in EJP09). Figure 7 illustrates the action thresholds to guide prioritisation of reactive repairs. The resulting observed data is fed into the DPLA, which continuously updates our understanding of pipe failure risks.

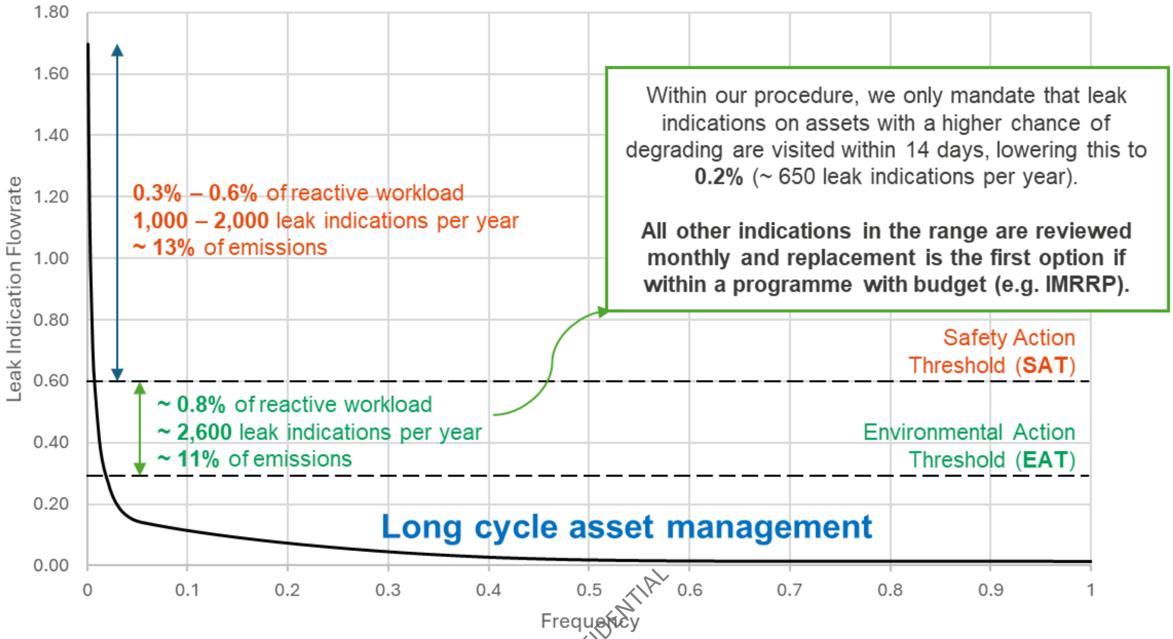

Figure 7: Action thresholds for reactive repairs.

Over time, as observed data is combined with other asset performance information, it shows a longer-term view of mains-asset health and failure rates, particularly recurring leakage. This evidence then informs decisions regarding **proactive mains replacement** or rehabilitation. Crucially, a one-off, individual leak does not automatically trigger a proactive mains replacement plan; we only commit to proactive replacement when the accumulated evidence demonstrates that the failure rate and its consequences are sufficiently high to make a proactive approach more cost-effective than continued reactive repairs.

Analysis of observed data has highlighted a significant opportunity to further enhance environmental performance such that reducing the duration of leakage events is a primary driver in lowering cumulative emissions. To effectively mitigate environmental impact and accelerate emissions reduction, an expanded programme of non-mandatory mains investment is justified based on a pay-back period aligned to Ofgem's guidelines, enabling more proactive intervention aligned with our sustainability objectives.

Following strategy approval, annual proactive mains replacement programmes (ALIPs) are then developed for each network, identifying the highest-risk pipe IDs and detailing projects with clear financial and performance targets focused on asset health, safety, and leakage reduction.

7 Annex F: CBA Costs and Benefits Explanation

The following table sets out the basis for the costs and benefits assumptions used in the CBA calculations. This provides the option-level information requested in the CBA table “**Option 1_workings**” sheets.

We have taken a conservative approach to long-term assumptions in our CBA calculations, choosing to use present day assumptions across the full planning horizon. We have therefore NOT increased the following over the longer term, which could all increase the benefit to cost (NPV and payback) of our proposed investment:

- **Costs in RIIO4 onwards** (Repex & Opex costs) to account for anticipated real price effects, given historic and likely future trends in inflation across different cost types
- **Future property prices (when calculating property damage)** to account for anticipated real price effects, given historic and likely future trends in house prices compared to the wider economy.
- **Population density changes (**when calculating fatality risks) which could increase monetised fatality risk avoided by our proposed investment.
- **Demand changes (**when calculating leakage volumes) which could increase monetised benefits of leakage avoided by our proposed investment

We have undertaken a range of sensitivity tests, including testing the impact of different FES scenarios, which is discussed in our business case summary section of each justification paper.

Unit	Basis of costs & benefits used in CBA
Repex	Repex costs for each proactive option are set out in Section 8: Options considered of the EJP.
Opex	This covers the repair costs (the direct costs of an asset failure). Our models predict a failure rate based on assumed asset deterioration rates x cost per repair. This has been derived based on historic repair-costs captured in SAP and varies by asset class. Calculated as per NARMs methodology.
Leakage	Calculated as per NARMs methodology. Model derives a volume of gas from an asset failure, relative to asset condition.
Fatality Risk	Calculated as per NARMs methodology. Model predicts total number of fatalities, based on average population in close proximity to the asset. Ofgem conversion factor within “fixed data” used to calculate monetary value for CBA.
Non-Fatality Risk	Calculated as per NARMs methodology. Model predicts total number of non-fatal injuries, as a proportion of fatalities. Ofgem conversion factor within “fixed data” used to calculate monetary value for CBA.

Unit	Basis of costs & benefits used in CBA
Other private costs	Calculated as per NARMs methodology. This category has been used to capture the secondary impacts of failure, including customer compensation payments, legal costs, other costs such as traffic management orders, lane-rental costs or other permitting-costs, customer visits / inspections.
Property damage	Calculated as per NARMs methodology. This values the property and repair costs following an explosion which has resulted in property damage.
Customer interruptions	This values the number of customers impacted by a supply interruption, using customer willingness to pay valuations derived through customer research, for different duration interruptions.

Table 7: Data for CBA

8 Annex G: Robust and Efficient Unit Costs

Forecasting of Cadent's IMRRP costs for RIIO-3 have been grounded in a solid understanding of future works both in terms of developing methods to draw a detailed view of a schemes from our core systems and mapping data and by seeking to identify the changing complexities which will face us as we come to the end of the 30:30 programme. This section focuses on the development of the rates applied to volumes already established elsewhere in this document and utilised in the CBA process.

Cadent have leveraged the improvements in data analytics and AI available to place several lenses on the data available to us and provide a step change in accuracy and completeness of our network understanding and specifically that of the pipes to be addressed in our RIIO-3 programme. Critically this has developed our understanding of not just the length, diameter and pressure tier of a main to be replaced but the number of connection points, proximity to impactful infrastructure (hospitals, railways, schools) overall improving our ability to make business decisions and to iterate our chosen programme to identify the most efficient and beneficial solution.

Mains Replacement works are a risk reduction activity through the abandonment of aged gas distribution assets. In most cases these abandoned assets are replaced with modern PE alternatives maintaining or enhancing the existing supply. Mains replacement can be split into several distinct activities, and our modelling of Tier 1 costs has dealt with these separately. Below you can see a description of each item alongside the materiality of the activity to the overall business plan:

#	Cost/Activity	Description	Tier 1 (£m)
1	**LDP Contractor**	Costs relating to the teams of individuals and equipment used conducting mains replacement along with the various overheads of the companies that employ them. This predominantly relates to the excavation of existing pipe work and the assembly of its replacement along with reconnection of the customers serviced by the gas mains involved.	58%
2	**LDP CE's**	Compensation Event costs where a material change is agreed to have occurred between the work as sold to our Local Delivery Partners and that found on site during works. This is a key mechanism to avoid requiring the LDPs to take unknown risk and to secure the best possible price for the works Cadent require.	4%
3	**Support Services**	To enable the mains replacement team to complete their work safely and efficiently support services are often but not always provided by a third party. These are most commonly: Traffic Management – Delivery, Installation and Removal of traffic management to protect the works and members of the public Purge and Relight – Resources competent to work on gas pipework downstream of the metre. Most critically ensuring that gas supply is safely reinstated after the property has been cut off during works Reinstatement – compliantly reinstating the excavations made during mains replacement to appropriate highway specification where required	5%
4	**Stubs**	A mains replacement project of any size will end either at the extremity of the network where no pipework continues, or it will abut upstream pipework. Where upstream pipework comprises a joint to a parent main a stub is a short length of main left leading up to the parent main to avoid impacting the perpendicular carriageway. Policy now dictates that these stubs be assessed to determine the appropriate remediation.	0
5	**Pipe and Fittings**	Issued from Cadent's primary and secondary stores P&F are the main building blocks of the network. Predominantly comprising pipe work and couplings of assorted sizes.	7%
6	**Cadent Other**	Includes NRSWA/TMA costs paid out to Highways Authorities to allow works to take place in their jurisdiction. Also includes less common costs such as legal fees for easements, vehicles and equipment purchased direct by Cadent.	5%
7	**CMO**	The Contract Management Organisation is contracted by Cadent gas to manage the subcontractors predominantly engaged in Mains Replacement	11%
8	**Cadent Overheads**	These costs represent the indirect costs incurred by Cadent in undertaking Mains Replacement including commercial teams, Investment Planning Office and Head Office Departments	10%

Table 8: Description and materiality of elements of mains replacement cost build up

Note that stubs costs in the above table are set to £0, stubs costs have been considered separately and documented later on in this appendix.

Local Delivery Partner (LDP) Contractor costs are by far the most material associated to mains replacement and can be further differentiated to mains related and service related costs. Mains costs have drawn on the previously mentioned wealth of data and, with the support of third party AI tools, 1600km of Cadent's most recent (2024 cost base) tender returns for year five have been reviewed.

The output of this review was a set of unit rates which distinguished between:

- insertion and open cut
- diameter band
- location

These recent tenders provided the most recent view of mains replacement work unit costs and, alongside historic cost ratios between diameter bands and replacement technique (insertion vs open cut), unit rates could be interpolated. Location was isolated not simply at a Cadent network level but provided unit rates localised at highway authority level. This was critical in accurately demonstrating the impact of significant changes in the location of RIIO-3 work. Service Costs were similarly derived from supply chain rates but used current rates being paid to suppliers for relays and transfers. Highway Authority level values were determined by the rate currently paid in that area.

The efficiency of these base rates was further reinforced using the AI based Cadent developed Commercial Price Assessment Tool (CPAT). The CPAT takes the prices received from the supply chain along with the schedules of cost components that support them and provide comparisons. The tool highlighted where there are inconsistencies between suppliers and what is driving the differences in their scheme prices. Below can be seen an extract of the dashboard

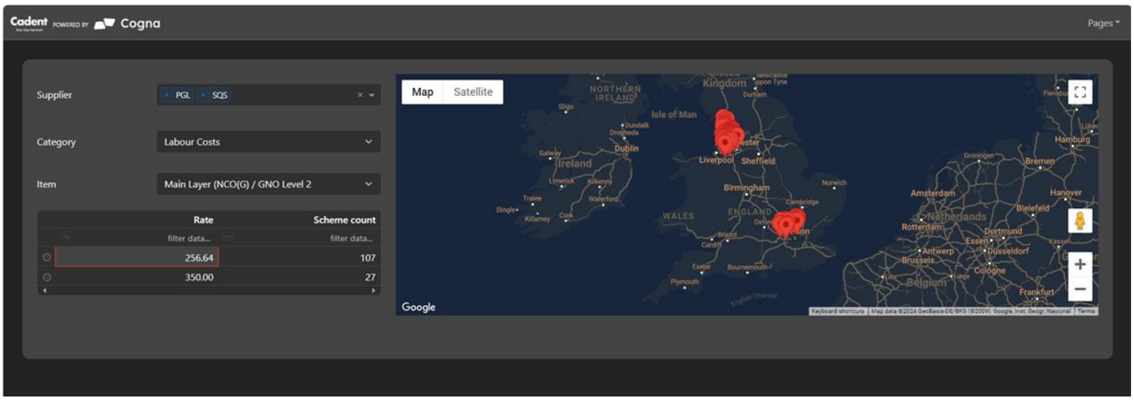

Figure 8: Commercial Price Assessment Tool (CPAT)

In tandem with the above benchmarking made between suppliers' further assurance was sought against our 'SPM' (Standard Pricing Model). The SPM provides a bottom-up target cost for Packages and Projects so we can benchmark costs vs our LDPs and provide indicative costs prior to launching the Procurement event.

Throughout RIIO-2 Cadent have noted an increasing trend in the complexity of work being undertaken with reference to things like works in junctions, Local Authority restrictions or accessibility to construct. Cadent have looked to draw on the collective experience of Cadent staff and key stakeholders across our Networks to build a picture of drivers of complexity for MRP schemes. These factors having been given a "ranking" relating to the impact they have on the cost of a given scheme were then mapped across a sample of 1,600km of 'real life' procured year four works. Through this analysis Cadent identified a relationship between Low, Medium and High Complexity PONs and LDP costs. Below is an example of the East Anglia network showing a difference of up to 116% between the low and medium scoring schemes.

[redacted]

Table 9: East Anglia network showing a difference of up to 116% between the low and medium scoring schemes

Having established the relationship between these factors and having the mapping data required to extrapolate this across RIIO-3 we are able to understand the pattern between RIIO-3 and RIIO-2 from a complexity work mix perspective. The result of utilising the above methodology on the RIIO-3 proposed volume for can be seen in the example below for North London and North West. The table shows the variance in the proportion of work sitting in the "Low", "Medium" and "High" categories between year four (RIIO-2) and each year of RIIO-3 based on the proposed portfolio of works.

Network	Complexity Banding	Year 4	Year 6	%var	Year 7	%var	Year 8	%var	Year 9	%var	Year 10	%var
North London	Low	58.95%	55.53%	-3.43%	51.31%	-7.65%	51.29%	-7.66%	57.20%	-1.75%	58.34%	-0.62%
North London	Medium	40.62%	41.67%	1.05%	46.29%	5.67%	45.20%	4.58%	40.17%	-0.45%	39.56%	-1.06%
North London	High	0.42%	2.80%	2.38%	2.40%	1.97%	3.51%	3.09%	2.63%	2.21%	2.10%	1.67%
				3.43%		**7.65%**		**7.66%**		**1.75%**		**0.62%**
North West	Low	78.66%	76.11%	-2.55%	75.84%	-2.81%	77.48%	-1.17%	77.16%	-1.50%	76.80%	-1.85%
North West	Medium	20.74%	23.68%	2.94%	23.62%	2.88%	22.10%	1.35%	22.35%	1.60%	22.54%	1.79%
North West	High	0.60%	0.21%	-0.39%	0.53%	-0.07%	0.42%	-0.18%	0.50%	-0.10%	0.66%	0.06%
				2.55%		**2.81%**		**1.17%**		**1.50%**		**1.85%**

Table 10: Variance in the proportion of work sitting in the "Low", "Medium" and "High" categories

The overall materiality of complexity scoring, and measurement principles detailed above and be seen from the below, which demonstrates the overall LDP cost 'without' complexity % uplifts being applied across the full business plan and the LDP total costs with the above principles adopted.

[redacted]

Table 11: The overall materiality of complexity scoring

Across the networks an average of 15.17% increase in cost has been seem between RIIO-2 and RIIO-3. Of the 15.17% increase, we can attribute 3.26% directly to complexity increasing. This complexity measure represents costs which Asset Information may not identify, such as Local Authority relationships, road-to-property gradients etc. The residual 11.91% increase can be isolated to asset-based information for example:

- Diameter mix (Larger diameters being completed vs RIIO-2)
- Location/Highway Authority of future works

LDP Compensation Events are tracked by Cadent's commercial team. This tracking provides historical data of the root cause of a given change event, the value ultimately agreed to represent the impact of the event and the scheme to which was associated. Compensation Events are another cost that can be influenced by geography since events like the frequency of specialist reinstatement, scope creep due to mapping inaccuracies or ground contamination are Highway Authority (HA) specific. It is possible to map records of compensation events to HA alongside the meterage reported in RRP to derive a unit rate which can be applied to the pipelines in the RIIO-3 program.

Support Services include both purge and relight activities and traffic management (TM). To cost purge and relights we have taken a similar approach to services using the current year four rates paid as a starting point. These rates being the result of a competitive tender specific to the network in which they are applied. The exception is WM where the LDPs are able to provide a fully domestic service and have tendered MRP works inclusive of purge and relights. In this case the average rates from neighbouring networks EM and NW have been used.

Several of the most common site lay outs of 'on-site' TM have been used to develop the unit rates for traffic management which have used historic averages and also considered the surface category of the road. For example, it has been established that in 40% of cases schemes in the footway would require TM; 20% of which would be a 2-way unmanned set up. These frequencies were used as weightings against the rates of the incumbent TM supplier in each network such that a unit rate for a day's TM in a given surface category could be derived. To determine the number of day's work associated to a given length of main the productivity was calculated by reviewing cumulative delivery data across the first three years of RIIO-2. Each network maintains a record by scheme of the work completed each week by each of the LDPs active in their area. This record will include the volume of main abandoned/laid and is critical for tracking Cadent's performance against output targets as well as to ensure payments are made based on actual delivery. Using this data the number of weeks and mains length abandoned indicates the average weekly production for each scheme. The scheme can be linked to their respective Highway Authority to find the average productivity according to geography.

These components could be used to generate a TM cost based on the length of main, surface category and locations already provided in the IMRRP program.

Pipe and Fittings lends itself to a bottom-up modelling approach as the components of a length of new main are well known and follow and established best practice. A model was developed to produce a bill of materials for a mains replacement scheme depending on:

- The volume of pipe of varying diameter
- A given number of transfers and relays of services
- The number of connections
- Bypass Requirements
- Live or Dead insertion

This model was used to produce several base rates, using the lengths of IMRRP in our plan an overall cost of Pipe and Fittings for each year of the proposed RIIO-3 program was produced.

Cadent Other costs are predominantly related to NRSWA and TMA costs or 'off site' TM which includes permit cost and parking bay suspensions. As with other cost components we have sought to maintain a low-level geographic view of permit costs. We have done this by taking a three-year extract of the permits issued in our networks and the schemes delivered over the same period from RRP. This presented us with a view of the number of permits we were encountering for a given length delivered. This rate of permits per metre was applied to the volumes for RIIO-3 to provide a view at HA level of the number of permits of distinct categories that may be required. It also allowed a cost of permit to be calculated using the unique rates each HA charges for a given permit.

The following categories within Cadent Other have used a run rate from prior years or the current year four budget rate and held it flat into GD3.

- Vehicles & Mobile Plant - (e.g. Road Sweepers)
- Tools & Equipment – (e.g. Ad hoc purchases of signing lighting and guarding systems)
- Other costs (e.g. stationary, legal costs, consultancies)
- Parking Bay Suspensions Outside of London

Parking Bay Suspensions for London have not used a continuation of the year four prices as the level of spend here is considerably higher and more sensitive to a change in HA within the network area. This can be attributed to the sensitivity of parking bays to population density and the variability of the latter over the London Network. Here Cadent have reviewed the spend on PBS through our supply chain partners and identified the scheme on which it was incurred. This has allowed us to build a HA level £/m unit rate like that used for permitry which could be applied to RIIO-3 volumes by location.

<u>Contract Management Organisation (CMO)</u> costs have remained static year on year across RIIO-2 in line with the consistency of the Mains Replacement Volumes they have been instrumental in delivering. The CMO are a third-party organisation engaged by Cadent to provide safety and programme management as well as cost management of the teams undertaking mains replacement works. The CMO element of the RIIO-3 allowance has been based on the £/m unit rate assigned in the year four budget. Being driven by volume it is therefore assumed that the CMO indirect cost will flex slightly and linearly with the amount of main abandoned each year over the proposed program.

Cadent Indirect as with CMO costs have been consistent over the RIIO-2 term which is reflective of the teams involved within Cadent delivering the MRP program. As such these costs have also been driven by our current year four budget for those in our commercial and investment project office with our finance team feeding in typical recharges for head office, OCIP and Logistics.

Stubs cost approach

The cost associated with our stubs has been derived following the methodology and logic applied for our RIIO-2 stubs reopener submitted in March 2024. For our RIIO-3 submission we have taken further efficiencies and cost savings into account. Our cost data reflects:

- A change in the assumption of works left retrospectively
- A lower overhead for works completed in parallel with Mains Replacement

We have embedded our stubs processes across our networks throughout RIIO-2. This has allowed us to minimise the occasions that we have to create a stub and then return to it at a later date.

We have reduced our overhead for our stubs completed in line with MRP as the overhead applied to the stubs, reopener included allocated corporate functions such as finance or engineering safety. These were relevant to the reopener as this overhead was not applied at the time the base allowance and reopener was set.

Costs per KM tables for each scenario *not including associated services.

Cost range per km taken from each scenario Table

	Open Cut cost range per KM	Insertion cost range per KM	Cisbot cost range per KM
650km in RIIO-3	[redacted]		
RIIO-2 approach: 230km in RIIO-3			
390km in RIIO-3			
480km in RIIO-3			

Table 12: Cost range Per km Summary

9 Annex H: Detailed Options-Level Data

9.1 Option 1: 650km in RIIO-3 - chosen

Volume of Mains Replaced (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
EE	24.74	36.27	60.45	56.53	48.89	**226.88**
NL	9.84	11.46	18.08	17.08	16.11	**72.57**
NW	17.31	25.29	41.84	42.37	29.75	**156.57**
WM	15.07	22.31	37.25	37.49	30.21	**142.34**
Total	**66.96**	**95.33**	**157.62**	**153.48**	**124.96**	**598.35**

Table 13: Option 1 - Mains volume

Volume of Mains Refurbished CISBOT (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	3.83	3.17	2.86	2.82	2.84	**15.52**
NL	4.70	4.69	4.69	4.69	4.68	**23.45**
NW	0.60	0.60	0.60	0.60	0.59	**2.98**
WM	1.79	1.77	1.77	1.72	0.25	**7.29**
Total	**10.91**	**10.22**	**9.92**	**9.83**	**8.36**	**49.25**

Table 14: Option 1 - CISBOT volume

Volume of Service Interventions (number)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	493	1,467	2,887	2,569	1,884	**9,299**
NL	1,486	799	2,328	2,204	1,877	**8,694**
NW	467	1,223	1,829	1,455	611	**5,583**
WM	472	1,434	2,379	2,331	1,027	**7,642**
Total	**2,917**	**4,923**	**9,423**	**8,559**	**5,398**	**31,219**

Table 15: Option 1 - Services volume

£m / year						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	[redacted]					
NL						
NW						
WM						
Total						

Table 16: Option 1 - Repex cost

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9.2 Option 2: 230km in RIIO-3

Volume of Mains Replaced (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	19.74	19.54	19.65	18.66	19.15	**96.73**
NL	9.78	9.23	9.74	9.14	9.35	**47.23**
NW	9.39	9.44	9.08	9.25	8.85	**46.01**
WM	8.61	9.05	7.15	7.81	8.02	**40.64**
Total	**47.51**	**47.26**	**45.61**	**44.86**	**45.37**	**230.61**

Table 17: Option 2 - Mains volume

Volume of Service Interventions (number)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	262	857	720	1,284	1,457	**4,579**
NL	808	781	1,107	1,395	847	**4,938**
NW	334	243	771	756	506	**2,610**
WM	257	268	592	488	405	**2,011**
Total	**1,661**	**2,149**	**3,190**	**3,923**	**3,215**	**14,138**

Table 18: Option 2 - Services volume

£m / year						
Region	**2026/27**	**2027/28**	**2028/29**	**2029/30**	**2030/31**	**Total**
EE	[redacted]					
NL						
NW						

£m / year						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
WM	[redacted]					
Total						

Table 19: Option 2 - Repex cost

9.3 Option 3: 390km in RIIO-3

Volume of Mains Replaced (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
EE	25.09	29.26	29.37	29.34	29.04	**142.08**
NL	11.02	11.64	9.74	9.14	9.35	**50.90**
NW	14.58	14.30	9.08	9.25	8.85	**56.06**
WM	13.62	14.16	13.57	12.01	12.17	**65.53**
Total	**64.32**	**69.36**	**61.75**	**59.74**	**59.40**	**314.57**

Table 20: Option 3 - Mains volume

Volume of Mains Refurbished CISBOT (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
EE	3.83	3.19	2.86	2.82	2.84	**15.55**
NL	4.63	4.70	4.62	4.68	4.61	**23.23**
NW	0.56	0.59	0.60	0.55	0.56	**2.87**
WM	1.79	1.77	1.77	1.72	0.25	**7.29**
Total	**10.82**	**10.25**	**9.85**	**9.77**	**8.26**	**48.94**

Table 21: Option 3 - CISBOT volume

Volume of Service Interventions (number)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	720	1,198	1,546	1,742	1,522	**6,727**
NL	1,384	641	1,980	2,168	1,991	**8,163**
NW	574	305	717	1,180	782	**3,558**
WM	455	504	996	626	540	**3,122**
Total	**3,133**	**2,650**	**5,238**	**5,716**	**4,835**	**21,570**

Table 22: Option 3 - Services volume

£m / year						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	[redacted]					
NL						
NW						
WM						
Total						

Table 23: Option 3 - Repex cost

9.4 Option 4: 480km in RIIO-3

Volume of Mains Replaced (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
EE	24.95	37.50	39.35	39.10	38.84	**179.73**
NL	11.00	11.56	16.88	17.07	15.87	**72.38**
NW	17.28	19.30	19.21	18.97	18.46	**93.22**
WM	15.61	19.09	18.33	17.64	16.87	**87.54**
Total	**68.84**	**87.45**	**93.77**	**92.77**	**90.05**	**432.87**

Table 24: Option 4 - Mains volume

Volume of Mains Refurbished CISBOT (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
EE	3.83	3.19	2.86	2.82	2.84	**15.55**
NL	4.63	4.57	4.60	4.65	4.66	**23.12**
NW	0.56	0.59	0.60	0.55	0.60	**2.90**
WM	1.79	1.72	1.48	1.50	0.78	**7.27**
Total	**10.81**	**10.08**	**9.54**	**9.53**	**8.88**	**48.84**

Table 25: Option 4 - CISBOT volume

Volume of Service Interventions (number)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	510	1,533	1,687	2,358	2,038	**8,126**
NL	1,369	477	2,510	2,457	2,248	**9,061**
NW	624	582	1,285	1,180	964	**4,636**
WM	512	1,312	746	949	720	**4,239**
Total	**3,016**	**3,904**	**6,228**	**6,944**	**5,969**	**26,062**

Table 26: Option 4 - Services volume

£m / year						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	[redacted]					
NL						
NW						
WM						
Total						

Table 27: Option 4 - Repex cost

9.5 Option 5: Unconstrained

Volume of Mains Replaced (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	62.21	62.05	62.30	61.95	62.03	**310.54**
NL	61.60	62.14	62.30	62.04	27.15	**275.24**
NW	61.87	61.84	61.93	61.21	61.82	**308.66**
WM	60.47	60.65	60.83	61.36	60.07	**303.39**
Total	**246.15**	**246.68**	**247.35**	**246.56**	**211.07**	**1,197.82**

Table 28: Option 5 - Mains volume

Volume of Mains Refurbished CISBOT (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	155.04	-	-	-	-	**155.04**
NL	218.29	-	-	-	-	**218.29**
NW	132.24	-	-	-	-	**132.24**
WM	204.54	-	-	-	-	**204.54**
Total	**710.11**	**-**	**-**	**-**	**-**	**710.11**

Table 29: Option 5 - CISBOT volume

Volume of Service Interventions (number)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	1,667	2,792	3,482	3,243	2,712	**13,897**
NL	5,297	5,634	6,319	5,288	2,103	**24,642**
NW	3,093	3,865	3,610	2,789	4,124	**17,480**
WM	3,713	6,106	5,757	4,808	3,794	**24,179**
Total	**13,770**	**18,398**	**19,169**	**16,129**	**12,733**	**80,198**

Table 30: Option 5 - Services volume

£m / year						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	[redacted]					
NL						
NW						
WM						
Total						

Table 31: Option 5 - Repex cost